Public Services

128 North Second Street • Fourth Floor Courthouse • Yakima, Washington 98901
(509) 574-2300 • 1-800-572-7354 • FAX (509) 574-2301 • *www.co.yakima.wa.us*

LISA H. FREUND – Director

July 9, 2019

David Bowen
Department of Ecology, Central Region Office
1250 West Alder Street
Union Gap, WA 98903

Re: **Lower Yakima Valley GWMA - 2019 Second Quarter Report (IAA No. C 1200235)**

Dear David:

Enclosed please find one (1) copy of Yakima County's second-quarter report as required under Attachment A, Statement of Work, Agreement No. C 1200235 between the State of Washington Department of Ecology and Yakima County.

This report addresses deliverables 1.1 and 2.2 as required under the agreement.

Deliverable 2.1, invoices, to be sent separately.

If you have any questions, please let me know.

Thank you.

Lisa Freund, Director
Yakima County Public Services

enclosure

Yakima County ensures full compliance with Title VI of the Civil Rights Act of 1964 by prohibiting discrimination against any person on the basis of race, color, national origin, or sex in the provision of benefits and services resulting from its federally assisted programs and activities. For questions regarding Yakima County's Title VI Program, you may contact the Title VI Coordinator at 509-574-2300.

If this letter pertains to a meeting and you need special accommodations, please call us at 509-574-2300 by 10:00 a.m. three days prior to the meeting. For TDD users, please use the State's toll free relay service 1-800-833-6388 and ask the operator to dial 509-574-2300.

IAA No. C 1200235 – Second Quarter 2019 Report
Lower Yakima Valley GWMA
June 30, 2019

TASK 1 - ADMINISTRATIVE FUNCTIONS
DELIVERABLES

1.1 Meeting Records

For each meeting of the GWAC, submit a copy of the agenda, minutes, attendance and public meeting notice at the end of each quarter.

Attachment [A] includes the public meeting notices, final agenda and meeting summary of the December 13, 2018 GWAC meeting and the final agenda and draft meeting summary of the June 20, 2019 GWAC meeting. No working groups met in this quarter.

TASK 2 - PROGRAM FUNCTIONS
DELIVERABLES

2.2 Status Report

Submit written quarterly status reports summarizing GWAC plans, activities and work products, and describing any interlocal agreements or other contracts by the end of each quarter.

The GWAC held one meeting in the second quarter. No further GWAC meetings are planned.

Submittal of Program to Ecology.

The GWAC met on June 20, 2019 to consider final approval of the GWMA Program and submittal of the Program to the Department of Ecology. Following discussion, the GWAC voted to submit the final Program document to Ecology. The GWAC also discussed the Yakima County Letter of Concurrence and resolved a concern with the Yakima Health District Concurrence Letter.

The public was invited to a public meeting on March 12, 2019 and also given time to submit comments on the draft GWMA Program. Public comment was published on the GWMA website and presented to the GWAC at the June 20, 2019 meeting.

Attachment [B] includes the Lower Yakima Valley Groundwater Management Program (LYV-GWMA) Volumes I – IV dated June, 2019, the Comprehensive List of Changes to Volumes I to IV, GWMA Program Findings, Response to Comments and Letters of Concurrence.

Ambient Groundwater Monitoring Network (AMN)

Environmental Services Director David Haws reported on the initial results found and published by Pacific Groundwater Group (PGG) in the Lower Yakima Valley Groundwater Management Area Ambient Groundwater Monitoring Well Installation Report.

Attachment [C] includes the Lower Yakima Valley Groundwater Management Area Ambient Groundwater Monitoring Well Installation Report prepared by Pacific Groundwater Group.

Working Group Activities

No working groups met in the second quarter.

GWMA Website

The GWMA website continued to be updated in real time.

Contracts and Interlocal Agreements

No contracts were executed in the second quarter.

Attachment A

- Public Meeting Notices
- Final Agenda and Meeting Summary of the December 13, 2018 GWAC Meeting
- Final Agenda of the June 20, 2019 GWAC Meeting
- Draft Meeting Summary of the June 20, 2019 GWAC Meeting
- Attendance Roster for the June 20, 2019 GWAC Meeting

D0003 S3088

SUNNYSIDE SUN

P.O. Box 878 • 600 S. Sixth Street
Sunnyside, WA 98944
Phone (509) 837-4500
Fax (509) 837-6397

WE GLADLY ACCEPT

INVOICE

Billing Date 06/12/19
Account Number 030110-00000
Telephone 509-574-2300

Yakima County Public Services
128 N. 2nd St. 4th Floor
Yakima, WA 98901

LEGAL ADVERTISING INVOICE

Item Invoiced	StartDate	EndDate	Insertions
Yakima County Notice	06/12/19	06/12/19	1
Invoice #: 184 FC3463-100-120 6/20 Mtg.			

Total Due 54.25

PLEASE INCLUDE INVOICE NUMBER ON ALL PAYMENTS

Legals must be paid for before affidavits can be sent

Thank you!

RECEIVED
JUN 14 2019
PS ACCOUNT

Funding Control FC3463-100-120
Authorized By JCC
Date Authorized 6-17-19

Yakima County Notice of Public Meeting
Lower Yakima Valley Groundwater Advisory Committee

NOTICE IS HEREBY GIVEN that Yakima County is holding a public meeting of the Lower Yakima Valley Groundwater Advisory Committee on **Thursday, June 20, 2019, at 5:00 PM at Denny Blaine Boardroom, Sunnyside School District No. 201, 810 E. Custer, Sunnyside, WA 98944** pursuant to Chapter 173-100-080 WAC Ground Water Management Areas and Programs.

For Additional Information

To learn more about the Lower Yakima Valley Groundwater Management Area, the Groundwater Advisory Committee, and its goals and objectives, please see the Lower Yakima Valley Groundwater Management Area on the County webpage at: http://www.yakimacounty.us/gwma/

For more information about the meeting, please contact Jacob Clay, Yakima County Public Services Administrative Manager at 574-2300.

If you are a person with a disability who needs any accommodation in order to participate in this program, you may be entitled to receive certain assistance at no cost to you. Please contact the ADA Coordinator at Yakima County no later than forty-eight (48) hours prior to the date service is needed.

Yakima County ADA Coordinator
128 N. 2nd Street, Room B27
Yakima, WA 98901
(509) 574-2210
7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)

Dated this Monday, June 10, 2019
Publish: Wednesday, June 12, 2019
PUBLISH SUNNYSIDE SUN
June 12, 2019

Affidavit of Publication

STATE OF WASHINGTON
ss.
County of Yakima

Debbie Guerrero, being first duly sworn on oath deposes and says that she is the Office Manager of the SUNNYSIDE SUN, a weekly newspaper.

That said newspaper is a legal newspaper, published in the English language continually as a weekly newspaper in the city of Sunnyside, YAKIMA County, Washington, and it is now and during all of said time printed in an office maintained at the aforesaid place of publication of said newspaper, and that the said Sunnyside Sun was on the 4th Day of April, 1969 approved as a legal newspaper by the Superior Court of said Yakima County.

That the annexed is a true copy of a LEGAL PUBLICATION –
Yakima County Public Services
FC3463–100–120 6/20 Mtg.

published in regular issues (and not in supplemental forms) of said newspaper once each week for a period of 1 consecutive issue(s) commencing 06/12/19 and ending on 06/12/19, both dates inclusive, and that such newspaper was regularly distributed to its subscribers during all of said period.That the full amount of the fee charged for the foregoing publication is the sum of $54.25, amount has been paid in full, at the rate of $7.75 per column inch per insertion.

Debbie Guerrero

Subscribed and sworn to before me 6/12/2019

Karen Zackula

Notary Public in and for the State of Washington

KAREN ZACKULA
NOTARY PUBLIC
STATE OF WASHINGTON
COMMISSION EXPIRES JUNE 18, 2021

06/12/19 08:38

Legals (1 column)

Yakima County Notice of Public Meeting
Lower Yakima Valley Groundwater Advisory Committee

NOTICE IS HEREBY GIVEN that Yakima County is holding a public meeting of the Lower Yakima Valley Groundwater Advisory Committee on **Thursday, June 20, 2019, at 5:00 PM at Denny Blaine Boardroom, Sunnyside School District No. 201, 810 E. Custer, Sunnyside, WA 98944** pursuant to Chapter 173-100-080 WAC Ground Water Management Areas and Programs.

For Additional Information

To learn more about the Lower Yakima Valley Groundwater Management Area, the Groundwater Advisory Committee, and its goals and objectives, please see the Lower Yakima Valley Groundwater Management Area on the County webpage at: http://www.yakimacounty.us/gwma/

For more information about the meeting, please contact Jacob Clay, Yakima County Public Services Administrative Manager at 574-2300.

If you are a person with a disability who needs any accommodation in order to participate in this program, you may be entitled to receive certain assistance at no cost to you. Please contact the ADA Coordinator at Yakima County no later than forty-eight (48) hours prior to the date service is needed.

Yakima County ADA Coordinator
128 N. 2nd Street, Room B27
Yakima, WA 98901
(509) 574-2210
7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)

Dated this Monday, June 10, 2019
Publish: Wednesday, June 12, 2019
PUBLISH SUNNYSIDE SUN
June 12, 2019

[redacted]

YAKIMA HERALD-REPUBLIC
WE TELL YOUR STORIES YAKIMAHERALD.COM

El Sol de Yakima

-Ad Proof-

This is the proof of your ad scheduled to run on the dates indicated below.
Please confirm placement prior to deadline, by contacting your account rep at (509) 577-7740.

Date:	06/10/19
Account #:	110536
Company Name:	YAKIMA COUNTY SURFACE WATER MANAGEMENT
Contact:	Tina Beck,AP
Address:	128 NORTH 2ND STREET ROOM 408 YAKIMA, WA 98901
Telephone:	(509) 574-2343

Ad ID:	890687
Start:	06/12/19
Stop:	06/12/19
Total Cost:	$116.16
# of Inserts:	2
Lines:	66.0
Ad Class:	6021
Ad Class Name:	Public Legal Notices
Account Rep:	Simon Sizer
Phone #	(509) 577-7740
Email:	ssizer@yakimaherald.com

Run Dates:
Yakima Herald-Republic 06/12/19
YakimaHerald.com 06/12/19

Ad Proof

Yakima County

Notice of Public Meeting Lower Yakima Valley Groundwater Advisory Committee

NOTICE IS HEREBY GIVEN that Yakima County is holding a public meeting of the Lower Yakima Valley Groundwater Advisory Committee on **Thursday, June 20, 2019, at 5:00 PM at Denny Blaine Boardroom, Sunnyside School District No. 201, 810 E. Custer, Sunnyside, WA 98944** pursuant to Chapter 173-100-080 WAC Ground Water Management Areas and Programs.

For Additional Information
To learn more about the Lower Yakima Valley Groundwater Management Area, the Groundwater Advisory Committee, and its goals and objectives, please see the Lower Yakima Valley Groundwater Management Area on the County webpage at: http://www.yakimacounty.us/gwma/

For more information about the meeting, please contact Jacob Clay, Yakima County Public Services Administrative Manager at 574-2300.

If you are a person with a disability who needs any accommodation in order to participate in this program, you may be entitled to receive certain assistance at no cost to you. Please contact the ADA Coordinator at Yakima County no later than forty-eight (48) hours prior to the date service is needed.

Yakima County ADA Coordinator
128 N. 2nd Street, Room B27
Yakima, WA 98901
(509) 574-2210
7-1-1 or 1-800-833-6384
(Washington Relay Services for deaf and hard of hearing)

Dated this **Monday, June 10, 2019**

(890687) June 12, 2019

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Meeting Time and Location

Thursday, December 13, 2018 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom
Sunnyside School District No. 201
810 E. Custer Ave.
Sunnyside, WA 98944

Agenda

	Topic	
	Welcome, Meeting Overview and Introductions: • **Committee members** • **Others attending the meeting**	**Jim Davenport, Facilitator**
	• Introduction of new Environmental Services Director • Monitoring Well Update	Commissioner Rand Elliott David Haws
	Consideration and possible action approving final GWMA program	**Commissioner Elliott/ Jim Davenport**
	Submission of Minority Reports	Jim Davenport
	Committee Business • **Approve the August 9, 2018 GWAC Meeting Summary**	**Jim Davenport**
	Public Comments	
	Adjourn	

Committee Members

Stuart Turner, agronomist, Chelsea Durfey (alternate)	Turner and Co.
Bud Rogers, Kathleen Rogers (alternate)	Lower Valley Community Representative Position 1
Patricia Newhouse, Sue Wedam (alternate)	Lower Valley Community Representative Position 2
Doug Simpson	Irrigated Crop Producer
Dr. Jessica Black, Dr. Alex Alexiades (alternate)	Heritage University
Jean Mendoza, Eric Anderson (alternate)	Friends of Toppenish Creek
Jan Whitefoot, Jim Dyjak (alternate)	Concerned Citizens of the Yakama Reservation
Steve George, Frank Lyall (alternate)	Yakima County Farm Bureau
Jason Sheehan, Dan DeGroot (alternate)	Yakima Dairy Federation
Ron Cowin	Sunnyside-Roza Joint Board of Control
Laurie Crowe, Rodney Heit (alternate)	South Yakima Conservation District
John Van Wingerden III, (alternate)	Port of Sunnyside
Rand Elliott, Vern Redifer (alternate)	Yakima County Commission
Holly Myers, Ryan Ibach (alternate)	Yakima Health District
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center
Lucy Edmondson, Nick Peak (alternate)	U.S. Environmental Protection Agency
Elizabeth Sanchey, Stuart Crane (alternate)	Yakama Nation
Gary Bahr, Perry Beale (alternate)	Washington Department of Agriculture
Andy Cervantes, Sheryl Howe (alternate)	Washington Department of Health
David Bowen, Sage Park (alternate)	Washington Department of Ecology
Lino Guerra, Rick Perez (alternate)	Hispanic Community Representative
Robert Black (alternate)	U.S. Geological Survey

Committee Ground Rules:

- Come to committee meetings prepared
- Treat one another with civility
- Respect each other's perspectives
- Listen actively

- Participate actively
- Honor time frames
- Silence electronic devices during meetings
- Speak from interests, not positions.

2018 Meeting Dates:

~~January 4~~	April 5	~~July 19~~
~~January 18~~	~~April 19~~	August 9
~~February 1~~	May 3	~~August 16~~
February 15	May 17	December 13
March 1	~~June 7~~	
~~March 15~~	June 21	

Meeting Materials:

Name	Date Provided	From
2018_08_09 GWAC Draft Meeting Summary	8/13/2018 and 12/5/2018	Lisa.freund@co.yakima.wa.us
2018_12_13 Agenda	12/5/2018	Lisa.freund@co.yakima.wa.us
Draft GWMA Program (dated Nov. 2018) Volumes I and II	11/21/2018	Lisa.freund@co.yakima.wa.us
Comprehensive List of Changes Vol I_II and Not Changed	At Table	Lisa.freund@co.yakima.wa.us
Ecology's Draft GWMA Program (dated Aug. 20, 2018) Volumes I, II, III and IV	11/21/2018	david.bowen@ecy.wa.gov
Next Steps_WAC 173-100-110	At Table	

YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA ADVISORY COMMITTEE (GWAC)

MEETING SUMMARY

Thursday, December 13, 2018 – 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom
Sunnyside School District No. 201
810 E. Custer Ave
Sunnyside, WA 98944

Note: This document is only a summary of issues and actions of this meeting. It is not intended to be a transcription of the meeting, but an overview of points raised and responses from Yakima County and Groundwater Advisory Committee members. It may not fully represent the ideas discussed or opinions given. Examination of this document cannot equal or replace attendance.

I. Call to Order: This meeting was called to order at 5:02 PM by Facilitator Jim Davenport.

Member	Seat	Present	Absent
Stuart Turner	Agronomist, Turner and Co.,	✓	
Chelsea Durfey	(alternate)		✓
Bud Rogers	Lower Valley Community Representative Position 1	✓	
Kathleen Rogers	Lower Valley Community Representative Position 1 (alternate)	✓	
Patricia Newhouse	Lower Valley Community Representative Position 2	✓	
Sue Wedam	Lower Valley Community Representative Position 2 (alternate)	✓	
Doug Simpson	Irrigated Crop Producer	✓	
Jean Mendoza	Friends of Toppenish Creek	✓	
Eric Anderson	Friends of Toppenish Creek (alternate)		✓
Jan Whitefoot	Concerned Citizens of the Yakama Reservation		✓
Jim Dyjak	Concerned Citizens of the Yakama Reservation (alternate)	✓	
Steve George	Yakima County Farm Bureau	✓	
Frank Lyall	Yakima County Farm Bureau (alternate)	✓	
Jason Sheehan	Yakima Dairy Federation	✓	
Dan DeGroot	Yakima Dairy Federation (alternate)	✓	
Ron Cowin	Roza-Sunnyside Joint Board of Control	✓	

	Roza-Sunnyside Joint Board of Control (alternate)		
Laurie Crowe	South Yakima Conservation District	✓	
Rodney Heit	South Yakima Conservation District (alternate)	✓	
John Van Wingerden III	Port of Sunnyside	✓	
Rand Elliott	Yakima County Board of Commissioners	✓	
Myers, Holly	Yakima Health District	✓	
Ryan Ibach	Yakima Health District (alternate)	✓	
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center	✓	
Lucy Edmondson	U.S. Environmental Protection Agency	✓	
Nick Peak	U.S. Environmental Protection Agency (alternate)		✓
Elizabeth Sanchey	Yakama Nation		✓
Stuart Crane	Yakama Nation (alternate)	✓	
Gary Bahr	WA Department of Agriculture		✓
Perry Beale	WA Department of Agriculture (alternate)	✓	
Andy Cervantes	WA Department of Health	✓	
Sheryl Howe	WA Department of Health (alternate)		✓
David Bowen	WA Department of Ecology	✓	
Sage Park	WA Department of Ecology (alternate)	✓	
Lino Guerra	Hispanic Community Representative	✓	
Rick Perez	Hispanic Community Representative (alternate)		✓
Jessica Black	Heritage University		✓
Alexander V. Alexiades	Heritage University (alternate)		✓
Robert Black	USGS	✓	

15

Welcome, Meeting Overview and Introductions: Jim Davenport welcomed the group and called for a moment of silence. Those in attendance then introduced themselves, and Jim reviewed the agenda.

II. Introduction of the New Environmental Services Director:
Commissioner Rand Elliott introduced David Haws, Yakima County's new Environmental Services Director (replacing Don Gatchalian).

Monitoring Well Update. David reported that 24 monitoring wells have been drilled to date and it is likely a few more will be added.

Jim noted that David's division will cover implementation after program adoption.

Lisa Freund, in response to a question, affirmed that a quorum was present.

A member inquired if the Hispanic representative was in attendance (yes).

Jim briefly described the adoption process moving forward: SEPA review, Department of Ecology's hearing, and program certification.

David Bowen elaborated on Jim's description of the process, describing that the next step is for the lead agency (Yakima County) to conduct SEPA review. After SEPA, the Department of Ecology will hold a public hearing, as will Yakima County – they may possibly hold a joint hearing. In addition, following SEPA, there will be another comment period, and then a public notice for Ecology's hearing.

After Ecology's public hearing, the Department (Ecology) and affected government agencies (South Yakima Conservation District, irrigation districts, Yakima Health District and Yakima County) have 90 days to review the program for concurrency. Ecology will work with the

agencies to issue consolidated findings. Yakima County then brings the consolidated findings back to the GWAC.

The GWAC then formally submits the program to the Department of Ecology which certifies its consistency with the intent of WAC 173-100-100. The Board of County Commissioners then adopts the Program.

David Bowen added that the current funding appropriation expires in June 2019. Accordingly, a contract extension has been forwarded to Yakima County for its consideration.

Jim Davenport then reviewed WAC 173-100-110 (SEPA review) and 173-100-120 (hearings and implementation) handout.

Program review (how we got here). Jim described the discussion and actions at the last meeting (see August 9, 2018 meeting summary). He observed that Yakima County had made the changes requested at the August 9 meeting. There were a few exceptions, which were forwarded to Ecology and EPA for response. Nine weeks later Ecology tendered a document that was considerably different than the GWAC's August 9 version. Accordingly, he and staff worked with Rand to determine how to move forward. The decision was to bring both Program drafts back to the GWAC. Those drafts are before you now: Yakima County's version and Ecology's version.

Lisa Freund then described the list of changes requested at the August 9 meeting and how the County responded (see handout).

A member observed that there are still errors in both versions—is the group being asked to adopt a program with errors in it?

Jim asked to table that consideration – the group needs to come to a decision regarding which version to adopt before identifying changes.

David Bowen then reviewed the meeting he had on August 15 with County staff, at which time the County asked for assistance with the technical review.

To that end, the GWAC's draft program was forwarded to Ecology's Environmental Assessment Program (EAP) team, headquartered in Lacey. This is an independent review team tasked with editing technically demanding documents. The EAP's work product is before you in four volumes: volume 1 (the succinct narrative, targeted to funders and legislators); volume 2 (appendices); volume 3 (showcase of the work the GWAC conducted

– e.g., Deep Soil Sampling, Education and Outreach, Nitrogen Availability Assessment); and Volume 4 (Catch-all for Minority Reports, *et al*).

Jim Davenport then asked the group if they had had enough time to review the document and understand what's there. (No one spoke).

III. Consideration and possible action approving final GWMA Program:

Jim then stated that the group needed to determine how to proceed–that is, try to reach agreement on a single course of action. He asked, "Do we have consensus to move forward on Ecology's draft?" [Hands were raised; but not counted]. Jim stated that if a single course of action could not be agreed to, he would revert to parliamentary procedure.

Jim then asked, "Is there consensus on moving this document forward for SEPA consideration?" He asked for feedback from the group.

Steve George stated that if Jim was asking the group to agree on a document, he could not agree on either.

Jim then asked Rand Elliott to lead the group. Rand explained that a motion was made on August 9 to approve the County draft, provided that changes agreed to that night were made. He stated, "before you now is the new County version, with changes agreed to on August 9."

Motion

Ryan Ibach then made a motion to accept Ecology's version; Pat Newhouse seconded the motion.

Rand opened the floor for comments. Members recognized the work that Jim Davenport and the County had undertaken to prepare the County's version of the Program. It was generally agreed that in reading Ecology's draft, however, it was more compact, easier to read and worked better than Yakima County's version.

Perry Beale observed that the Department of Agriculture (WSDA) would approve either; however, Ecology's version was more accurate relative to the tables and data.

Others commended the County for its work, especially Jim Davenport's efforts.

Lucy Edmondson [reading from a script] stated that EPA had previously gone on record stating that the draft report would be improved by including a more thorough accounting of the amount of nitrogen coming from dairy operations. Data from robust scientific studies was not included in the current draft...it's time to move the technically edited version of the

report from Ecology's EAP program out to the larger forum. Additional data, policies, and input from the public can lead to a final strategy to address nitrate contamination in the drinking water aquifer in the Lower Yakima Valley.

A member expressed concern with two of the recommended alternatives. Rand responded that the group had already agreed to the alternatives. The member can raise her concerns during the upcoming public process.

Vote to accept Ecology's version of the Program

Rand then asked if there were further comments. Hearing none, a vote was taken on Ryan's motion to accept Ecology's version of the program. 17 members voted *aye; two were opposed and two abstained. **Motion carried; Ecology's version of the program will be forwarded to Yakima County for SEPA review.** (*ayes: Perry Beale, Laurie Crowe, Stu Turner, Dr. Troy Peters, Lucy Edmondson, Jim Dyjak, Lino Guerra, Ryan Ibach, Jason Sheehan, Pat Newhouse, Andy Cervantes, David Bowen, Bud Rogers, Ron Cowin, John Van Wingerden III, Doug Simpson and Rand Elliott. Opposed: Jean Mendoza and Steve George. Abstaining: Stuart Crane and Robert Black).

Program Dedication

A member asked if the final Program could be dedicated to former member Jim Trull, who died several years ago, in acknowledgment of his "leadership and participation." **The group agreed**.

A member asked who would facilitate the group after December, when Rand Elliott is no longer in office. Jim replied that the group can make a decision at its next meeting.

IV. Submission of Minority Reports:

A discussion ensued regarding when minority reports should be submitted. A member questioned how could a minority report be accepted now – the Program has not been finaled. Members cannot make a minority report until the final document is approved.

Following discussion, the group agreed that there should be two opportunities to issue a minority report: 1) within the next seven days (before SEPA review); and 2) after the program is consolidated.

David Bowen suggested that no typos or other errors be corrected before this approved draft is submitted for SEPA, noting, "let's keep it clean." There will be an opportunity at the next juncture during the public hearing process to make these corrections. **The group agreed by consensus.**

V. Public Comments:

Frank Lyall stated that $2.4 million has been spent on this inefficient process. Meanwhile, no one has died [in the Lower Yakima Valley] from consuming nitrates. He added the program lacked credibility. It was a bifurcated process: only people who will agree with the document are those who trust Ecology – now It's an Ecology Document. There's no local trust for government or what comes out of Olympia.

Kathleen Rogers followed up on Frank's comment, agreeing that no one has come forward who has become ill [because of nitrate consumption]. However, she has a neighbor who lives near the dairy cluster and they have recently recorded higher nitrate readings [than previously]. It's time to move on [in addressing the problem].

David Newhouse commented that nitrate supplements are being heavily advertised for its health benefits.

VI. Committee Business: The August 9, 2018 meeting summary was approved as presented.

VII. Next Steps: Members have seven days in which to issue a minority report before the Program is submitted to Yakima County Planning for SEPA review. The next opportunity to issue a minority report will be after the program is consolidated. The program will come back before the GWAC after consolidated findings have been prepared.

The meeting was adjourned at 6:22 PM.

VIII. Meeting Summary approved by the GWAC on June 20, 2019.

LOWER YAKIMA VALLEY

GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Meeting Time and Location

Thursday, June 20, 2019 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom
Sunnyside School District No. 201
810 E. Custer Ave.
Sunnyside, WA 98944

Agenda

	Topic	
	Welcome, Meeting Overview and Introductions: • **Committee members** • **Others attending the meeting**	**Lisa Freund, Yakima County**
	Review Program Timeline	David Haws, Yakima County
	Summary of Program comments, findings and Program edits	**David Bowen, DOE**
	Resolve Statement of Nonconcurrence **(ACTION ITEM)**	Commissioner Norm Childress; David Bowen
	Formally Submit Program to Ecology (ACTION ITEM)	**Commissioner Norm Childress; David Bowen**
	Committee Business • Approve the December 13, 2018 GWAC Meeting Summary **(ACTION ITEM)**	Lisa Freund
	Present Ambient Monitoring Initial Report	**David Haws**
	Public Comments	
	Adjourn	

Committee Members

Stuart Turner, agronomist, Chelsea Durfey (alternate)	Turner and Co.
Bud Rogers, Kathleen Rogers (alternate)	Lower Valley Community Representative Position 1
Patricia Newhouse, Sue Wedam (alternate)	Lower Valley Community Representative Position 2
Doug Simpson	Irrigated Crop Producer
Dr. Jessica Black, Dr. Alex Alexiades (alternate)	Heritage University
Jean Mendoza, Eric Anderson (alternate)	Friends of Toppenish Creek
Jan Whitefoot, Jim Dyjak (alternate)	Concerned Citizens of the Yakama Reservation
Steve George, Frank Lyall (alternate)	Yakima County Farm Bureau
Jason Sheehan, Dan DeGroot (alternate)	Yakima Dairy Federation
Ron Cowin	Sunnyside-Roza Joint Board of Control
Laurie Crowe, Rodney Heit (alternate)	South Yakima Conservation District
John Van Wingerden III, (alternate)	Port of Sunnyside
Commissioner Norm Childress (alternate)	Yakima County Commission
Holly Myers, Ryan Ibach (alternate)	Yakima Health District
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center
Lucy Edmondson, Nick Peak (alternate)	U.S. Environmental Protection Agency
Elizabeth Sanchey, Stuart Crane (alternate)	Yakama Nation
Gary Bahr, Perry Beale (alternate)	Washington Department of Agriculture
Andy Cervantes, Sheryl Howe (alternate)	Washington Department of Health
David Bowen, Sage Park (alternate)	Washington Department of Ecology
Lino Guerra, Rick Perez (alternate)	Hispanic Community Representative
Robert Black (alternate)	U.S. Geological Survey

Committee Ground Rules:

- Come to committee meetings prepared
- Treat one another with civility
- Respect each other's perspectives

- Listen actively
- Participate actively
- Honor time frames
- Silence electronic devices during meetings
- Speak from interests, not positions.

2019 Meeting Date:

June 20

Meeting Materials:

Name	Date Provided	From
2018_12_13 GWAC Draft Meeting Summary	12/5/2018 and 6/12/2019	jacob.clay@co.yakima.wa.us
2019_06_20 Agenda	6/12/2019	jacob.clay@co.yakima.wa.us
Draft GWMA Program (dated June 2019) Volumes I, II, III & IV	6/5/2019	jacob.clay@co.yakima.wa.us
List of GWMA Program Edits	6/5/2019	jacob.clay@co.yakima.wa.us
GWMA Program Findings	6/5/2019	jacob.clay@co.yakima.wa.us
Response to Comments	6/5/2019	jacob.clay@co.yakima.wa.us
Yakima Health District Letter of Concurrence	6/5/2019	jacob.clay@co.yakima.wa.us
Sunnyside Division Board of Control Letter of Concurrence	6/5/2019	jacob.clay@co.yakima.wa.us
South Yakima Conservation District Letter of Concurrence	6/5/2019	jacob.clay@co.yakima.wa.us

PGG Well Installation Report	6/12/2019	jacob.clay@co.yakima.wa.us
Yakima County Letter of Concurrence	6/20/2019	jacob.clay@co.yakima.wa.us

YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA ADVISORY COMMITTEE (GWAC)

MEETING SUMMARY

Thursday, June 20, 2019 – 5:00 p.m. – 7:00 p.m.

Denny Blaine Boardroom
Sunnyside School District No. 201
810 E. Custer Ave
Sunnyside, WA 98944

Note: This document is only a summary of issues and actions of this meeting. It is not intended to be a transcription of the meeting, but an overview of points raised and responses from Yakima County and Groundwater Advisory Committee members. It may not fully represent the ideas discussed or opinions given. Examination of this document cannot equal or replace attendance.

I. Call to Order: This meeting was called to order at 5:10 PM by Facilitator Lisa Freund.

Member	Seat	Present	Absent
Stuart Turner	Agronomist, Turner and Co.,	✓	
Chelsea Durfey	(alternate)		✓
Bud Rogers	Lower Valley Community Representative Position 1	✓	
Kathleen Rogers	Lower Valley Community Representative Position 1 (alternate)	✓	
Patricia Newhouse	Lower Valley Community Representative Position 2	✓	
Sue Wedam	Lower Valley Community Representative Position 2 (alternate)	✓	
Doug Simpson	Irrigated Crop Producer	✓	
Jean Mendoza	Friends of Toppenish Creek	✓	
Eric Anderson	Friends of Toppenish Creek (alternate)		✓
Jan Whitefoot	Concerned Citizens of the Yakama Reservation		✓
Jim Dyjak	Concerned Citizens of the Yakama Reservation (alternate)		✓
Steve George	Yakima County Farm Bureau	✓	
Frank Lyall	Yakima County Farm Bureau (alternate)		✓
Jason Sheehan	Yakima Dairy Federation	✓	
Dan DeGroot	Yakima Dairy Federation (alternate)	✓	
Ron Cowin	Roza-Sunnyside Joint Board of Control	✓	

	Roza-Sunnyside Joint Board of Control (alternate)		
Laurie Crowe	South Yakima Conservation District	✓	
Rodney Heit	South Yakima Conservation District (alternate)		✓
John Van Wingerden III	Port of Sunnyside	✓	
Norm Childress	Yakima County Board of Commissioners	✓	
Myers, Holly	Yakima Health District	✓	
Ryan Ibach	Yakima Health District (alternate)	✓	
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center	✓	
Lucy Edmondson	U.S. Environmental Protection Agency	✓	
Nick Peak	U.S. Environmental Protection Agency (alternate)		✓
Elizabeth Sanchey	Yakama Nation		✓
Stuart Crane	Yakama Nation (alternate)	✓	
Gary Bahr	WA Department of Agriculture	✓	
Perry Beale	WA Department of Agriculture (alternate)		✓
Andy Cervantes	WA Department of Health	✓	
Sheryl Howe	WA Department of Health (alternate)		✓
David Bowen	WA Department of Ecology	✓	
Sage Park	WA Department of Ecology (alternate)	✓	
Lino Guerra	Hispanic Community Representative		✓
Rick Perez	Hispanic Community Representative (alternate)		✓
Jessica Black	Heritage University	✓	
Alexander V. Alexiades	Heritage University (alternate)		✓
Robert Black	USGS	✓	

Welcome, Meeting Overview and Introductions: Yakima County Public Services Director Lisa Freund, on behalf of Yakima County and the Department of Ecology, welcomed the group to the final meeting of the Lower Yakima Valley GWAC. She noted how momentous it was to get to this point after seven years of work. She asked the committee members to note the two action items on the agenda which would complete their work. She then introduced District 3 Commissioner Norm Childress, who will serve as Committee Chair in place of Commissioner Rand Elliott, who retired last year. Norm is very experienced in matters of public process and procedure, having served as mayor of Grandview for many years and on various committees. Customary introductions followed. Lisa called for a

moment of silence to contemplate the work ahead as well as the work already accomplished.

She asked the group to review the agenda and asked for additional agenda items; there were none.

II. Review Program Timeline:

Lisa introduced David Haws, Yakima County's Environmental Services Director, who provided an overview of the establishment and work of the GWAC.

David reviewed the GWMA's purpose: to reduce nitrate contamination in groundwater below state drinking standards. The GWMA Program was developed in accordance with WAC 173-100. The result would be the implementation of a locally driven plan. He referred to the six key elements contained in the WAC for creating a Groundwater Management Program, including defining the problem, as well as its causes and sources, developing water quality goals and land use strategies for goal achievement, as well as creating strategies for implementation.

Over the past seven years, the GWAC, and its working groups, along with various outside agencies, have worked on and through these key elements, the results of which can be found in Volumes I and II of the Program and the corresponding appendices. Sixty-four recommended actions were agreed upon as possible solutions to the nitrate problem, which formed the basis of the Program.

After the GWAC's adoption of its proposed Program in December 2018, SEPA review was conducted, followed by a public comment period, and a public hearing on March 12, 2019. Comments received from these sources were considered in preparation of the final document. Hence, all the steps outlined in WAC 173-100 have now been completed, with the exception of resolving a Statement of Nonconcurrence, and formally presenting the Program to the Department of Ecology (two of the action items on the agenda).

A member questioned the reference to "targets" in the presentation, wondering what they were and where they might specifically be found. A discussion ensued regarding how this was presented in the various volumes of the Program, the ultimate goal or target being to reduce nitrate levels to below state standards. Questions were raised and discussed as to the timeframe for goal achievement (five years from the establishment of the GWMA, or five years from the adoption and implementation of the plan), as well as how progress would be measured.

David Bowen, from the Department of Ecology, said a firm timeline would be impossible to predict due to implementation and funding variables. However, the monitoring wells should

help indicate if progress is, indeed, being made. A benchmark for the nitrate level has been established through previous well sampling. The collaboration of governments and agencies, implementing best management practices and some of the other sixty-four recommendations will drive implementation leading to improvement of those levels. A review in approximately five years will indicate any progress and any changes that might need to be made. A concern was voiced that five years would be too late, and that a midterm evaluation would have been better.

III. Summary of Program Comments, Findings, and Program Edits:

David Bowen gave a summary of the work and actions which have occurred since the last GWAC meeting (12/13/18). These included a SEPA review conducted by Yakima County which resulted in a Determination of Non-Significance. A public comment period of approximately a month was conducted and a public hearing held within the boundaries of the GWMA as prescribed by the WAC. All comments received during this time were reviewed by Yakima County and Department of Ecology staff. The consensus response to these comments as well as any recommendations regarding them were placed in Appendices A and B of the Response to Comments document.

David said that after this process, all affected agencies were notified, including the Port of Sunnyside which might play a role in the implementation of the Program. Yakima County submitted a letter of concurrence, while the Yakima Health District submitted one of non-concurrence because of concerns with the presence and wording of the minority report (This will be discussed in greater detail later in the meeting).

David concluded his presentation by discussing his research in past GWAC meetings about the acceptance of minority reports as well as describing the edits and corrections that have been made and may yet need to be made in the Program document. He also affirmed the hard work of the committee over the past seven years and was eager to make progress in reducing nitrate levels.

After the presentation, a member catalogued the issues and corrections she believed still needed attention. Responses were given by David and others regarding these issues. Finally, reference was made to comments made in a letter by Dan De Boer which supposedly had not been adequately addressed and how a health survey had been handled in the past, and how these issues were addressed in the minority report.

IV. Resolve Statement of Nonconcurrence:

Lisa invited Ryan Ibach from the Yakima Health District to speak regarding the letter of non-concurrence which had been submitted by the District.

Ryan first wanted to clarify if all minority reports would be published in Volume IV. David Bowen responded that the sole minority report is posted on the GWMA website but was not published in the Program.

Ryan then pointed out a statement within the minority report that indicates that it presents "an alternate GMWA program or plan." His understanding from past meetings was that any minority reports would be to express differing opinions or disagreements regarding specific topics only, not used to publish plans outside of that agreed upon by the consensus of the GWAC. David Bowen agreed that this was the initial intent of the committee (specific points of disagreement only), but that over time there appeared to be an acceptance by members for the submission of an overall minority report.

Lisa then referenced the discussion in the previous meeting regarding the time frames for submitting minority reports. The first opportunity was before the beginning of the SEPA period and the second was immediately following the consolidated Program presentation to the Department of Ecology. To help determine the consideration and placement of any minority reports, she asked if there would be additional reports submitted. When none were offered, it was agreed (by silent assent) that no other reports were to be submitted.

Minority report author Jean Mendoza explained that, in her opinion, there were gaps in the GWMA report as presented. The purpose of the minority report submitted was to fill those gaps. She said she would be honored if the committee would consider including some of the points established in the minority report for the final version of the Program. David Bowen agreed that there are issues which need further study, such as the legacy nitrate issue. This will be a part of the ongoing implementation process.

Ryan again expressed concern that a minority report should express disagreements on specific points, but not be presented as an alternate GWMA plan. It was suggested by another member that the current minority report should be presented in this fashion. David Bowen said if this were the case, then there was probably not any issue of non-concurrence.

Discussion continued regarding information that was included in or excluded from the Program and how it might affect the perception of the report. Concern was again expressed that the Program, as presented, reflected the consensus of the overall committee. If the minority report presented itself as an alternate plan, it should not be included with the official Program.

Lisa then referenced the disclaimer statement found at the beginning of Volume IV (p. 4) regarding member contributions. "Groundwater advisory committee members were given an opportunity to express differing opinions with aspects of this plan. Some members also chose to submit additional recommendations or information to be considered as the implementation phase begins. These are individual contributions and do not necessarily reflect the consensus or the opinion of the GWAC. Specific questions related to the content or science of a minority report should be directed to the author of the minority report." In light of this, could the current minority report be adopted with the overall Program and be placed in Volume IV? There was no opposition expressed and this satisfied the members from YHD. David Bowen added that if any other minority reports should be offered, they would likewise be placed in that volume.

V. Formally Submit Program to Ecology:
Commissioner Norm Childress, on behalf of the Board of County Commissioners presented the Program to the Department of Ecology for implementation. He agreed with the statements made by others that it was a living, imperfect document that included a great deal of information and many good suggestions. Further meetings and discussions would not result in a perfect plan. The overall goal is to reduce nitrate levels and it is time to implement the plan and move forward with monitoring progress. He asked if there were any objections to adoption and presentation. None was expressed; consensus was thus considered, and the Program officially presented to Ecology.

VI. Committee Business: The December 13, 2018 meeting summary was approved as presented.

VII. Present Ambient Monitoring Initial Report: David Haws gave a PowerPoint overview of the purpose and results of the initial well monitoring. Thirty-one (31) wells have been established to establish a baseline for water quality for the purpose of tracking progress. This is in connection with the WAC 173-100 requirement to evaluate the effectiveness of the Program. Final well locations were placed equidistantly apart throughout the GWMA, having been evaluated for access, safety, and feasibility, avoiding the EPA Dairy Cluster as well as the Port of Sunnyside sprayfield, each of which are monitored separately from the GWMA. The results of the testing indicated an overall nitrate level of 12.19 mg/L (although fifty-five (55) percent of the wells tested at below 10 mg/L). David expressed again that this only establishes a baseline for overall water quality as of late 2018 and early 2019. More

testing will need to be done to establish possible trends. However, there is no current funding for additional or ongoing testing. Such will need to be secured as a part of the implementation of the Program. A member asked if, with the next round of well analysis, data from the EPA Dairy Cluster and the Port of Sunnyside would be added in order to gather information from those zones. David Bowen indicated that this could be done initially, but eventually local governments and agencies will need to gather the necessary data in connection with their respective areas of expertise. The Department of Ecology will continue to do what is within their capabilities and available funding, but others must assist in the long term.

VIII. Public Comments: No public comments were offered.

IX. Adjourn: The meeting was adjourned at 6:41 PM. Immediately after this, however, a member reminded the committee members of the decision at the December 2018 meeting to dedicate the Program in memory of Jim Trull. Lisa reminded the group that another GWAC member, David Cole, had also passed away before completion of its work. Did the group have any objection to dedicating the Program to both Jim and David? No objection was expressed to such a dedication.

X. Meeting Summary approved by the GWAC on _____.

DRAFT

GWAC Attendance Roster

Member	20-Jun-2019
Stuart Turner	Present
Chelsea Durfey (alternate)	Absent
Bud Rogers	Present
Kathleen Rogers (alternate)	Present
Patricia Newhouse	Present
Sue Wedam (alternate)	Present
Doug Simpson	Present
Jean Mendoza	Present
Eric Anderson (alternate)	Absent
Jan Whitefoot	Absent
Jim Dyjak (alternate)	Absent
Steve George	Present
Frank Lyall (alternate)	Absent
Jason Sheehan	Present
Dan DeGroot (alternate)	Present
Ron Cowin	Present
Laurie Crowe	Present
Rodney Heit (alternate)	Absent
John Van Wingerden	Present
Norm Childress	Present
Holly Myers	Present
Ryan Ibach (alternate)	Present
Dr. Troy Peters	Present
Lucy Edmondson	Present
Nick Peak (alternate)	Absent
Elizabeth Sanchey	Absent
Stuart Crane (alternate)	Present
Gary Bahr	Present
Perry Beale (alternate)	Present
Andy Cervantes	Present
Sheryl Howe (alternate)	Absent
David Bowen	Present
Sage Park (alternate)	Present
Lino Guerra	Absent
Rick Perez (alternate)	Absent
Jessica Black	Present
Alexander V. Alexiades (alternate)	Absent
Robert Black (alternate)	Present

Attachment B

- Lower Yakima Valley Groundwater Management Program (LYV-GWMA) Volumes I – IV dated June 2019
- Comprehensive List of Changes to Volumes I to IV
- GWMA Program Findings
- Response to Comments
- Letters of Concurrence from South Yakima Conservation District, Sunnyside Division Board of Control and Yakima County
- Letter of Non-concurrence from Yakima Health District

Lower Yakima Valley Groundwater Management Program

Volume I

June 2019~~August 20, 2018~~

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

~~Primary Author: James H. Davenport, Attorney at Law, on behalf of, and with assistance of Yakima County Department of Public Services~~

~~Thank you in particular to Vern Redifer, Lisa Freund, Chris Saunders, Phil Rosenkranz, Bobbie Brady, Patty LeBlanc, Michael Martian, and Cynthia Kozma.~~

This program reflects the work of the Lower Yakima Valley Groundwater Advisory Committee. This program was approved ~~by the Lower Yakima Valley Groundwater Advisory Committee on XXX~~ December 13, 2018

This document reflects the consensus of the Lower Yakima Valley Groundwater Advisory Committee. It does not necessarily reflect the views or policies of individuals or government agencies that participate on the committee, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Formatted: Indent: First line: 0.5"

Groundwater Advisory Committee

Commented [RM(1]: Added Robert Black USGS

Active	
Name	**Affiliation**
Rand Elliott	Yakima County Board of Commissioners
Vern Redifer	Yakima County Public Services
Elizabeth Sanchey	Yakama Nation
Stuart Crane	Yakama Nation
Steve George	Yakima County Farm Bureau
Frank Lyall	Yakima County Farm Bureau
Jason Sheehan	Yakima Dairy Federation
Dan DeGroot	Yakima Dairy Federation
Stuart Turner	Agronomist, Turner and Co.
Chelsea Durfey	Agronomist, Turner and Co.
Jean Mendoza	Friends of Toppenish Creek
Eric Anderson	Friends of Toppenish Creek
Jan Whitefoot	Concerned Citizens of the Yakama Reservation
Jim Dyjak	Concerned Citizens of the Yakama Reservation
Laurie Crowe	South Yakima Conservation District
Rodney Heit	South Yakima Conservation District
John Van Wingerden	Port of Sunnyside
Gary Bahr	WA Department of Agriculture
Perry Beale	WA Department of Agriculture
Andy Cervantes	WA Department of Health
Sheryl Howe	WA Department of Health
David Bowen	WA Department of Ecology
Sage Park	WA Department of Ecology
Lucy Edmondson	U.S. EPA
Nick Peak	U.S. EPA
Holly Myers	Yakima Health District
Ryan Ibach	Yakima Health District
Dr. Troy Peters	WSU Irrigated Agriculture Research and Extension Center
Ron Cowin	Roza-Sunnyside Joint Board of Control
Lino Guerra	Hispanic Community Representative
Rick Perez	Hispanic Community Representative
Doug Simpson	Irrigated Crop Producer
Bud Rogers	Lower Valley Representative Pos. 1
Kathleen Rogers	Lower Valley Representative Pos. 1
Patricia Newhouse	Lower Valley Representative Pos. 2
Sue Wedam	Lower Valley Representative Pos. 2
Dr. Jessica Black	Heritage University
Dr. Alex Alexiades	Heritage University
Robert Black	USGS Washington Water Science Center

Previous Participants:

Name	Affiliation
Helen Reddout	Community Association for Restoration of the Environment
Wendell Hannigan	Community Association for Restoration of the Environment
Bruce Perkins	Benton-Franklin Health District
Mark Nielson	Benton Conservation District
Heather Wendt	Benton Conservation District
Jaclyn Ford	WA Department of Agriculture
Tom Ring	Yakama Nation
Ginny Prest	WA Department of Agriculture
Charlie McKinney	Department of Ecology
Tom Tebb	Department of Ecology
Robert Farrell	Port of Sunnyside
Lonna Frans	USGS Washington Water Science Center
Robert Morales	Lower Valley Community Representative
Ramon Tobias	Hispanic Community Representative
Margarita Tobias	Hispanic Community Representative
Don Young	Yakima County Farm Bureau
Justin Waddington	Yakima County Farm Bureau
Dr. Kefy Desta	WSU Irrigated Agriculture Research and Extension Center
Ginny Stern	WA Department of Health
Gordon Kelly	Yakima Health District
David Cole	Yakima Health District
Tom Eaton	U.S. EPA
Marie Jennings	U.S. EPA
Bill Dunbar	U.S. EPA
Matt Bachmann	USGS Washington Water Science Center
Jim Newhouse	South Yakima Conservation District
Jim Trull	Sunnyside Valley Irrigation District

Table of Contents

Volume I

TABLE OF CONTENTS IV

Table of Figures viivi

Table of Tables viiivii

EXECUTIVE SUMMARY 1

Funding 1

Program Content 2

Initiatives Completed by the GWAC 2

Recommendations and Alternative Management Strategies 3

Implementation 3

INTRODUCTION 4

The Issue 4

The Response 4

Background 8

Organization this document 14

NITROGEN IN THE ENVIRONMENT 15

Nitrate Leaching 15

Lag Time 15

Health Effects 15

Preliminary Assessment 16

Yakima River Surface Water Quality 18

SOURCES OF NITRATE 19

The Nitrogen Availability Assessment 19

Irrigated Agriculture 21

Livestock Operations/CAFOs 25

Residential, Commercial, Industrial and Municipal Groundwater 27

Atmospheric Deposition 31

Legacy Nitrogen 31

CHARACTERIZATION OF THE AREA 3433

Physical Basin Characteristics 3433

Land and Water Use 5655

Demographics 7069

GWAC INITIATIVES 7277
Education and Public Outreach 7277
Best Management Practices Identification 7877
Groundwater Monitoring 7877
Deep Soil Sampling Program 8483
Identification of Nitrogen Sources 8584
Geographic Information System 8685
RECOMMENDED ACTIONS 9593
Recommended Actions 9593
Draft Recommendations: 105103
IMPLEMENTATION WORK PLANS 107105
Parties Responsible for Implementation of the Recommended Actions 107105
Management Committee 108105
Implementation Functions 108106
Schedule For Implementation Of The Recommended Actions 109107
Monitoring System For Evaluation Of Effectiveness Of Recommended Action 109107
REFERENCES 110108
~~TABLE OF CONTENTS ..... iv~~
~~Table of Figures ..... vi~~
~~Table of Tables ..... vii~~
~~EXECUTIVE SUMMARY ..... 1~~
~~Funding ..... 1~~
~~Program Content ..... 2~~
~~Initiatives Completed by the GWAC ..... 2~~
~~Recommendations and Alternative Management Strategies ..... 3~~
~~Implementation ..... 3~~
~~INTRODUCTION ..... 4~~
~~The Issue ..... 4~~
~~The Response ..... 4~~
~~Background ..... 8~~
~~Organization this document ..... 14~~
~~NITROGEN IN THE ENVIRONMENT ..... 15~~
~~Nitrate Leaching ..... 15~~
~~Lag Time ..... 15~~
~~Health Effects ..... 15~~
~~Preliminary Assessment ..... 16~~

Yakima River Surface Water Quality 18
SOURCES OF NITRATE 19
The Nitrogen Availability Assessment 19
Irrigated Agriculture 21
Livestock Operations/CAFOs 24
Residential, Commercial, Industrial and Municipal Groundwater 27
Atmospheric Deposition 31
Legacy Nitrogen 31
CHARACTERIZATION OF THE AREA 32
Physical Basin Characteristics 32
Land and Water Use 54
Demographics 68
GWAC INITIATIVES 70
Education and Public Outreach 70
Best Management Practices Identification 76
Groundwater Monitoring 76
Deep Soil Sampling Program 82
Identification of Nitrogen Sources 83
Geographic Information System 84
RECOMMENDED ACTIONS 93
Recommended Actions 93
Draft Recommendations: 103
IMPLEMENTATION WORK PLANS 105
Parties Responsible for Implementation of the Recommended Actions 105
Yakima County as "Lead Agency" 105
Schedule For Implementation Of The Recommended Actions 106
Monitoring System For Evaluation Of Effectiveness Of Recommended Action 106
REFERENCES 107

Table of Figures

FIGURE 1 – GWMA BOUNDARY 8
FIGURE 2 – YAKAMA INDIAN RESERVATION 9
FIGURE 3 – WATER MOVEMENT IN THE SUBSURFACE 11
FIGURE 4 – NITROGEN SOURCES 20
FIGURE 5 – BIOSOLIDS APPLICATION SITES 30
FIGURE 6 – GEOLOGY 36
FIGURE 7 – SURFACE HYDROGEOLOGIC UNITS 38
FIGURE 8 – SPRINGS WITHIN THE TOPPENISH BASIN 41
FIGURE 9 – MEAN ANNUAL RECHARGE WITHIN THE GWMA 43
FIGURE 10 – GROUNDWATER LEVELS WITHIN THE GWMA 45
FIGURE 11 – GROUND SURFACE CONTOURS (TOPOGRAPHY) WITHIN THE GWMA 47
FIGURE 12 – DEPTH TO GROUNDWATER AND DIRECTION OF FLOW WITHIN THE GWMA 49
FIGURE 13 – SOIL TYPES 51
FIGURE 14 – HYDRAULIC CONDUCTIVITY FOR SOIL TYPES IN THE GWMA 53
FIGURE 15 – YAKIMA COUNTY ZONING WITHIN GWMA 57
FIGURE 16 – HISTORICAL PHOTOGRAPHS OF AGRICULTURE IN YAKIMA COUNTY. 59
FIGURE 17 – THE NATIONAL MAP COMPANY'S 1930 MAP ENTITLED LATEST OFFICIAL SURVEY OF WASHINGTON 61
FIGURE 18 – LOCATIONS OF CROPS GROWN WITHIN THE GWMA (2015) 64
FIGURE 19 – SUNNYSIDE VALLEY AND ROZA IRRIGATION DISTRICTS WITHIN THE GWMA 68
FIGURE 20 – NITRATE PILOT PROJECT WATER TEST LOCATIONS 74
FIGURE 21 – HIGH RISK WELL ASSESSMENT TEST LOCATIONS 77
FIGURE 22 – SGS 2017 GROUNDWATER WELL TEST LOCATIONS 82
FIGURE 23 – ALL WATER QUALITY SAMPLING LOCATIONS (3 TESTING PROGRAMS) 83
FIGURE 24 – TOTAL NITROGEN AVAILABILITY 87
FIGURE 25 – NITROGEN AVAILABILITY AND USGS WELLS 88
FIGURE 26 – USGS WELL DATA OVERLAID ON SOIL TYPES SIMPLIFIED BY HYDRAULIC CONDUCTIVITY GROUPS 89
FIGURE 27 – USGS WELL DATA OVERLAID ON IRRIGATION CANAL AND DRAIN INFORMATION 90
FIGURE 28 – USGS WELL DATA OVERLAID ON CROPPING PATTERNS 91
FIGURE 29 – USGS WELL DATA OVERLAID ON MAP OF POINT SOURCES 92
FIGURE 30 – USGS WELL DATA OVERLAID ON MAP OF ON-SITE SEWAGE SYSTEMS 93

Table of Tables

TABLE 1 – SUMMARY OF REGULATORY AUTHORITY ..... 12~~12~~13

TABLE 2 – ESTIMATED NITROGEN AVAILABLE PER ACRE FROM ALL SOURCES AT THE LOW, MEDIUM, AND HIGH RANGES ..... 20~~20~~21

TABLE 3 – SUMMARY OF FERTILIZER TYPES USED FOR THE TOP 15 CROPS IN THE GWMA. ..... 21~~21~~22

TABLE 4 – PRIMARY SOIL HYDRAULIC CONDUCTIVITY ..... 50~~49~~53

TABLE 5 – ALL SOIL TYPES WITHIN THE GWMA ..... 52~~51~~55

TABLE 6 – CLIMATE SUMMARY FOR WAPATO, WASHINGTON (OCTOBER 1, 1915 TO SEPTEMBER 5, 2013) ..... 54~~53~~57

TABLE 7 – CLIMATE SUMMARY FOR SUNNYSIDE, WASHINGTON (SEPTEMBER 14, 1894 TO JANUARY 5, 2014) ..... 55~~54~~58

TABLE 8 – CLIMATE SUMMARY FOR PROSSER, WASHINGTON (JULY 1, 1925 TO JANUARY 4, 2015) ..... 55~~54~~58

TABLE 9 – HISTORICAL SUMMARY OF CROP TYPES IN YAKIMA COUNTY ..... 62~~61~~65

TABLE 10 – HISTORICAL SUMMARY OF CROP TYPES IN YAKIMA COUNTY ..... 62~~61~~65

TABLE 11 – HISTORICAL SUMMARY OF LIVESTOCK IN YAKIMA COUNTY ..... 63~~62~~66

TABLE 12 – TOP 15 CROPS IN THE GWMA ..... 65~~61~~68

TABLE 13 – POPULATION OF CITIES WITHIN THE GWMA ..... 70~~69~~73

Executive Summary

The Lower Yakima Valley Groundwater Management Area (GWMA) was formed in 2012 to address the goal of reducing nitrate concentrations in groundwater. A recent groundwater study in the Lower Yakima Valley, which sampled over 150 private domestic wells in 2017, found 20 percent of the wells consistently exceeded the drinking water standard (USGS 2018~~7~~).

While many sources contribute to nitrates in groundwater, data from these wells indicate that human activities at the land surface have affected water quality.

One objective of the Lower Yakima Valley Groundwater Advisory Committee (GWAC), also formed in 2012, was to develop a program that would achieve the goal of reducing nitrate levels in groundwater. This document is that program. It describes the committee's completed work, including the committee's decisions, recommendations, and accomplishments. This work is the foundation for the implementation phase.

The GWAC is a large and diverse committee, including representatives from all identified groups affected by groundwater quality, including local, state, and federal government agencies; local citizens; farmers, dairy producers, and agronomists; irrigation districts; conservation districts; environmental groups; and other vested parties. This committee and its workgroups met regularly over the past six years with~~. The diversity of the committee members' interests often made for contentious discussions, but~~ members ~~were~~ committed to resolving issues~~., continued to participate, and were usually respectful.~~ The tremendous amount of work produced and the ability to reach consensus on many issues, demonstrates the high level of commitment by the committee members.

Funding

Funding to support the development and planning stage of the GWMA was appropriated by the Washington State Legislature primarily through the efforts of Senator Jim Honeyford of Sunnyside.

Program Content

The program content describes the issue of elevated nitrate in groundwater, how the GWMA was established in the Lower Yakima Valley, and defines the goals and objectives ~~deveoped~~developed for the GWMA. This report explains the environmental and health effects of nitrate in the environment, describes the sources of nitrate, and the different regulatory authorities that aeffect nitrate in groundwater. Additionally, the report characterizes the Lower Yakima ~~Valley,~~Valley; it discusses the accomplishments and the recommended actions of the GWAC.

Initiatives Completed by the GWAC

Since its inception in 2012, the committee has accomplished the following actions:

- Conducted free well water testing for residents
- ~~Distributed point-of-use water treatment systems~~
- Educated the public in both English and Spanish through a variety of outreach methods:
    - Door-to-door discussion and surveys
    - Fact sheets
    - Community fairs
    - Community billboards
    - Website posts
    - Radio public service announcements
    - News releases
- Established a comprehensive database that graphically displays information (GIS)
- Collected deep soil samples from 175 fields (to a depth of six feet)
- Conducted a detailed nitrogen availability assessment to identify the predominant sources of nitrogen
- Collected samples from 159 private domestic wells for six consecutive months to assess drinking water quality.
- Developed sampling plans for all future monitoring work
- Installcd~~ation of 20 to~~ 3~~1θ~~ monitoring wells for ~~future~~ monitoring of long-term ambient groundwater quality~~trends (in process)~~
- Compiled Best Management Practices (BMPs) for agriculture and livestock activities
- Developed alternative management strategies to reduce nitrate loading to groundwater from a variety of sources

Recommendations and Alternative Management Strategies.

Through the workgroups and other contracted work, the GWAC identified over 250 potential alternative management strategies that could reduce nitrate concentrations in groundwater. These are described in Appendix ~~I~~H. The committee discussed each strategy, and reached consensus (Appendix J) and prioritized 65 strategies (see Recommended Actions section). These recommendations include the following action categories, to be implemented by the appropriate local, state, and federal governmental agencies, along with farmers, citizens, and other interested groups.

- Support the implementation phase of the GWMA
- Continue groundwater and soil monitoring
- Promote voluntary source reduction strategies for all nitrate sources
- Continue education and public outreach strategies for all Lower Yakima Valley residents, including homeowners and farmers
- Improve irrigation efficiency
- Develop and support research about innovative nitrate reduction strategies
- Consider incentives that support nitrate reduction
- Explore technology to utilize nutrients as energy
- Enhance and streamline regulatory and enforcement mechanisms
- Maintain the established GIS database

Implementation

The next phase of the GWMA program is implementation. The GWAC's completed work from the assessment and planning phase provides a solid foundation for this next phase. Within this document are specific recommendations for reducing nitrate concentrations in groundwater.

~~At one of its final meetings, the GWAC recommended that Yakima County act as lead agency in future Lower Yakima Valley groundwater management.~~

Formatted: Highlight

Implementation of recommendations is subject to future funding.

Introduction

The Issue

Groundwater in the Lower Yakima Valley contains elevated nitrate concentrations. Several historic groundwater studies have documented nitrate concentrations in excess of the drinking water standard of 10 mg N/L. A compilation of data collected between 1988 and 2008 indicated that 12 percent of wells tested in the area had nitrate concentrations above the standard (PGG 2011). This information prompted the formation of the Lower Yakima Valley Groundwater Management Area (GWMA). Since then, a more recent groundwater study in the Lower Yakima Valley sampled over 150 private domestic wells in 2017 and found that 26 percent of the wells had at least one of its six samples exceeding the drinking water standard. Twenty percent of the wells sampled consistently exceeded the drinking water standard for all samples collected. Nitrate was not detected in 13 percent of the wells sampled (USGS 2018~~7~~).

Formatted: Not Highlight

Nitrate is the most prevalent contaminant in groundwater (Spalding and Exner 1993), and there are health effects associated with elevated nitrate concentrations in drinking water (WDOH 2016).

Nitrate impacts to groundwater are common in agricultural areas (Harter 2009). There are many sources that contribute to nitrates in groundwater, including animal and human wastes, fertilizers, plants, and atmospheric deposition. In the Lower Yakima Valley, agriculture is the primary economic and land use activity, and most cropland is irrigated (PGG 2011).

The Response

A GWMA was designated in the Lower Yakima Valley to address the issue of elevated nitrate in groundwater.

Formation of the Lower Yakima Valley GWMA

~~Grass roots organizations such as Community Association for Restoration of the Environment (CARE) and Concerned Citizens for the Yakama Reservation (CCYR) identified the problem in 1997.~~ In 2008, the *Yakima Herald Republic* ran a series of ~~A~~articles entitled "Hidden Wells, Dirty Water" written by Leah Beth Ward ~~ran in the *Yakima Herald Republic* in 2008~~, detailing nitrate issues affecting public and private wells. The articles suggested that a lack of coordination between local, state, and federal agencies aggravated the problem. These newspaper articles prompted a series of public meetings hosted by the Environmental Protection Agency (EPA) along with state and local agencies.

Formatted: Not Highlight

In November 2009, the EPA designated the Lower Yakima Valley as an Environmental Justice Community.

In January 2010, EPA issued a finding in support of Section 1431 of the Safe Drinking Water Act to address groundwater contamination. EPA found that groundwater in the Lower Yakima Valley is contaminated. This water is an underground source of drinking water, and contamination may present an imminent and substantial endangerment to human health. (Ecology 2010)

EPA conducted groundwater sampling in February and April of 2010.

A preliminary assessment and recommendations document were developed by a group of local, state, and federal agencies (Ecology, 2010). This report summarized the groundwater issues in the Lower Yakima Valley and identified a number of regulatory options for addressing the elevated nitrate concentrations. These options included establishment of a GWMA, Special Protection Area, Aquifer Protection Area, Sole Source Aquifer, Watershed Management Plan, and Total Daily Maximum Load (TDML). Yakima County Commissioners chose to establish a GWMA, and signed an interagency agreement with Ecology in September 2010.

General provisions for groundwater management areas are described in Chapter 173-100 of the Washington Administrative Code (WAC) and are explained in greater detail in Appendix A.

Goal, Process, Objectives and Tasks

The GWMA was established in 2011. The Groundwater Advisory Committee (GWAC) is a multi-agency and citizen-based group that was formed in 2012. The membership of the committee reflects the diverse interest in groundwater protection and the coordinative nature of the effort. Citizens, representatives from the agriculture, environmental groups, and local, state, and federal government agencies were appointed to bring diverse knowledge and represent different perspectives.

The GWAC held public meetings roughly every other month for six years. Meetings were scheduled in advance with an agenda and subsequent meeting minutes. Decisions were made by seeking consensus. When consensus could not be reached, decisions were made by a minimum of 75% majority with a minority report. The committee chose to use credible data and valid scientific protocols to assist with making decisions.

The committee also formed the following work groups to focus on specific issues:

- Education and public outreach
-
- Data collection, characterization and monitoring
- Livestock and CAFO
- Irrigated agriculture

Formatted: Bulleted + Level: 1 + Aligned at: 0" + Indent at: 0.25"

- Residential, commercial, industrial and municipal (RCIM)
- Regulatory framework
- Funding

These high-functioning workgroups typically met monthly, and were responsible for reporting back to the GWAC about their work.

The committee developed operating guidelines, which clarified the goals, objectives, and work plan. This document is included in Volume III ~~4~~ as an attachment.

Formatted: Not Highlight

Goal

The goal of GWAC is to bring nitrate concentrations in groundwater to below the state drinking water standard.

Process

The process identified to achieve this goal includes the following steps:

- Characterize the area
- Identify the problem and causes
- Establish and agree on a goal
- Delineate alternatives to meet goal
- Choose alternatives
- Implement the plan
- Periodically review the plan

Objectives

The following objectives were developed by the GWAC:

- Data and monitoring
  - Collect existing information into a shared data management system.
  - Establish a long-term groundwater monitoring program.
  - Identify sources of nitrate contamination.
- Problem identification
  - Characterize the nature and extent of nitrate concentrations in groundwater.
  - Identify the sources causing elevated nitrates in groundwater.
  - Identify and describe the activities contributing to groundwater contamination based on scientific data and evaluation.
- Measures to reduce groundwater contamination
  - Develop effective and coordinated Best Management Practices (BMPs) to address specific nitrate sources.
  - Develop strategies for implementing BMPs.
  - Support enforcement of new and existing laws and ordinances.

- Education
    - Establish education programs that promote groundwater protection.
    - Establish clearinghouse for information.
    - Educate private well owners.
- Drinking water systems
    - Assess feasibility of expanding public water supply systems.
    - Consider options to encourage expansion of public water supplies to areas with contaminated groundwater.
    - Assist residents that have contaminated water supplies with access to safe and reliable water supplies.

Further, the GWAC decided that:

- Pollution prevention will be a guiding principle for all work done by the GWAC.
- Participation by the Yakama Nation will be requested and encouraged in a way that is consistent with their sovereignty.
- Participating agencies will maintain their regulatory authority using their own discretion. They will also seek opportunities to coordinate actions and address regulatory gaps.
- The GWAC will seek sustainable funding sources to carry out its mission.

Assuring residents have clean and safe drinking water was a priority. One of the first objectives was to educate people about the problem and provide information on how they could protect themselves.

The GWAC tasked itself with identifying the primary sources of nitrate using scientific data. Another important task was identifying and developing practices that would minimize nitrate concentration of groundwater. To accomplish its tasks, GWAC developed a plan that would recommend strategies for implementing improved practices and providing appropriate education and outreach on health risks and how to prevent exposure.

This document is a summary of the committee's work. It focuses on the decisions that were reached (largely through consensus), the recommendations for future work, and ways to reduce nitrate concentrations in groundwater. Additionally, it highlights the extensive work accomplished over the last six years to characterize the area and establish a framework for implementation.

Tasks

Developing a GWMA program is the primary task. This program describes the elements identified in their work plan to achieve their objectives. Each objective is focused toward meeting the goal of reducing nitrate levels in groundwater to below the state drinking water standard.

This program completes the characterization and planning phase of the GWMA and lays the foundation for the next phase of implementation. The implementation phase will focus on carrying out the recommendations.

Other tasks that support this effort are described in the committee's operating guidelines and are attached in Volume III4.

Formatted: Not Highlight

Background

There are many elements that make the Lower Yakima Valley a unique environment. This section (1) describes the physical and jurisdictional boundaries of the GWMA, (2) explains why nitrate in groundwater is a concern, and (3) gives a brief overview of the regulatory authority that exists to manage the resources and activities in the Lower Yakima Valley.

Boundary of the Groundwater Management Area

The Lower Yakima Valley GWMA is located south of Union Gap, north and east of the Yakima River, and west of the Yakima-Benton County line (Figure 1). The northern boundary generally lies on the southern slopes of Ahtanum Ridge, several miles southwest of the Cold Creek Syncline. Its total area is 175,161 acres. The GWMA includes the incorporated communities of Zillah, Sunnyside, Granger, Grandview, and Mabton as well as the rural settlements of Buena and Outlook.

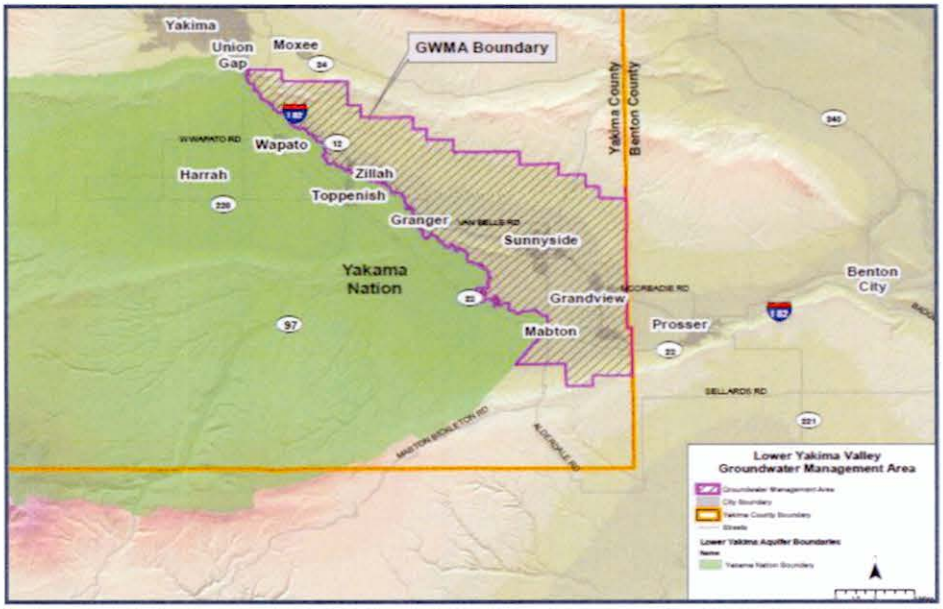


Figure 1 – GWMA Boundary

The Yakama Nation[1] (Figure 2) elected not to include the reservation as part of the GWMA, choosing to address nitrate levels independently. However, they were represented on the GWAC and participated in meetings and workgroups. ~~on the Lower Yakima Valley Groundwater Advisory Committee, choosing to address nitrate levels independently.~~

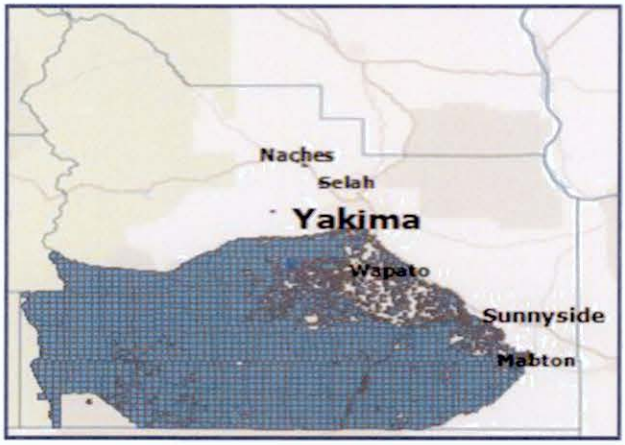


Figure 2 – Yakama Indian Reservation

Jurisdictional Boundaries: Federal, State, Local, and Tribal

The GWMA is within the jurisdiction of Yakima County with the exception of land within the municipalities of Zillah, Granger, Sunnyside, Grandview, and Mabton. While properties owned by the United States exist within the GWMA, they do not present issue areas that relate to the nitrate problem addressed by this program.

[1] Confederated Tribes and Bands of the Yakama Nation (Yakama Nation). The Yakama Indian Reservation lies along the southwest side of the Yakima River and extends beyond Yakima County boundaries into the northern edge of Klickitat County and southeastern corner of Lewis County. It covers an area of approximately 1.3 million acres. The Yakama Nation has nearly 9,000 enrolled members from 14 bands and tribes.

Concerns with Nitrate and Drinking water systems

Nitrate has a drinking water standard of 10 mg/L (as nitrogen). This standard is set to protect public health (further discussion on health effects in the section on Nitrogen in the Environment).

Public drinking water supply systems must meet certain criteria established by the Washington State Department of Health. Customers of public water supply systems may be exposed to elevated nitrate concentrations in groundwater that exceed the drinking water standard; however, water system operators are required to monitor regularly for nitrate and promptly warn their customers if the drinking water standard is exceeded. If subsequent samples show that nitrate levels continue to exceed the maximum contaminant level (MCL), the state may require a system to implement a permanent solution such as disconnection of a contaminated well, drilling a deeper well into a less contaminated zone of the drinking water aquifer, or treatment.

Private domestic wells are not regulated by the Washington State Department of Health. Users of drinking water systems that are not regulated by the state may be exposed to nitrate levels that exceed the drinking water standard. It is the responsibility of the homeowner or consumer to monitor their own drinking water quality.

How nitrate can get into groundwater

Groundwater contamination is almost always the result of human activity. Any activity that discharges or applies chemicals or water to the land surface may cause impacts to groundwater quality. Water has a natural ability to dissolve and transport materials including contaminants. This also creates an opportunity for groundwater contamination to occur. Figure 3 illustrates water movement in the subsurface. Soils that are permeable will transmit water down into the groundwater. Depending on the nature of the contaminant that has been released into the environment, the contaminant may move with water through the unsaturated zone and into groundwater. Contaminants can also move into the groundwater system through root systems, animal burrows, abandoned wells, and other holes or cracks that create pathways for contaminants to move.

Groundwater moves slowly and so do the contaminants in groundwater. Groundwater velocity is measured in feet per day while surface water velocity is measured in feet per second. Contaminants are generally diluted as recharge water mixes with groundwater; however, since groundwater moves slowly, the amount of mixing and dilution is much less than that of surface water.

Wells that are near a source of contamination are at risk of becoming contaminated. Contamination of groundwater can result in impacts to drinking water, loss of water supply, degraded surface water, and potential health problems. Groundwater is difficult and expensive to clean up. Prevention is the best way to protect groundwater quality.

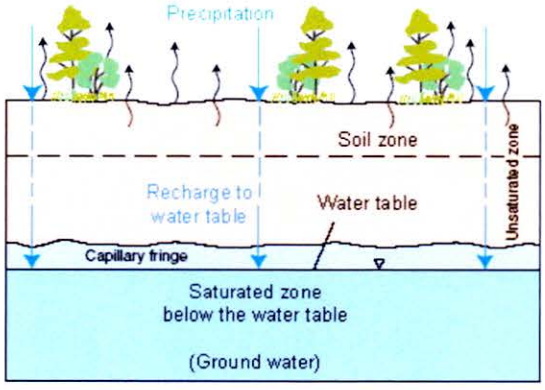


Figure 3 – Water movement in the subsurface.

(Heath, 1983)

Formatted: Not Highlight

Regulatory Authority

There are a variety of regulatory authorities that protect groundwater in the Lower Yakima Valley including local, state, and federal agencies. These authorities cover many aspects of water quality protection. The regulations include groundwater quality and quantity, drinking water, surface water, as well as management of discharges for on-site sewage systems, biosolids, municipal wastewater, industrial wastewater, CAFOs (concentrated animal feeding operations), underground injection control wells, and abandoned wells. Guidelines and technical assistance are also provided for agriculture. Table 1 summarizes the government agencies, their responsibility, and their legal authority. A more detailed explanation can be found in Appendix B.

Formatted: Not Highlight

Table 1 – Summary of Regulatory Authority.

Regulatory Agency	Authority	What it covers	Brief Description
Environmental Protection Agency	Safe Drinking Water Act	Drinking water	Establishes MCLs[1] for drinking water.
	Clean Water Act	Surface water	Authority to regulate discharges to surface water.
Washington State Legislature	Water Pollution Control Act	Protection of water quality	Authority for groundwater quality standards and discharges to surface and groundwater.
	Water Resources Act	Protection of water quantity	Authority for allocating water rights.
Washington State Department of Ecology	Groundwater Quality Standards	Protection of groundwater quality	Establishes numeric criterion, antidegradation and treatment technology standards.
	Surface Water Quality Standards	Protection of surface water quality	Establishes criterion for different water body types and antidegradation.
	NPDES[2] permits	Discharge to surface water	Individual permit for a specific discharge to surface water.
	State Waste Discharge Permits	Discharge to groundwater	Individual permit for a specific discharge to groundwater.
	General permits	Discharges	Covers a large number of facilities with similar features.
	Biosolids Management	Biosolids	Protect human health and the environment where biosolids are managed.
	Well Construction	Standards for installation of wells	Protect water resources by developing construction, installation, and decommissioning standards.
	Underground Injection Control Program	Underground injection control wells	Register and permit underground injection control wells.

Regulatory Agency	Authority	What it covers	Brief Description
Washington State Department of Health	Public Drinking Water Systems	Drinking water	Covers both large and small systems.
	On-site Sewage Systems	On-site Sewage Systems	Establishes regulations for siting, installing, maintaining, and inspecting on-site sewage systems.
Washington State Department of Agriculture	Dairy Nutrient Management Act	Livestock and agriculture	Inspect agriculture and livestock facilities, inventory cropland and facilities.
Yakima County	Local ordinances	Land use	Zoning for different land uses.
		Wells	Inspect well installation and decommissioning, drinking water quality.
		On-site Sewage systems	Siting, installation, and inspections of residential on-site sewage systems.
Natural Resource Conservation Service	Federal assistance	Provide technical assistance	Guidelines for a variety of agricultural activities.
South Yakima Conservation District	Local assistance	Provide technical assistance	Provide assistance to farmers.

1 MCL = Maximum Contaminant Level

2 NPDES = National Pollutant Discharge Elimination System

Organization this document

The suggested content of a GWMA Program is defined by Chapter 173-100 WAC. The program laid out in the following pages generally follows this structure:

- Nitrogen in the environment
- Sources of nitrate
- Characterization of the area
- Initiatives completed by the GWAC
- Recommended actions

Committee members who have differing opinions with aspects of this plan had an opportunity to file a minority report and have it attached to this document in Volume IV.

Nitrogen in the Environment

Nitrogen is a natural element that can be concentrated in the environment through many sources and activities. It is present in human and animal wastes, plants, fertilizers, and precipitation. Nitrogen exists in different forms and behaves differently depending upon its form. Nitrate is the most mobile form, and moves with water readily through subsurface soils, making it the most prevalent contaminant in groundwater. Elevated nitrate is a concern because it can cause negative health effects.

The transformation of nitrogen in the environment is a complex topic that is described in detail in Appendix C. The appendix includes an illustration of the nitrogen cycle, a description of the numerous forms of nitrogen and its most common forms, a description of the transformation processes, the conditions required, and the environmental processes that affect the transport of nitrate to groundwater.

Nitrate Leaching

Nitrate is soluble in water and moves readily through subsurface soils with precipitation or recharge water. This process is known as *nitrate leaching*. Many factors affect how much nitrate will leach to groundwater, including the type and amount of nutrients applied, when they are applied, the type of crop grown, the type of soils, the climate, the timing and amount of irrigation, and the amount of nitrogen already in the soils (Redding 2016).

Lag Time

Lag time is the amount of time between an action and a response. With land treatment systems, this is the time between when nutrients are applied at the land surface and when they are utilized by a crop, denitrified, or migrate to groundwater. The retention of nutrients in the soil depends on the same factors that affect leaching to groundwater. Typically, there is a lag between when an action is taken at the land surface and the resulting effects on groundwater quality (Meals and Dressing 2010).

There are two components that aeffect lag time; this includes 1) the vertical component as nitrate transforms and moves downward in the vadose zone, and 2) the horizontal component which considers flow in groundwater from the point where it enters groundwater to reach a measured well. High water recharge rates shorten travel time to a deep water table, but in irrigated areas with high irrigation efficiency and low recharge rates, the transfer to a deep water table may take longer (Harter 2012a).

Formatted: Not Highlight

Health Effects

Nitrate is an acute contaminant, which means a single exposure can affect a person's health. The primary health effect associated with nitrate exposure is the formation of

methemoglobin (metHb), which reduces the ability of red blood cells to carry oxygen. This can result in a condition known as methemoglobinemia. While it is normal to have some metHb, adverse effects may appear in children and infants at modest increases in metHb that are otherwise within the normal range for adults (OEHHA 2018). Infants are particularly susceptible because their hemoglobin is more readily oxidized to metHb, they have a higher gastric pH which leads to the presence of nitrate-reducing bacteria, and they have lower concentrations of enzymes capable of converting metHb back to hemoglobin. One of the more serious health effects of methemoglobinemia is cyanosis (the lack of oxygenated blood). Clinical effects can be observed as bluish-grey skin when metHg levels are between 1 and 15 percent, the severity of symptoms increases with increasing metHg levels; a high risk of mortality occurs at levels greater than 70 percent metHg (ATSDR 2017).

Methemoglobinemia in infants is often closely associated with bacterial contamination of well water, which may lead to gastrointestinal infection and diarrhea (Avery, 1999; Powlson et al., 2008). However, other data indicate that infection is unlikely to be the primary cause (Knobeloch et al. 2000) and there is consistent evidence of nitrate as a causative agent in induction of methemoglobinemia. Exposure to nitrate is primarily through consumption of water and food. Because of their susceptibility, it's recommended that infants younger than three months avoid vegetables such as carrots, spinach, and squash, which are naturally high in nitrate. There have been no documented cases of methemoglobinemia in the United States attributed to nitrate in drinking water when nitrogen concentrations were less than 10 mg/L.

Formatted: Not Highlight

Drinking water that exceeds the MCL of 10 mg/L should not be given to infants under 12 months old, and the water should not be used to make formula or juice for them. If an infant shows signs of "blue baby syndrome" (bluish skin, shortness of breath), medical attention should be sought immediately. Women who are pregnant or think they may be pregnant should not drink water that exceeds the MCL. People of any age with certain rare blood enzyme disorders which affect their ability to convert methemoglobin to hemoglobin [glucose-6-phosphate dehydrogenase (G6PD) or cytochrome b5 reductase deficiencies] should avoid drinking water that exceeds the MCL. (WDOH 20168).

Formatted: Not Highlight

Preliminary Assessment

Background information on nitrate in the Lower Yakima Valley was compiled by several government agencies to characterize the issue of nitrate in groundwater and to offer possible ways to address the issue. These agencies included the Washington State Departments of Agriculture, Ecology, and Health; Yakima County Public Works; and the U.S. Environmental Protection Agency (Ecology 2010). The observations and recommendations from this preliminary assessment provided the pathway for the development of the GWMA.

The following are some of the significant findings of this report (Ecology 2010 – Preliminary Assessment):

- Over 2,000 people in the area are exposed to elevated nitrates over the maximum contaminant level (MCL) through their drinking water.
- The population is served by a mix of public and private water supplies. Approximately one third of residents (24,000) rely on private domestic wells for drinking water.
- Nitrate concentrations are greatest in shallow groundwater.
- Typically, private wells draw water from the shallow portion of the surface aquifer. Public drinking water systems tend to rely on deeper wells or a mix of sources.
- Water that exceeds nitrate concentrations may also be at risk of bacterial contamination.
- Agricultural practices, including the use of fertilizer and the management of manure, are linked to nitrate loading and incidents of nitrate contamination in groundwater (Ecology 2010 – Preliminary Assessment).
- There is a correlation between nitrates and well depth.
- Data were insufficient to determine nitrate trends in groundwater (1990 – 2008).
- The natural level of nitrate is defined as less than 0.3 mg/L. Concentrations below this level have been documented from pristine areas within the Lower Yakima Valley. Concentrations above 0.3 mg/L indicate impacts from human activity.
- The variability in nitrate concentrations throughout the Lower Yakima Valley suggests no clear, uniform trend (increasing, decreasing, or stable) in groundwater.

The following are recommendations from the preliminary assessment (Ecology 2010 – Preliminary Assessment):

- Develop a comprehensive strategy that focuses on assuring long-term access to safe and reliable drinking water supplies for valley residents.
- Initiate education and outreach to help the public make informed choices.
- Test wells.
- Identify the sources of contamination.
- Mitigate the sources of nitrate and bacterial contamination.
- Enforce the existing laws.
- Learn more about the issues.

Owners of private wells who are unsure about their water quality may have their water tested for coliform bacteria and nitrate. The Yakima Health District can advise where to get water tested and has specific recommendations for testing. Many certified labs in Washington charge $20 to $40 per test. If nitrate test results are over 8 mg/L, annual testing is recommended. If results are less than 8 mg/L, testing every three years is recommended.

Nitrates in groundwater can affect both domestic animals and wildlife. This occurs directly by ingestion, or indirectly through impacts to habitats, where groundwater discharging to surface water contributes to nutrient loading of streams, lakes, and wetlands.

Yakima River Surface Water Quality

Scientific studies document the hydraulic connection between the Yakima River and groundwater. The determination of whether a reach is gaining or losing water depends on the local head difference and often changes seasonally (USGS 2009a). Other published USGS studies have documented varying relationships between groundwater and surface water nitrogen within the Lower Yakima Basin (Domagalski et al. 2008; Puckett et al. 2008; McCarthy and Johnson 2009; Tesoriero et al. 2009; Domagalski and Johnson 2011; Domagalski and Johnson 2012).

Temperature, dissolved oxygen (DO), and acidity (pH) are the properties affecting the Yakima River's surface water quality. Nitrogen is an aquatic nutrient in surface water that contributes to algae growth, but it is not included in the Yakima River's surface water quality total maximum daily load (TMDL). TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards.

Sources of Nitrate

The GWAC identified all significant sources of nitrate in the Lower Yakima Valley. These sources were quantified in a nitrogen availability assessment and include irrigated agriculture; livestock and concentrated animal feeding operations (CAFOs); residential, commercial, industrial, municipal (RCIM) sources; and atmospheric sources.

The Nitrogen Availability Assessment

The Washington State Department of Agriculture (WSDA) completed a nitrogen availability assessment for the GWMA (WSDA 2018). This assessment considered the amount of nitrogen applied to the land surface, the bottom of the root zone, or at the end of the treatment zone. It did not calculate the amount of nitrogen migrating from the land surface to groundwater. Three scenarios were calculated for each nitrogen source by using high, medium, and low estimates, capturing not only typical contributions, but also best- and worst-case contributions.

One of the goals of this assessment was to use as much locally derived information as possible, thereby achieving a refined estimate of the contribution from each of the significant sources.

Data from the assessment are incorporated into the GIS database at Yakima County. The database is intended to be a living document that can be updated as new information becomes available.

A copy of the nitrogen availability assessment (WSDA 2018) is contained in Volume III - Accomplishments. Highlights of the assessment are described below.

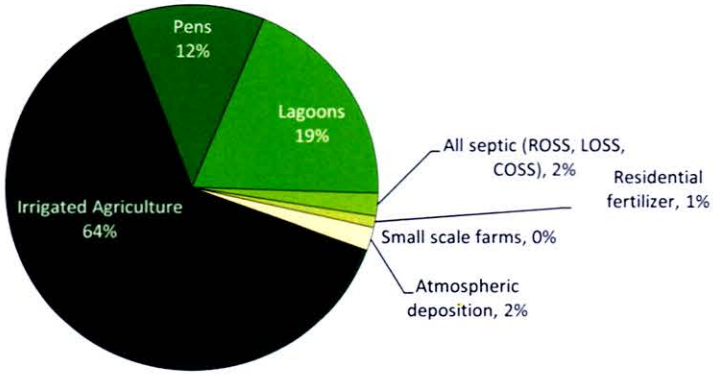
Table 2 describes the nitrogen available for transport from all sources for low, medium, and high scenarios. Figure 4 illustrates the relative percent for medium estimates of nitrogen available in the environment. These numbers were calculated by factoring in the acreage of each source and the amount of nitrogen available. The medium scenario is highlighted because it represents the most likely scenario. The high and low scenarios represent the outer boundaries of what is likely.

Table 2 – Estimated nitrogen available per acre from all sources at the low, medium, and high ranges

Source		Area (acres)	Low Scenario (lb/ac/yr)	Medium Scenario (lb/ac/yr)	High Scenario (lb/ac/yr)
Irrigated Agriculture		85,775	0-58	0-148	0-284
CAFO	Pens	2,096	67	480	892
	Lagoons	210	1,354	7,448	13,542
RCIM	Residential On-site sewage	398	223	403	662
	Large On-site sewage	3	195	209	225
	Commercial On-site sewage	30	163	173	183
	Residential fertilizer	4,381	4.7	11.7	18.6
	Small scale farms	2,096	4.3	10.7	17.1
Atmospheric deposition		87,082	1.53	2.05	6.15

N = nitrogen
CAFO = concentrated animal feeding operation
RCIM = residential, commercial, industrial, municipal
ROSS = residential on-site sewage system
LOSS = large on-site sewage system
COSS = commercial on-site sewage system
(WSDA 2018)

Figure 4 – Nitrogen sources



ROSS = Residential On-site Sewage System
LOSS = Large On-site Sewage System
COSS = Commercial On-site Sewage System.
Source: (WSDA 2018)

Biosolids were not included in this assessment, but their relative contribution is discussed in this section.

When the acreages utilized in the WSDA analysis are summed, the total is greater than the acreage within the GWMA. This is because some acreage has been counted more than once, due to multiple nitrogen inputs. For example, land used for double cropping (silage corn, triticale, alfalfa) and multiple purposes (farming, on-site sewage) have multiple nitrogen inputs. Acreage for which atmospheric deposition has been estimated includes all the GWMA acreage for which WSDA (2018) did not assume that component as part of its estimate (e.g., CAFOs, livestock pens, and manure lagoons). This system was necessary to obtain total nitrogen availability.

Irrigated Agriculture

Irrigated agriculture makes up approximately 85,775 acres (49 percent), of the total land area within the GWMA boundary (WSDA 2018).

Formatted: Space Before: 12 pt

Diverse crops are grown in the GWMA. Table 3 lists the top crops in the GWMA, along with the type of fertilizer used. Each crop has a unique cultivation practice.

Table 3 – Summary of fertilizer types used for the top 15 crops in the GWMA.

Crop	Commercial fertilizer (% of acres)	Manure (% of acres)	Compost (% of acres)	Acres using multiple sources (%)
Apple	86.3	0	13.7	0
Corn (silage)	49.6	53.9	0	3.5
Triticale	27.2	74.8	0.8	2.8
Grapes (juice)	91	0	11.6	2.6
Alfalfa	91.8	8.2	0	0
Pasture	97.2	2.8	0	0
Cherry	80.5	0	19.5	0
Hops	97.3	2.7	16	16
Grapes (wine)	100	0	20	20
Pear	76.6	0	23.4	0
Mint	100	0	0	0
Wheat	93.9	22.4	0	16.3
Corn (grain)	71.3	62.6	0	33.9
Asparagus	100	0	0	0
Peach/Nectarine	81	0	19	0

(WSDA 2018)

Crops Supporting Livestock Operations

A significant portion of irrigated agricultural acreage within the GWMA (31,790 acres or 37~~2~~ percent of irrigated acres, and 18 percent of the GWMA acreage) is dedicated to crops and

land uses that support livestock operations. These crops include alfalfa, corn, triticale, and pasture grass.

Triticale is normally used for double-cropping, meaning two crops are grown on the same acreage in one year (WSDA 2018). Triticale is planted in the fall (September – October) and harvested in the spring (April – May). Silage corn is seeded immediately afterward and harvested in late summer or fall (August – October).

Alfalfa is a complex perennial crop. It removes large quantities of nutrients from the soil. It can meet most of its nitrogen needs through fixation of atmospheric nitrogen, but it is dependent both on the presence of rhizobia bacteria in the soil and on whether supplemental nitrogen is added. Alfalfa uses nitrogen from other sources, such as manure or commercial fertilizer, if they are available. The practice of nitrogen supplementation on alfalfa does occur within the GWMA. However, agricultural practices used for perennial crops such as alfalfa and pasture grass remove the majority of the plant residue from the field during harvest or through grazing.

Tree Fruit and Vegetable Crops

The primary crops grown in the region are tree fruits, grapes (both juice and wine), hops, wheat, mint, and asparagus. The orchard and vineyard crops (e.g., apples, grapes, cherries, pears, peaches, and nectarines) are not replanted annually. Rather, they are replanted as appropriate to enhance farming efficiency and anticipate market preference and demand.

Fertilizers

Fertilizers available within the GWMA include commercial fertilizer, manure, compost, and cover crops. There is no accurate current data regarding these four nitrogen sources within the GWMA. Interviews with farmers and crop consultants indicate that the most commonly used product is commercial fertilizer. The exceptions were for corn and triticale, where many acres were fertilized with manure (WSDA 2018).

The timing of fertilizer application can affect nitrogen availability for plant uptake and resultant leaching of excess nitrogen. For instance, commercial fertilizers are formulated to release a specific amount of nutrients at a specific rate over a select period of time. Slow-release fertilizers are designed to release a small, steady amount of nutrients over a course of time. Nitrogen from compost or manure is released over a much longer period of time at a much lower rate. Manure, compost, and commercial fertilizer also react differently at the point of application. Compost or manure adds nutrients and minerals that can improve soil health. These organic nutrients also add structure to the soil which enhances moisture holding capacity and soil biological communities.~~.~~

Generally, crop fertilizer application choices are affected by several parameters, including fertilizer type, crop nitrogen needs, application recommendations, expected crop pricing, and anticipated yields. They also may be influenced by recommendations from crop consultants

and fertilizer guides, historical practices, and practices of other growers in the community. This variability, in combination with effects of fertilizer types used, irrigation type and practices, application timing, soil type and organic matter content, soil nutrient content, manure nutrient content, handling and storage before application, organic carbon cycling and mineralization, and fertilizer fixing in alfalfa will all affect whether or not any fertilizer application represents a nitrogen loading risk. Timing of nitrogen application was not addressed by WSDA (2018) in their nitrogen availability assessment of the GWMA.

High nutrient applications or application of multiple nutrient sources may be used on permanent tree fruit and vegetable crops to improve soil health and maximize fruit production. Producers of crops intended for human consumption may be reluctant to make manure and compost application because of concerns about pathogen transfer, reducing fertilization options (WSDA 2018).

Annual crops such as silage corn, triticale (for silage), and wheat use both commercial nitrogen and manure throughout the GWMA (WSDA 2018). Generally, the nitrogen application for this corn/triticale cropping system is split — one in the fall and one in the spring. Corn (silage and grain) use similar amounts of commercial nitrogen and manure on most of the acreage (WSDA 2018).

Fertilizers of any type should be applied only at an *agronomic rate*; that is, the rate of application that supplies crop nutrient needs to achieve realistic yields, while at the same time minimizing the movement of nutrients to surface water and groundwater.

Commercial Fertilizer

There is no public record of the total amount of commercial fertilizers sold or used within the GWMA. Crop consultants or agronomists are used by the majority of commercial farms operating within the GWMA. These consultants are not usually farmers. They recommend specific pesticide and fertilizer applications across multiple crops on many different farms.

Manure

Manure is a widely used source of organic fertilizer in the GWMA, obtained from CAFOs within the GWMA. While total volume of manure production can be calculated as a function of total animals, no public records exist that explain how much manure is used to fertilize crops and how much is exported to land within or outside the GWMA.

Manure contains two primary forms of nitrogen: ammonium and organic nitrogen. Organic nitrogen is nearly immobile. It becomes mobile and available to crops through mineralization, the process by which soil microbes decompose organic nitrogen into ammonium. The rate of mineralization varies with soil temperature, soil moisture, and the amount of oxygen in the soil. After mineralization, microorganisms within the soil convert

ammonium into nitrate. This process, called nitrification, occurs most rapidly when the soil is warm, moist, and well-aerated.

Manure contains high concentrations of organic nitrogen and ammonium and low concentrations of nitrate compared to inorganic fertilizer. It is difficult to estimate nitrogen loading to soil, air, and water from manure application without analysis of nitrogen content.

Compost

Compost is also an organic fertilizer used in the GWMA. Compost supplies organic nitrogen, organic matter and other nutrients and minerals to the soils.

Cover Crops

Cover crops can utilize nitrogen within the soil. However, they can also be a source of nitrogen if plowed back into the soil on-site. The variety of cover crops and number of years of integration of cover crops into the soil can affect overall nitrogen concentrations in the soil.

Water Applications

Irrigation practices can mobilize nitrate in the environment. Excess irrigation water can leach nitrate to groundwater and can aeffect surface water through field runoff or as irrigation return flows.

Irrigation water requirements vary based on crop type.

Irrigation water can also be a source of nitrate, which should be taken into account when calculating application rates. The average nitrogen concentration of high flow (late spring) and low flow (late summer) conditions of the Yakima River at Kiona during the 2012 irrigation season was 0.809 mg/L (USGS 2013). Groundwater quality varies dramatically across the GWMA.

Irrigated agriculture is mapped statewide by WSDA, including the area within the GWMA. There is no current data regarding the distribution of the three general irrigation methods (sprinkler, drip, rill) within the GWMA. Interviews with farmers and crop consultants indicate that sprinkler irrigation was used on 61 percent of the total irrigated acreage in the GWMA, and drip irrigation (including drip, micro sprinkler, drip/sprinkler, and combinations) was used on 23 percent of the acreage. Rill irrigation was used on 15 percent of the acreage (WSDA 2018).

Silage corn and triticale cultivation is almost all irrigated with sprinkler or center pivot irrigation systems. Triticale cultivation rarely occurs on rill-irrigated fields (Sheehan, pers. comm.).

Livestock Operations/CAFOs

CAFOs are concentrated animal feeding operations for the cultivation of livestock or livestock products. These include dairy, beef, pigs, chickens, and other products.

A 2012 assessment of dairy operations in Yakima County estimated there were 99,532 milk cows on 97 farms (WSDA 2018). The majority are located within the GWMA. CAFOs are increasing in size, while the number of farms is decreasing (WSDA 2018).

For the purposes of this report, livestock operations and CAFOs can contribute nitrogen from pens, corrals, compost areas, and lagoons. Land application of manure from these operations is considered in the irrigated agriculture section.

Manure and other animal by-products~~wastes~~ contain nutrients that are beneficially reused to grow crops. They increase soil fertility and crop yield, and their use is a historic practice. Manures are recommended over commercial fertilizers where there is a desire to build the soil profile by increasing and diversifying soil organisms, increasing moisture holding capacity, and reducing the need for inputs.

Livestock operations have the potential to release nitrate, chloride, sulfate, and bacteria to surface or groundwater (Harter et al. 2002; Harter and Lund 2012). Impacts to groundwater depends on contaminant characteristics, nutrient and water management practices, climatic conditions, soil types, the geology, and groundwater characteristics (Viers et al. 2012). Nitrogen sources can be animal holding areas, manure storage impoundments (either lagoons or settling ponds/basins), and manure applications to cropland (Harter et al. 2002).

The national statistical average of manure production of milk cows (in 2000) was 15.24 tons per animal unit of manure excreted per year. The national statistical average of nitrogen per ton of manure excreted is 10.69 pounds of nitrogen per ton (Kellogg et al. 2000). The formulas used by the Washington State Department of Agriculture (2010) to calculate animal manure production, nitrogen production, and losses due to volatilization or denitrification for Holstein cows are as follows:

- **Annual manure production** is calculated using the following formula:

[[(number of milking cows) (1.4) (108)] + [(number of dry cows) (1.4) (51)] + [(number of heifers) (0.97) (56)] + [(number of calves) (0.33) (83)]] (365)/2000

- ~~**((# of milking cows)*1.4 108) + ((# of dry cows)*1.4*51) + # of heifers)*0.97*56) = ((# of calves)I0.33*83)] *365/2000**~~

Formatted: Not Highlight

Formatted: Font: Bold

Formatted: Normal,GW Normal, Indent: Left: 0.75", Right: 0", Space After: 0 pt, Line spacing: single, No bullets or numbering, Tab stops: Not at 6.5"

Formatted: Font: Bold

Formatted: Normal,GW Normal, Indent: Left: 0.75", No bullets or numbering

- **Nitrogen production** is calculated using the following formula:

  [[(number of milking cows) (1.4) (0.71)] + [(number of dry cows) (1.4) (0.3)] + [(number of heifers) (0.97) (0.27)] + [(number of calves) (0.33) (0.42)]] (365)/2000

  Formatted: Normal,GW Normal, Indent: Left: 0.75", No bullets or numbering

  ~~((# of milking cows)*1.4*.710 + ((# of dry cows)*1.4*.3) + ((# of heifers)* 0.97*.27)+((# of calves)*0.33*.42)]*365/2000~~

  Formatted: Font: Bold

- **Losses due to volatilization** during storage are estimated at 35 percent. This does not include application losses.

Waste Storage Facilities (Lagoons)

Liquid manure stored in lagoons can be a source of nitrogen and other contaminants. Contents of lagoons often consist of liquid manure (including urine), rainfall, snowmelt, and any liquid diverted from production areas. Design, construction, and management of lagoons are important for protecting groundwater. In studying lagoons, researchers found substantial variation in the composition of solids, liquids, and dissolved constituents; they also found leakage rates causing a wide variation in the potential to affect groundwater quality (Ham 2002; Harter and Lund 2012a).

Lagoons include impoundments, settling basins, settling ponds, and ponds. There are a wide variety of construction and operational techniques for lagoons; some are earthen impoundments that are drained and cleaned as needed, while others are concrete lined, engineered basins.

Lagoon nitrogen concentration depends on farm practices and unit operations on site. Operational differences are often related to the type of solids separation systems utilized. Other factors include whether irrigation water is mixed with liquid manure for land application and potential seasonal effects.

WSDA (2018) conducted lagoon assessments on 115 lagoons in the GWMA, inspecting each lagoon when it was nearly full and again when it was nearly empty. This assessment allowed WSDA to determine average lagoon capacity, depth, and surface area. These measurements were used to calculate discharge using Darcy's Law. Assumptions were necessary to determine liner permeability and thickness. Nitrogen loading was calculated using a total nitrogen concentration of 1,053 mg N/L.

Pens and Corrals

Animal confinement systems include pens, corrals, and freestalls, as well as resting, feeding, and housing areas. These areas are typically unvegetated and vary depending upon the animal type and the individual livestock operation. WSDA (2018) estimates that there are 1,597 acres of dairy CAFO pen area and 499 acres of nondairy CAFO pen area, for a total of 2,096 acres of pens in the Lower Yakima Valley.

Pens and corrals can have a surface of unlined and compacted soil or concrete. Over time the soil becomes compacted, which decreases the permeability. Manure accumulating on the surface mixes with the soil layer and forms a low permeability interface layer that reduces the permeability of corral and pen surfaces (Harter and Lund 2012a). Nitrogen loading from corrals and pens at CAFOs is governed by engineered sloping, catch basins, soil type, feedlot age, unsaturated zone thickness, stocking rate, rainfall, and evapotranspiration rates. In some situations, increased short-term leaching in corrals may occur due to cracking during seasonal weather events. The nitrogen loading rates of pens varies depending upon number and size of stock and management. Nitrogen leaching potential in pens and compost areas is controlled by precipitation, management of manure in the pen areas, and compaction by livestock or equipment.

Animals may spend time in freestall barns, milking parlors, or loafing sheds. These facilities are built with concrete floors and are cleaned multiple times a day. Potential leaching from these types of buildings, even anticipating cracks in concrete floors that could provide a pathway to leaching, is less likely than leaching from pens and lagoons.

Compost Areas

There are 536 acres associated with composing activities (WSDA 2018). "'Composting' means the biological degradation and transformation of organic solid waste under controlled conditions designed to promote aerobic decomposition. Natural decay of organic solid waste under uncontrolled conditions is not composting." (WAC 173-350-100). Composting may refer to a category of activities rather than a specific practice or technology. These activities include composting in bags, spreading material out over a concrete pad or large surface area to dry, turning frequently, and adding moisture to material that has dried out. Composting reduces the weight of the basic material. Compost is used by organic growers to amend soil structure, density, and nutrients, as well as to prevent weeds.

Residential, Commercial, Industrial and Municipal Groundwater

Non-agricultural sources of nitrate within the GWMA boundaries include on-site sewage systems used for residential or commercial purposes, biosolids, residential lawn fertilizer use, hobby farms, underground injection control wells, and abandoned wells.

Residential On-site Sewage Systems

Residential On-site Sewage Systems (ROSS) are more commonly found in the rural areas of the GWMA, which are not served by municipal sewage collection and treatment systems. On-site sewage systems collect and treat wastewater generated by a residence. Wastewater from the house is collected in a on-site sewage tank where solids settle and remain in the tank. The liquid portion flows into the drainfield and infiltrates the ground.

There are 6,044 residential households within the GWMA that discharge wastewater to an on-site sewage system (WSDA 2018). The contribution from ROSS was calculated based on assumptions of the number of people per household and the amount of nitrogen and liquid generated per person each day. Assumptions were also used to estimate nitrogen losses. WSDA (2018) estimates between 7 to 17 grams of nitrogen are discharged into an on-site sewage system every day, which equates to a concentration of 26 to 75 mg N/L. The average concentration is 11 grams N/person/day or 50 mg N/L.

Minimum land area requirements for on-site sewage systems are established in WAC 246-272A-0320. The land area depends on the type of water supply and the soil type. The minimum area ranges from 12,500 square feet (3.5 houses per acre) to 2.5 acres.

The highest density of on-site sewage systems is within and near urban growth areas associated with municipalities. All of the densities meet the most stringent minimum land area requirements with an average land area ranging between over 12 acres per ROSS to 6.4 acres per ROSS.

- The highest density of on-site sewage systems is found on the east and north side of Sunnyside, where the density of on-site sewage systems ranges from 80 to 100 on-site sewage systems per section (average land area ranges from 8 acres to 6.4 acres per ROSS).
- West of Sunnyside, near Outlook, on-site sewage system density approaches 80 systems per section (average land area 8 acres per ROSS).
- In the Zillah to Buena area, density approaches 80 systems per section (average land area 8 acres per ROSS).
- Slightly lower on-site sewage system density is found south of Grandview, Sunnyside, and Mabton where the on-site sewage system density ranges from 50 to 70 per section (average land area ranges from 12.8 acres to 9.1 acres per ROSS).

Many residents that use on-site sewage systems to treat their wastewater also have a private domestic well for their source of drinking water. The proximity of a well to an on-site sewage system or a large density of homes using on-site sewage systems can cause impacts to local groundwater quality and can affect drinking water quality for residents. For example, in the Buena community within the GWMA, failing on-site sewage systems and related contaminated wells caused Yakima County to respond with grant-funded installation of a

public water system and a wastewater treatment system utilizing a combined on-site sewage /sewer system (Redifer 2014).

The frequency of on-site sewage tank pumping for each residential on-site sewage system in the GWMA is unknown. In a survey conducted by Yakima County 82 percent of 458 surveys collected indicated that they had their on-site sewage tank pumped recently.

The predominant soil types underlying the ROSS drain fields located within the GWMA are characterized as silt loams that are porous and have a well-developed structure. The estimated depth to groundwater is equal to or greater than 10 feet at approximately 90 percent of the ROSS locations~~.~~ (s~~S~~ee Figure 1~~2~~4, Depth to Groundwater).

Large On-site Sewer Systems

A large on-site sewer system (LOSS) serves multiple residences or establishments, serving twenty or more people per day or having a design volume of over 3,500 gallons. Washington State Department of Health records show that there are two of these systems located within the GWMA. One system is located outside of Zillah with a design capacity of 5,000 gallons. The second is located outside of Granger with a design capacity of 4,850 gallons. Annual LOSS reports are submitted to the DOH.

Commercial On-site Sewer Systems

A commercial on-site sewer system (COSS) is used for employees working at agricultural businesses or other businesses that operate year round and are not classified as a LOSS by the DOH. These locations include wineries, schools, agriculture packing lines, small businesses (e.g., stores and fire stations), agricultural business offices, maintenance buildings, churches, and confined animal feeding operations (CAFOs).

Biosolids

Biosolids are a nutrient-rich soil amendment derived from public waste treatment plant septage. Septage is a class of biosolids that comes from on-site sewage tanks, treatment works, and similar systems receiving domestic wastes (WAC 173-308-050). Biosolids are produced by treating sewage sludge to meet certain quality standards that allow it to be applied to the land for beneficial use.

Biosolids are permitted for use on 6.5 percent (11,346 acres) of the total GWMA (1,758,000 acres), but only 0.08 percent of the GWMA (1,393 acres) have received biosolids applications from 2010 through 2017 (figure 5). Ecology requires soil testing of the top 3 feet of soil and restricts application of biosolids based on the cumulative soil nitrate value and the crop grown (Severtson 2017).

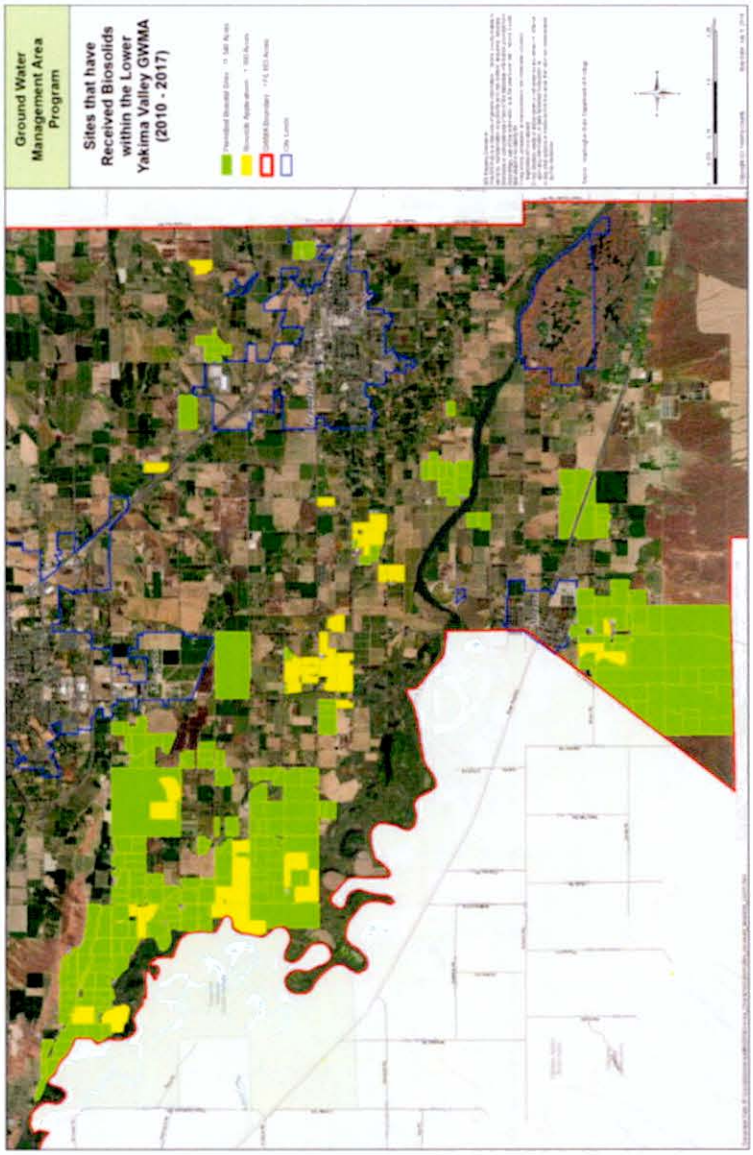


Figure 5 – Biosolids Application Sites

Residential Lawn Fertilizers

Residents use lawn fertilizers for the care and maintenance of their lawns. Not all residents fertilize their lawns. There is no available data about the frequency or amount of fertilizer used by residents. WSDA (2018) used assumptions to estimate the amount of nitrogen that might be applied to residential lawns within the GWMA.

Other factors that could affect nitrogen availability are irrigation and whether lawn clippings are removed or left on the lawn.

Hobby Farms

Hobby farms are defined as minimalist agricultural entities on parcels of land measuring less than 10 acres that are operated without the intention of profit. These farms may also be a source of nitrogen depending upon the individual practices. Nitrogen contributions on these parcels may come from individual gardens, pastures, pets, and other animals.

Underground Injection Control Wells

Underground injection control wells are typically located in roadways for stormwater management.

Abandoned Wells

Abandoned or improperly constructed wells can be a direct conduit for contaminants to reach the groundwater.

Atmospheric Deposition

Atmospheric deposition of nitrogen is the process by which aerosol particles collect or deposit themselves on the earth's surfaces. It may be either wet or dry deposition. Nitrogen emissions may come from transportation, agriculture, power plants, industrial, and natural sources. In agricultural areas, emissions from operations involve animals or fertilized cropland. Emissions may travel from very long or very short distances (Viers et al. 2012). Deposition monitoring is conducted by the National Atmospheric Deposition Program. There is one monitoring station in Eastern Washington, in Whitman County (WSDA 2018).

Legacy Nitrogen

Legacy nitrogen is the residual nitrogen that accumulates in soil after the growing season. Portions of the nitrogen retained in the soil are in the form of organic nitrogen, which mineralizes slowly over time. There is also residual nitrate that can migrate to groundwater with recharge. The amount of residual nitrogen in the soil of the Lower Yakima Valley is unknown. Research on the topic of legacy nitrogen indicates that the amount of stored nitrogen may be significant in agricultural areas and may take a long time to be converted or utilized. However, some studies have documented rapid improvements based on implementing Best Management Practices (Sebilo et al. 2013; Rudolf et al. 2015; Dalgaard 2014; Exner et al. 2013; Van Meter et al. 2016).

Farming practices have made improvements over the years in how nutrients, water and chemicals are applied. It is unclear how the lingering effects of historical practices aeffect water quality and it is unclear how the improvements in farming practices translate into improvements in water quality. No scientific studies within the GWMA area were presented or considered by the GWAC to evaluate legacy effects on water quality.

Characterization of the Area

The following section is a description of the Lower Yakima Valley Groundwater Management Area (GWMA) with a focus on 1) physical basin characteristics, 2) land and water use, and 3) population demographics. This information relates to Yakima County in some instances and only to the GWMA in other instances.

Physical Basin Characteristics

Physical basin characteristics described in this section include: geology, hydrogeology, topography, depth to groundwater, soil, and climate.

Geology

The primary geologic features discussed include the stratigraphic units of the Columbia River Basalt Group, the Ellensburg Formation, and the Lower Yakima Valley Fill. A more detailed description of the geology is contained in Appendix D.

Columbia River Basalt Group

The Columbia River Basalt Group (CRBG) is a thick sequence of Miocene eruptive basalts estimated to be several thousand feet thick and interbedded with a few minor sedimentary strata. It is subdivided into three primary formations: the Saddle Mountains Basalt, the Wanapum Basalt, and the Grande Ronde Basalt (USGS 2009a; GSI 2009a, 2011). The Saddle Mountains Basalt is often exposed at the surface, with thicknesses ranging from 180 to 800 feet and averaging more than 500 feet in the Yakima Basin.

The Ellensburg Formation

The Ellensburg formation was formed from lava debris created during volcanic activity. The debris are sedimentary materials that were deposited upon the lava plain, transported by eastward flowing streams or aeolian processes moving ash and pumice (USGS 1962). The majority of the volcanic materials were deposited upon the lava plain after these flows ceased and the Cascades continued to rise (USGS 1962, 1999a).

The Ellensburg Formation consists primarily of semi-consolidated clay, silt, and sand with only small amounts of gravel and conglomerate. It often appears as sedimentary interbeds found between the various CRBG formations, members, and flow units. These interbeds vary in nature and composition, typically ranging between 1 and 100 feet thick. (USGS 1962).

Lower Yakima Valley Fill

The Lower Yakima Valley fill are a variety of fine and coarse-grained sediments overlying the Ellensburg Formation (USGS 2009a). These sediments were depositied about 16,000 years ago during the glacial outburst floods created by Lake Lewis. The water in Lake Lewis

remained for undefined periods before draining through Wallula Gap, permitting surface loess and basalt materials collected in the flood's transit southeast from the Spokane area to settle to the lake's bottom. This settled material formed at least some of the fine-grained gravelly and sandy materials extant today on the valley bottom of the Yakima River within the GWMA (Figure 6).

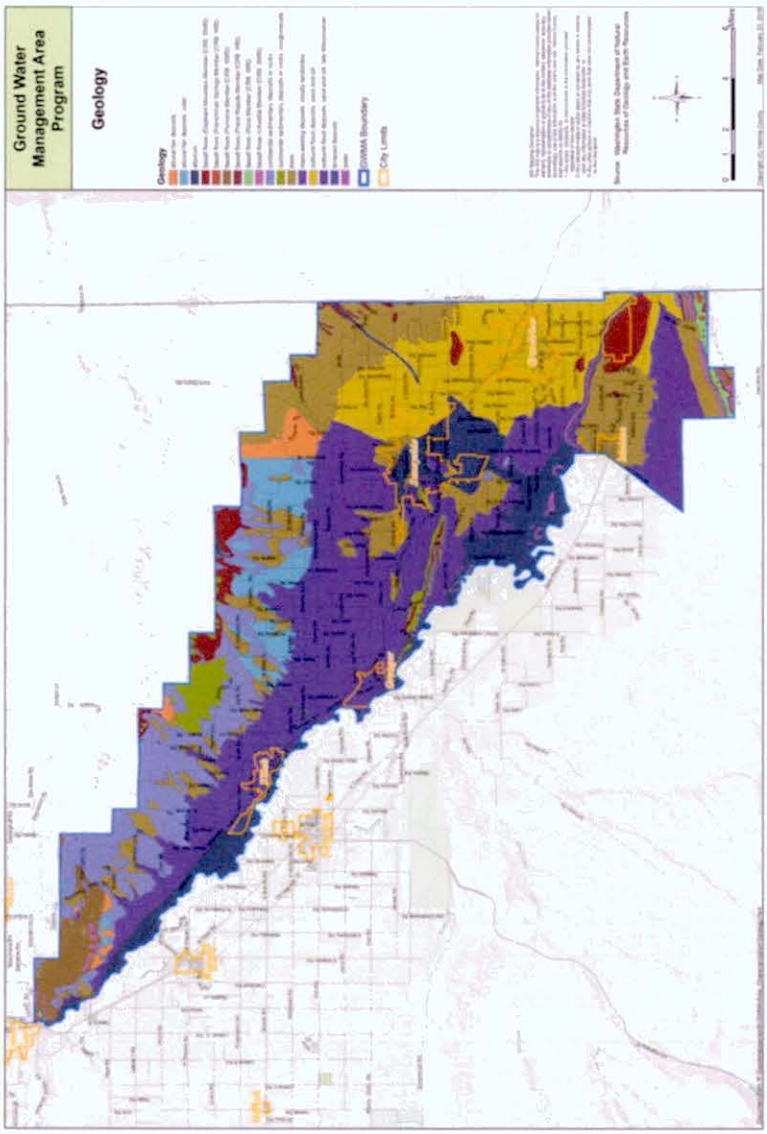


Figure 6 – Geology

Hydrogeology

The geologic framework and some of its hydrogeologic units of the Columbia Plateau regional aquifer system were described by Drost and others (USGS 1990b). The aquifer system consists of a large thickness of basalt made of numerous flows with minor interbedded sediments (USGS 1990b). The principal water-bearing zones in the basalt sequence are those upper parts of certain flows rendered relatively permeable by weathering, jointing, and vesicularity (USGS 1962).

The physical characteristics of the materials within the hydrogeologic units of the GWMA are described by the U.S. Geological Survey (USGS) (see Table 1 in USGS 2009a). The units have various consolidated or unconsolidated structures. The unconsolidated units include alluvial, alluvial fan, terrace, glacial, loess, lacustrine, and flood (Touchet Beds) deposits that range from coarse-grained gravels to fine-grained clays, with some cemented gravel (Thorp gravel and similar unnamed gravels). Most of the unconsolidated units consist of coarse-grained deposits. The consolidated units are principally deposits of the Ellensburg Formation, but also include some undifferentiated continental sedimentary deposits. These units include continental sandstone, shale, siltstone, mudstone, claystone, clay, and lenses or layers of un-cemented and weakly to strongly cemented gravel and sand (conglomerate). These clastic deposits are one of the most stratigraphically complex parts of the aquifer system (USGS 2009a).

Most domestic wells are completed in the sediments above basalt. There are several basalt wells providing domestic water supply along the northern fringe of the project area. Figure 7 shows the surface hydrogeologic units within the GWMA (USGS 2009a).

Formatted: Not Highlight

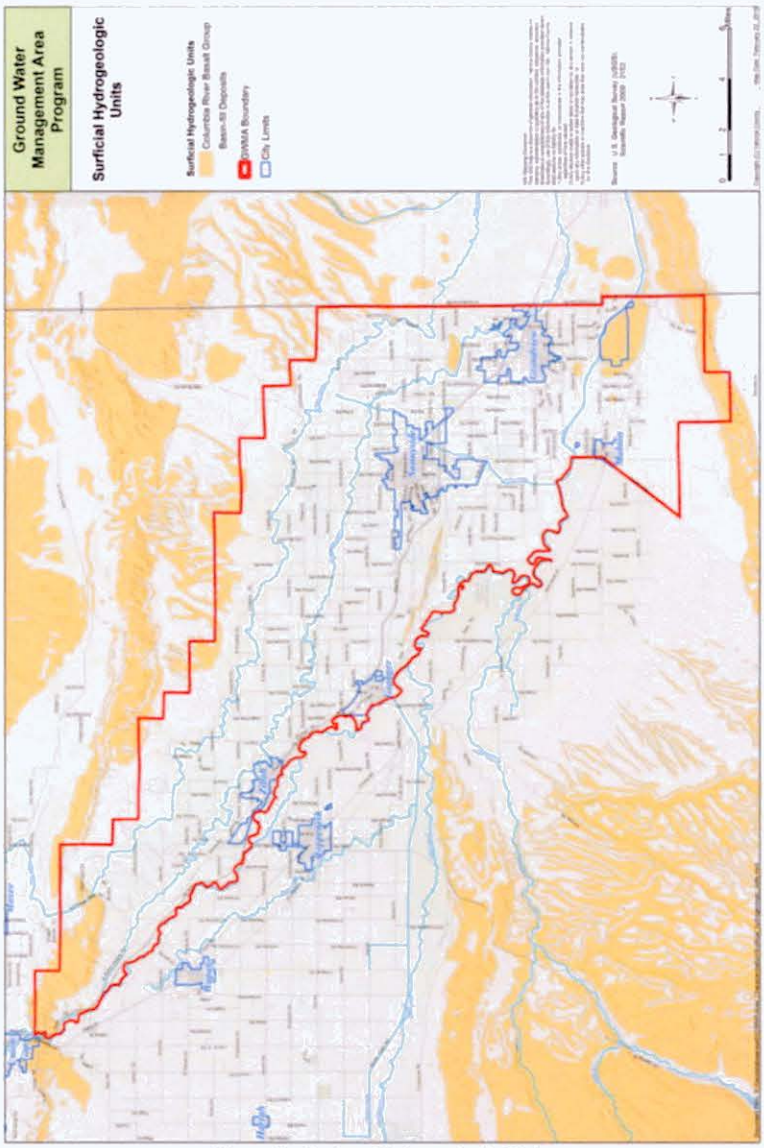


Figure 7 – Surface Hydrogeologic Units

Aquifers

An aquifer is a water-bearing layer of rock that will yield water in a usable quantity to a well or a spring. There are generally two kinds of aquifers: confined and unconfined.

In 2009, the USGS published a study of the hydrogeology of aquifers in the Yakima River Basin. The study found that there are two main aquifer types in the GWMA. The first is a surface unconfined to semi-confined alluvial aquifer. This aquifer is composed of highly layered alluvial material with predominantly silt, sand, and cobbles with a total thickness of up to 500 feet (USGS 2009a). The second aquifer is an extensive basalt aquifer of great thickness underlying the surface aquifer. The basalt aquifer is believed to be semi-isolated from the surface aquifer and stream systems.

Natural groundwater flow within the shallower surface aquifer generally follows topography, but may be locally influenced by irrigation practices, ponds, lagoons, drains, ditches, and canals. Groundwater in this shallower aquifer generally flows toward the Yakima River (USGS 2009a) and is used locally for irrigation and residential water supply.

Porosity is the ratio of the volume of interstices of a material to the volume of its mass. Natural rock materials differ in porosity. The porosity of some consolidated rocks, such as tightly cemented sandstone or massive lava flows, is only a few percent or even a fraction of a percent. The porosity of some clays may exceed 50 percent. The well-sorted materials in unconsolidated rocks, such as clay or clean, even-textured sand or gravel, have very high porosity. Poorly sorted materials, in which the smaller particles fill the openings between the larger grains, have low porosity.

Both confined and unconfined aquifers are present within the GWMA. A confined aquifer is a water-bearing stratum that is confined or overlain by a rock layer that does not readily transmit water or that is impermeable. An artesian aquifer is a confined aquifer where the groundwater is under positive pressure. This positive pressure causes the water level in a well to rise to a point where hydrostatic equilibrium has been reached.

Unconfined aquifers are those into which water seeps from the ground surface directly above the aquifer. An unconfined aquifer, also called a water table aquifer, is an aquifer that has the water table as its upper boundary, and where the pressure is equal to the atmospheric pressure.

The *potentiometric surface* (static level) is the level to which water rises in a well. In a confined aquifer this surface is above the top of the aquifer unit. In an unconfined aquifer, it is the same as the water table, or groundwater level.

The amount of water entering and exiting the aquifer can affect the potentiometric surface of the aquifer. Inputs to the aquifer system include infiltration of water from precipitation, irrigation, or wastewater sources. Outputs from the aquifer may include pumping of wells or surface water discharge. A variety of factors affect groundwater in the Lower Yakima Valley,

including precipitation, irrigation, wastewater discharges, surface water interactions, pumping of wells, and the presence of irrigation canals.

Figure 8 shows the location of known springs within the Toppenish Basin (USGS 2009a).

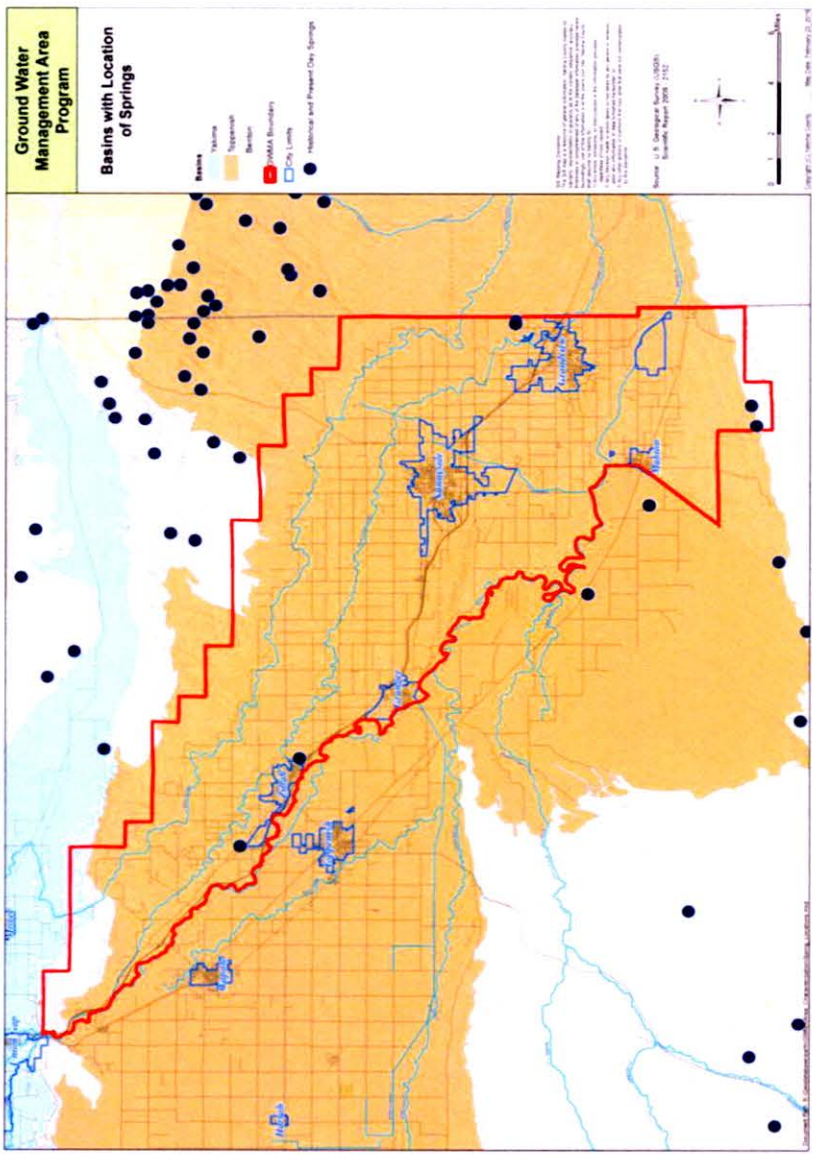


Figure 8 – Springs within the Toppenish Basin

Groundwater Recharge

Groundwater recharge is a hydrologic process where water moves downward from the land surface to groundwater. Recharge is the primary method through which water enters an aquifer. Recharge includes all infiltration sources, including precipitation, surface water, irrigation water, and wastewater.

The delivery and use of surface water in the irrigation districts results in a source of recharge (10 to 20 inches per year) from water that infiltrates into the ground and migrates past the root zone and into groundwater. The USGS established recharge rates by a one-day time-step model, utilizing the daily inputs from 25 years (1959 – 2001) of historical records, taking evapotranspiration of plants (Vaccaro 2016; USGS 2007a). Figure 9 shows the mean annual recharge of the surface aquifers within the GWMA, based on Figure 10 of the USGS report (~~USGS~~ 2007a). USGS calculated the specific discharge for each model cell, and could readily provide a GIS coverage or MODFLOW input file with those data. The ranges shown in Figure 10 of the USGS (2007a) report were chosen to facilitate illustration of the estimates for the entire study area. The methods used to estimate recharge are clearly documented in the USGS report. A better estimate of current recharge could be made using the additional detailed information if those data were made available.

A more detailed description of Vaccaro's discussion on recharge (2016) can be found in ~~Appenidix~~Appendix D~~xx~~.

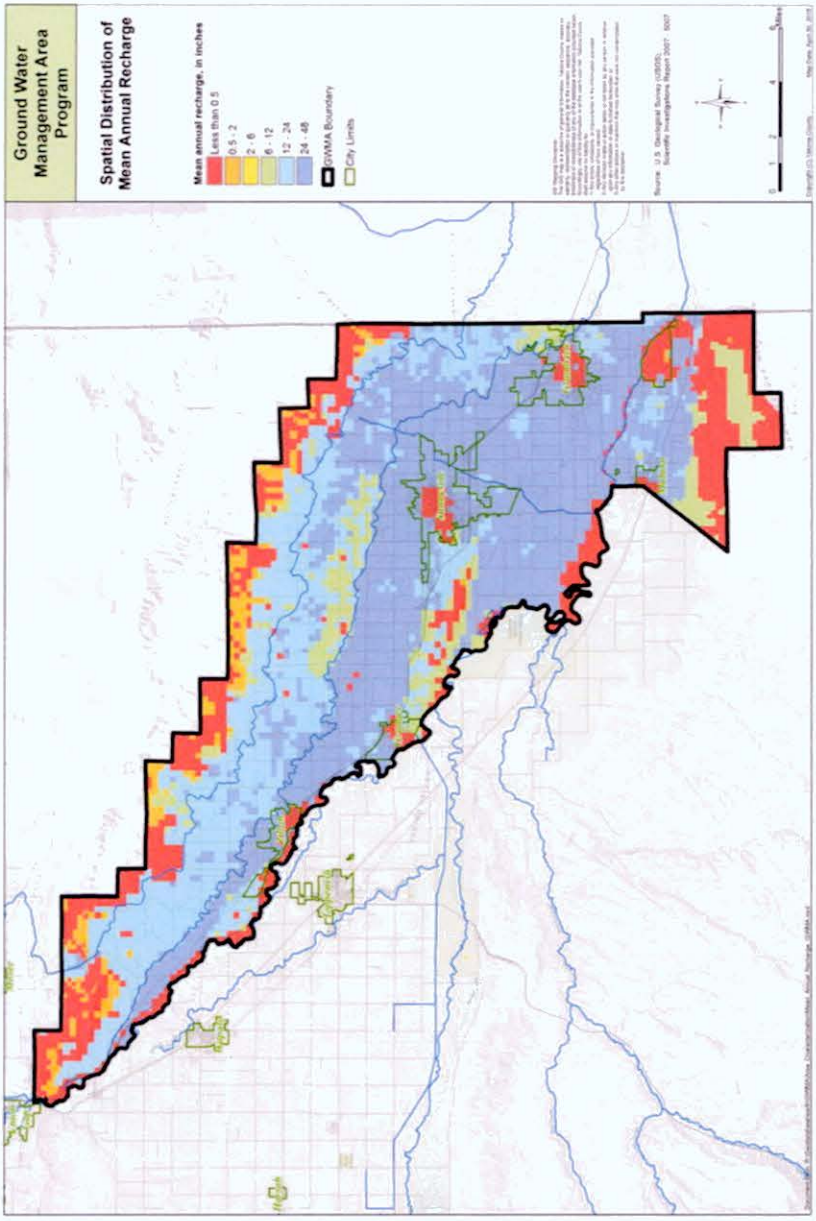


Figure 9 – Mean Annual Recharge within the GWMA

Groundwater Flow

There are two main aquifers underlying the area bordered on the north by the Ahtanum Ridge, on the south by the Toppenish Ridge, and bisected by the Wapato Syncline (USGS 2009a). These include a surface unconfined to semi-confined alluvial aquifer and a basalt aquifer underlying the sedimentary deposits (USGS 2009a). The basalt aquifer is believed to be semi-isolated from the surface aquifer and stream systems. Groundwater flow generally follows topography towards the Yakima River. It is likely that the minor components of flow are enhanced by irrigation practices upland from the Yakima River (USGS 2009a; Vacarro 2016).

Groundwater levels can fluctuate for a variety of reasons. Groundwater contours are mapped in Figure 10 based on USGS (2009a).

The *vadose zone* is the unsaturated zone between the land surface and the top of the water table. *Depth to water* is the distance between the ground surface and the water table. Time of travel through the vadose zone is dependent on depth to water, the vadose zone material, the amount of recharge, and other factors.

Earthen materials within the vadose zone have different degrees of permeability. *Permeability* is a measurement of infiltration rate, describing the ability of fluids to move through a material. It is intrinsic to the aquifer matrix material. Permeability is applied to both unsaturated and saturated flow and is independent of moisture content.

Moisture movement through the vadose zone is controlled by both material property and percent saturation or moisture content.

Unconfined (water table) aquifers flow generally in accordance with the topography towards rivers, streams, lakes, and springs. The direction of groundwater flow in unconfined aquifers is normally perpendicular to groundwater contours (USGS 2009a). Groundwater flows from the direction of the highest potential energy to the lowest potential energy. The four types of potential energy that influence groundwater flow include gravitational potential, pressure potential, matric potential, and osmotic potential.

The hydraulic conductivity of bedrock units, Columbia River Basalt Group basalts, and basin fill units were estimated from specific capacity data reported on drillers' logs (USGS 2009a). The median lateral hydraulic conductivity of bedrock, basalt, and basin fill units were 3, 3, and 6 feet per day, respectively, throughout the larger study area of the Yakima River Basin (USGS 2009a).

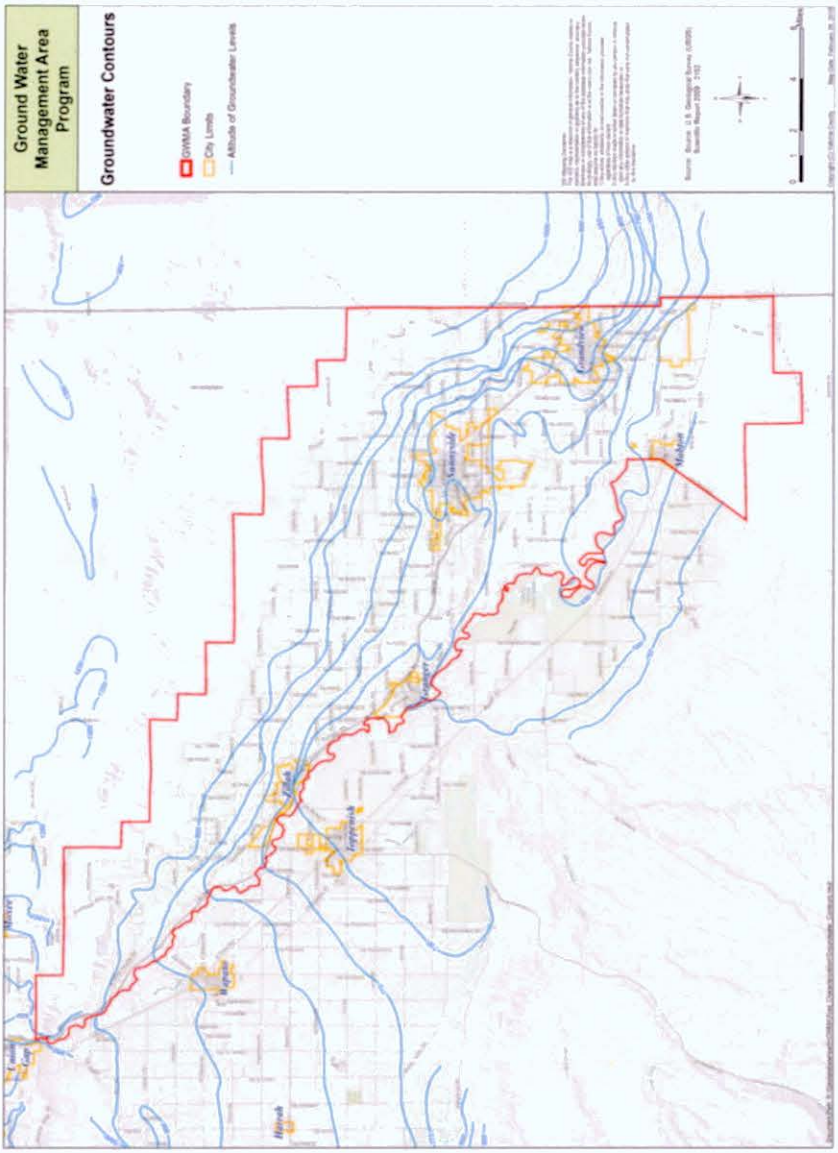


Figure 10 – Groundwater Levels within the GWMA

Topography

The topography within the GWMA is undulating hillsides with elevations from approximately 400 meters (1312 feet) above sea level to the valley floor and river floodplain at an elevation of approximately 230 meters (755 feet) above sea level. Figure 11 shows topography contours.

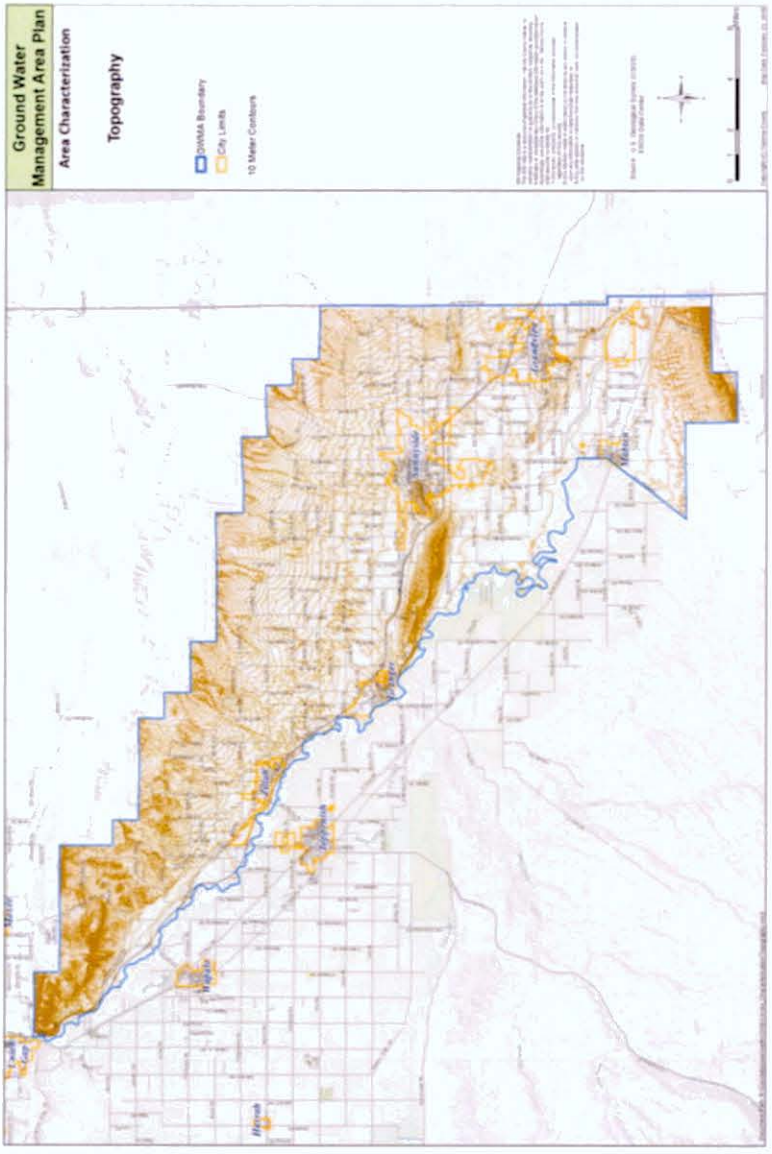


Figure 11 – Ground Surface Contours (Topography) within the GWMA

Depth to Groundwater

Depth to groundwater is typically shallow (0 – 15 feet) at the valley bottom northeast of Granger, north and southeast of Sunnyside, surrounding Grandview, and southeast of Mabton. Depth to groundwater is marginally deeper (15 – 25 feet) in adjacent lands north of Granger, east to areas north of Sunnyside to Grandview, and in the areas surrounding Mabton. Depth to groundwater is deep (25 – 100 feet) roughly in the areas between the Sunnyside Valley Irrigation District (SVID) and Roza Irrigation District (RID) irrigation canals. Depth to groundwater becomes much deeper (100 – 1,000 feet) in areas above the RID irrigation canal. Figure 12 illustrates depth to groundwater and the general directions of groundwater flow within the GWMA, derived from USGS (2009a).

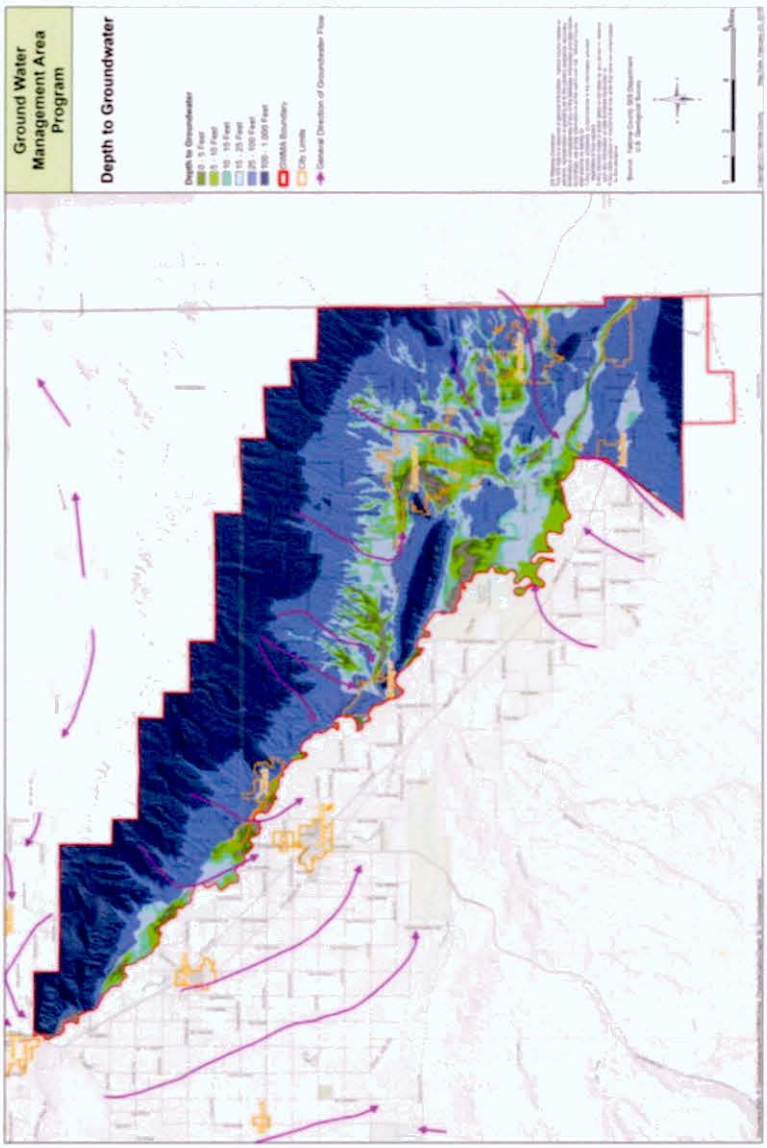


Figure 12 – Depth to Groundwater and Direction of Flow within the GWMA

Soil Types

There are 89 soil types within the GWMA (NRCS, 2018 ~~Soil Survey n.d.~~). They differ based on constituency of materials (coarse to very fine sands, loams, clay), values of porosity, specific yield, hydraulic conductivity, and infiltration rate.

Predominant soil types within the GWMA include the following: Scoon silt loam and Burke silt loam (surface roughly 300 meters [1,000 feet] above sea level); Warden fine sandy loam interlineated generally northeast to southwest with Harwood-Burke-Wiehl very stony silt loams and Esquatzel silt loam (surface roughly 250 – 300 meters [800 – 1,000 feet] above sea level); and Esquatzel silt loam, Quincy loamy fine sand, Wanser loamy fine sand, Warden fine sandy loam, and Warden silt loam (roughly within the valley bottom from 200 – 250 meters [650 – 800 feet] above sea level). The hydraulic conductivity of each of these primary soils is presented in Table 4

Table 4 – Primary Soil Hydraulic Conductivity

Soil Type	Hydraulic Conductivity (cu. In / hr)	NRCS rate
Warden silt loam	0.57-1.98	Moderate
Warden fine sandy loam	0.57-1.98	Moderate
Esquatzel silt loam	0.57-1.98	Moderate
Shano silt loam	0.57-1.98	Moderate
Quincy loamy fine sand	5.95-19.98	Rapid
Wanser loamy fine sand	5.95-19.98	Rapid
Harwood Burke-Wiehl silt loam	0.00-0.06	Very slow, impermeable
Burke silt loam	0.00-0.06	Very slow, impermeable
Scoon silt loam	0.00-0.06	Very slow, impermeable

(NRCS, 2018 ~~Soil Survey~~)

All of the 89 soil types within the GWMA are illustrated in Figure 13 and listed by color code in Table 5. Soils were sorted by Yakima County into the hydraulic conductivity categories utilized by the U.S. Department of Agriculture, Natural Resources Conservation Service. These are illustrated in Figure 14.

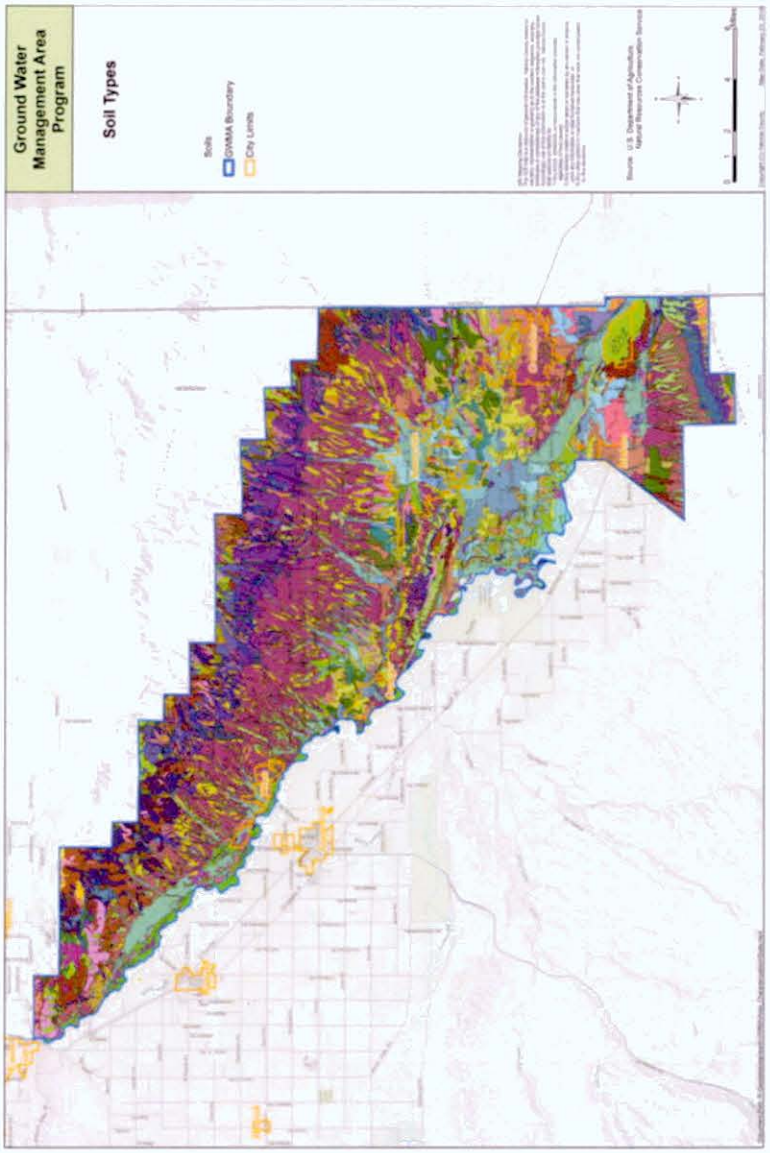


Figure 13 – Soil Types

Table 5 – All Soil Types within the GWMA

Soils

- Bakeoven very cobbly silt loam, 0 to 30 percent slopes
- Burke silt loam, 2 to 5 percent slopes
- Burke silt loam, 5 to 8 percent slopes
- Burke silt loam, 8 to 15 percent slopes
- Cleman very fine sandy loam, 0 to 2 percent slopes
- Cleman very fine sandy loam, 2 to 5 percent slopes
- Dam
- Esquatzel silt loam, 0 to 2 percent slopes
- Esquatzel silt loam, 2 to 5 percent slopes
- Fiander silt loam
- Finley cobbly fine sandy loam, 0 to 5 percent slopes
- Finley silt loam, 0 to 2 percent slopes
- Finley silt loam, 2 to 5 percent slopes
- Finley silt loam, 5 to 8 percent slopes
- Finley silt loam, 8 to 15 percent slopes
- Gorst loam, 2 to 15 percent slopes
- Harwood-Burke-Wiehl silt loams, 15 to 30 percent slopes
- Harwood-Burke-Wiehl silt loams, 2 to 5 percent slopes
- Harwood-Burke-Wiehl silt loams, 30 to 60 percent slopes
- Harwood-Burke-Wiehl silt loams, 5 to 8 percent slopes
- Harwood-Burke-Wiehl silt loams, 8 to 15 percent slopes
- Harwood-Burke-Wiehl very stony silt loams, 15 to 30 percent slopes
- Hezel loamy fine sand, 0 to 2 percent slopes
- Hezel loamy fine sand, 2 to 15 percent slopes
- Kiona stony silt loam, 15 to 45 percent slopes
- Kittitas silt loam
- Lickskillet very stony silt loam, 5 to 45 percent slopes
- Logy silt loam, 0 to 2 percent slopes
- McDaniel-Rock Creek complex, 5 to 30 percent slopes
- Mikkalo silt loam, 0 to 5 percent slopes
- Mikkalo silt loam, 15 to 30 percent slopes
- Mikkalo silt loam, 5 to 15 percent slopes
- Moxee cobbly silt loam, 0 to 30 percent slopes
- Moxee silt loam, 15 to 30 percent slopes
- Moxee silt loam, 2 to 15 percent slopes
- Outlook fine sandy loam
- Outlook silt loam
- Pits
- Prosser silt loam, 0 to 15 percent slopes
- Quincy loamy fine sand, 0 to 10 percent slopes
- Ritzville silt loam, 15 to 30 percent slopes
- Ritzville silt loam, 2 to 5 percent slopes
- Ritzville silt loam, 30 to 60 percent slopes
- Ritzville silt loam, 5 to 8 percent slopes
- Ritzville silt loam, 8 to 15 percent slopes
- Ritzville silt loam, basalt substratum, 15 to 30 percent slopes
- Ritzville silt loam, basalt substratum, 5 to 15 percent slopes
- Scoon silt loam, 15 to 30 percent slopes
- Scoon silt loam, 2 to 5 percent slopes
- Scoon silt loam, 5 to 8 percent slopes
- Scoon silt loam, 8 to 15 percent slopes
- Scooteney cobbly silt loam, 0 to 5 percent slopes
- Scooteney silt loam, 0 to 2 percent slopes
- Scooteney silt loam, 2 to 5 percent slopes
- Scooteney silt loam, 5 to 15 percent slopes
- Shano silt loam, 15 to 30 percent slopes
- Shano silt loam, 2 to 5 percent slopes
- Shano silt loam, 5 to 8 percent slopes
- Shano silt loam, 8 to 15 percent slopes
- Sinloc fine sandy loam, 0 to 2 percent slopes
- Sinloc silt loam, 0 to 2 percent slopes
- Sinloc silt loam, 2 to 5 percent slopes
- Sinloc silt loam, 5 to 8 percent slopes
- Starbuck silt loam, 2 to 15 percent slopes
- Starbuck-Rock outcrop complex, 0 to 45 percent slopes
- Starbuck-Rock outcrop complex, 45 to 60 percent slopes
- Umapine silt loam, drained, 0 to 2 percent slopes
- Umapine silt loam, drained, 2 to 5 percent slopes
- Wanser loamy fine sand
- Warden fine sandy loam, 0 to 2 percent slopes
- Warden fine sandy loam, 2 to 5 percent slopes
- Warden fine sandy loam, 5 to 8 percent slopes
- Warden fine sandy loam, 8 to 15 percent slopes
- Warden silt loam, 0 to 2 percent slopes
- Warden silt loam, 15 to 30 percent slopes
- Warden silt loam, 2 to 5 percent slopes
- Warden silt loam, 5 to 8 percent slopes
- Warden silt loam, 8 to 15 percent slopes
- Water
- Weirman fine sandy loam
- Weirman gravelly fine sandy loam
- Weirman sandy loam, channeled
- Willis fine sandy loam, 2 to 5 percent slopes
- Willis silt loam, 2 to 5 percent slopes
- Willis silt loam, 8 to 15 percent slopes
- Yakima silt loam
- Zillah sandy loam
- Zillah silt loam
- Zillah silt loam, channeled

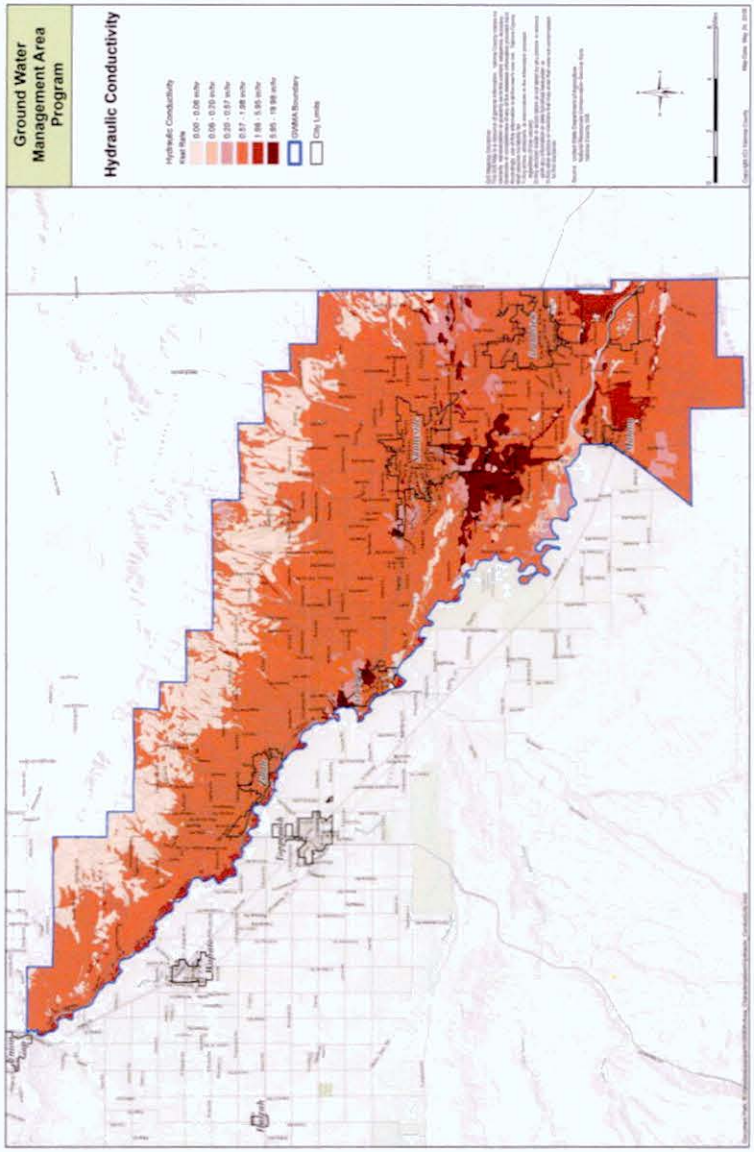


Figure 14 – Hydraulic Conductivity for Soil Types in the GWMA

Climate

The Western Regional Climate Center maintains climate data at three stations within the Lower Yakima Valley at Wapato (Table 6), Sunnyside (Table 7), and Prosser (Table 8). Temperatures have historically ranged from 24 to 90 degrees Fahrenheit over the course of a year (WRCC, 2017 ~~n.d.~~). The data does not anticipate or address climate change.

Table 6 – Climate Summary for Wapato, Washington (October 1, 1915 to September 5, 2013)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Average Max. Temperature (°F)	38.6	47.4	57.5	66	74.5	81.2	89.2	87.8	79.5	66.5	49.8	39.5	64.8
Average Min. Temperature (°F)	22.8	27.4	33	39.3	46.9	53.6	59.4	57.3	48.9	38.4	29.9	24.7	40.1
Average Total Precipitation (in.)	1.02	0.68	0.55	0.47	0.53	0.57	0.23	0.28	0.34	0.54	0.98	1.15	7.35
Average Total Snow Fall (in.)	5.8	2.2	0.7	0	0	0	0	0	0	0	1.9	5.4	15.9
Average Snow Depth (in.)	2	1	0	0	0	0	0	0	0	0	0	1	0

(WRCC, 2017 ~~Western Regional Climate Center~~)

Table 7 – Climate Summary for Sunnyside, Washington (September 14, 1894 to January 5, 2014)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Average Max. Temperature (F)	39	47	58	67	75	82	90	89	80	67	51	40	65.3
Average Min. Temperature (F)	23	27	32	38	45	51	55	53	46	37	30	25	38.4
Average Total Precipitation (in.)	0.9	0.6	0.5	0.5	0.5	0.5	0.2	0.3	0.4	0.6	0.9	0.9	6.8
Average Total Snow Fall (in.)	4.5	1.8	0.2	0	0	0	0	0	0	0	1.8	4	12.4
Average Snow Depth (in.)						No	Data						

(WRCC, 2017~~Western Regional Climate Center~~)

Table 8 – Climate Summary for Prosser, Washington (July 1, 1925 to January 4, 2015)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual total
Average Max. Temperature (F)	38	46	56	65	73	80	89	87	78	65	49	40	63.9
Average Min. Temperature (F)	24	28	33	38	45	50	55	53	47	39	31	26	38.9
Average Total Precipitation (in.)	1.1	0.7	0.6	0.6	0.6	0.7	0.2	0.3	0.4	0.7	1	1.2	7.95
Average Total Snow Fall (in.)	2.6	1.2	0.1	0	0	0	0	0	0	0	0.9	2.3	7.2
Average Snow Depth (in.)	1	0	0	0	0	0	0	0	0	0	0	0	0

(WRCC, 2017~~Western Regional Climate Center~~)

Land and Water Use

This section focuses on the current and historical land uses, crops grown, types of fertilizers used, water sources, and irrigation methods used within the Lower Yakima Valley GWMA.

Land Use

Land use within the GWMA is subject to the Yakima County Code. Most of the land within the GWMA is within the code's designated agricultural zone. Figure 15 illustrates Yakima County zoning districts within the GWMA.

Agriculture is the primary economic and land use activity in the area. Approximately 70 to 80 percent of the land is used for agriculture (Ecology, 2010). Agricultural production on the 464,000 irrigated acres within the Yakima River Basin is estimated to be worth over $2 billion annually (apples, $1 billion; dairy, $900 million; hops, $500 million).

In 2007, the total market value of Yakima County crops sold was over $1.2 billion, and the average market value per farm was $340,058. In 2012, the total market value of Yakima County crops sold was over $1.6 billion and the average market value per farm was $523,548 (Yakima Valley Trends 2018a).

In 2007, the value of Yakima County milk production was $325 million. In 2012, the value of Yakima County milk production was $439 million (Yakima Valley Trends 2018b).

In 2007, Yakima County's net cash farm income was over $372 million and its net cash farm income per farm was $105,100. In 2012, its net cash farm income was over $321 million and its net cash farm income per farm was $102,356 (Yakima Valley Trends 2018c).

In 2007, the 68,087 acres of fruit trees in Yakima County were valued at almost $750 million. In 2012, the 62,415 acres of fruit trees in the county were valued at over $935 million (Yakima Valley Trends 2018d).

Most cropland in the area is irrigated. Major commodities grown in the valley include apples, pears, cherries, peaches, vegetables, hay, mint, and hops. In 2002, Yakima County ranked first statewide for apple, milk, hop, and grape production and first nationally for apple and hop production. Concentrated animal feeding operations (CAFOs) greatly expanded starting in the late 1980s (Drennan, 2013~~(WSDA n.d.)~~), and the number of dairy cows in Yakima County reached 37 percent of Washington State's cattle population in 2008 (Yakima Valley Trends 2018e). Also, animal feeding operations operate at various sizes, from very small home lots to large commercial feedlots. The CAFOs are concentrated in the lower parts of the valley in and around the cities of Sunnyside, Grandview, Mabton, and Granger. Some are located in more distant parts of the valley and on the Yakama Indian Reservation.

Formatted: Not Highlight

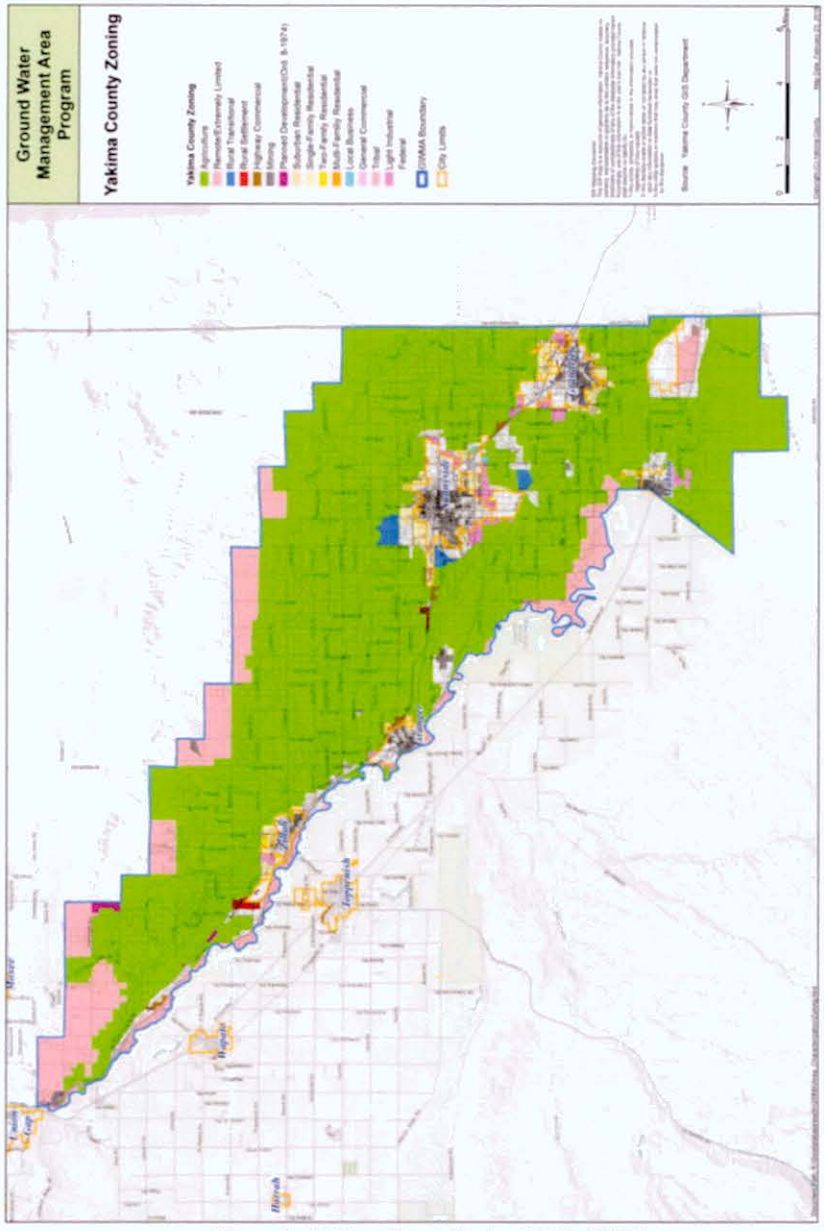


Figure 15 – Yakima County Zoning Within GWMA

Farming has been a historic land use practice in the Lower Yakima Valley since the mid-1800s. The Yakima Valley Museum maintains a collection of historical photographs (figure 165). ~~A more detailed description of historical land use and agriculture is presented in Appendix D.~~

Formatted: Not Highlight

European-style agriculture began in the Yakima River Basin in the mid-nineteenth century, with the arrival of Catholic missionaries. They established a mission in 1852 on Atanum (now Ahtanum) Creek, using irrigation on a small scale. Miners and cattlemen immigrated to the basin in the 1850s and 1860s. In 1859, Ben Snipes first drove cattle through the Yakima Valley. Five years later, he returned and established the Snipes and Allen Company, grazing 40,000 – 50,000 head of cattle in the Lower Yakima Valley. By the 1880s, about 200,000 cattle, 350,000 sheep, and 125,000 horses grazed in the Yakima Valley. By the mid-1860s, irrigation of the valley bottoms began. Private companies built canal systems between 1880 and 1904 and delivered water for the irrigation of large areas. Outlying areas were used extensively for raising livestock. The Northern Pacific Railway was constructed through the Yakima Valley, reaching Yakima in December 1884 and Seattle in 1896, further facilitating the development of irrigated agriculture through transport of agricultural goods to markets. Statehood in 1889 assisted Lower Yakima Valley agricultural growth, with Yakima contending for state capital. When the National Reclamation Act passed in 1902, about 85,000 acres were under irrigation in the Yakima Valley, mostly by surface water (Boening 1919).

By 1901, farming had largely replaced livestock ranching in the easily irrigated acres of the valley. A state survey of that year reported the following crops grown in the Yakima Valley: apples, pears, prunes, plums, cherries, apricots, peaches, and grapes; alfalfa, corn, wheat, barley, oats, rye, flax, broom corn, and other grasses, including brome, orchard, tall meadow fescue, timothy, red top, and clover; melons, potatoes, garden vegetables, hops, and sugar beets (Jensen and Olshausen 1901).

Crops

The Yakima Valley Museum maintains a collection of historical photographs that indicate significant production of hops, primarily in the Moxee and North Yakima area.

In the Lower Valley, early agriculture primarily involved the production of hay, but early crops also included hops (Jensen and Olshausen 1901). Orchards were planted in the Sunnyside area by 1908. Between 1905 and 1912 the Lower Yakima Valley towns of Sunnyside, Mabton, Toppenish, Wapato, Grandview, Granger, and Zillah were all incorporated.

A 1917 survey showed the following crops produced in the Yakima Valley: strawberries, cherries, prunes, apples, peaches, pears, apricots, grapes, cantaloupes, watermelons, onions, turnips, green corn, carrots, rutabagas, cabbage, asparagus, tomatoes, green peppers, squash,

pumpkins, beans, potatoes, hops, sugar beets, alfalfa hay, wheat, oats, and barley (Drennan, 2013~~WSDA 2013~~).

Formatted: Not Highlight

By the early 1920s, field crops such as potatoes, onions, and corn were primarily watered by flood irrigation, either through total inundation or rill irrigation.

Tree fruits had become successful export products by the 1930s.



Figure 16 – Historical photographs of agriculture in Yakima County.

Historical photographs courtesy of the Yakima Valley Museum. For further study, see http://www.yakimamemory.org/.

The Federal Reclamation Act of 1902 and Washington State's Yakima Federal Reclamation Act of 1905 authorized construction of water delivery facilities to irrigate about 500,000 acres of land within the Yakima River Basin, including those within the Lower Yakima Valley. Six dams and five reservoirs were constructed as part of the Yakima Project.

These federal reservoirs provide storage to meet water requirements of the major irrigation districts during the period of the year called "storage control," when the natural streamflow from unregulated streams can no longer meet demands.

Farm sizes were relatively small during the first half of the twentieth century. There were 6,351 farms in Yakima County, making up 600,106 acres of farmland, in 1925 (Drennan,~~WSDA~~ 2013).

Formatted: Not Highlight

> Farmers often produced their own livestock feed on farm, and maintained soil fertility through crop rotations and the retention of manure and crop residues on-farm. Weeds, insects, and plant diseases were controlled largely through mechanical practices, crop rotation, and the use of natural predators. During this time the conversion from horse-powered farming to the widespread use of tractors was taking place. . . . This spread of mechanization made it possible for farmers to use agricultural practices like intensive inversion-based tillage that remove all cover from the soil and use large amounts of fuel. (Drennan, ~~WSDA~~ 2013)

Formatted: Not Highlight

The National Map Company's 1930 map entitled *Latest Official Survey of Washington* shows the route of two railroads then running through the GWMA area, used to transport agricultural goods to market (Presby Museum; Goldendale, Washington) (See Figure 17). The number of railroad depots indicates the abundance of agricultural commodity sent to market. The Union Pacific route stopped in Grandview, Forsell, Waneta, Midvale, Morris, Emerald, Bain, Noride, Granger, Blaine Acres, Dalton, Boone, Pam, Zillah, Buena, Flint, Sawyer, Dunbro, and Parker en route to Union Gap and Yakima. The Northern Pacific route stopped at Grandview, Lichty, Sunnyside, Outlook, Nass, Sinto, Granger, Boone, Gilliland, Cenauer, Zillah, Keck, Cutler, Buena, Sawyer, Donald, Mellis, and Parker en route to Union Gap and Yakima.



Figure 17 – The National Map Company's 1930 map entitled Latest Official Survey of Washington.

The number of farms and the area being farmed throughout Yakima County stabilized during the 1940s. In the 1950s, the total number of farms began to decrease while the total amount of land being farmed increased, due primarily to the growth of land used as pasture. Between the 1960s and early 2000s, the total amount of land being farmed in Yakima County remained relatively constant.

Table 9 displays the number of acres historically farmed in Yakima County organized by crop category. Additional information on specific field crops is presented in Table 10. Data were collected by the U.S. Department of Commerce (USDOC), Bureau of the Census and published in the United States Census of Agriculture (USDOC Agriculture). The census information does not segregate data into geographic subdivisions of Yakima County. Nevertheless, the information does reflect trends in agricultural practices within the GWMA, because the GWMA constitutes a major portion of the county's agricultural economy(Drennan, 2013).

Table 9 – Historical summary of crop types in Yakima County

Crop Type	Number of acres farmed (x1000)			
	1935	1959	1982	2007
Apples, cherries, peaches, pears, plums, prunes and grapes	52.0	83.0	89.0	95.0
Corn, wheat, oats, barley, rye and triticale	55.0	94.0	101.0	83.0
Hay, forage, haylage and silage (including small grains cut for hay, wild hay, sorghum cut for silage or greenchop)	71.0	49.0	32.0	52.0
Potatoes, sugar beets, mint, hops, dill and dried herbs	18.0	48.0	36.0	44.0
Vegetables (including snap and string beans, cabbages, sweet corn, tomatoes and watermelons)	6.0	23.0	20.0	10.0
Field seeds and grass seeds	0.0	10.0	0.5	1.0
Legumes (excluding cover crops)	0.1	0.3	3.3	0.5
Berries	0.0	0.1	0.0	0.1

(Drennan,~~WSDA~~ 2013)

Formatted: Not Highlight

Table 10 – Historical summary of specific field crop~~s types~~ in Yakima County

Crop Type	Number of acres farmed (x1000)			
	1935	1959	1982	2007
Sweet Corn	1.0	9.0	5.0	2.0
Asparagus	2.0	10.0	10.0	2.5
Hops	4.0	19.0	19.0	19.0
Mint	0.0	10.0	25.0	10.0
Sugar Beets	1.0	19.0	8.0	2.0
Alfalfa	65	40	30	41
Alfalfa seed	0.295	10	3	1
Wheat	20	31	60	21
Corn for grain and silage	8	43	21	42
Barley	7	17	17	0.5

(Drennan,~~WSDA~~ 2013)

Formatted: Not Highlight

~~Table 11 – Historical summary of livestock in Yakima County~~

~~Animal~~	~~1935~~	~~1959~~	~~1982~~		~~2007~~
~~Cattle and calves~~	~~51~~	~~135~~	~~152~~		~~213~~
~~Dairy Cows~~	~~20~~	~~18~~	~~19~~		~~90~~
~~Chickens~~	~~220~~	~~240~~	~~520~~		~~300~~
~~Sheep~~	~~100~~	~~75~~	~~25~~		~~10~~

~~Number of Livestock (x1000)~~
~~(WSDA 2013).~~

Formatted Table

Trends in U.S. farming began to shift after World War II from mixed crop and livestock operations to specialized monocultures (table 11). Livestock were raised separately on feedlots. Crop rotation decreased. Livestock manure, commercial fertilizer, and pesticides were readily available. Yields of corn, wheat, and rice increased during the latter half of the twentieth century due to large-scale mechanization of tilling, planting, and harvesting; improved plant varieties; development of irrigation infrastructure; availability of low cost fertilizers and pesticides; and favorable commodity prices. Economies of scale led farm sizes to increase. By 2007, there were 3,540 farms totaling 1,649,281 acres in Yakima County (Drennan, ~~WSDA~~ 2013).

Formatted: Not Highlight

Table 11 – Historical summary of livestock in Yakima County

Animal	1935	1959	1982		2007
Cattle and calves	51	135	152		213
Dairy Cows	20	18	19		90
Chickens	220	240	520		300
Sheep	100	75	25		10

Number of Livestock (x1000)
(Drennan, ~~WSDA~~ 2013).

Formatted: Not Highlight

The Washington State Department of Agriculture maintains an annual inventory of crops grown on particular properties. Figure 18 illustrates the variety and location of crops grown within the GWMA in 2015.

Formatted: Not Highlight

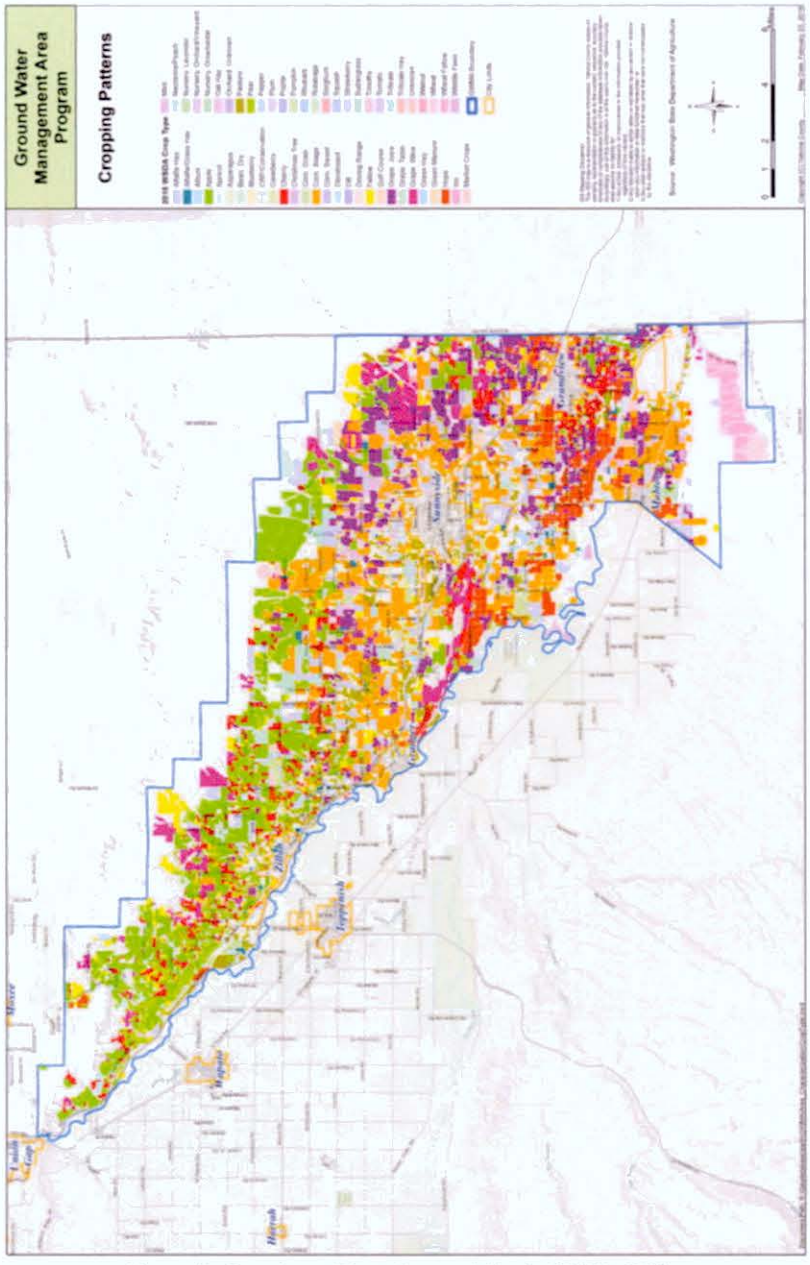


Figure 18 – Locations of Crops Grown within the GWMA (2015)

Table 12 – Top 15 crops in the GWMA

Crop Type	Acreage
Apple	17,333
Corn (silage)	16,778
Triticale	10,780
Grape (juice)	10,257
Alfalfa	7,989
Pasture	6,731
Cherry	6,336
Hops	5,961
Grape (wine)	5,126
Pear	3,331
Mint	1,418
Wheat	1,283
Corn (grain)	1,166
Asparagus	854
Peach/Nectarine	843

(WSDA 2018)

Formatted: Not Highlight

Table 12 describes the top most recent account of crops grown within the GWMA. The acreage totals in the table do not account for multiple cropping in a single year. According to WSDA (2018), double cropping occurred on 10,780 acres of triticale, primarily on the same ground as corn silage after the corn silage had been harvested.

Fertilizers

In 1954, fertilizers were applied to 136,553 farmed acres within Yakima County. In 1964, the number of acres fertilized increased to 203,062 acres. The fertilized area within Yakima County remained fairly constant through 2007.

The manure-fertilized area in 2002 was 28,152 acres. In 2007, the area fertilized by manure was calculated at 27,742 acres, which is approximately 14 percent of the total fertilized acres within the county (Drennan,~~WSDA~~ 2013; USDOC 2010).

The USDOC Agricultural Census also collected information between 1954 and 1974 about the number of acres within Yakima County fertilized with commercial fertilizer. The maximum number occurred in 1970, when approximately 110,000 acres received commercial fertilizer (Drennan,~~WSDA~~ 2013).

The use of commercial fertilizers began to increase between 1900 and 1944. After World War I, the use of pesticides increased as well. WSDA interviewed commodity-specific experts to obtain a typical range of use rates for manure, compost, and commercial fertilizer for each of the GWMA's 15 top commodities (WSDA 2018); they found that 19 percent of total GWMA irrigated acreage was fertilized by manure, 74 percent by commercial fertilizer, and 8 percent by compost.

Water Use

The Lower Yakima Valley south of Union Gap is semi-arid, with a mean annual precipitation of 6.8 inches. Precipitation and snowpack in the Cascade Mountains, along with groundwater, provide the source water and natural storage capacity for the Yakima River. The Yakima River is the primary source of irrigation water. Diversions from the river are managed by the U.S. Bureau of Reclamation (USBR, 2018).

Irrigation water can also be drawn from wells pursuant to individual water rights recognized by the Washington State Department of Ecology (Ecology). Under the Washington State groundwater code (RCW 90.44.050), prospective groundwater users must obtain authorization of a water right for irrigation (other than that exempted by the statute). Post-1945 well-drilling technologies, legal rulings, and the onset of a multi-year dry period beginning in 1977 stimulated the drilling of numerous irrigation wells. Population growth in the basin has also resulted in increased drilling of shallow domestic wells in addition to deeper public supply wells. There are now more than 20,000 wells in the basin, of which more than 70 percent are shallow (less than 250 feet). Ecology's online water rights database indicates that there are 2,874 active groundwater rights associated with wells in the Yakima Basin. Some of these are emergency drought wells. They collectively can withdraw about 529,231 acre-feet during dry years. The irrigation rights are for the irrigation of about 129,570 acres. There are about 16,600 groundwater claims in the basin, for approximately 270,000 acre-feet of groundwater (USGS 2011b).

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

The three largest irrigation providers in the lower valley are the Wapato Irrigation Project, Sunnyside Valley Irrigation District (SVID), and the Roza Irrigation District (RID). Wapato Irrigation Project serves irrigators within the Yakama Indian Reservation and is managed by the U.S. Bureau of Indian Affairs on behalf of the USBR. In 2012, SVID served 94,614 acres. SVID diverts its water near Parker into a 60-mile canal running generally northwest to southeast through the GWMA, in essentially the same direction of groundwater flow. ~~The SVID's primary canal and delivery laterals are lined up to the hills south of Moxee.~~ RID serves 72,491 acres, but the higher elevations of the district are not within the GWMA. Those within the GWMA are on the north slopes of the valley (Drennan, ~~WSDA~~ 2013). RID diverts its water from the Yakima River upstream of the city of Selah into a 94.8-mile canal. ~~Its primary canal is lined and its delivery laterals are primarily contained. The wasteways in both SVID's and RID's irrigation systems are unlined.~~

Formatted: Not Highlight

Diverse crops are grown in both the SVID and RID service areas. Generally, forage crops dominate the SVID and tree fruits dominate the RID. Both canals end, returning tail water to the Yakima River, near Benton City. From the canals, water travels 709 miles of laterals to over 5,300 locations. Diversions usually begin in March to prime the canal system and cease in mid-October. On-farm deliveries typically begin in early April. Figure 19 shows the service areas of SVID and RID within the GWMA.

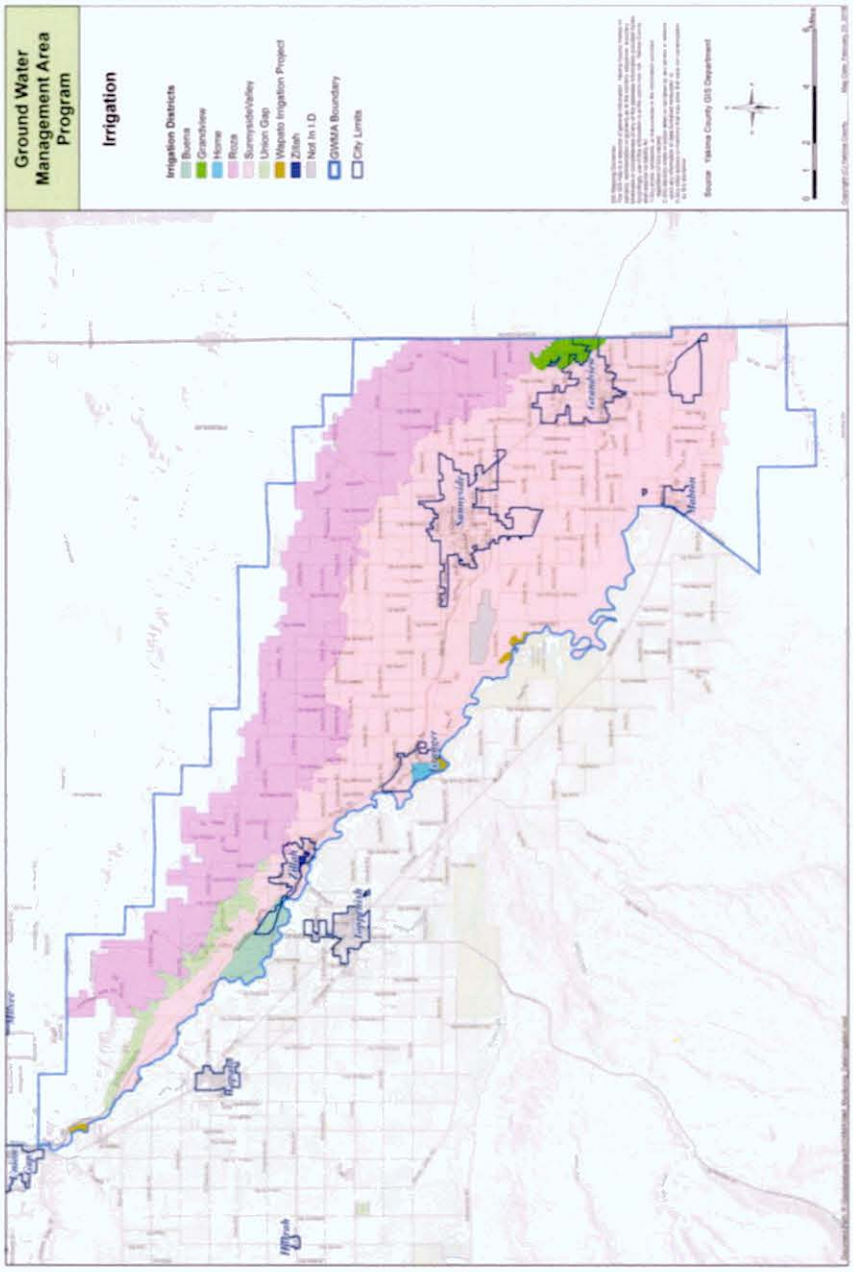


Figure 19 – Sunnyside Valley and Roza Irrigation Districts within the GWMA

Irrigation Methods

Irrigation in the Yakima River Basin is accomplished using one of three methods: rill, sprinkler, or drip. Rill (or gravity) irrigation is the oldest and simplest form in use, consisting of an open channel (head ditch) that delivers water to the high point of a field. Water flows out of the head ditch and into small furrows cut into the field between each crop row. Water exits the furrows at the low point of the field and is collected in a second open channel (tail water ditch). This tail water may be reused by pumping it back to the head ditch multiple times or transported by gravity flow to other farmed land. The tail water may then be routed to a drain that feeds into the regional drainage network. On many rill-irrigated fields, the open head ditch has been replaced with PVC pipe. Manually operated spigots or sliding gates direct irrigation water into the furrows.

A variety of sprinkler systems are used throughout the Yakima River Basin, and each system varies in its efficiency of delivering water. Portable handline, portable solid set, wheel lines, and big guns are examples of simple systems to operate, but they also require manual labor to move from place to place in a field. Fixed in-ground solid set, center pivots, and linears are automated systems. They are more expensive to install and more complex to operate, but they provide a more even coverage and give the farmer greater control over the irrigation process. These systems can be fully automated, enabling the farmer to irrigate a large area with less labor. Sprinklers can be used for sunburn and frost control on fruit, but this can also lead to overapplication of water. Adding this extra water could drive nutrients into groundwater, depending on the amount of water applied and the amount of nutrients in the soil.

Drip irrigation employs plastic lines with small openings to deliver water directly to the base of the plant. The drip lines may be installed above or below the soil. A properly operating drip irrigation system enables maximum use of the farm's allotment of water; very little water is lost to evaporation, no tail water is generated, and virtually no water is lost to the groundwater system. Drip systems are used primarily to deliver water, but they can also be used to deliver nutrients and pesticides. (USGS 2004).

Irrigation efficiency varies depending upon the method. Rill irrigation methods are approximately 50 percent efficient, sprinkler irrigation is approximately 75 percent efficient, and center pivot irrigation is approximately 90 percent efficient in delivering water to the crop. Typically, efficient irrigation systems also provide uniform coverage. The most sophisticated systems use feedback from soil-moisture probes and GPS to cycle the irrigation system off and on (USGS 2004).

Sprinkler irrigation systems increased in the Roza and Sunnyside Irrigation Districts between 2005 and 2012, the years for which records are available. Rill irrigation systems have decreased. Sprinkler irrigation in those districts is somewhat lower than it is statewide. Low-

flow drip irrigation had increased to 26.16 percent of the acreage in the Roza District by 2010 (Drennan, ~~WSDA~~ 2013).

Formatted: Not Highlight

Demographics

This section focuses on the characteristics of the people who live in the GWMA, including population, income, education, household and family size, ethnicity, and language.

Population

Yakima County is the second-largest county in Washington by area, occupying 4,311 square miles, and the eighth-largest county in the state by population, with 244,654 people (USDOC 2010). Twenty-three percent of the Yakima County population (56,210 people) live within the GWMA, with approximately 63 percent residing in cities (Table 13) (USDOC 2010).

Table 13 – Population of Cities within the GWMA

City	Population
Sunnyside	15,858
Grandview	10,862
Granger	3,246
Zillah	2,964
Mabton	2,286

~~Source:~~ (USDOC 2010)

Approximately 36 percent of the population (19,952 people) reside in unincorporated rural areas that are not served by public water or sewer. These residents typically rely on private domestic wells for their drinking water and on-site sewage systems (OSS, or septic system) to dispose of their waste (USDOC 2010).

In the GWMA, economics and livelihood play a critical role in the decision to live in a rural area instead of an urban one. Affordable housing is a draw to rural areas, and so is the proximity to agricultural employment. Farmers, for example, usually live on or near the acreage they farm.

However, other factors are at play in addition to affordable housing and agriculture. In recent decades in Yakima County, large-tract farmsteads have been parceled and sold in smaller pieces over time. The smaller parcels are not large enough to make a living at traditional farming, but they do offer part-time farming opportunities for people already employed and seeking a country lifestyle. This is the chief characteristic of rural living in Yakima County and the GWMA (Yakima County 2017). The desire for a country environment in part accounts for the growing number of rural GWMA households, ranging in property size from 0.5 to 10 acres, with distances from urban areas that preclude them from receiving municipal water or sewer services.

Income

Yakima County's median household income of $43,506 is below Washington State's median income of $59,478. The county's per capita income of $19,433 is also below Washington State's per capita income of $30,742 (USDOC 2013).

Education

Educational attainment is a good indicator of the earnings potential of an individual. It also reveals the quality of the labor force. The U.S. Census (five-year American community survey over the years 2009 to 2013) shows that in Yakima County, 16.8 percent of all persons aged 25 years and over have less than a ninth grade education, while 15.5 percent of the same age group had four or more years of college education. In comparison, at the state level, 4 percent have less than a ninth grade education and 31.6 percent have four or more years of college. Census data for 18- to 24-year-olds indicates that 31.2 percent of Yakima County residents have less than a high school diploma, compared to 16.4 percent for the state (Yakima County 2017).

Households and Families

The average household size in the GWMA ranges from 3.36 to 3.98 people per household, larger than in Yakima County (3.02 people) and Washington State (2.54 people). Average family size in the GWMA ranges from 3.72 to 4.38 people — again, larger than the average county family size (3.53) or the state (3.11). In the GWMA, 80.2 percent of all households are comprised of families compared to 73.0 percent for the county and 64.5 percent for the state (USDOC 2013).

Ethnicity

The GWMA has a higher concentration of individuals whose ethnicity is Hispanic or Latino compared to Yakima County, Washington State, or the nation, and a lower concentration of American Indian, Alaska natives, and African Americans (USDOC 2013).

The Yakima Indian Reservation borders the western boundary of the GWMA. Although the reservation is not within the GWMA boundary, tribal representatives participated in the GWAC.

Language

In Yakima County, 39.6 percent of the population over age 5 speaks a language other than English at home (predominantly Spanish). Additionally, 18.6 percent speak English less than "very well," indicating that the other 21.0 percent are bilingual. In the GWMA, 60.6 percent of the population over age 5 speaks a language other than English at home, and 24 percent speak English less than "very well," indicating that the other 36.4 percent are bilingual. (USDOC 2013)

GWAC Initiatives

Education and Public Outreach

The education and public outreach is an essential component for a successful program since it is an integral part of each objective. Meeting objectives at all levels entails good communication with affected parties. And since success relies heavily on residents within the Lower Yakima Valley GWMA changing their habits, education and public outreach is the center point of all initiatives.

The GWAC determined it was a priority to inform residents about the health risks from drinking water with elevated concentrations of nitrate, especially for vulnerable individuals.

The goal of the education and public outreach efforts was to inform and educate the public about nitrate groundwater contamination and its health and environmental impacts, promote GWMA activities, and encourage engagement in the process by the community and key stakeholders.

The primary objectives ~~initiatives~~ were to:

- Educate at-risk audiences about the risks of elevated nitrate to human health and how to protect themselves from that risk;~~Promote the protection of groundwater quality.~~
- Inform audiences about the GWAC planning process; ~~Provide a forum for stakeholders to discuss nitrate reduction methods and improvement of groundwater quality.~~
- ~~Establish a GWMA website to serve as the central clearinghouse for all GWMA related activities.~~
- ~~And to educate residents on health risks, treatment programs, and testing of private domestic wells.~~Invite participation in the development of the GWMA program

A GWMA website was established and maintained to serve as the central clearinghouse for all GWMA related activities.

The detailed plan developed for education and public outreach is contained in appendix E. The educational materials produced are contained in Volume III – Accomplishments. These materials were ~~often~~ produced in both English and Spanish to accommodate as many community members as possible.

Many of the education and public outreach efforts included a survey component to provide direct and immediate feedback, which allowed efforts to be refined to be as effective as possible. It was noted that personalized letters based on individual well water quality results were the most effective at informing residents.

Nitrate Treatment Pilot Program

One of the highest priorities was to provide outreach to residents that were drinking water with elevated concentrations of nitrate and to provide free water treatment systems. This effort was led by Yakima County, who partnered with the Departments of Health, Ecology, EPA, the Yakima Health District, and the Yakama Nation.

An intensive bilingual outreach effort was implemented distributing 7,641 English/Spanish packets to every household on a private well via either mail or hand delivery. Public meetings were held with an interpreter, bilingual radio and TV spots were aired; door-to-door intensive Spanish-language outreach conducted, and a toll-free bilingual hot line was established.

Approximately between 700 and 1,000 homes in the GWMA were supplied by water wells with nitrates in excess of the drinking water standard; however, only 177 households requested a water treatment system. Education and technical assistance were integral components of this effort. The lessons learned from this early program included:

- The health effects of nitrate are difficult to convey, because nitrate in water is not visible, and understanding threshold and risk factors associated with drinking water with elevated nitrate concentrations was challenging.
- There is a lack of interest from the public because there were no local reports of nitrate related health problems in the news.
- The GWMA is a large rural area, which makes it challenging to conduct a comprehensive and extensive outreach program without existing community infrastructure.
- Comprehension skills in some households required one-on-one site assistance to verify information and to complete applications.

The Nitrate Treatment Program illustrated the challenge of communicating complex messages to a discrete, hard-to-reach audience. However, it was successful at introducing the nitrate issue to residents within the GWMA.

Water quality samples were also taken from numerous private domestic wells. Figure 20 shows the Nitrate Pilot Project well water test locations.

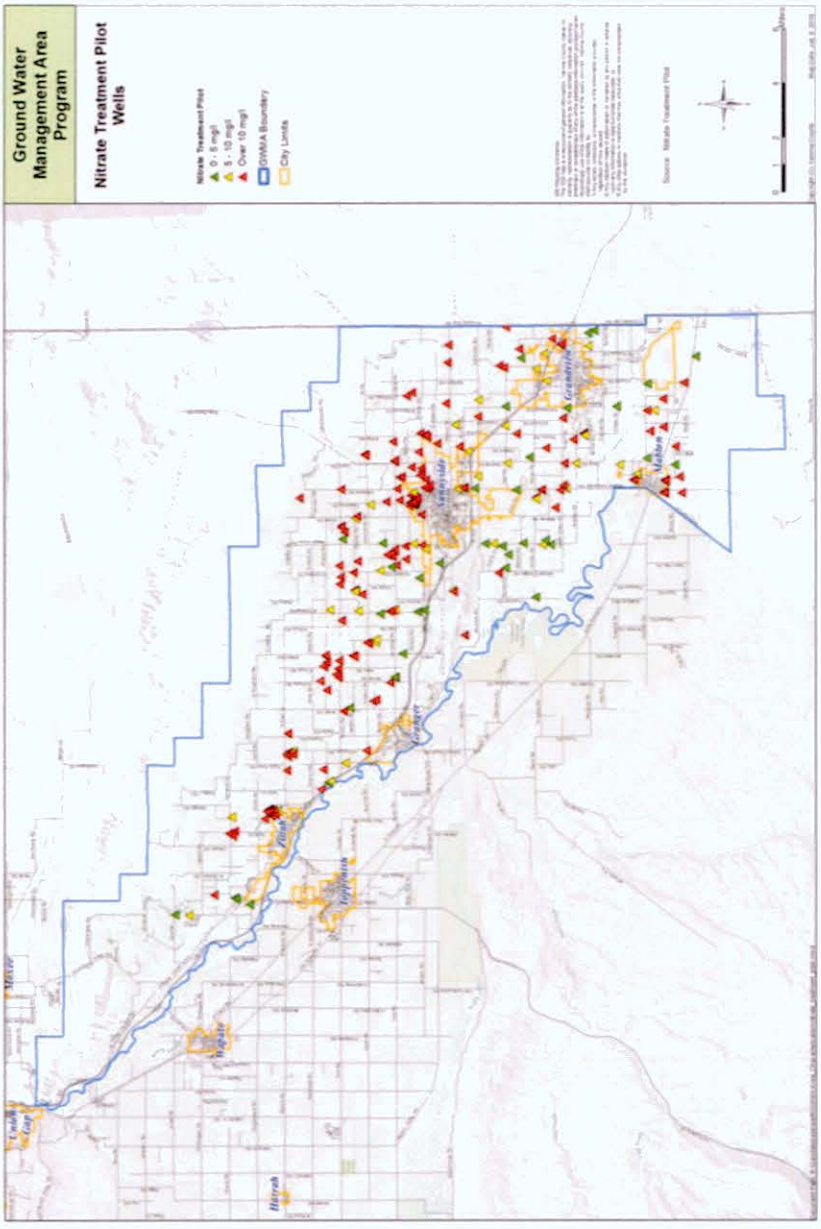


Figure 20 – Nitrate Pilot Project Water Test Locations

GWMA Website

The GWMA website was developed early in the process. The website contains information about the goals and objectives of the committee, meeting notices, agenda, and minutes, upcoming events, products and information. The website was redesigned twice and underwent numerous revisions as GWAC activities, outreach, and the evolving GWMA Program took shape.

The GWMA website (yakimacounty.us/541/Groundwater-Management-Area) serves as the information clearinghouse. It provides a central source of information about the GWAC, the working groups and their products, and links to technical assistance. It is also intended to inform the public about the GWMA Program development.

Although the website link was advertised on nearly every English/Spanish document, presentation and billboard, the visits to the website and the specific pages that were viewed (resource materials) suggested that the primary users were GWAC members and researchers. The education and public outreach work group speculated that the web's most practical use was for agencies and individuals seeking academic information about the GWMA. While efforts were made to make it more inviting to the public (bilingual content, graphics, surveys), there was no evidence that the effort was successful.

Outreach Campaigns:

Two education and public outreach campaigns are described below.

Door-To-Door Public Opinion Survey

A bilingual door-to-door survey was developed to measure what residents in the GWMA served by private wells knew (or didn't know) about their private wells, about nitrates in drinking water, and about the formation of the GWMA. The eight targeted areas encompassed 300 households ranging from Konnowac Pass in the northeast to County Line Road to the southeast. The areas chosen were known to either have high nitrate in groundwater or were located in areas where little data on nitrate levels existed.

Heritage University students collected survey information from 136 households. The results indicated that 69 percent (94 households) surveyed were aware of the potential health risks associated with drinking water with high levels of nitrate. Over half of those surveys had their private well tested for nitrate. Four percent (six households) believed someone in their home had become ill from drinking their well water. None, however, indicated that high levels of nitrate were the source of the illness. One residence reported having an infant, one residence had a pregnant woman, and seven residences reported having a chronically ill individual. Forty two percent of those surveyed had heard of the Lower Yakima Valley Groundwater Management Area. Volume III – Accomplishments contains the survey results.

High-Risk Well Assessment Surveys

This education and public outreach campaign took a closer look at the water quality of private domestic wells in the GWMA, and measured households' understanding of their well maintenance responsibilities, how their own actions might influence groundwater quality, and also measured the awareness of how to protect the quality of their drinking water. Four hundred sixty six sampling surveys were conducted. Water quality samples were also taken. Test locations are shown in Figure 21. Although the sample size was too small to assess data patterns, the lessons learned included:

1) Residents on private wells need to test their wells.
2) Well owners should become more familiar with their wells (e.g., location of their well, find well log, depth of well, condition of well).
3) Understand the possible connection between not testing a well and its likelihood of testing high for nitrate.

All of the extensive education and public outreach material are consolidated in Volume III – Accomplishments.

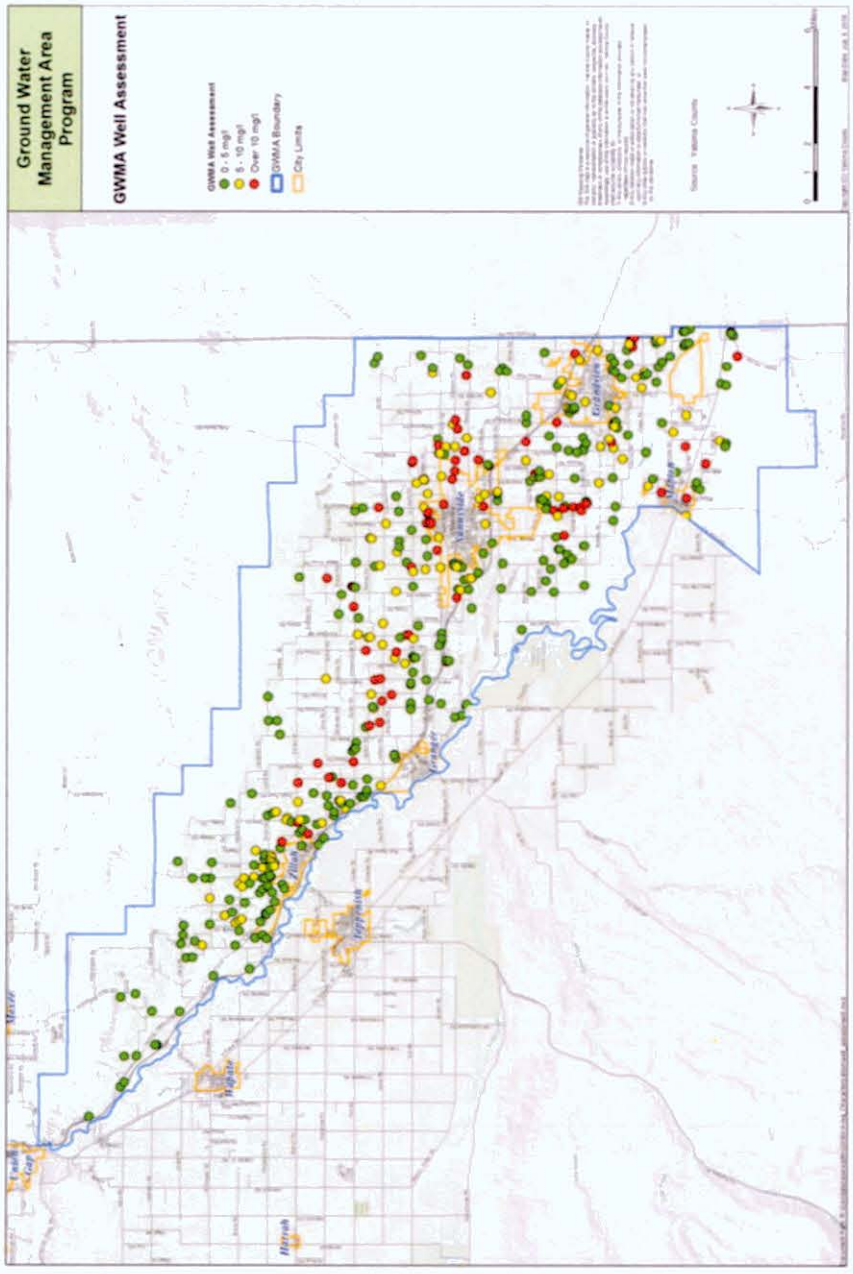


Figure 21 – High Risk Well Assessment Test Locations

Best Management Practices Identification

The GWMA initially contracted with a consulting firm, HDR to produce a list of potential Best Management Practices (BMPs) that may be applicable to agricultural, industrial, urban, and domestic activity within the GWMA. The Irrigated Agriculture Workgroup of the Groundwater Advisory Committee reviewed the HDR produced list and selected those BMPs they felt particularly relevant to their respective operations. Those BMPs are set forth in Appendix G. The Livestock/CAFO Workgroup of the Committee elected to review the BMPs listed by the Natural Resources Conservation Service (NRCS) to determine those particularly relevant to livestock/CAFO operations. Those BMPs are set forth in Appendix H.

Groundwater Monitoring

Groundwater monitoring efforts include a number of planning and data assessment documents, a quality assurance project plan, a drinking water sampling effort, and the siting and installation of an ambient groundwater monitoring network. These items are discussed in greater detail below. Additionally, the published documents are contained in Volume III-Accomplishments.

Groundwater Monitoring Plan

The GWMA began the planning process by consolidating groundwater quality data and considering different types of groundwater monitoring programs. Pacific Groundwater Group (2013g) conducted an analysis of existing groundwater quality data by creating a database containing over 2,500 groundwater nitrate results from local, state and federal government agencies, and well locations of almost 7,800 wells. Analysis of this data indicate that well depths range from 1 foot to over 2,700 feet below land surface. Approximately half of these wells are shallower than 136 feet. Nitrate concentrations are at or below the natural background concentration of 0.3 mg/L for 14.3% of samples. Nitrate concentrations exceed the drinking water standard of 10 mg/L for 12.9% of samples. Trend analysis was also conducted for this dataset despite the limitations. Both the median and mean concentrations have increased since 1975 (PGG 2013g).

Figure 23 consolidates groundwater quality results from all monitoring efforts.

This information was used to propose potential groundwater monitoring projects. Pacific Groundwater Group (2013g) identified the following types of monitoring:

- Spatial data gaps
- Hotspots
- Increasing trends
- Ambient groundwater monitoring – installed 31~~ing~~ monitoring wells in randomly placed locations to assess the long-term groundwater quality of the GWMA over time. Δ

comprehensive groundwater monitoring ~~The~~ network could include monitoring wells and existing private domestic wells.

- **Drinking water assessment** – determining the quality of water from common water supply aquifers used by individuals drinking water from private domestic wells.
- BMP effectiveness monitoring
- Health risks

The **highlighted** groundwater monitoring programs were initiated by the GWAC and are described in greater detail below.

The GWAC developed an Interim Final Groundwater Monitoring Plan (PGG 2014e) in order to establish a network of wells and field procedures to evaluate current and future nitrate concentrations in groundwater.

Quality Assurance Project Plan

A quality assurance project plan (QAPP) was developed for groundwater monitoring efforts. This QAPP specifies how samples will be collected, the data quality objectives, the station quality objectives for various sampling efforts, the analytical data quality objectives, the quality control checks and the data validation and usability requirements. All samples must be analyzed by an accredited laboratory. (PGG 2013d)

Data Analysis

Statistical methods for analyzing groundwater quality data are described in (PGG 2013g).

Pacific Groundwater Group (2013g) recommends basic summary statistics for all data sets considering: the number of samples, the number of locations, the number and percentage of non-detects, minimum, maximum, mean, median, variance and standard deviation. The following statistical procedures are recommended:

- Data distribution determination
- Comparison to natural background
- Comparison to groundwater quality criterion
- Variability with depth
- Mann-Kendall Trend Test
- The purpose built wells for the ambient groundwater monitoring network provide the basis for future trend analysis. Mann-Kendall Trend Test is recommended, which requires a minimum of 10 data points per well, adjustments for outliers and seasonality.
- Trend analysis should not be conducted with existing data in the database if QA/QC data are not available (PGG 2013g).

The statistical methods for analyzing groundwater data are supported by other publications (Ecology 1996; Visser et al. 2009; Hirsch et al. 1991).

Drinking Water Quality Assessment

The U.S. Geological Survey (USGS) conducted an intensive groundwater nitrate sampling effort from drinking water sources. In 2017, nitrate samples were collected from 156 private domestic wells on six occasions, with 1,059 samples collected. Additionally 24 surface water drains were also sampled for nitrate concentrations (figure 22).

Nitrate concentrations in groundwater ranged from less than 0.04 to 45.2 mg/L. The average nitrate concentration was 6.1 mg/L. More than 20 percent of samples from the domestic wells had nitrate concentrations that exceeded the drinking water standard of 10mg/L. Twenty six percent of wells sampled had at least one nitrate concentration above the standard, and nitrate was not detected in 15% of well sampled. (USGS 2018)

Nitrate concentrations in surface drains ranged from 0.04 mg/L to 25.2 mg/L. The average nitrate concentration was 5.5 mg/L. Almost 13 percent of drain samples had nitrate concentrations that exceeded the drinking water standard of 10mg/L. Thirty-three percent of drains sampled had at least one nitrate concentration above the standard, and nitrate was not detected in 5 percent of drain sample sites. (USGS 2018)

This report and the supporting QAPP (USGS 2017) are contained in Volume III – Accomplishments.

Ambient Groundwater Monitoring Network

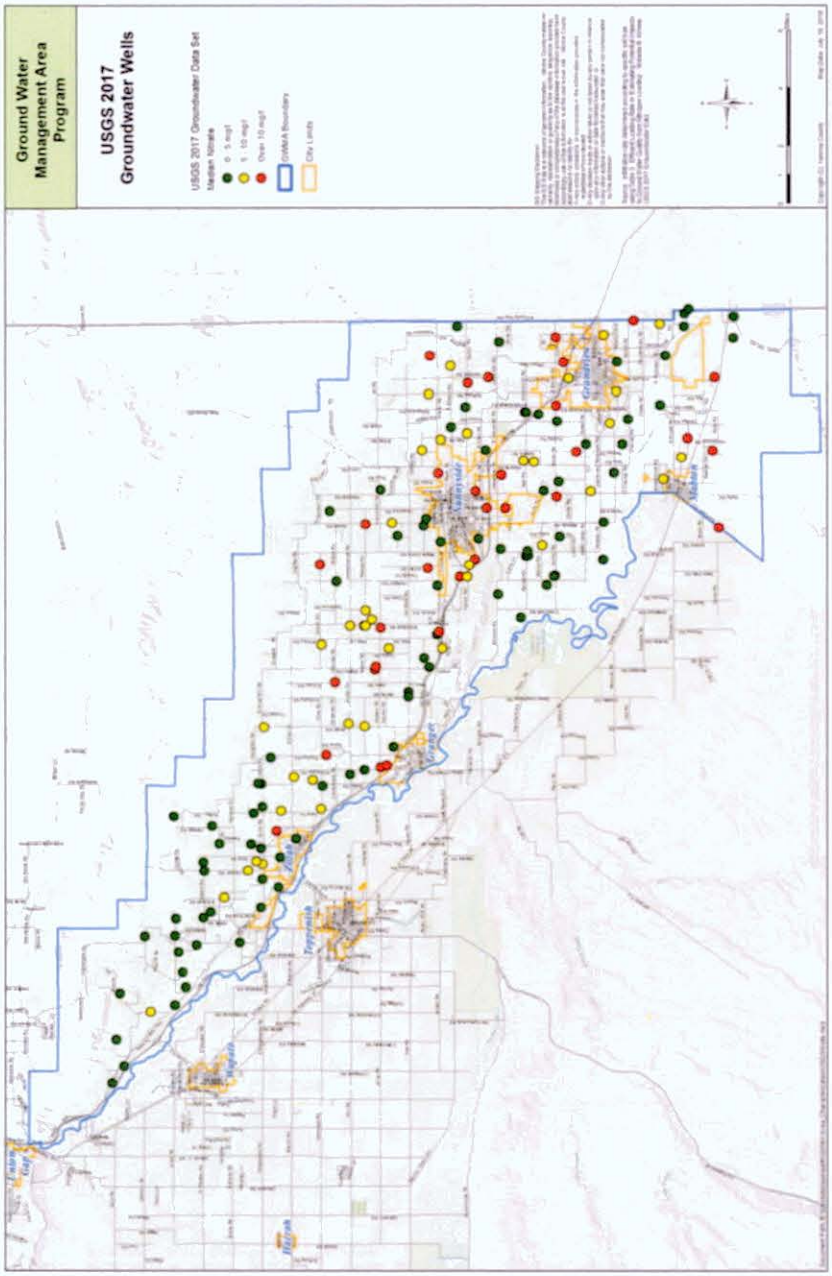
The GWAC decided that establishing an ambient groundwater monitoring network was a priority to establish a baseline of groundwater quality conditions and to track concentration changes over time. The foundation of this network is a ~~set of 20 to 30~~ network of 31 purpose-built wells (monitoring wells) completed at the water table. The water table is targeted since little data from this zone exists and because concentration changes associated with land use management changes will occur here first. Additionally the goal was to install a sufficient number of wells to adequately represent groundwater conditions across the GWMA and to locate the wells used a random location method. Pacific Groundwater Group (2016) identified the preliminary well drill sites and ranked them statistically. A contract was signed, and wells ~~are being~~ were installed in Yakima County public right-of-ways as close to the location site as possible in 2018. ~~The number of wells installed is contingent upon the drilling costs with the money that has been allocated. The goal is to have the wells installed in 2018.~~

Monitoring of these wells is expected to occur during the implementation phase and is contingent on funding.

Groundwater Hotspots

Hotspots are areas where the maximum nitrate concentrations exceeds 20 mg N/L. Seventy-one hotspots were initially identified in 2013 using the water quality database of over 2,500 existing groundwater nitrate results (PGG 2013g). Further refinement of these areas was one

of the potential monitoring programs that was considered by the GWAC, but was not chosen due to limited resources.


Ground Water Management Area Program
USGS 2017 Groundwater Wells
USGS 2017 Groundwater Data Set
Median Nitrate
0 - 5 mg/l
5 - 10 mg/l
Over 10 mg/l
GMA4A Boundary
City Limits
Goodland
Kanorado
Kanorado
Atwood
Atwood
Colby
Colby
Colby

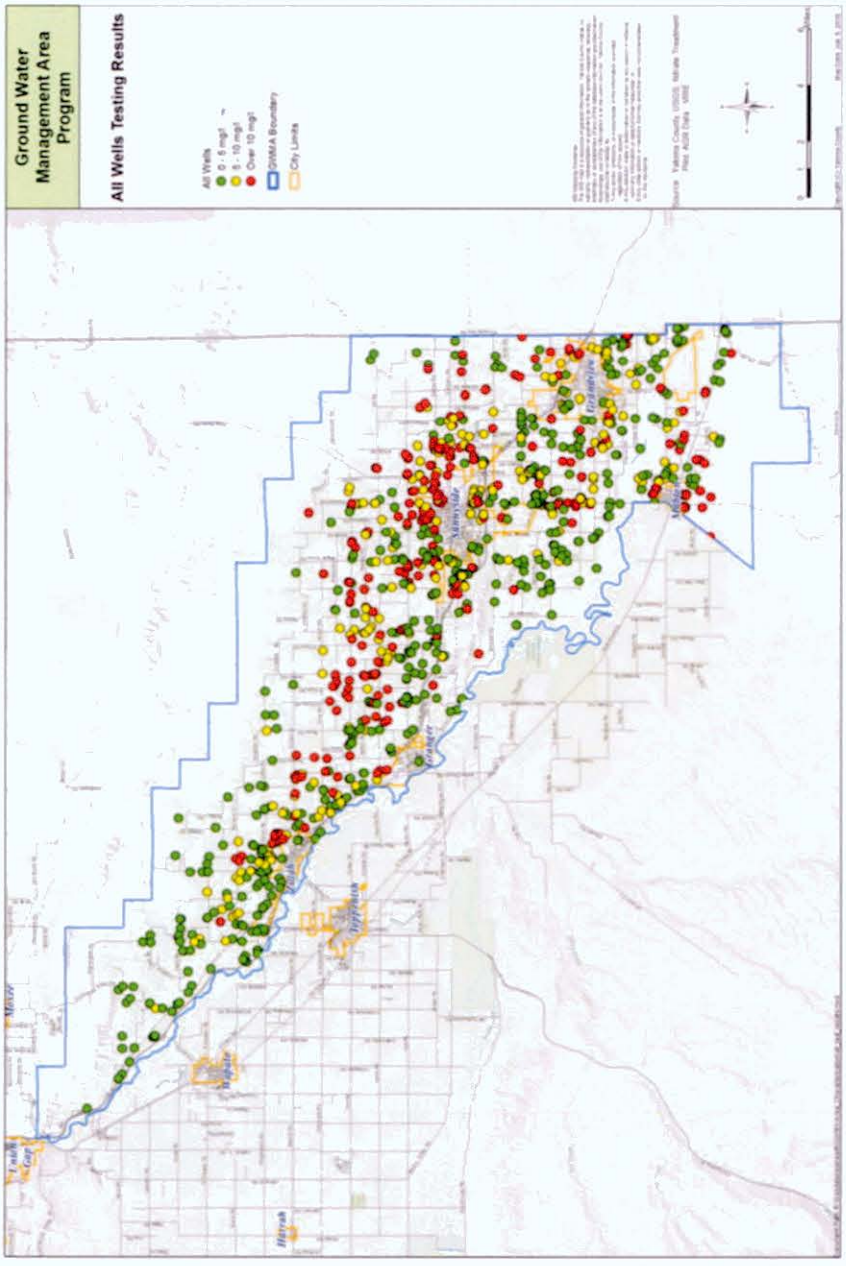


Figure 23 – All Water Quality Sampling Locations (3 Testing Programs)

Deep Soil Sampling Program

Deep soil samples were collected anonymously from agricultural fields in the spring and fall. A total of 175 fields were sampled at one foot increments down to six feet below land surface. Additionally each farmer was asked to fill out a survey about crop, water and nitrogen practices. The South Yakima Conservation District and Landau Associates performed four rounds (Fall 2014, Spring 2015, Fall 2015, and Spring 2016) of deep soil sampling (DSS) on agricultural land in the GWMA. All participants volunteered to participate in the Program, subject to the condition that the physical location of sampling was anonymous and undisclosed. A quality assurance project plan (QAPP) was developed, and was followed during sampling (PGG, 2014c).

The purposes of the deep soil sampling included:

1) Provide baseline data regarding the nitrogen content (nitrate, ammonium, and organic matter) of soils underlying a variety of soil, crop, and irrigation systems that represent a cross-section of agricultural activities.

2) Provide an initial assessment of current nitrogen and water management practices in place today and in the past.

3) Provide information regarding availability of soil nitrogen to crops.

4) Provide the foundation for a technically based education program.

5) Provide information about project design, practical realities, time requirements, and costs that can be used in developing subsequent project scopes.

Because of the anonymity of the data and the inability to track soil nitrate concentrations from one field over time, there are limitations with how this data can be used. Appendix F includes the deep soil sampling data, a discussion of the limitations, and two different preliminary analysis efforts. These analyses were conducted as an attempt to gain insights from the sampling effort. This initial effort also provides insights for overcoming information gaps that would enhance future deep soil sampling.

Formatted: Left, Indent: First line: 0", Space After: 0 pt, Line spacing: single

Formatted: Space After: 0 pt, Line spacing: single

Formatted: Space After: 6 pt

Formatted: Indent: Left: 0.5", Space After: 6 pt

Formatted: Space After: 6 pt

Formatted: Left, Indent: First line: 0", Space After: 0 pt, Line spacing: Multiple 1.15 li

Identification of Nitrogen Sources

A nitrogen availability assessment was completed to identify sources of nitrogen and determine their relative contribution. This assessment establishes a scientific baseline of the potential amount of nitrogen available for transport from different nitrogen sources within the GWMA. Nitrogen available for transport is nitrogen that has the potential to move from the land surface or soil profile into groundwater. The study did not calculate how much actually is transported to groundwater. (WSDA 2018)

This assessment is a refined estimate of nitrogen availability using local information where available. This is a qualitative assessment rather and a quantitative assessment, and since the data is incorporated into Yakima County's GIS database, it is a living document that can be refined in the future.

Relative nitrogen contributions are estimated for the major sources in the GWMA, and are compiled in Table 2 and Figure 4.

Geographic Information System

A geographic information system (GIS) database was developed specifically for the GWMA. Yakima County maintains this database which includes information on land use, water quality and other natural resource data. All data generated by the GWAC was included in the GIS database. This includes nitrogen available from sources (WSDA, 2018), and drinking water quality results collected from private domestic wells (USGS, 2018).

Data from these two efforts were mapped and are presented in the following figures:

- Figure 24. Total Available Nitrogen
- Figure 25. Available Nitrogen with Drinking Water Nitrate Concentrations
- Figure 26. Soil types with Drinking Water Nitrate Concentrations
- Figure 27. Canals and Drains with Drinking Water Nitrate Concentrations.
- Figure 28. Crops with Drinking Water Nitrate Concentrations
- Figure 29. Point sources with Drinking Water Nitrate Concentrations
- Figure 30. Residential On-site Sewage Systems with Drinking Water Nitrate Concentrations

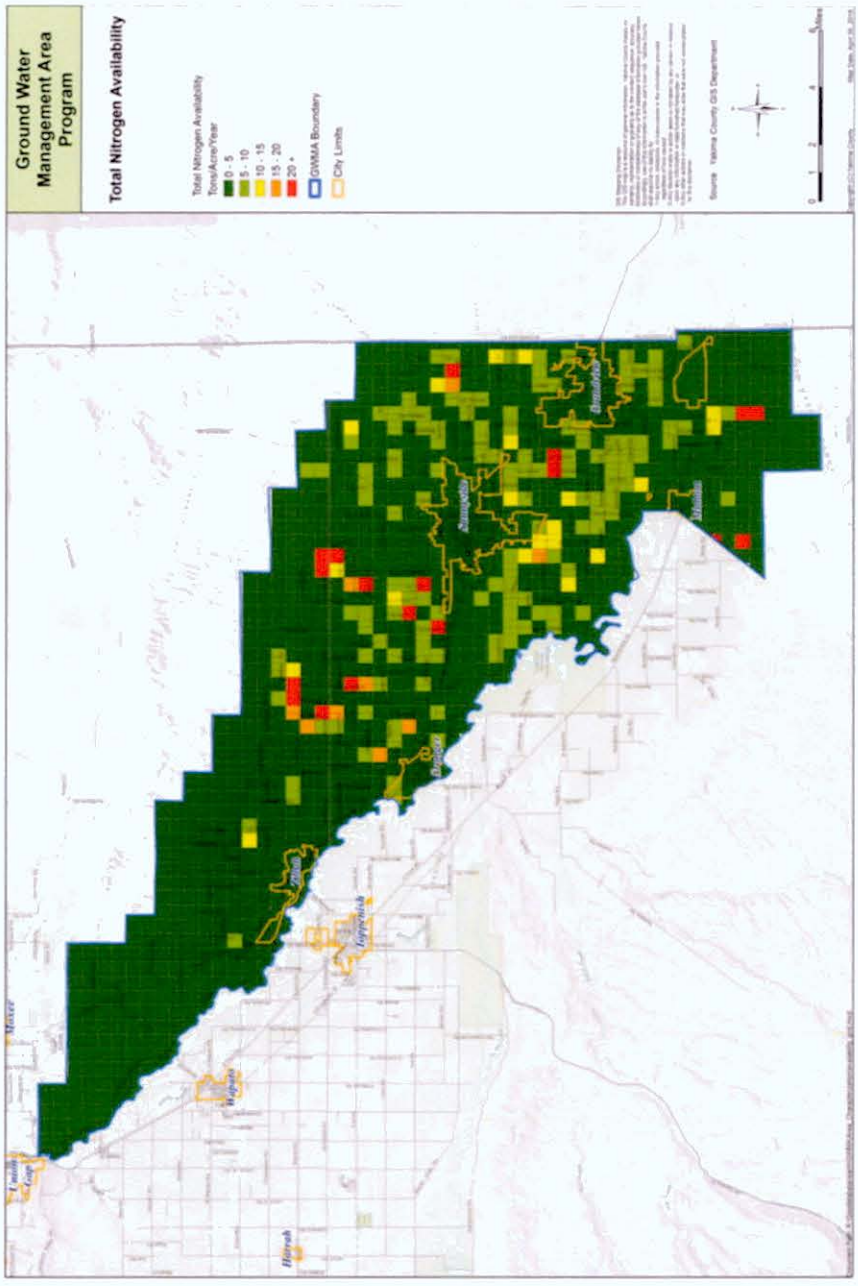


Figure 24 – Total Nitrogen Availability

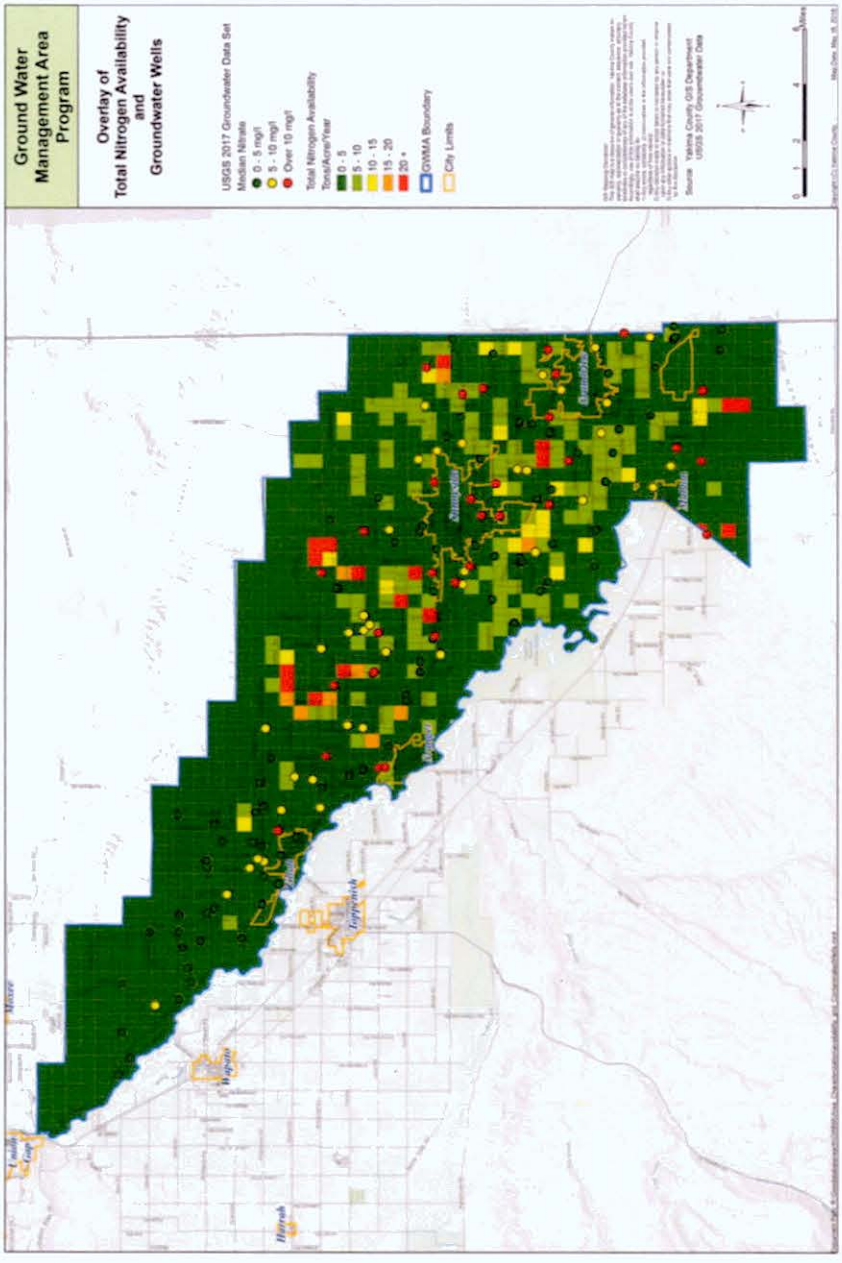


Figure 25 – Nitrogen Availability and USGS Wells

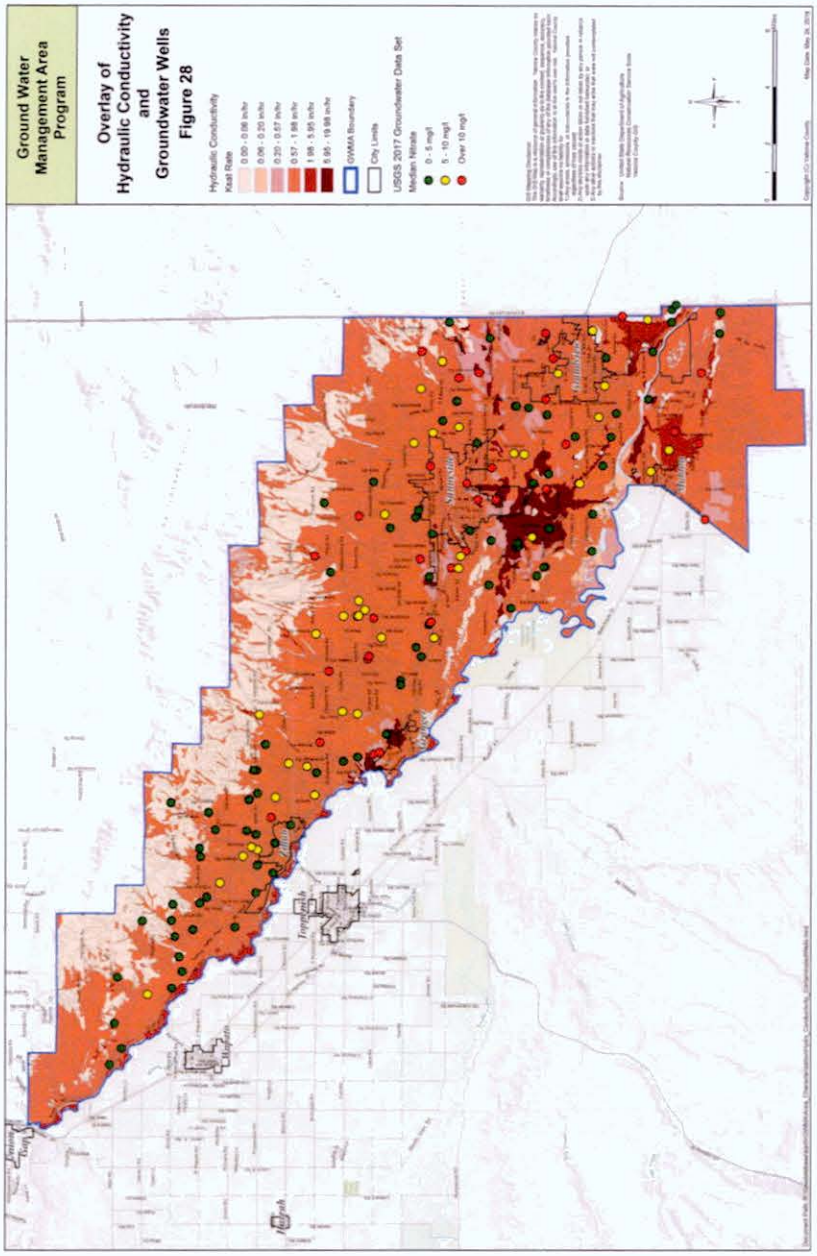


Figure 26 – USGS Well Data Overlaid on Soil Types Simplified by Hydraulic Conductivity Groups

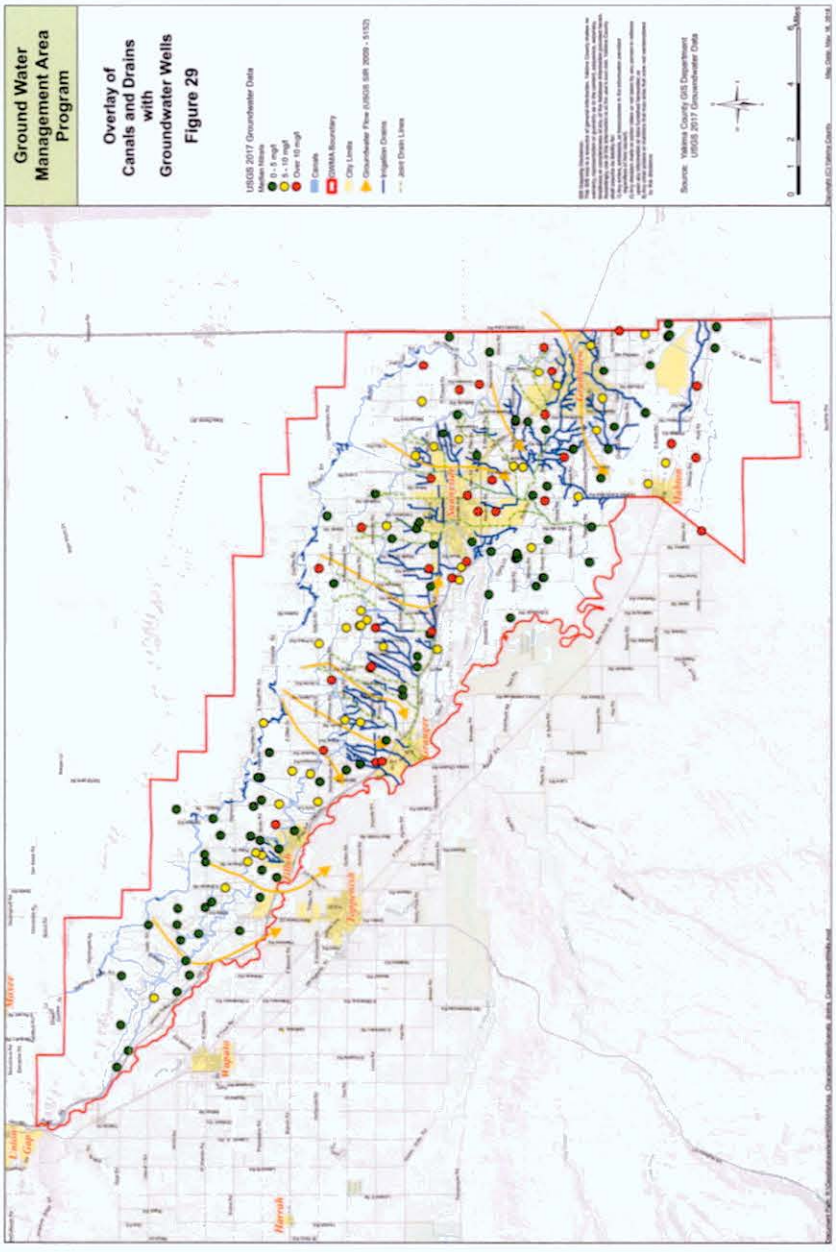


Figure 27 – USGS Well Data Overlaid on Irrigation Canal and Drain Information

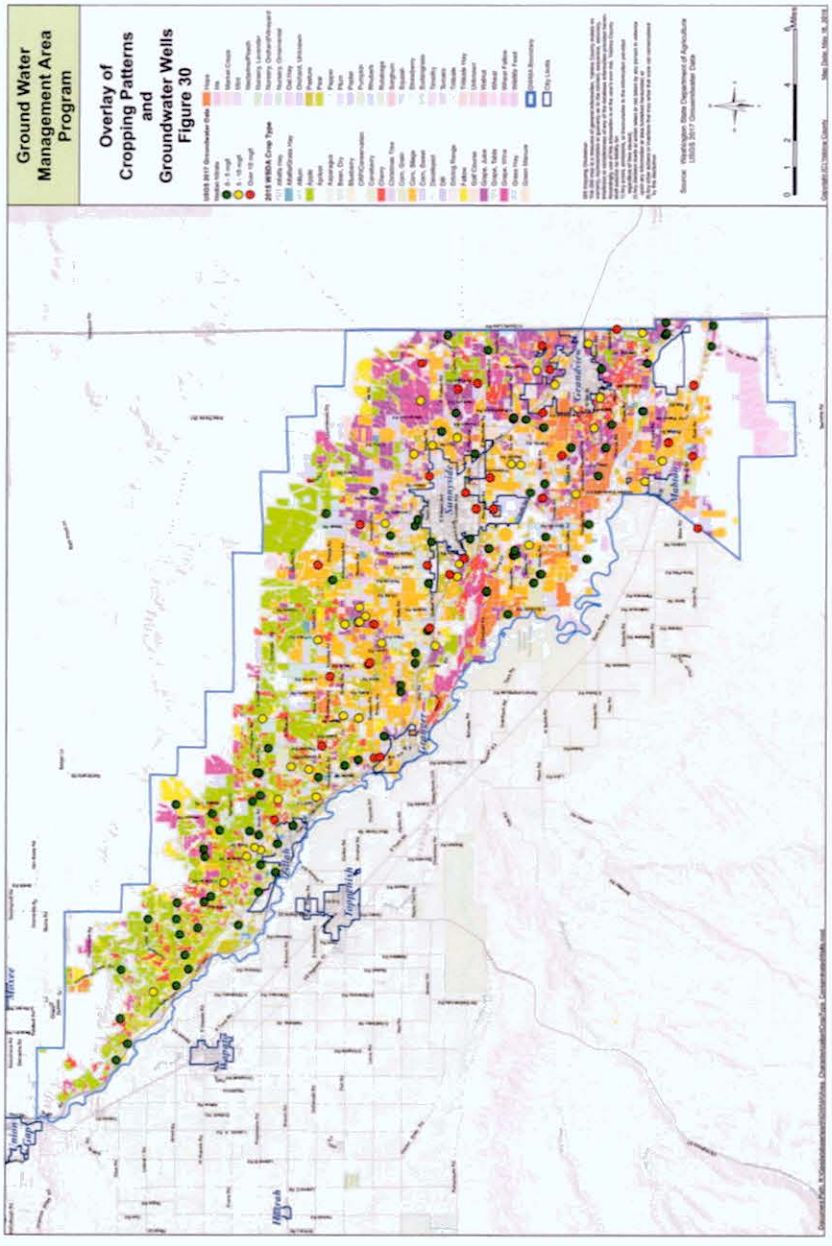


Figure 28 – USGS Well Data Overlaid on Cropping Patterns

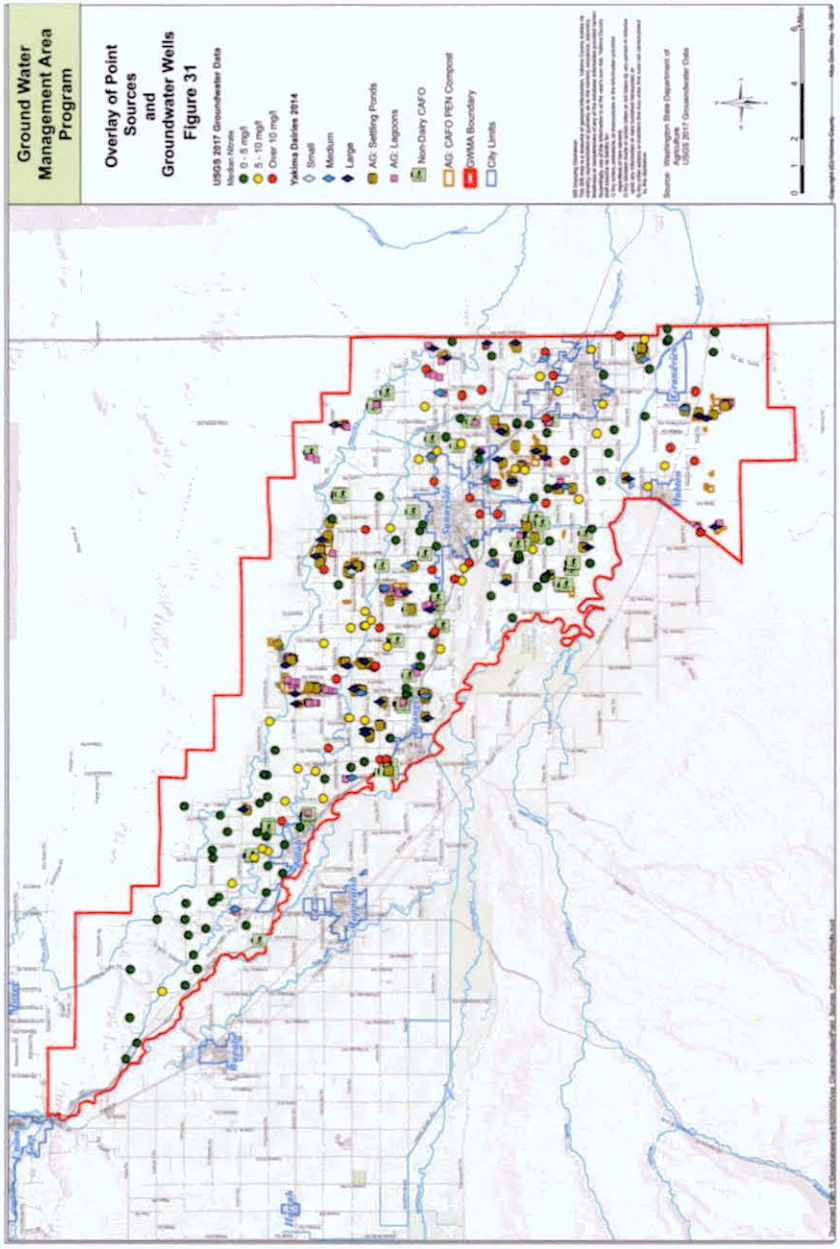


Figure 29 – USGS Well Data Overlaid on Map of Point Sources

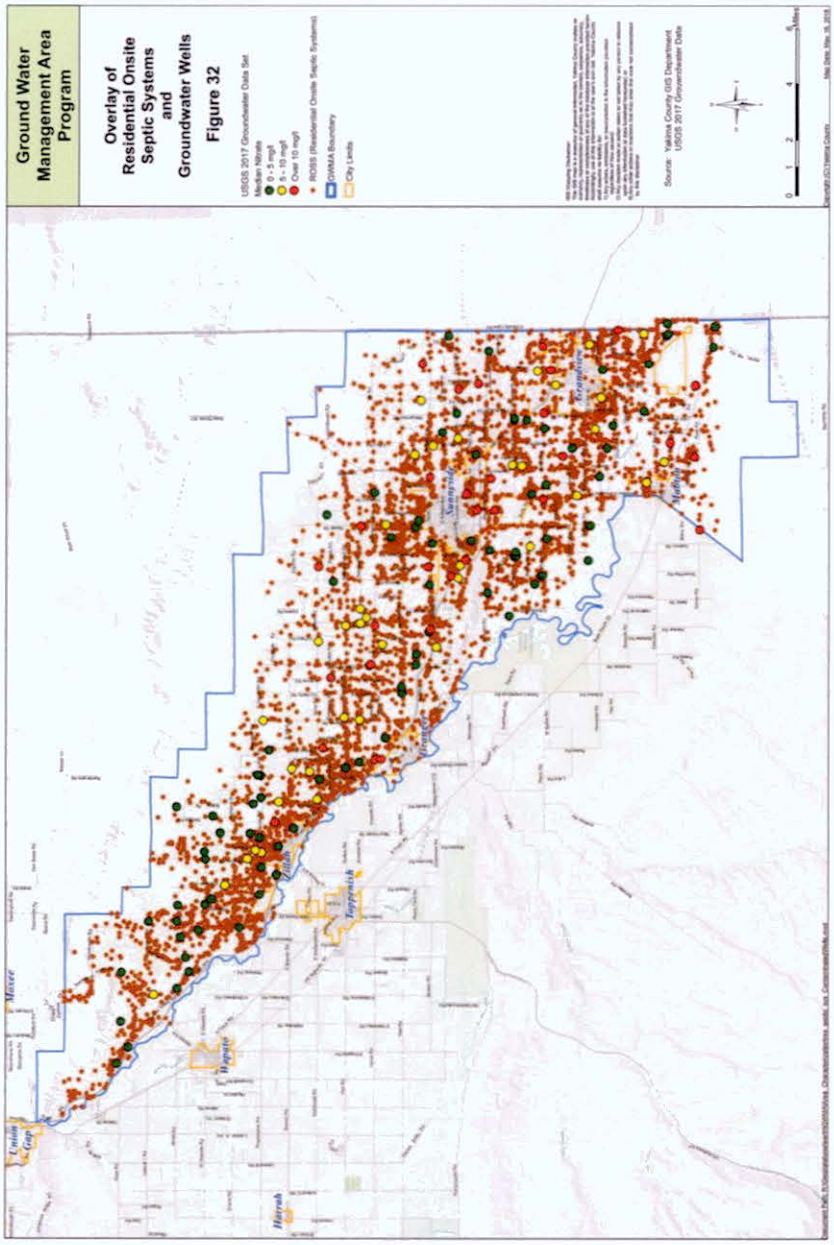


Figure 30 – USGS Well Data Overlaid on Map of On-site Sewage Systems

Recommended Actions

The GWAC developed a list of recommended actions (Appendix J). These actions were prioritized from the list of alternatives presented in Appendix I, by a voting process from GWAC members. GWAC members placed a value or -3 to +3 with each recommendation, and the results were totaled. The following recommended actions are listed in order of priority. The number of GWAC votes and the implementing agency are listed in the parentheses.

Recommended Actions

1. **Install Ambient Groundwater Monitoring Wells. (42 – Yakima County)**
   Monitoring well construction.
2. **Collect data from Ambient Groundwater Monitoring Wells. (42 – Yakima Health District)**

   Study short-term seasonal variations in nitrate concentrations over next year or two and address effects of changes in nutrient application over the agricultural cycle. Study long-term trends that develop over several years to track whether time-based performance objectives are being met.
3. **Establish a Lead Agency responsible for implementation and oversight of the GWMA Groundwater Management Plan and acquisition of stable funding to support their activities. (41 – Yakima County)**

   Administer the Groundwater Quality Program (subject to state funding). Administer funds and distribute to other entities by subcontract. Host the GWMA website. Maintain a GIS database on the GWMA.
4. **Publish and distribute homeowner guide on how to maintain septic systems. (40 – Yakima Health District)**
5. **Fund SYCD, through State Conservation Commission budget, for projected educational, administrative, nutrient management planning, engineering, cost share, and lending activities. (39 – WCC)**
6. **Establish a local forum for disseminating information and facilitating technical exchange regarding Best Management Practices (BMPs) for irrigated agriculture and livestock management and groundwater protection. (36 – SYCD and WCC)**

Prepare a fact sheet/develop outreach campaign to growers that explains agronomic rates, applying nutrients at the right time/right place/right amount. Endorse and distribute materials that will educate producers about the facts related to all fertilizer types, including livestock nutrient and the science of groundwater protection.

~~6.~~

Formatted: Indent: Left: 0.75", No bullets or numbering

Formatted: Indent: Left: 1.5", No bullets or numbering

7. **Develop a post-GWAC agricultural producer education and outreach campaign. (36 – WCC, WSU Extension Service, WSDA, Ecology, Yakima County, SYCD, and agriculture associations)**

Create a broad-based advocacy group (e.g., regulatory agencies, agricultural industry associations such as the Farm Bureau, Dairy Federation, hop growers, wine grape growers and producers) to carry out the educational components. Create a central repository (e.g., website) of agricultural information that provides technical assistance to growers and producers, provides education on nitrate, and identifies BMPs specific to each local agricultural industry. Address consequences of too much irrigation. Recommend technological improvements in irrigation that permit easier management of water. Provide descriptions of specific improved technology. Explore economic viability of technological advancements, BMP implementation, irrigation water management, soil nutrient management, and manure management and application.

Elements could include:

- Encouraging commodity groups to provide education on water management and fertilizer use through regular meetings.
- Distributing information to producers on what can happen with applied nitrogen, what should be applied, and reasonable agronomic rates of application.
- Encouraging agencies and subject matter experts to make presentations at trade shows.
- Asking agricultural consultants to share the latest BMP developments with their clients.
- Increasing livestock operators' awareness of the need for procedures for proper management of animal manure.~~wastes and wastewater.~~
- Providing producers with information on funding sources (e.g., industry, government, educational institutions, industry associations, etc.) that will improve their ability to apply BMPs.
- Enlisting partners (farm bureau/federations/associations) to host workshops/informational meetings regarding GWMA goals and recommendations.

8. **Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and the Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development. (35 – Ecology, Yakima County and Yakima Health District)**

   Collect data to track water quality improvement progress and nutrients generated, applied, or exported within the GWMA. Generate data through soil testing, Ambient Groundwater Monitoring Plan implementation including purpose built and existing wells, sampling of liquid and solid waste to be field applied, composted, or exported, the CAFO General Permit, and tracking nutrients applied by non-dairy operations. Collect, analyze, and interpret data to track water quality improvement progress, nutrients imported, generated, applied, or exported, which will inform the implementation of an Adaptive Management Plan within the GWMA.

9. **Monitor nitrate concentrations of irrigation water at headgates. (35 – Roza-SVID Joint Board of Control)**

   Report nitrate concentrations annually to Department of Ecology.

10. **Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results. (34 – WSDA)**
11. **Provide financial assistance for implementation of Irrigation Management Plans. (32 – NRCS and Ecology)**

    Details include 1) conversions from rill irrigation to sprinkler or drip irrigation, 2) installation of flow meters and moisture meters to reflect over-irrigation, high water table, drought conditions, 3) the cost of hiring third-party sampling, measuring equipment, personnel or self-test kits, 4) management of sprinkler systems so they do not drive nutrients past the root system.

12. **Study potential nitrate contamination attributable to improperly operated septic systems. (32 – Yakima Health District)**

    Consider restoration/retrofit of older septic systems through incentives or county property tax breaks. Require nitrogen-reducing technologies for on-site septic systems where appropriate. Assist hobby farmers to locate ROSS drain fields on their property to avoid animal farming over the drain field.

13. **Encourage advanced irrigation management. Integrate management of synthetic/organic fertilizers and application of water. (31 – SYCD, WSDA and WSU Extension Service)**

Recognizing that there is significant cost involved in changing an irrigation system, look for strategic opportunities where the use of more advanced irrigation management systems could have the greatest benefit for reducing nitrogen impacts to groundwater. One example of advanced irrigation management is electronic sensor irrigation water management (IWM). Identify federal, state, and local incentive programs (like EQIP -- NRCS Environmental Quality Incentives Program), such as grants, and low-interest loans, to facilitate a transition to more advanced irrigation management in those areas. Provide financial assistance for 1) conversions from rill irrigation to sprinkler or drip irrigation, 2) installation of flow meters and moisture meters to reflect over-irrigation, high water table, and drought conditions, 3) the cost of hiring third-party sampling, measuring equipment, personnel, or self-test kits, 4) management of sprinkler systems so they do not drive nutrients past the root system. Establish a voluntary irrigation management cost-share program from which data may be shared with the public.

14. **Educate producers regarding application of nutrients at agronomic rate. (30 – South Yakima Conservation District, Washington Department of Agriculture, Washington State University, Private Industry and Producers)**

    Develop technologies and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies.

15. **Develop a bilingual, health-risk education and outreach campaign. (28 – DOH, Yakima Health District and Yakima County)**

    Establish a public education program regarding nitrate pollution and health risk over a 5- to 10-year period. Partner with UW Pediatric Environmental Health Specialty Unit to continue training local healthcare providers to recognize and address nitrate risk in their patients (pregnant women and infants up to six months).

16. **Contract with USGS to collect data from water well system per 2017. (28 – Yakima County)**
17. **Encourage municipalities within the GWMA to extend municipal sewer systems within urban growth areas and retire ROSS and LOSS; alternatively, extend public water systems. Encourage connection of residences within urban growth zones to sewer systems extended by municipalities. (26 – Yakima County)**
18. **Identify and support opportunities, including education research institutions for private, public, and industry investment in technology and**

management of fertilizers and manures, including separation of solid and liquid wastes. (26 – WCC)

19. **Operate a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts. (25 – WSU)**

    Inform farmers of the relative propensity of wheel lines, center pivots, and drip lines to cause leaching and that fertilization and supplemental irrigation beyond the optimum rate will not necessarily produce better yields or higher profits without serious side effects. Advise regarding corn and triticale water practices.

20. **Continue research of water management with application of agricultural nutrients. (25 – WSU)**

    Develop water sorption graph or chart. List volumes of water applied, soil types, infiltration rates, water holding capacity, absorption/compaction rates, depths to water, pre-season and post-season appropriate moisture levels, evapotranspiration rates.

21. **Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups to reflect greatest effectiveness in nitrate reduction. (25 – WSDA and SYCD)**

    Focus implementation of BMPs based on information and data included in the Nitrogen Availability Assessment, Soil Sampling Program, Ambient Groundwater Monitoring Plan, USGS Reports, and other similar scientifically based publications. GWMA: Publish lists as appendices to GWMA Program. WSDA: List Lower Yakima Valley GWMA-specific BMPs; determine who implements each BMP and who monitors it. Determine the time frame in which to measure/monitor each BMP. SYCD: provide farmer-specific consultation.

22. **Continue to provide underlying soils information to individual livestock operations, provide same for all irrigated agriculture. (25 – WSDA and SYCD)**

    So that individual property owners can evaluate contamination potential, already in DNMP process.

23. **Monitor changes occurring in agricultural operations. Evaluate whether those changes positively affect improvement in groundwater quality. (25 – SYCD and WSDA)**

    Requires cooperation of producers & landowners, multi-year effort to account for crop rotation, dry vs. wet years, changing technology, decades to monitor

groundwater quality change. WSDA: prepare report to Legislature and Department of Ecology.

24. **Establish a multi-year Deep Soil Sampling Program where farmers subscribe for a duration with pre-determined fiscal remuneration for completed sampling. Cost share with farmer. Farmer to provide checklist indicating performance with BMPs. Test throughout growing year, in order to observe effects of fertilization throughout year. Share data with public. (25 – SYCD)**

    Farmers would subscribe for a duration with pre-determined fiscal remuneration for completed sampling. Cost share with farmer. Farmer would provide checklist indicating performance with BMPs. Testing would occur throughout growing year, in order to observe effects of fertilization throughout year. Data grossly accumulated would be shared with public without attribution to individual farmers. Anecdotal results of deep soil sampling carried out by SYCD with farmers with pre-existing relationship with SYCD were informative. Word-of-mouth reporting within farmer community greatly increased acres sampled.

25. **Streamline current regulatory enforcement activities. (25 – EPA, WSDA, and Ecology)**

    Improve customer service and protocols, increase clarity of process, escalate enforcement for facilities not following management practices, identify methods to discourage repeatedly unfounded complaints, and improve overall transparency.

26. **Analyze the trends of nitrate data contained within reports required by NPDES and SWD permits. (23 – Ecology)**
27. **Integrate use of animal waste and synthetic fertilizer. (23 – WSU and livestock producers)**

    Research chemical integration of animal manure~~waste~~ and synthetic fertilizers with objective of balancing nutrient application amounts in order to maximize crop production and full nitrogen uptake.

28. **Create Irrigation Management Plans (similar to Nutrient Management Plans) for farms over a minimum size and provide financial assistance for implemented plans. (23 – SYCD, WSDA, and WSU Extension Service)**

    Use available techniques to determine how much and when irrigation is needed instead of irrigating according to a prearranged schedule. Analyze irrigation practices to discover whether frequency or volume creates greater propensity for leaching. Manage sprinkler systems so they do not drive nutrients past the root system. Improve micro-irrigation system design and operation. Schedule water

and nitrogen application according to the need for optimal crop yields. Monitor the timing of application of fertilizers to fields and how much water was then applied.

29. **Complete NRCS Technical Note 23 inspections on all waste storage ponds (lagoons) within the GWMA boundaries. (23 – WSDA)**
30. **Develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the GWMA as a pilot project. (23 – Ecology)**

    Educate the public regarding liability of an ill-secured well, and the importance of the integrity of wells, particularly those without a well log. Educate realtors and banking industry officials about disclosure of abandoned wells in property transfers. Compare Google Earth to GIS images to determine where building or usage changes indicate possible well usage changes. Focus first on hotspot high density areas in GWMA. Ground truth suspected problem wells. Offer incentives for property owners to identify and properly abandon wells. Offer grant funding to Yakima Health District or professional engineers for well inspections and to assist in abandoned well decommissioning. Provide some form of protection for self-reporting of abandoned or improperly decommissioned wells.

31. **Explore investment in animal and agricultural waste to energy technology. (22 – US DOE and USDA)**

    Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives).

32. **Adopt and Implement an Adaptive Management Plan. (22 – Yakima County)**

    Utilizing data collected, progress made, or lack of progress, to inform the community on adjustments that need to be implemented. Plan would incorporate necessary adjustments to availability of technology, education and outreach, tracking exports, land use regulations, treatment systems, and other changes to inform decision makers regarding management changes necessary for a successful Program.

33. **Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater. (20 – EPA and Ecology)**
34. **Determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported. (19 – DOH)**

    So that the LOSS will continue to operate as designed.

35. **Quantify the nutrient value and rate of release of nitrate from livestock waste under various Lower Yakima Valley conditions to become part of nutrient management guidelines. (19 – WSDA and WSU)**
36. **Require new developments outside towns to address potential impacts on groundwater quality. (19 – Yakima Health District)**

    Work with Yakima County Planning and Building Divisions' permit program to identify methods of permitting while reducing impacts to groundwater.

37. **Develop and implement Nutrient Management Plans for all farmers. (19 SYCD and Livestock producers)**

    Mandatory or Voluntary. Farming operations currently are not required to hold permits or prepare a Nutrient Management Plan.

38. **Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of manure and other livestock wastes. (18 – WSDA)**
39. **Encourage appropriate use of surface banding ("dribbling," "stripping" of liquid fertilizer, "broadcasting" or prompt incorporation of manures and fertilizers after application to cropland. (18 – WSDA and SYCD)**

    Broadcast is effective for corn, alfalfa, triticale. Incorporation should occur within 24 hours.

40. **Make grants and allocate cost share funding or other funding assistance to people implementing environmental protection measures affecting groundwater quality. (17 – Ecology and WSDA)**

    Assign personnel to investigate which environmental protection measures utilized by irrigated agriculturalists and livestock/dairy producers have positive influence on groundwater quality and explore means to share costs of implementing such measures. (Coordinated DOE, WSDA, Conservation District program). See NRCS Environmental Stewardship Program (2012). Also WCC, Voluntary Stewardship Program (Bill Isler), USDA Rural Community Assistance Group environmental program.

41. **Identify and support opportunities, including education research institutions for private, public and industry investment in technology and management of fertilizers and manures, including separation of solid and liquid wastes. (17 – WSDA)**

    WSDA construct GWMA administrative program.

42. **Establish time-based performance objectives against which well-monitoring data can be compared. (16 – Ecology and DOH)**

    E.g., number of at risk wells, BMP implementation, funding success, reduction in number of underperforming farming practices. Use both method-based measurement and performance-based measurement.

43. **Require new developments to address potential impacts on groundwater quality. Limit new development utilizing septic system where soil filtration rate is high, where housing density is already big, where nitrate concentration is already great downstream of the septic plume. Consider the nitrate density element (# of systems per-area) when approving proposed septic systems in order to reduce the nutrient nitrogen in domestic wastewater discharged from OSS. (15 – Yakima County)**

    Recommendations for conditions on issuance of building permits. Determine "density" evaluation criteria. Including those technologies verified by the U.S. EPA's Environmental Technology Verification Program: fixed film trickling filter biological treatment, media filter biological treatment, and submerged attached-growth biological treatment. Recommend use of anaerobic digestion in waste storage lagoons as a BMP.

44. **Perform an engineering study of water supply alternatives. (14 – Yakima County)**

    Possible alternatives: 1) Discontinue use of contaminated shallow wells. Build new 1,500-foot community wells. 2) Rebuild, repair, or replace poorly constructed wells. 3) Construct a potable water line from nearby developed area into deadhead water stations at central rural location (permit potable water collection at deadhead water stations). 4) Offer incentives to drill deeper wells or connect households on private wells near community water systems to connect to a community water system (Nitrate Treatment Pilot Program – June 2011).

45. **Review applications for and issue exemptions for agricultural composting operations in a manner that protects public health and the environment, as required by state rules and regulations. (12 – Ecology)**

46. **Provide funding for municipalities to replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching. (11 – Municipalities)**

    Municipalities need to estimate costs and system integration.

47. **Develop an urban and hobby agriculturalist education and outreach campaign. (10 – Yakima County)**

    Provide information targeted to small farm/hobby farm/ranchettes about manure management. Publish and distribute homeowner guides on proper septic system construction, operation, and maintenance. Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations. Recommend against farming around a water well.

48. **Contract with USGS to do particle tracking model study to indicate where groundwater moves faster (permeability). (9 – Yakima County)**

    USGS Particle Tracking Model Overview – potentially combined with MT3D MODFLOW application to the vadose Zone.

49. **Amend the Dairy Nutrient Management Act to extend WSDA's authority to manure application on properties other than those owned by dairies, provide more complete disclosure of Nutrient Management Plans. (8 – WSDA)**
50. **Provide assistance to local departments of health regarding the regulation of agricultural composting operations. (7 – Ecology)**
51. **Document and publish regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP). (7 – WSDA)**

    Explore the possibility of disclosing non-proprietary data produced through the DNMP process. Summarize the DNMP reporting and provide information that would disclose the amount of manure the CAFO's in the GWMA create and where it is distributed.

52. **Assess Nitrogen Loading. Building from the WSDA's Nitrogen Availability Assessment, develop a Nitrogen Loading Assessment for all agricultural, residential and commercial properties, using newly collected data. (5 – WSDA, Ecology and Yakima County)**

    Hire a technical consultant to conduct a literature review to determine the most relevant information and accurate factors for use in the Nitrogen Loading Assessment. Periodically repeat the grower survey used in the NAA to compare against currently established data. Collect data on how many acres in the GWMA are fertilized in various crops with manure and/or commercial fertilizer. Update and monitor the percentage of acreage in various crops, particularly silage corn and field corn. Study effect nitrogen contribution from cover crops. Determine acreage for triticale. Discover commercial fertilizer tonnage for Yakima County

and/or for GWMA. Explore how much nitrogen leaches into groundwater from drains and wasteways. Study atmospheric deposition more comprehensively. Understand the difference between plant uptake and plant removal of nitrogen. Ask EPA to use its CMAQ model, or other tools, to estimate emissions of reactive nitrogen - gaseous nitrogen oxides (NOx), ammonia (NH3), nitrous oxide (N2O), the anion nitrate, NO3,- from animal agriculture, manure and fertilizer applications. Use this to inform the nitrogen balance database and refine estimates of atmospheric deposition.

53. **Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, per WAC 173.350.040. (4 – Yakima Health District)**

54. **Make capital improvements. (2 – Livestock producers)**

    Install liners in liquid manure~~waste~~ storage lagoons. Install impervious surfaces beneath silage storage.

55. **Inspect, monitor, and regulate stockpiled manures. (1 – Ecology)**

    Coordinate with WSDA. Currently being done; currently required as part of dairy nutrient management plans.

Draft Recommendations:

(Obtaining a Total Value of Zero or Less)

56. **Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits. (0 – Washington State Legislature)**

    In the nature of Phase I Environmental Audits. Make nitrate-related information/data available for water quality management.

57. **Revise WAC 246-203-130 (keeping of animals) (-1 – DOH)**

    So that it includes specific and enforceable requirements designed to protect health.

58. **Require facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume. (-3 – Ecology)**

Addressed by Department of Ecology General Permit for Food Processing, specific problems can be addressed through "special protection areas," WAC 173-200-090.

59. **Improve composting regulations (statutory) (-4 – Ecology, WSDA)**

    Unclear as to particular regulations proposed.

60. **Establish a monitoring system for compliance with NRCS Standard 317 on new composting facilities at Washington dairies (phased in for existing facilities). (-4 – WSDA)**
61. **Develop educational materials that could be elected by instructors at 8-12 levels about aquifer protection, groundwater and BMP. (-6 – WA Superintendent of Public Instruction and Educational Service District 105)**
62. **Require commodity commissions to dedicate "check off" money for research and development in water quality technology and practices. (-7 – Washington State Legislature)**
63. **Estimate emissions of reactive nitrogen – gaseous nitrogen oxides (NO_x), ammonia (NH_3), nitrous oxide (N_2O), the anion nitrate (NO_3) – from animal agriculture, manure and fertilizer applications in the Lower Yakima Valley. (-33 – Ecology, Yakima Clean Air Agency, and WSDA)**

    Use this to inform the nitrogen balance database for the GWMA area and refine estimates of atmospheric deposition.

64. **Study the relationship between nitrogen emissions and atmospheric deposition of reactive nitrogen. (-37 – Ecology and EPA)**

    Develop a model that predicts what percentage of emissions return to the GWMA area as atmospheric deposition.

Implementation Work Plans

This program is the plan for ~~implantation~~implementation. There are many aspects of the plan, including alternative management strategies as presented in the recommendations section. This follows the recommended general framework guidelines listed in WAC 173-100-100. A comprehensive list of alternative management strategies are contained in Appendix I. Additionally, the recommendations received during public comment of this program are contained in Appendix K.

Formatted: List Paragraph,GW List Paragraph, Line spacing: Multiple 1.15 li, Pattern: Clear (White)

Parties Responsible for Implementation of the Recommended Actions

The parties responsible for implementation of the recommended actions include:

- Yakima County
- Washington State Department of Ecology
- Washington State Department of Agriculture
- Washington State Department of Health
- Washington State Conservation Commission
- South Yakima Conservation District
- Washington State University Extension Service
- Agricultural Producers
- Roza-Sunnyside Joint Board of Control
- Yakima Health District

Formatted: Space After: 0 pt, Line spacing: Double

The Lower Yakima Valley Groundwater Management Program is intended to provide a framework to assist cooperation between affected agencies and private citizens through implementation of adopted management strategies.

~~This program is the plan for implantation. There are many aspects of the plan, including alternative management strategies as presented in the recommendations section. This follows the recommended general framework guidelines listed in WAC 173-100-100.~~

Formatted: Normal,GW Normal, Indent: Left: 0.25", Line spacing: single, No bullets or numbering

Formatted: Font: Font color: Black

Formatted: Normal,GW Normal, No bullets or numbering

Management Committee~~Yakima County as "Lead Agency"~~

While permanent funding sources are secured, a facilitation team should be formed to begin water protection activities in the GWMA. Representation should consist of a core committee of 6-8 members representing entities identified as responsible for implementation: Yakima County, Yakima Health District, Department of Health, Department of Agriculture, South Yakima Conservation District, Irrigation Districts, WSU Extension, Agricultural Producers, and Department of Ecology.

The team will identify the management structure best suited to meet the long-term goals of the implementation plan.
The final structure may include one of the following:
1) Lead Agency with full responsibility to implement;
2) A single agency acting as a Program facilitator (responsible for promoting communications between the agencies); or
3) Joint leadership committee comprised of the agencies authorized to carry out specific measures called out in the program.

Formatted: Space After: 0 pt, Line spacing: single

The facilitation team should develop a set of roles and responsibilities in implementing, tracking the implementation, and periodic review of the Program as required in the WAC. Periodic review of the need to update should begin 5 years after certification. ~~The GWAC recommended by a vote of 14-1, 1 abstention, 1 not voting, at the May 17, 2018 meeting that Yakima County act as "lead agency" in future Lower Yakima Valley groundwater management programs. The County's activity as lead agency is subject to available funding.~~

Implementation Functions

Formatted: Heading 2,GW Heading 2, Line spacing: s

~~As the Lower Yakima Groundwater Management Area's Lead Agency, Yakima County may~~ The Implementation committee may perform any of the following functions:

- Seek and administer funding for the accomplishment of recommendations made by the final GWMA Program.
- Encourage local, state and federal agencies to perform those activities recommended by the final GWMA Program.
- Maintain the GWMA website including the developed GIS database on the GWMA.
- Participate in educational activities in partnership with other appropriate agencies in a manner consistent with GWMA recommendations.

- ~~Install ambient groundwater monitoring wells and arrange~~ Collect water quality data from the ambient groundwater monitoring wells installed in 2018~~for data collection from those wells~~.
- Collect data to track water quality improvement progress and nutrients generated, applied, or exported within the GWMA.
- Describe the characteristics of groundwater.
- Analyze nitrogen availability periodically, at least equivalent to WSDA (2018), in order to compare and contrast changes over time.
- When appropriate, call upon citizen involvement in decision making.
- Report at least triennially on the status of groundwater quality within the GWMA.
- Recommend strategies to mitigate adverse effects to groundwater quality within the GWMA.
- Develop and implement an Adaptive Management Plan within the GWMA.

Schedule For Implementation Of The Recommended Actions

Those recommendations based upon the implementation of Best Management Practices by agricultural producers should begin immediately.

Those recommended actions that depend upon the availability of public funding will likely require one to two years lead time to secure that funding prior to their implementation.

Those recommended actions that collect data over time, including the proposed Ambient Water Quality Monitoring Well Program, or voluntary Deep Soil Sampling Program, will be implemented over time.

These recommended actions and the program plan will be periodically reviewed.

Monitoring System For Evaluation Of Effectiveness Of Recommended Action

The Ambient Water Quality Monitoring System is ~~intended to be~~ comprised of ~~between 20 to~~ 31~~0~~ randomly placed, water table elevation groundwater quality monitoring wells. Data from these wells will be collected sufficiently often to track seasonal variation and general water quality over time.

References

Alt, D.D. (2001). *Glacial Lake Missoula and Its Humongous Floods.* Mountain Press Publishing Co., Missoula, MT.

Alt, D.D., and Hyndman, D.W. (2007). *Roadside Geology of Washington.* Mountain Press Publishing Co., Missoula, MT.

Anderson, H.W. Jr. (1987). Effects of Agriculture on Quality of Water in Surficial Sand-Plain Aquifers in Douglas, Kandiyohi, Pope, and Stearns Counties, Minnesota. U.S. Geological Survey Water-Resources Investigations Report 87–4040, p. 45. https://pubs.usgs.gov/wri/1987/4040/report.pdf.

Armstrong, S., Aulbach, C., Becenti, T.L., Campbell, N.P., Crane, S., Hendry, J., Jennings, J., Kandle, E., Ray, R., and Repasky, T.R. (1995). A Multi-Disciplinary Study of Groundwater in Toppenish Creek Basin, Yakama Indian Reservation: The 1st Symposium on the Hydrology of Washington State. Abstracts, August 28–30, 1995, Olympia, Washington, pp. 136–137.

ATSDR, (2017). Toxicological Profile for Nitrate and Nitrite. U.S. Dept. of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. July.

Avery AA, (1999). Infantile methemoglobinemia: reexamining the role of drinking water nitrates. Environmental Health Perspectives 107(7): 583-586.

Beck, B.F., Asmussen, L., and Leonard, R. (1985). Relationship of Geology, Physiography, Agricultural Land Use, and Ground-Water Quality in Southwest Georgia, September 1985. https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1745-6584.1985.tb01511.x.

Beeson, M.H., and Tolan, T.L. (1990). The Columbia River Basalt Group in the Cascade Range: A middle Miocene reference datum for structural analysis. *Journal of Geophysical Research* 95: 19547–19559.

Benton County, Board of County Commissioners. (2013). Letter of request to withdraw from the Lower Yakima Valley Groundwater Management Area. April 9, 2013. http://www.yakimacounty.us/DocumentCenter/View/15961.

Bjornstad, B. (2006). *On the Trail of the Ice Age Floods: A Geological Guide to the Mid-Columbia Basin.* Keokee Books, Sandpoint, ID.

Boening, R.M. (1919). History of irrigation in the state of Washington: The state epoch of canal building. *The Washington Historical Quarterly* 10(1) (Jan. 1919): 21–45. http://www.jstor.org/stable/23908750.

Formatted: No underline
Formatted: No underline
Field Code Changed
Formatted: No underline
Field Code Changed
Formatted: No underline
Formatted: No underline
Formatted: No underline
Field Code Changed

Carson, R.J., and Pogue, K.R. (1996). Flood Basalts and Glacier Floods: Roadside Geology of Parts of Walla Walla, Franklin, and Columbia Counties, Washington. Washington Division of Geology and Earth Resources Information Circular 90. Washington State Department of Natural Resources, Olympia. http://www.dnr.wa.gov/publications/ger_ic90_roadside_floodbasalts_glacierfloods.pdf.

Clark, G.M., Mueller, D.K., and Mast, M.A. (2000). Nutrient concentrations and yields in undeveloped stream basins of the United States. *Journal of the American Water Resources Association* 36(4): 849–860.

Coffin, C., Plotnikoff, R., and Anderson, R. (2006). Lower Yakima River Suspended Sediment Total Maximum Daily Load Study: Water Quality Effectiveness Monitoring Report. Publication 06-03-014. Washington State Department of Ecology, Olympia. https://fortress.wa.gov/ecy/publications/documents/0603014.pdf.

Crowe, L. (2014). Personal communication, South Yakima Conservation District, February 2014.

Dalgaard, T., Hansen, B., Hasler, B., Hertel, O., Hutchings, N., Jacobsen, B., Jensen, L., Kronvang, B., Olesen, J., Schjorring, J., Kristensen, I., Graversgaard, M., Termansen, M., and Vejre, H. (2014). Policies for agricultural nitrogen management – trends, challenges, and prospects for improved efficiency in Denmark. *Environmental Research Letters*, 9(11): 1–16.

De Fraiture, C., Molden, D., and Wichelns, D. (2010). Investing in water for food, ecosystems, and livelihoods: An overview of the comprehensive assessment of water management in agriculture. *Agricultural Water Management* 97: 495–501.

Domagalski, J.L., Ator, S., Coupe, R., McCarthy, K., Lampe, D., Sandstrom, M., and Baker, N. (2008). Comparative study of transport processes of nitrogen, phosphorus, and herbicides to streams in five agricultural basins, USA. *Journal of Environmental Quality* 37: 1158–1169. https://doi.org/10.2134/jeq2007.0408.

Domagalski, J.L., and Johnson, H.M. (2011). Subsurface transport of orthophosphate in five agricultural watersheds, USA. *Journal of Hydrology* 409: 157–171.

Domagalski, J.L., and Johnson, H. (2012). Phosphorus and Groundwater: Establishing Links Between Agricultural Use and Transport to Streams. U.S. Geological Survey Fact Sheet 2012–3004. https://pubs.usgs.gov/fs/2012/3004.

Drennan, M. (2013) Agricultural History of Yakima County. Olympia, WA, 45 pgs. http://www.yakimacounty.us/DocumentCenter/View/2375.

Formatted: Not Highlight

Formatted: Not Highlight

Driscoll, F. (1986). *Groundwater and Wells* (Second Edition). St. Paul, MN.

Duff, J.H., Tesoriero, A.J., and Richardson, W.B. (2008). Whole-stream response to nitrate loading in three streams draining agricultural landscapes. *Journal of Environmental Quality* 37: 1133–1144.

Dyer, K.L. (1965). Interpretation of chloride and nitrate ion distribution patterns in adjacent irrigated and nonirrigated panoche soils. *Soil Science Society of America Proceedings* 29: 170–176.

Ebbert, J.C., and Kim, M.H. (1998). Relation between irrigation method, sediment yields, and losses of pesticides and nitrogen. *Journal of Environmental Quality* 27: 372–380.

Ecology (Washington State Department of Ecology). (1985). Water in the Lower Yakima River Basin, Washington. Publication WSB 53. [By Molenaar, D.] Washington State Department of Ecology, prepared in cooperation with the U.S. Geological Survey, *Water Supply Bulletin* 53.

Ecology (Washington State Department of Ecology). (1996). A Report on Nitrate Contamination of Ground Water in the Mid-Columbia Basin. Report 96-14. [By Cook, K., Faulconer, L., and Jennings, D.] Washington State Department of Ecology, Olympia.

Ecology (Washington State Department of Ecology). (1997). Suspended Sediment and DDT Total Maximum Daily Load Evaluation Report for the Yakima River. Publication 97-321. [By Joy, J. and Patterson, B.A.] Washington State Department of Ecology, Olympia. https://fortress.wa.gov/ecy/publications/documents/97321.pdf.

Ecology (Washington State Department of Ecology). (2005). Implementation Guidance for the Ground Water Quality Standards. Publication 96-02, revised October. [By Kimsey, M.] Washington State Department of Ecology, Olympia. https://fortress.wa.gov/ecy/publications/documents/9602.pdf.

Ecology (Washington State Department of Ecology). (2010). Lower Yakima Valley Groundwater Quality: Preliminary Assessment and Recommendations Document. Ecology Publication 10-10-009. Prepared by Washington State Department of Ecology, Washington State Department of Agriculture, Washington State Department of Health, Yakima County Public Works Department, and U.S. Environmental Protection Agency. https://fortress.wa.gov/ecy/publications/documents/1010009.pdf.

Ecology (Washington State Department of Ecology). (2011). Order Designating the Lower Yakima Valley Groundwater Management Area. Administrative Order 8861, November 15, 2011. http://www.yakimacounty.us/DocumentCenter/View/15881.

Ecology (Washington State Department of Ecology). (2013). Letter accepting Benton County's request to withdraw from the Lower Yakima Valley Groundwater Management

Area. June 7, 2013.
http://www.yakimacounty.us/DocumentCenter/View/15962.

Ecology (Washington State Department of Ecology). (2017). Concentrated Animal Feeding Operation National Pollutant Discharge Elimination System and State Waste Discharge General Permit. https://ecology.wa.gov/DOE/files/c8/c8a7577c-059a-4816-84ef-143e8faa5134.pdf.

EPA (U.S. Environmental Protection Agency). (1977). Environmental Effects of Septic Tank Systems. EPA-600-3-77-096. https://nepis.epa.gov/Exe/ZyPDF.cgi/9100T3XP.PDF?Dockey=9100T3XP.PDF.

EPA (U.S. Environmental Protection Agency). (1999). Preliminary Data Summary: Feedlots Point Source Category Study. EPA-821-R-990-0022.

EPA (U.S. Environmental Protection Agency). (2001). Environmental Assessment of Proposed Revisions to the National Pollutant Discharge Elimination System Regulation and the Effluent Guidelines for Concentrated Animal Feeding Operations. EPA-821-B-01-001. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. Page 21.

EPA (U.S. Environmental Protection Agency). (2002). Onsite Wastewater Treatment Systems Manual. EPA-625-R-000-08. U.S. Environmental Protection Agency, Office of Water, Office of Research and Development, Washington, D.C. https://nepis.epa.gov/Exe/ZyPDF.cgi/30004GXI.PDF?Dockey=30004GXI.PDF.

EPA (U.S. Environmental Protection Agency). (2004). Risk Assessment Evaluation for Concentrated Animal Feeding Operations. EPA-600-R-040-42. U.S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. https://nepis.epa.gov/Exe/ZyPDF.cgi/901V0100.PDF?Dockey=901V0100.PDF.

EPA (U.S. Environmental Protection Agency). (2009). Livestock Manure Management, pg. 52. http://www.epa.gov/outreach/reports/05manure.pdf.

~~EPA (U.S. Environmental Protection Agency). (2010). Washington State Department of Agriculture, Washington State Department of Ecology, Washington State Department of Health, Yakima County Department of Public Works, "Lower Yakima Valley Groundwater Quality, Preliminary Assessment and Recommendations Document," Ecology Publication 10-10-009.~~

EPA (U.S. Environmental Protection Agency) (2011). EPA Region 9, Animal waste – What's the Problem? Page 1. http://www.epa.gov/region9/animalwaste/problem.html. Accessed January 2011.

EPA (U.S. Environmental Protection Agency). (2013). Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington. EPA-910-R-12-004. https://www.epa.gov/sites/production/files/2017-12/documents/lower-yakima-valley-groundwater-report-2013.pdf.

Formatted: Line spacing: Multiple 1.08 li

Executive Order 12898. (1994). Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations. 59 Fed. Reg. 7629 (Feb. 16, 1994). https://www.archives.gov/files/federal-register/executive-orders/pdf/12898.pdf.

Exner, M., Hirsh, A., and Spalding, R. (2014). Nebraska's groundwater legacy: nitrate contamination beneath irrigated cropland. *Water Resources Research* 50: 4474–4489.

Foster, D.R. (1992). Land-use history (1730–1990) and vegetation dynamics in central New England, U.S.A. *Journal of Ecology* 80: 753–772.

GEFM (Group of Environmental Fluid Mechanics) (2018). "Hyporheic Flow." Accessed August 29, 2018. http://www.envirofluidgroup.it/it/ricerca/132-hyporeic-flow.html.

Glover, J.E., and Zimmer, D.W. (1980). Status of Water Quality in the Yakima Basin from 1976 to 1979. USDI Water and Power Resources Service, Pacific Northwest Region, Boise, ID.

Green, C.T., Fisher, L.H., and Bekins, B.A. (2008). Nitrogen fluxes through unsaturated zones in five agricultural settings across the United States. *Journal of Environmental Quality* 37: 1073–1085.

GSI (GSI Water Solutions, Inc.). (2009a). Geologic Framework of Selected Sedimentary and Columbia River Basalt Group Units in the Columbia Basin Ground Water Management Area of Adams, Franklin, Grant, and Lincoln Counties, Washington, Edition 3. Consultant report prepared for the Columbia Basin Ground Water Management Area of Adams, Franklin, Grant, and Lincoln Counties, prepared by GSI Water Solutions, Inc. and the Franklin County Conservation District, June 2009.

GSI (GSI Water Solutions, Inc.). (2009b). Groundwater Level Declines in the Columbia River Basalt Group and Their Relationship to Mechanisms for Groundwater Recharge: A Conceptual Groundwater System Model. Columbia Basin Ground Water Management Area of Adams, Franklin, Grant, and Lincoln Counties. Prepared for the Columbia Basin Ground Water Management Area of Adams, Franklin, Grant, and Lincoln Counties, prepared by GSI Water Solutions, Inc., Kennewick, Washington, June 2009. https://fortress.wa.gov/ecy/publications/documents/1503201.pdf.

GSI (GSI Water Solutions, Inc.). (2011). Geologic Framework of Selected Sedimentary and Columbia River Basalt Group Units in the Columbia Basin Ground Water Management Area of Adams, Franklin, Grant, and Lincoln Counties, Washington, Edition 4. Consultant report prepared for the Columbia Basin Ground Water Management Area of Adams, Franklin, Grant, and Lincoln Counties, prepared by GSI Water Solutions, Inc. and the Franklin County Conservation District, June 2011.

Ham, J.M., Reddi, L.N., and Rice, C.W. (1999). Animal Waste Lagoon Water Quality Study: A Research Report by Kansas State University. https://www.bookstore.ksre.ksu.edu/pubs/LAGOON.pdf.

Ham, J.M., and DeSutter, T.M. (1999). Seepage losses and nitrogen export from swine-waste lagoons: A water balance study. *Journal of Environmental Quality* 28: 1090–1099.

Ham, J.M. and DeSutter, T.M. (2000). Toward site specific design standards for animal waste lagoons: Protecting groundwater quality. *Journal of Environmental Quality* 29: 1721–1732.

Ham, J.M. (2002). Seepage losses from animal waste lagoons: A summary of a four-year investigation in Kansas. *Transactions of the American Society of Agricultural Engineers* 45: 983–992.

Harter, T., Davis, H., Mathews, M.C., and Meyer, R.D. (2002). Shallow groundwater quality on dairy farms with irrigated forage crops. *Journal of Contaminant Hydrology* 55: 287–315.

Harter, T. (2009). Agricultural impacts on groundwater nitrate. *Southwest Hydrology* July/Aug.: 22+. http://www.swhydro.arizona.edu/archive/V8_N4/feature2.pdf.

Harter, T., and Lund, J.R. (2012a). Technical report 1: Project and technical report outline. In *Addressing Nitrate in California's Drinking Water, with a Focus on Tulare Lake Basin and Salinas Valley Groundwater.* Report for the State Water Resources Control Board Report to the Legislature. Center for Watershed Sciences, University of California, Davis. http://groundwaternitrate.ucdavis.edu/files/139111.pdf.

Harter, T., and Lund, J.R. (2012b). Project and Technical Report Outline, Technical Report 1, Addressing Nitrate in California's Drinking Water.

HDR (HDR Engineering). (2013a). Consolidated Comments to HDR's Draft Technical Memorandum No. 1—Nitrate Regulatory Review, August 5, 2013. Comments on Regulatory Framework and Authority—LYV-GWMA. ~~https://www.yakimacounty.us/DocumentCenter/View/17681/20130805-HDR-Comments-to-Reg-Review~~.

HDR (HDR Engineering). (2013b). Lower Yakima Valley Nitrate Regulatory Framework and BMPs. Technical Memorandum #1: Scope 1, Task 2–Regulatory Review. August 27, 2013. https://www.yakimacounty.us/DocumentCenter/View/17683/20130827-HDR-Memo-Reg-Review.

HDR (HDR Engineering). (2013c). Draft Initial Best Management Practices Database Summary. August 30, 2013.

https://www.yakimacounty.us/DocumentCenter/View/17684/20130830-HDR-Draft-Initial-BMP-Database-Summary.

Heath, R., (1983). Basic Ground-Water Hydrology. US Geological Survey Water Supply Paper 2220, Alexandria, Virginia, 84 pgs.

Hirsch, R., Alexander, R., and Smith, R. (1991). Selection of methods for the detection and estimation of trends in water quality. *Water Resources Research* 27(5): 803–813.

Hodne, C. (2005). Concentrating on Clean Water: The Challenge of Concentrated Animal Feeding Operations. A report for the Iowa Policy Project, Mount Vernon, Iowa. http://www.iowapolicyproject.org/2005docs/050406-cafo-fullx.pdf.

Jensen, C.A., and Olshausen, B.A. (1901). Soil Survey of the Yakima Area, Washington. Natural Resources Conservation Service, U.S. Department of Agriculture. https://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/washington/yakimaWA1901/yakimaWA1901.pdf.

Kellogg, R., Lander, C., Moffitt, D., and Gollehon, N., (2000). Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients: Spatial and Temporal Trends for the United States. USDA, NRCS, publication numger nps00-0579, 140 pgs.https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012133.pdf

Killpack, S., and Buchholz, D. (1993). Nitrogen Cycle. Pub WQ 252. University of Missouri Extension, Department of Agronomy, Columbia, MO. http://extension.missouri.edu/publications/displayprinterfriendlypub.aspx?p=wq252.

Koelliker, J.K., Steichen, J.M., Yearout, R.D., Heiman, A.T., and Grosh, D.L. (1987). Identification of Factors Affecting Farmstead Well Water Quality in Kansas. Report G1226-02. Kansas Water Resources Research Institute, Kansas State University, Manhattan, KS.

Knobeloch L, Salna B, Hogan A, Postle J, Anderson H, (2000). Blue babies and nitrate-contaminated well water. Environmental Health Perspective 108(7): 675-678

Krider, J.N. (1987). Assessing animal waste systems impacts on groundwater: Occurrences and potential problems. P. 123 *in* Frank M. D'Itri and Lois G. Wolfson (eds.), *Rural Groundwater Contamination*. Lewis Publishers, Chelsea, MI. [Cites National Academy of Sciences, Subcommittee on Nutrients and Toxic Elements in Water, "Nutrients and Toxic Substances in Water for Livestock and Poultry" (1974); and NAS Safe Drinking Water Committee, "Drinking Water and Health" (1977).]

Kross, B.C., Hallberg, G.R., Bruner, D.R., Cherryholmes, K., and Johnson, J.K. (1993). The nitrate contamination of private well water in Iowa. *American Journal of Public Health* 83(2):

270–272.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1694569/pdf/amjph00526-0112.pdf.

Libra, R.D., Hallberg, G.R., Ressmeyer, G.R., and Hoyer, B.E. (1984). Groundwater Quality and Hydrogeology of Devonian-Carbonate Aquifers in Floyd and Mitchell Counties, Iowa. Iowa Geological Survey, Iowa City.
https://s-iihr34.iihr.uiowa.edu/publications/uploads/OFR-1984-2.pdf.

Mackin, J.H. (1961). A Stratigraphic Section in the Yakima Basalt and the Ellensburg Formation in South-Central Washington. Report of Investigations No. 19. Washington Division of Mines and Geology, Department of Conservation, Olympia.
http://www.dnr.wa.gov/Publications/ger_ri19_strat_yakima_basalt_ellensburg_form.pdf.

McCaffrey, R., King, R.W., Wells, R., Lancaster, M., and Miller, M.M. (2016). Contemporary deformation in the Yakima fold and thrust belt estimated with GPS. *Geophysical Journal International* 207(1): 1–11.
https://doi.org/10.1093/gji/ggw252.

McCarthy, K.A., and Johnson, H.M. (2009). Effect of Agricultural Practices on Hydrology and Water Chemistry in a Small Irrigated Catchment, Yakima River Basin, Washington. U.S. Geological Survey Scientific Investigations Report 2009-5030. U.S. Geological Survey, Reston, VA.

McCurdy, M., and McSweeney, K. (1993). The origin and identification of macropores in an earthen-lined dairy manure storage basin. *Journal of Environmental Quality* 22: 148–154.

McDowel, S., and Biggers, A. (2017). What is methemoglobinemia? *Healthline*. Accessed August 30, 2018.
https://www.healthline.com/health/methemoglobinemia.

McNab, W.W., Singleton, M.J., Moran, J.E., and Esser, B.K. (2007). Assessing the impact of animal waste lagoon seepage on the geochemistry of an underlying shallow aquifer. *Environonmental Science & Technololgy* 41(3): 753–758.

Meals, D., and Dressing, S., 2010. Lag Time in Water Quality Response to Best Management Practices: A Review. Journal of Environmental Quality, 39:85-96.

NOAA (National Oceanic Atmospheric Administration). (2018~~n.d.~~). Local climatological data publications. National Centers for Environmental Information. Accessed August 30, 2018.
https://www.ncdc.noaa.gov/IPS/lcd/lcd.html?_page=0&state=WA&_target1=Next+%3E.

NRCS Soil Survey. (2018~~n.d.~~). Web Soil Survey. Natural Resources Conservation Service, U.S. Department of Agriculture. Accessed January 30, 2018.
https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

O'Leary, M., Rehm, G., and Schmitt, M. (2002). Understanding Nitrogen in Soils. Pub. WW-03770-GO. University of Minnesota Extension Service, St. Paul.

OEHHA, (2018). Public Health Goal, Nitrate and Nitrite in Drinking Water. Pesticide and Environmental Toxicology Branch, Office of Environmental Health Hazard Assessment, California Environmental Protection Agency. May.

PGG (Pacific Groundwater Group). (2011). Request for Identification: Lower Yakima Valley Groundwater Management Area. Prepared for Yakima County, Yakima, Washington, by Pacific Groundwater Group, Seattle. http://www.yakimacounty.us/DocumentCenter/View/2359.

PGG (Pacific Groundwater Group). (2013a). Yakima County Consultant Agreement with HDR Engineering and Pacific Groundwater Group, June 25, 2013. Yakima County, Yakima, Washington. https://www.yakimacounty.us/DocumentCenter/View/17680/20130625-HDR-Consultant-Agreement.

PGG (Pacific Groundwater Group). (2013b). Technical Memorandum: Considerations for Further Scoping of Deep Soil Sampling (DSS), Lower Yakima Valley GWMA. Memo from Pony Ellingson and Stephen Swope, to Don Gatchalian (Yakima County), August 6, 2013. Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17682/20130806-PGG-Memo-DSS-Scoping.

~~PGG (Pacific Groundwater Group). (2013c). Draft Deep Soil Sampling Plan, Lower Yakima Valley Groundwater Management Area (with comments). Prepared for Lower Yakima Valley GWMA, Yakima County, by Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17685/20130902-PGG-DSS-Plan-Version-0.~~

PGG (Pacific Groundwater Group). (2013d). Groundwater Monitoring, Quality Assurance/Quality Control Plan: Lower Yakima Valley GWMA, Initial Characterization. JE 1308. Prepared for Yakima County, Washington, by Pacific Groundwater Group, Seattle, September 16, 2013. http://www.yakimacounty.us/DocumentCenter/View/15880.

~~PGG (Pacific Groundwater Group). (2013e). Draft Deep Soil Sampling Plan, Lower Yakima Valley Groundwater Management Area. Prepared for Lower Yakima Valley GWMA, Yakima County, by Irrigated Agriculture Working Group. https://www.yakimacounty.us/DocumentCenter/View/17687/20131003-PGG-DSS-Plan-Version-1.~~

PGG (Pacific Groundwater Group). (2013f). Technical Memorandum: Calculations to Allocate Soil Samples in 2014—Revision 1. Memo from Pony Ellingson, PGG, to Laurie Crowe and Jim Trull, November 25, 2013. Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17688/20131125-PGG-Memo-Soil-Sample-Allocations.

PGG (Pacific Groundwater Group). (2013g). Potential Groundwater Monitoring Stations, Yakima Groundwater Management Area. Prepared for HDR Inc., Yakima County, and Lower Yakima Valley Groundwater Advisory Committee, by Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17689/20131203-PGG-Potential-Monitoring-Well-Locations.

Formatted: Line spacing: Multiple 1.08 li

PGG (Pacific Groundwater Group). (2014a). Potential Groundwater Monitoring Stations, Response to Comments. Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17690/201403-PGG-Response-To-Comments.

PGG (Pacific Groundwater Group). (2014b). Potential Groundwater Monitoring Stations, Response to Comments PowerPoint Presentation. Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17691/20140320-PGG-Response-To-Comments-on-March-6-Presentation.

PGG (Pacific Groundwater Group). (2014c). Deep Soil Sampling Plan, Lower Yakima Valley Groundwater Management Area. Prepared for Yakima County, by Irrigated Agriculture Working Group. https://www.yakimacounty.us/DocumentCenter/View/17692/20140328-PGG-DSS-Plan-Version-6.

PGG (Pacific Groundwater Group). (2014d). Draft Groundwater Monitoring Plan, Yakima Groundwater Management Area, Response to Comments June 2014. https://www.yakimacounty.us/DocumentCenter/View/17693/201406-PGG-Response-To-Comments.

PGG (Pacific Groundwater Group). (2014e). Interim Final Groundwater Monitoring Plan, Lower Yakima Valley GWMA, Initial Characterization. JE 1308. Prepared for Lower Yakima Valley Groundwater Advisory Committee and Yakima County, by Pacific Groundwater Group, Seattle, August 15, 2014. http://www.yakimacounty.us/DocumentCenter/View/13277.

PGG (Pacific Groundwater Group). (2015). Yakima County Consultant Agreement for Professional Services with Pacific Groundwater Group, December 8, 2015. Yakima County, Yakima, Washington. https://www.yakimacounty.us/DocumentCenter/View/17696/20151123-PGG-Consultant-Agreement.

PGG (Pacific Groundwater Group). (2016a). Technical Memorandum: Draft Ambient Groundwater Monitoring Network Location Selection Method. Memo from Stephen Swope and Pony Ellingson (PGG) to Yakima GWMA Data Committee, March 18, 2016. https://www.yakimacounty.us/DocumentCenter/View/17697/20160318-PGG-Memo-Network-Location-Selection.

PGG (Pacific Groundwater Group). (2016b). Draft Technical Memorandum: Proposed Groundwater Monitoring Locations from Irrigation Drains, Lower Yakima Valley GWMA. Memo from Glenn Mutti-Driscoll, Steve Swope, and Charles Ellingson (PGG) to Lower Yakima Valley GWMA Data Committee, April 12, 2016. https://www.yakimacounty.us/DocumentCenter/View/17698/20160412-PGG-Memo-Proposed-Drain-Monitoring-Locations.

PGG (Pacific Groundwater Group). (2016c). Lower Yakima Valley GWMA Proposed Ambient Groundwater Monitoring Network. Prepared for Lower Yakima Valley Groundwater Advisory Committee and Yakima County, by Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17700/20160608-PGG-Ambient-Monitoring-Network-Report-Final-for-Approval-approved-11-2016.

PGG (Pacific Groundwater Group). (2016d). Lower Yakima Valley GWMA Proposed Ambient Groundwater Monitoring Network Attachments. Prepared for Lower Yakima Valley Groundwater Advisory Committee and Yakima County, by Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17699/20160608-PGG-Ambient-Monitoring-Network-Report-Attachments.

PGG (Pacific Groundwater Group). (2018a). Yakima County Consultant Agreement for Professional Services with Pacific Groundwater Group, January 9, 2018. Yakima County, Yakima, Washington. https://www.yakimacounty.us/DocumentCenter/View/17702/20180109-PGG-Contract-for-Ambient-Monitoring-Wells.

PGG (Pacific Groundwater Group). (2018b). Technical Specification: Groundwater Monitoring Wells, Yakima County. Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17726/20180216-PGG-Draft-Drill-SpecsYakima-V4.

~~PGG (Pacific Groundwater Group). (2018c). Preliminary Drill Sites and Field Locations. February 13, 2018. https://www.yakimacounty.us/DocumentCenter/View/17703/20180213-PGG-YakimaGWMA_Field_Locations_v20180213.~~

~~PGG (Pacific Groundwater Group). (2018d). Preliminary Drill Sites and Field Locations. February 15, 2018. https://www.yakimacounty.us/DocumentCenter/View/17705/20180215-PGG-YakimaGWMA_Field_Locations_v20180215.~~

PGG (Pacific Groundwater Group). (2018e). Contract Specifications for the Construction of Lower Yakima Valley GWMA Monitoring Wells. Yakima County Public Services Project FC 3463. https://www.yakimacounty.us/DocumentCenter/View/17707/20180315-PGG-Contract-Documents.

~~PGG (Pacific Groundwater Group). (2018f). Preliminary Drill Sites and Field Locations. April 5, 2018. https://www.yakimacounty.us/DocumentCenter/View/17709/20180405-PGG-YakimaGWMA_Field_Locations_v20180405.~~

~~PGG (Pacific Groundwater Group). (2018g). Yakima County Monitoring Well Installation Coordinates. April 5, 2018. https://www.yakimacounty.us/DocumentCenter/View/17708/20180405-PGG-Drill-site-coordinates-v20180405.~~

Poe, F.W. (1961). Irrigation Return Flows and Water Quality in the Yakima River Basin. Master's Thesis, University of Washington, Seattle.

Powlson, D., Addiscott, T., Benjamin, N., Cassman, K., de Kok, T., van Grinsven, H., L'Hirondel, J., Avery, A., and van Kessel, C., (2008). When Does Nitrate Become a Risk for Humans? Journal of Environmental Quality, Feb, pgs 291 – 295.

Prest, G. (2016). Statement in Regulatory Framework Work Group. Washington State Department of Agriculture.

Puckett, L.J., Zamora, C., Essaid, H., Wilson, J.T., Johnson, H.M., Brayton, M.J., and Vogel, J.R. (2008). Transport and fate of nitrate at the ground-water/surface-water interface. *Journal of Environmental Quality* 37: 1034–1050. doi: 10.2134/jeq2006.0550.

Redding, M. (2016). Manure and Groundwater Quality: Literature Review. Publication 16-03-026. Washington State Department of Ecology, Environmental Assessment Program, Olympia. https://fortress.wa.gov/ecy/publications/SummaryPages/1603026.html.

Redifer, V. (2014). Personal communication, Director, Yakima County Public Services, October 2014.

Richardson, A. (2016). Issue Paper presented December 5, 2016, LYV-GWAC Abandoned Wells Joint Working Group. Washington State Department of Ecology, Olympia. https://www.yakimacounty.us/DocumentCenter/View/17728/Abandoned-Wells-Per-Avery-Richardson.

RID (Roza Irrigation District). (1998). Roza Irrigation District Comprehensive Water Conservation Plan Report. Sunnyside, WA.

Ritter, W.F., and Chirnside, A.E.M. (1987). Influence of agricultural practices on nitrate in the water table aquifer. *Biological Wastes* 19(3): 165–178. https://doi.org/10.1016/0269-7483(87)90050-4.

Roman, C.T., Jaworski, N., Short, F.T., Findlay, S., and Warren, R.S. (2000). Estuaries of the northeastern United States: Habitat and land use signatures. Estuaries 23: 743–764.

Romey, B., and Cramer, S.P. (2001). Aquatic Habitat Survey of Irrigation Drainage Networks, Lower Yakima River Basin. Submitted to Roza-Sunnyside Board of Joint Control and United States Bureau of Reclamation, Yakima, WA. S.P. Cramer & Associates, Inc., Sandy, Oregon.

Royte, E. (2017). The simple river-cleaning tactics that big farms ignore (Iowa). *National Geographic*, December 7, 2017. https://news.nationalgeographic.com/2017/12/iowa-agriculture-runoff-water-pollution-environment.

RSJB (Roza-Sunnyside Joint Board). (1999). Water-Quality Laboratory Quality Assurance Manual. [By Rice, W.R.] Roza-Sunnyside Board of Joint Control, WA.

RSJB (Roza-Sunnyside Joint Board). (2001). History of Drainage Issues in the Yakima Valley. [By Rice, A.] Roza-Sunnyside Board of Joint Control, WA.

RSJB (Roza-Sunnyside Joint Board). (2009). Water Quality Conditions in Irrigation Waterways within the Roza and Sunnyside Valley Irrigation Districts, Lower Yakima Valley, Washington, 1997–2008. [By Zuroske, M.] Roza-Sunnyside Board of Joint Control, WA. http://www.svid.org/images/WQ%20Conditions%20in%20Irrigation%20waterwaysReportFinal.pdf.

Rudolf, D., Devlin, J., and Bekeris, L. (2015). Challenges and a strategy for agricultural BMP monitoring and remediation of nitrate contamination in unconsolidated aquifers. *Groundwater Monitoring and Remediation* 35(1): 97–109.

Scanlon, B.R., Reedy, R.C., and Bronson, K.F. (2008). Impacts of land use change on nitrogen cycling archived in semiarid unsaturated zone nitrate profiles, southern High Plains, Texas. *Environmental Science and Technology* 42(20): 7655–7572.

Scott, M.J., Vail, L.W., Stöckle, C., and Kemanian, A. (2004). Climate change and adaptation in irrigated agriculture—A case study of the Yakima River. *In* Annual Proceedings of the Universities Council and Water Resources, 20 July 2004. Southern Illinois University, Carbondale.

Sebilo, M., Mayer, B., Nicolardot, B., Pinay, G., and Mariotti, A. (2013). Long-term fate of nitrate fertilizer in agricultural soils. *PNAS* 110(45): 18185–18189.

Sell, R., and Knutson, L. (2002). Quality of Ground Water in Private Wells in the Lower Yakima Valley, 2001–02. Valley Institute for Research and Education, Yakima, WA. Washington State Department of Ecology Publication 02-10-074. https://fortress.wa.gov/ecy/publications/documents/0210074.pdf.

Severtson, P. (2017). E-mail to Laurie Davies, James Rivard, and Melanie Redding, Washington State Department of Ecology, April 20.

Sheehan, J. (2017). Personal communication, Jason Sheehan, dairy farmer.

Spalding, R., and Exner, M., (1993). Occurrence of Nitrate in Groundwater – A Review. Journal of Environmental Quality 22:392-402.

Spalding, R.F., Watts, D.G., Schepers, J.S., Burbach, M.E., Exner, M.E., Poreda, R.J., and Martin, G.E. (2001). Controlling nitrate leaching in irrigated agriculture. *Journal of Environmental Quality* 30: 1184–1194. doi:10.2134/jeq2001.3041184x.

Stadler, S., Osenbruck, K., Suckow, A., Sültenfuß, J., Oster, H., Himmelsbach, T., and Hotzl, H. (2008). Understanding the origin and fate of nitrate in groundwater of semi-arid environments. *Journal of Arid Environments* 72: 1830–1842.

Swann, C. (2013). The influence of septic systems at the watershed level. Urban Lake Management 821–834. http://www.sourcewaterpa.org/wp-content/uploads/2013/03/SwannC._Influence_of_Septic_Systems_at_the_Watershed_Level-1.pdf.

SYCD (South Yakima Conservation District). (2004). Conservation Practices and Water Quality Trends in Sulphur Creek Wasteway and Granger Drain Watersheds, 1997 to 2002. [By Zuroske, M.] South Yakima Conservation District, WA.

SYCD (South Yakima Conservation District). (2006). Water Quality in Small Irrigation Return Drains, Lower Yakima River, 2003 Irrigation Season. [By Zuroske, M.] South Yakima Conservation District, WA.

Tesoriero, A.J., Duff, J.H., Wolock, D.M., Spahr, N.E., and Almendinger, J.E. (2009). Identifying pathways and processes affecting nitrate and orthophosphate inputs to streams in agricultural watersheds. *Journal of Environmental Quality* 38: 1892–1900. doi: 10.2134/jeq2008.0484.

Tilman, D., Cassman, K.G., Matson, P.A., Maylor, R., and Polasky, S. (2002). Agricultural sustainability and intensive production practices. *Nature* 418(6898): 671–677. doi: 10.1038/nature01014.

Toor, G.S., Lusk, M., and Obreza, T. (2011). Onsite sewage treatment and disposal systems: Nitrogen. Publication SL348. Florida Cooperative Extension Service, Institute of Food and

Agricultural Science, University of Florida.
https://edis.ifas.ufl.edu/pdffiles/SS/SS55000.pdf.

University of Western Australia. (2013). Plant/Animal Production, The Role of Nitrogen in Agricultural Production Systems.
http://hsc.csu.edu.au/agriculture/production/3363/nitrogen.htm

USBR (U.S. Department of the Interior, Bureau of Reclamation). (2018). Projects and facilities: Yakima project. Reclamation: Managing Water in the West. Accessed September 5, 2018.
https://www.usbr.gov/projects/index.php?id=400.

~~USBR (U.S. Bureau of Reclamation). 2018. Yakima Project System Status. Accessed September 5, 2018.~~
~~https://www.usbr.gov/pn/hydromet/yakima/yakstats.txt.~~

~~Viers, J.H., Liptzin, D., Rosenstock, T.S., Jensen, V.B., Hollander, A.D., McNally, A., King, A.M., Kourakos, G., Lopez, E.M., De La Mora, N., Fryjoff-Hung, A., Dzurella, K.N., Canada, H.E., Laybourne, S., McKenney, C., Darby, J., Quinn, J.F., and Harter, T. (2012). Technical report 2: Nitrogen sources and loading to groundwater. In *Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater*. Report for the State Water Resources Control Board Report to the Legislature, California Nitrate Project, Implementation of Senate Bill X2 1. Center for Watershed Sciences, University of California, Davis.~~
~~http://groundwaternitrate.ucdavis.edu/files/139110.pdf.~~

~~Visser, A., Dubus, I., Broers, H.P., Brouyere, S., Korez, M., Orban, P., Goderniaux, P., Batlle-Aguilar, J., Surdyk, N., Amraoui, N., Job, H., Pinault, J.L., and Bierkens, M., 2009. "Comparison of methods for the detection and extrapolation of trends in groundwater quality", Journal of Environmental Monitoring, volume 11, pgs 2030-2043.~~
~~http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.889.5003&rep=rep1&type=pdf~~

USDA (U.S. Department of Agriculture). (1997). National Engineering Handbook: Irrigation Guide. USDA, Natural Resources Conservation Service, Washington, D.C.
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_033068.pdf.

USDA (U.S. Department of Agriculture). (2000). Manure Nutrients Relative to the Capacity of Cropland and Pastureland to Assimilate Nutrients: Spatial and Temporal Trends for the United States. [By Kellog, R.L., Lander, C.H., Moffit, D.C., and Gollehon, N.] USDA, Natural Resources Conservation Service, Washington, D.C.

https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_012133.pdf.

USDA (U.S. Department of Agriculture). (2008). Appendix 10D: Design and construction guidelines for waste impoundments lined with clay or amendment-treated soil. In *Agricultural*

Formatted: Indent: First line: 0", Space After: 0 pt, L
spacing: single

Waste Management System Component Design, Part 651, Agricultural Waste Management Field Handbook. USDA, Natural Resources Conservation Service. https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17767.wba.

USDA NASS (U.S. Department of Agriculture, National Agricultural Statistical Service). (2014). Census of Agriculture Historical Archive. 2002 Census Publications. Accessed September 5, 2018. http://agcensus.mannlib.cornell.edu/AgCensus/censusParts.do?year=2002.

USDI and Ecology (U.S. Department of the Interior and Washington State Department of Ecology). (2012). Yakima River Basin Integrated Water Resource Management Plan: Final Programmatic Environmental Impact Statement, Benton, Kittitas, Klickitat, and Yakima Counties, Washington. Ecology publication 12-12-002. U.S.D.I. Bureau of Reclamation, Yakima, and Washington State Department of Ecology, Olympia. https://fortress.wa.gov/ecy/publications/publications/1212002.pdf.

~~USDOC (U.S. Department of Commerce), Agriculture. Bureau of the Census, United States Census of Agriculture, https://www.agcensus.usda.gov.~~

USDOC (U.S. Department of Commerce). (2010). Decennial Census of Population and Housing. U.S. Census Bureau. https://www.census.gov/programs-surveys/decennial-census/decade.2010.html.

USDOC (U.S. Department of Commerce). (2013). American Community Survey, 2009–2013. U.S. Census Bureau.

USGS (U.S. Geological Survey). (1962). Geology and Ground-Water Resources of the Ahtanum Valley, Yakima County, Washington. [By Foxworthy, B.L.] U.S. Geological Survey Water Supply Paper 1598. U.S. Government Printing Office, Washington, D.C. http://pubs.er.usgs.gov/publication/wsp1598.

USGS (U.S. Geological Survey). (1963). Effects of Hydraulic and Geologic Factors on Streamflow of the Yakima River Basin, Washington. [By Kinnison, H.B., and Sceva, J.E.] U.S. Geological Survey Water-Supply Paper 1595. U.S. Government Printing Office, Washington, D.C. http://pubs.er.usgs.gov/usgspubs/wsp/wsp1595.

USGS (U.S. Geological Survey). (1982). Irrigation-Water Quality in the Sulphur Creek Basin, Yakima and Benton Counties, Washington, April 1976 through March 1977. [By Boucher, P.R., and Fretwell, M.O.] U.S. Geological Survey Open-File Report 81-1008, prepared in cooperation with the State of Washington Department of Ecology. U.S. Geological Survey, Tacoma, WA. https://pubs.usgs.gov/of/1981/1008/report.pdf.

USGS (U.S. Geological Survey). (1984). Sediment Transport by Irrigation Return Flows in Four Small Drains within the DID-18 Drainage of the Sulphur Creek Basin, Yakima County, Washington, April 1979 to October 1981. [By Boucher, P.R.] Water-Resources Investigations Report 83-4167. U.S. Geological Survey. https://pubs.er.usgs.gov/publication/wri834167.

USGS (U.S. Geological Survey). (1985). Overview of the occurrence of nitrate in ground water of the United States. [By Madison, R.J., and Brunett, J.O.] U.S. Geological Survey, National Water Summary 1984. U.S. Geological Survey Water-Supply Paper 2275: 93–105.

USGS (U.S. Geological Survey). (1990a). County-Level Estimates of Nitrogen and Phosphorus Fertilizer Use in the United States, 1945 to 1985. [By Alexander, R.B., and Smith, R.A.] U.S. Geological Survey Open-File Report 90-130. U.S. Geological Survey, Reston, VA. https://pubs.usgs.gov/of/1990/ofr90130/report.html.

USGS (U.S. Geological Survey). (1990b). Geologic Framework of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho. [By Drost, B.W., Whiteman, K.J., and Gonthier, J.B.] Water-Resources Investigations Report 87-4238. U.S. Geological Survey, Portland, OR. http://pubs.er.usgs.gov/publication/wri874238.

USGS (U.S. Geological Survey). (1992). Surface-Water-Quality Assessment of the Yakima River Basin, Washington: Analysis of Available Water-Quality Data through 1985 Water Year. [By Rinella, J.F., McKenzie, S.W., and Fuhrer, G.J.] U.S. Geological Survey Open-File Report 91-453. U.S. Geological Survey, Portland, OR. https://pubs.usgs.gov/of/1991/0453/report.pdf.

USGS (U.S. Geological Survey). (1993a). Effects of Agricultural and Residential Land Use on Groundwater Quality, Anoka Sand Plain Aquifer, East-Central Minnesota. [By Anderson, H.W., Jr.] Water-Resources Investigations Report 93-4074. U.S. Geological Survey, prepared in cooperation with the Minnesota Department of Natural Resources, Mounds View, MN. https://pubs.usgs.gov/wri/1993/4074/report.pdf.

USGS (U.S. Geological Survey). (1993b). Distribution and Sources of Nitrate, and Presence of Fluoride and Pesticides, in Parts of the Pasco Basin Washington, 1986–88. [By Ebbert, J.C., Cox, S.E., Drost, B.W., and Schurr, K.M.] U.S. Geological Survey Water-Resources Investigations Report 93-4197. U.S. Geological Survey, prepared in cooperation with the Washington State Department of Ecology, Tacoma, WA. https://pubs.usgs.gov/wri/1993/4197/report.pdf.

USGS (U.S. Geological Survey). (1994). Surface-Water-Quality Assessment of the Yakima River Basin in Washington: Analysis of Major and Minor Elements in Fine-Grained Streambed Sediment, 1987. [By Fuhrer, G.J., McKenzie, S.W., Rinella, J.F., Sanzolone, R.F.,

and Skach, K.A., with a section on geology by M.W. Gannett] U.S. Geological Survey Open-File Report 93-30.
https://pubs.usgs.gov/of/1993/0030/report.pdf.

USGS (U.S. Geological Survey). (1997). Irrigation and Surface-Water Quality in the Quincy and Pasco Basins, Washington. [By Kim, M.H., and Ebbert, J.C.] U.S. Geological Survey Fact Sheet 080-97.
https://pubs.usgs.gov/fs/1997/0080/report.pdf.

USGS (U.S. Geological Survey). (1998a). A Survey of Ground-Water Quality in the Toppenish Creek Basin, Yakama Indian Reservation, Washington 1989-91. [By Sumioka, S.S.] U.S. Geological Service Water Resources Investigations Report 97-4194.
https://pubs.usgs.gov/wri/1997/4194/report.pdf.

USGS (U.S. Geological Survey). (1998b). Shallow Ground-Water Quality Beneath Row Crops and Orchards in the Columbia Basin Irrigation Project Area, Washington. [By Jones, J.L., and Roberts, L.M.] U.S. Geological Survey Water-Resources Investigations Report 97-4238.
https://pubs.usgs.gov/wri/1997/4238/report.pdf.

USGS (U.S. Geological Survey). (1999a). Surface-Water-Quality Assessment of the Yakima River Basin in Washington: Spatial and Temporal Distribution of Trace Elements in Water, Sediment and Aquatic Biota, 1987–91. [By Fuhrer, G.J., Cain, D.J., McKenzie, S.W., Rinella, J.F., Crawford, J.K., Skach, K.A., and Hornberger, M.I., with a section on geology by M.W. Gannett] U.S. Geological Survey Water-Supply Paper 2354-A.
https://pubs.usgs.gov/wsp/2354a/report.pdf.

USGS (U.S. Geological Survey). (1999b). Surface-Water-Quality Assessment of the Yakima River Basin, Washington: Overview of Major Findings, 1987–91. [By Morace, J.L., Fuhrer, G.J., Rinella, J.F., McKenzie, S.W., and others.] U.S. Geological Survey Water Resources Investigations Report 98-4113.
https://pubs.usgs.gov/wri/1998/4113/report.pdf.

USGS (U.S. Geological Survey). (2000). Estimating the Probability of Elevated Nitrate (NO2+NO3-N) Concentrations in Groundwater in the Columbia Basin Groundwater Management Area, Washington. [By Frans, L.M.] U.S. Geological Survey Water Resources Investigations Report 00-4110.
https://pubs.usgs.gov/wri/wri004110/pdf/wri004110.pdf.

USGS (U.S. Geological Survey). (2002). Watershed Models for Decision Support in the Yakima River Basin, Washington. [By Mastin, M.C. and Vaccaro, J.J.] U.S. Geological Survey Open-File Report 02-404.
http://pubs.usgs.gov/of/2002/ofr02404.

USGS (U.S. Geological Survey). (2003a). Concentrations and Loads of Suspended Sediment and Nutrients in Surface Water of the Yakima River Basin, Washington, 1999–2000 — With an Analysis of Trends in Concentrations. [By Ebbert, J.C., Embrey, S.S., and Kelley, J.A.] U.S. Geological Survey Water Resources Investigations Report 03-4026. https://pubs.usgs.gov/wri/wri034026/pdf/wri034026.pdf.

USGS (U.S. Geological Survey). (2003b). Water Resources Data, Washington, Water Year 2002. [By Kimbrough, R.A., Wiggins, W.D., Smith, R.R., Ruppert, G.P., Knowles, S.M., and Renslow, V.F.] U.S. Geological Survey Water-Data Report WA-02-1. https://pubs.usgs.gov/wdr/WDR-WA-02-1/pdf/wdr-wa-02-1.pdf.

USGS (U.S. Geological Survey). (2003c). Water-Quality Trends in New England Rivers During the 20th Century. [By Robinson, K.W., Campbell, J.P., and Jaworski, N.A.] U.S. Geological Survey National Water Quality Assessment Program, Water-Resources Investigations Report 03-4012. https://pubs.usgs.gov/wri/wrir03-4012/wrir03-4012report.pdf.

USGS (U.S. Geological Survey). (2004). Water Quality in the Yakima River Basin, Washington, 1999–2000. [By Fuhrer, G.J., Morace, J.L., Johnson, H.M., Rinella, J.F., Ebbert, J.C., Embrey, S.S. Waite, I.R., Carpenter, K.D., Wise, D.R., and Hughes, C.A.] U.S. Geological Survey Circular 1237. https://pubs.usgs.gov/circ/2004/1237/pdf/circular1237.pdf.

USGS (U.S. Geological Survey). (2006a). Hydrogeologic Framework of Sedimentary Deposits in Six Structural Basins, Yakima River Basin, Washington. [By Jones, M.A., ~~Vaccaro, J.J., and Watkins, A.M.] U.S. Geological Survey Scientific Investigations Report 2006-5116. http://pubs.usgs.gov/sir/2006/5116~~.

USGS (U.S. Geological Survey). (2006b). Estimates of Ground-Water Pumpage from the Yakima River Basin Aquifer System, Washington, 1960–2000. [By Vaccaro, J.J. and Sumioka, S.S.] U.S. Geological Survey Scientific Investigations Report 2006-5205. http://pubs.usgs.gov/sir/2006/5205.

USGS (U.S. Geological Survey). (2006c). A Deep Percolation Model for Estimating Ground-Water Recharge: Documentation of Modules for the Modular Modeling System of the U.S. Geological Survey. [By Vaccaro, J.J.] U.S. Geological Survey Scientific Investigations Report 2006-5318. http://pubs.usgs.gov/sir/2006/5318.

USGS (U.S. Geological Survey). (2007a). Estimates of Ground-Water Recharge to the Yakima River Basin Aquifer System, Washington, for Predevelopment and Current Land-Use and Land-Cover Conditions. [By Vaccaro, J.J., and Olsen, T.D.] U.S. Geological Survey Scientific Investigations Report 2007-5007. http://pubs.usgs.gov/sir/2007/5007.

Formatted: Line spacing: Multiple 1.08 li

USGS (U.S. Geological Survey). (2007b). Estimates of Monthly Ground-Water Recharge to the Yakima River Basin Aquifer System, Washington, 1960–2001, for Current Land-Use and Land-Cover Conditions. [By Vaccaro, J.J., and Olsen, T.D.] U.S. Geological Survey Open File Report 2007-1238.
http://pubs.usgs.gov/of/2007/1238.

USGS (U.S. Geological Survey). (2007c). Environmental Setting of the Granger Drain and DR2 Basins, Washington, 2003–04. [By Payne, K.L., Johnson, H.M., and Black, R.W.] U.S. Geological Survey Scientific Investigations Report 2007-5102.
https://pubs.usgs.gov/sir/2007/5102/pdf/sir20075102.pdf.

USGS (U.S. Geological Survey). (2007d). Nutrient and Suspended-Sediment Transport and Trends in the Columbia River and Puget Sound Basins, 1993–2003. [By Wise, D.R., Rinella III, F.A., Rinella, J.F., Fuhrer, G.J., Embrey, S.S., Clark, G.M., Schwarz, G.E., and Sobieszczyk, S.] National Water Quality Assessment Program, U.S. Geological Survey Scientific Investigations Report 2007-5186.
https://pubs.usgs.gov/sir/2007/5186/pdf/sir20075186.pdf.

USGS (U.S. Geological Survey). (2008a). Extent and Depth to the Top of Basalt and Interbed Hydrogeologic Units, Yakima River Basin Aquifer System, Washington. [By Jones, M.A. and Vaccaro, J.J.] U.S. Geological Survey Scientific Investigations Report 2008-5045.
https://pubs.usgs.gov/sir/2008/5045/pdf/sir20085045.pdf.

USGS (U.S. Geological Survey). (2008b). Hydrographs Showing Ground-Water Level Trends for Selected Wells in the Yakima River Basin Aquifer System, Washington. [By Keys, M.E., Vaccaro, J.J., Jones, M.A., and Julich, R.J.] U.S. Geological Survey Data Series 343.
https://pubs.usgs.gov/ds/343.

USGS (U.S. Geological Survey). (2008c). Distribution of Elevated Nitrate Concentrations in Groundwater in Washington State. [By Frans, L.] U.S. Geological Survey Fact Sheet 2008-3063.
https://pubs.usgs.gov/fs/2008/3063/pdf/fs20083063.pdf.

USGS (U.S. Geological Survey). (2009a). Hydrogeologic Framework the Yakima River Basin Aquifer System, Washington. [By Vaccaro, J.J., Jones, M.A., Ely, M.D., Keys, M.E., Olsen, T.D., Welch, W.B., and Cox, S.E.] U.S. Geological Survey Scientific Investigations Report 2009-5152.
http://pubs.usgs.gov/sir/2009/5152.

USGS (U.S. Geological Survey). (2009b). Effect of Agricultural Practices on Hydrology and Water Chemistry in a Small Irrigated Catchment, Yakima River Basin, Washington. National Water-Quality Assessment Program, U.S. Geological Survey Scientific Investigations Report 2009–5030.
https://pubs.usgs.gov/sir/2009/5030/pdf/sir20095030.pdf.

Formatted: Line spacing: Multiple 1.08 li

USGS (U.S. Geological Survey). (2009c). Summary of Seepage Investigations in the Yakima River Basin, Washington. [By Magirl, C.S., Julich, R.J., Welch, W.B., Curran, C.R., Mastin, M.C., and Vaccaro, JJ.] U.S. Geological Survey Data Series 473. https://pubs.usgs.gov/ds/473.

USGS (U.S. Geological Survey). (2011a). River-Aquifer Exchanges in the Yakima River Basin, Washington. U.S. Geological Survey Scientific Investigations Report 2011-5026. https://pubs.usgs.gov/sir/2011/5026/pdf/sir20115026.pdf.

USGS (U.S. Geological Survey). (2011b). Numerical Simulation of Groundwater Flow for the Yakima River Basin Aquifer System, Washington. [By Ely, D.M., Bachmann, M.P., and Vaccaro, J.J.] U.S. Geological Service Scientific Investigations Report 2011-5155. https://pubs.usgs.gov/sir/2011/5155/pdf/sir20115155.pdf.

USGS (U.S. Geological Survey). (2012). Groundwater Status and Trends for the Columbia Plateau Regional Aquifer System, Washington, Oregon, and Idaho. [By Burns, E.R., Snyder, D.T., Haynes, J.V., and Waibel, M.S.] U.S. Geological Survey Groundwater Resources Program in cooperation with the Oregon Water Resources Department, Scientific Investigations Report 2012-5261. https://pubs.usgs.gov/sir/2012/5261/pdf/sir2012-5261.pdf.

USGS (U.S. Geological Survey). (2013). Estimation of Total Nitrogen and Total Phosphorus in Streams of the Middle Columbia River Basin (Oregon, Washington, and Idaho) Using SPARROW Models, with Emphasis on the Yakima River Basin, Washington. [By Johnson, H.M., Black, R.W., and Wise, D.R.] U.S. Geological Survey Scientific Investigations Report 2013–5199. https://pubs.usgs.gov/sir/2013/5199/pdf/sir20135199.pdf.

USGS (U.S. Geological Survey). (2014). Numerical Simulation of Groundwater Flow in the Columbia Plateau Regional Aquifer System, Idaho, Oregon, and Washington. [By Ely, D.M., Burns, E.R., Morgan, D.S., and Vaccaro, J.J.] U.S. Geological Survey Scientific Investigations Report 2014-5127. https://pubs.usgs.gov/sir/2014/5127/pdf/sir2014-5127.pdf.

USGS (U.S. Geological Survey). (2017). Quality Assurance Project Plan: Nitrate in Groundwater of the Yakima River Basin. Tacoma, WA, (prepared by R. Dinicola, R. Sheibley, and M. Bachmann), 46 pgs.

USGS (U.S. Geological Survey). (2018). Concentrations of Nitrate in Drinking Water in the Lower Yakima River Basin, Groundwater Management Area, Yakima County, Washington, 2017. [By Huffman, R.L.] U.S. Geological Survey Data Series 1084, p. 18. https://pubs.usgs.gov/ds/1084/ds1084.pdf.

Vaccaro, J.J. (2016). Assessment of the Availability of Groundwater for Residential Development in the Rural Parts of Yakima County, Washington. Vaccaro G.W. Consulting, LLC.

Vaccaro, J.J., and Watkins, A.M.(2006). U.S. Geological Survey Scientific Investigations Report 2006-5116.
http://pubs.usgs.gov/sir/2006/5116

van der Schans, M.L., Harter, T., Leijnse, A., Mathews, M.C., and Meyer, R.D. (2009). Characterizing sources of nitrate leaching from an irrigated dairy farm in Merced County, California. *Journal of Contaminant Hydrology* 110: 9–21. doi.org/10.1016/j.jconhyd.2009.06.002.

Van Meter, K., Basu, N., Veenstra, J., and Burras, C. (2016). The nitrogen legacy: emerging evidence of nitrogen accumulation in anthropogenic landscapes. *Environmental Research Letters* 11(3): 1–12.

~~State of~~ Vermont, State of. (2016). Vermont Nitrate Leaching Index, Vermont Open Geodata Portal.
http://geodata.vermont.gov/datasets/vt-nitrate-leaching-index/data?geometry=-86.522%2C40.368%2C-58.397%2C45.971.

Viers, J.H., Liptzin, D., Rosenstock, T.S., Jensen, V.B., Hollander, A.D., McNally, A., King, A.M., Kourakos, G., Lopez, E.M., De La Mora, N., Fryjoff-Hung, A., Dzurella, K.N., Canada, H.E., Laybourne, S., McKenney, C., Darby, J., Quinn, J.F., and Harter, T. (2012). Technical report 2: Nitrogen sources and loading to groundwater. In *Addressing Nitrate in California's Drinking Water with a Focus on Tulare Lake Basin and Salinas Valley Groundwater*. Report for the State Water Resources Control Board Report to the Legislature, California Nitrate Project, Implementation of Senate Bill X2 1. Center for Watershed Sciences, University of California, Davis.
http://groundwaternitrate.ucdavis.edu/files/139110.pdf.

Visser, A., Dubus, I., Broers, H.P., Brouyere, S., Korcz, M., Orban, P., Goderniaux, P., Battle-Aguilar, J., Surdyk, N., Amraoui, N., Job, H., Pinault, J.L., and Bierken, M. (2009). Comparison of methods for the detection and extrapolation of trends in groundwater quality. *Journal of Environmental Monitoring* 11: 2030–2043.

Walvoord, M.A., Phillips, F.M., Stonestrom, D.A., Evans, R.D., Harsough, P.C., Newman, B.D., and Striegl, R.G. (2003). A reservoir of nitrate beneath desert soils. *Science* 302: 1021–1024.

Ward, M.H., deKok, T.M., Levallois, P., Brender, J., Gulis, G., Nolan, B.T., and VanDerslice, J. (2005). Workgroup Report: Drinking-Water Nitrate and Health—Recent Findings and Research Needs. *Environmental Health Perspectives* 113(11): 1607–1614.

WDOH (Washington State Department of Health). (2005). Nitrogen Reducing Technologies for Onsite Wastewater Treatment Systems. Report to the Puget Sound Action Team.

Formatted: Line spacing: Multiple 1.08 li

Washington State Department of Health, Office of Environmental Health & Safety, Olympia, WA. https://www.doh.wa.gov/Portals/1/Documents/Pubs/337-093.pdf.

WDOH (Washington State Department of Health). (2007a). Dose-Response of Nitrates and other Methemoglobin Inducers on Methemoglobin Levels in Infants. [By VanDerslice, J.] Washington Department of Health Final Report for EPA Grant R829781.

https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.highlight/abstract/5379/report/F.

WDOH (Washington State Department of Health). (2007b). Coliform Bacteria and Drinking Water, WDOH Publication 331-181.

http://www.yakimaco.us/GWMA/documents/library/Washington_Department_of_Health_2007_Coliform_Bacteria_and_Drinking_Water_WDOH_Publication_331-181.pdf.

WDOH (Washington State Department of Health). (2007c). Nitrate in Drinking Water. WDOH Publication 331-214.

WDOH (Washington State Department of Health). (2016). Questions and Answers: Nitrate in Drinking Water. DOH 331-214 Updated. Washington State Department of Health, Environmental Public Health, Office of Drinking Water.

https://www.doh.wa.gov/Portals/1/Documents/Pubs/331-214.pdf.

WRCC (Western Regional Climate Center). (2017~~n.d.~~). https://wrcc.dri.edu.

WSDA (Washington State Department of Agriculture). (2010). Washington State Department of Agriculture spreadsheet "1998_2010BiennialRegAnimalNumbers_byDairy.xls"

~~WSDA (Washington State Department of Agriculture). (n.d.). Agricultural History of Yakima County. [By Drennan, M.] http://www.yakimacounty.us/DocumentCenter/View/2375.~~

WSDA (Washington State Department of Agriculture). (2017). 2015 Drought and Agriculture: A Study by the Washington State Department of Agriculture. AGR PUB 104-495. https://agr.wa.gov/FP/Pubs/docs/495-2015DroughtReport.pdf.

WSDA (Washington State Department of Agriculture). (2018). Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area: A Study by the Washington State Department of Agriculture and Yakima County. [By Bahr, G., Beale, P., Drennan, M., Hancock, J., McLain, K., Redifer, V., Martian, M., and Kozma, C.] AGR PUB 103-691. https://agr.wa.gov/FP/Pubs/docs/103-691YakimaGWMANitrogenTransportReport.pdf.

Formatted: Highlight

Formatted: Highlight

Yakima County. (2017). Horizon 2040 Comprehensive Plan. http://www.yakimacounty.us/846/Horizon-2040-Comprehensive-Plan.

Yakima Valley Trends. (2018a). Yakima County Agriculture: Total market value of crops & average market value per farm. http://www.yakimavalleytrends.ewu.edu/graph.cfm?cat_id=1&sub_cat_id=1&ind_id=1.

Yakima Valley Trends. (2018b). Yakima County Agriculture: Total value and state's share of the value of milk production. http://www.yakimavalleytrends.ewu.edu/graph.cfm?cat_id=1&sub_cat_id=1&ind_id=6.

Yakima Valley Trends. (2018c). Yakima County Agriculture: Total net farm income and income per capita. http://www.yakimavalleytrends.ewu.edu/graph.cfm?cat_id=1&sub_cat_id=1&ind_id=5.

Yakima Valley Trends. (2018d). Yakima County Agriculture: Total acres and value of tree fruit production (apples, cherries, etc.). http://www.yakimavalleytrends.ewu.edu/graph.cfm?cat_id=1&sub_cat_id=1&ind_id=3.

Yakima Valley Trends. (2018e). Yakima County Agriculture: Number of dairy cows in milk production and the share of all dairy cows used in milk production in the state. http://www.yakimavalleytrends.ewu.edu/graph.cfm?cat_id=1&sub_cat_id=1&ind_id=7.

Lower Yakima Valley Groundwater Management Program

Volume II

Appendices

June 2019~~August 20, 2018~~

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Volume II

APPENDIX A – AUTHORITY FOR GROUNDWATER MANAGEMENT AREAS 1

Washington State Law RCW 90.44.410 3
Washington State Regulation WAC 173-100-100 4

APPENDIX B – REGULATORY AUTHORITY 8

Safe Drinking Water Act 8
State Department of Health 9
Clean Water Act 10
Washington's Water Pollution Control Act and Water Resources Act 11
Well Construction 13
Resource Conservation and Recovery Act 14
Washington's Right to Farm Law 15
Interagency Cooperation 15
Yakima County's Role in Groundwater Quality Protection 17
Growth Management Act 17
Washington State Environmental Policy Act 23
Yakima Health District 23
Regulations Pertaining to Particular Sources 24
Crops Supporting Livestock Operations 24
Tree Fruit and Vegetable Crops 24
Fertilizers 24
Livestock Operations 25
Concentrated Animal Feeding Operations 28
Waste Storage Facilities (Lagoons) 30
Pens and Composting Areas 30
Water Applications 30
Residential Onsite Sewage Systems (ROSS) 30
Large Onsite Sewer Systems (LOSS) 33
Biosolids 33
Residential Lawn Fertilizers 34
Hobby Farms 34
Underground Injection Wells 34
Abandoned Wells 34

APPENDIX C – THE NITROGEN CYCLE 35

Nitrogen Forms 36
Nitrogen Transformation Processes 37
Processes that Affect Nitrogen Fate and Transport 38

APPENDIX D – PHYSICAL BASIN CHARACTERISTICS 40

Physical Basin Characteristics 40
Geology 40

Columbia River Basalt Group 40
The Ellensburg Formation 42
Lower Yakima Valley Fill 42
The Yakima Fold Belt 43
Groundwater Recharge 44

APPENDIX E – EDUCATION AND PUBLIC OUTREACH 45

Outreach Plan 46
Accomplishments Chronology 55

APPENDIX F – DEEP SOIL SAMPLING 60

Outcomes and Challenges 61
Going Forward 63
Deep Soil Sampling Data 65
Analytical Data Analysis 102
Analytical Data and Survey Data Analysis 130
Summary Analysis 131
Deep Soil Sampling Analysis of Fields Planted in Triticale 177

APPENDIX G – BEST MANAGEMENT PRACTICES RECOMMENDED BY IRRIGATED AGRICULTURE WORK GROUP 189

APPENDIX H – BEST MANAGEMENT PRACTICES RECOMMENDED BY LIVESTOCK/CAFO WORK GROUP 195

APPENDIX I – COMPREHENSIVE LIST OF ALTERNATIVE MANAGEMENT STRATEGIES 196

APPENDIX J – CONSENSUS LIST OF POTENTIAL RECOMMENDATIONS 215

Appendix A – Authority for Groundwater Management Areas

The Washington State Legislature adopted a law authorizing the identification of ground water management areas (RCW 90.44.400-440). The Department of Ecology adopted a regulation Groundwater Management Areas and Programs (Chapter 173-100 WAC), which includes a process for designation, guidelines, and criteria. GWMAs are designed to protect groundwater quality, to assure groundwater quantity, and to provide for efficient management of water resources for meeting future needs while recognizing existing water rights. The regulations adopted an approach intended to "forge a partnership between a diversity of local, state, tribal and federal interests in cooperatively protecting the state's groundwater resources."

In February 2010, the Department of Agriculture, Department of Ecology, Department of Health, Yakima County Department of Public Works, and U.S. Environmental Protection Agency published a report titled *Lower Yakima Valley Groundwater Quality, Preliminary Assessment and Recommendations Document.*[1] That preliminary assessment found that:

> "The existing studies and related water quality data indicate that nitrate and bacterial contamination of groundwater exist in the Lower Yakima Valley…Over 2,000 people in the area are exposed to nitrate over the maximum contaminant level (MCL) through their drinking water. While not all groundwater supplies have been impacted, many residents rely on private wells that are in the most vulnerable portions of the aquifer. Approximately 12 percent of domestic well users are exposed to nitrate levels in their drinking water that exceed the health-based standard of 10 mg/L."[2]

The *Preliminary Assessment* made recommendations for subsequent action, including:

- Development of a conceptual site model for the Lower Valley
- Development of a nitrogen loading model for the Yakima basin

---

[1] *Lower Yakima Valley Groundwater Quality, Preliminary Assessment and Recommendations Document*, Washington State Department of Agriculture, Washington State Department of Ecology, Washington State Department of Health, Yakima County Department of Public Works, U.S. Environmental Protection Agency, Ecology Publication No. 10-10-009, February 2010. (Hereafter, "*Preliminary Assessment.*")

[2] Preliminary Assessment, p. ES 2.

- Acknowledgement of the connection between groundwater and surface water
- Determination of the sources of contamination
- Identification of agricultural operations that use flood irrigation
- Assessment of agricultural applications of nitrogen fertilizers and Best Management Practices
- Education and outreach regarding nitrates and bacteria
- Assessment of cumulative risk factoring in synergistic health effects
- Exploration of shifting residents to public water systems where feasible
- Involvement of the Yakima Health District
- Exploration of the concept of developing a groundwater management area as one potential funding option
- Development of measures of success
- Identification and implementation of appropriate enforcement actions

The *Preliminary Assessment* also identified four "needs":

1. Better characterization of vulnerable groundwater supplies.

2. Improve water quality monitoring and coordination of data that can identify trends in water quality.

3. Funding options to support lower valley initiatives to better manage potential contaminant sources and improve groundwater quality.

4. A mechanism to coordinate future efforts and implement actions that result in improved water quality.

On April 17, 2012, the Department of Ecology and Yakima County executed an Interagency Agreement. The Agreement provided funds from Ecology to the County for the formation of a Groundwater Management Area for the lower Yakima Valley as set forth in WAC 173-100. The Agreement stated that "The purpose of the GWMA is to reduce nitrate contamination in groundwater to below state drinking water standards."

Yakima County was charged by the Agreement with performing the actions of Lead Agency[3] for the development of a Groundwater Management Program, preparing a work plan, and budgeting for development of a GWMA Program.

---

[3] The role of lead agency is described in WAC 173-100-080.

The lead agency shall be responsible for coordinating and undertaking the activities necessary for development of the groundwater management program. These activities shall include collecting data and conducting studies related to hydrogeology, water quality, water use, land use, and population projections; scheduling and coordinating advisory committee meetings; presenting draft materials to the committee for review; responding to comments from the committee; coordinating SEPA review; executing interlocal agreements or other contracts; and other duties as may be necessary. The lead agency shall also prepare a work plan, schedule, and budget for the development of the program that shows the responsibilities and roles of each of the advisory committee members as agreed upon by the committee. Data collection, data analysis and other elements of the program development may be delegated by the lead agency to other advisory committee members.

The contents of a GWMA Program are identified in RCW 90.44.410. Yakima County has therefore conducted studies and collected data. It has not analyzed data or drawn conclusions therefrom. Information related to hydrogeology, water quality, water use, land use, and population are included in this Program.

Washington State Law RCW 90.44.410

Requirements for groundwater management programs – review of programs.

(1) The groundwater area or sub-area management programs shall include:

(a) A description of the specific groundwater area or sub-areas, or separate depth zones within any such area or sub-area, and the relationship of this zone or area to the land use management responsibilities of county government;

(b) A management program based on long-term monitoring and resource management objectives for the area or sub-area;

(c) Identification of water resources and the allocation of the resources to meet state and local needs;

(d) Projection of water supply needs for existing and future identified user groups and beneficial uses;

(e) Identification of water resource management policies and/or practices that may impact the recharge of the designated area or policies that may affect the safe yield and quantity of water available for future appropriation;

(f) Identification of land use and other activities that may impact the quality and efficient use of the groundwater, including domestic, industrial, solid, and other waste disposal, underground storage facilities, or storm water management practices;

(g) The design of the program necessary to manage the resource to assure long-term benefits to the citizens of the state;

(h) Identification of water quality objectives for the aquifer system which recognize existing and future uses of the aquifer and that are in accordance with department of ecology and department of social and health services drinking and surface water quality standards;

(i) Long-term policies and construction practices necessary to protect existing water rights and subsequent facilities installed in accordance with the groundwater area or sub-area management programs and/or other water right procedures;

(j) Annual withdrawal rates and safe yield guidelines which are directed by the long-term management programs that recognize annual variations in aquifer recharge;

(k) A description of conditions and potential conflicts and identification of a program to resolve conflicts with existing water rights;

(l) Alternative management programs to meet future needs and existing conditions, including water conservation plans; and

(m) A process for the periodic review of the groundwater management program and monitoring of the implementation of the program.

(2) The groundwater area or sub-area management programs shall be submitted for review in accordance with the State Environmental Policy Act (SEPA).

Washington State Regulation WAC 173-100-100

Groundwater management program content.

The program for each groundwater management area will be tailored to the specific conditions of the area. The following guidelines on program content are intended to serve as a general framework for the program, to be adapted to the particular needs of each area. Each program shall include, as appropriate, the following:

(1) An area characterization section comprised of:

(a) A delineation of the groundwater area, subarea or depth zone boundaries and the rationale for those boundaries;
(b) A map showing the jurisdictional boundaries of all state, local, tribal, and federal governments within the groundwater management area;
(c) Land and water use management authorities, policies, goals and responsibilities of state, local, tribal, and federal governments that may affect the area's groundwater quality and quantity;

(d) A general description of the locale, including a brief description of the topography, geology, climate, population, land use, water use and water resources;
(e) A description of the area's hydrogeology, including the delineation of aquifers, aquitards, hydrogeologic cross-sections, porosity and horizontal and vertical permeability estimates, direction and quantity of groundwater flow, water-table contour and potentiometric maps by aquifer, locations of wells, perennial streams and springs, the locations of aquifer recharge and discharge areas, and the distribution and quantity of natural and man-induced aquifer recharge and discharge;
(f) Characterization of the historical and existing groundwater quality;
(g) Estimates of the historical and current rates of groundwater use and purposes of such use within the area;
(h) Projections of groundwater supply needs and rates of withdrawal based upon alternative population and land use projections;
(i) References including sources of data, methods and accuracy of measurements, quality control used in data collection and measurement programs, and documentation for and construction details of any computer models used.

(2) A problem definition section that discusses land and water use activities potentially affecting the groundwater quality or quantity of the area. These activities may include but are not limited to:

(a) Commercial, municipal, and industrial discharges.

(b) Underground or surface storage of harmful materials in containers susceptible to leakage.

(c) Accidental spills.

(d) Waste disposal, including liquid, solid, and hazardous waste.

(e) Storm water disposal.

(f) Mining activities.

(g) Application and storage of roadway deicing chemicals.

(h) Agricultural activities.

(i) Artificial recharge of the aquifer by injection wells, seepage ponds, land spreading, or irrigation.

(j) Aquifer over-utilization causing seawater intrusion, other contamination, water table declines or depletion of surface waters.

(k) Improperly constructed or abandoned wells.

(l) Confined animal feeding activities.

The discussion should define the extent of the groundwater problems caused or potentially caused by each activity, including effects which may extend across groundwater management area boundaries, supported by as much documentation as possible. The section should analyze historical trends in water quality in terms of their likely causes, document declining water table levels and other water use conflicts, establish the relationship between water withdrawal distribution and rates and water level changes within each aquifer or zone, and predict the likelihood of future problems and conflicts if no action is taken. The discussion should also identify land and water use management policies that affect groundwater quality and quantity in the area. Areas where insufficient data exists to define the nature and extent of existing or potential groundwater problems shall be documented.

(3) A section identifying water quantity and quality goals and objectives for the area which (a) recognize existing and future uses of the aquifer, (b) are in accordance with water quality standards of the department, the department of social and health services, and the federal environmental protection agency, and (c) recognize annual variations in aquifer recharge and other significant hydrogeologic factors;

(4) An alternatives section outlining various land and water use management strategies for reaching the program's goals and objectives that address each of the groundwater problems discussed in the problem definition section. If necessary, alternative data collection and analysis programs shall be defined to enable better characterization of the groundwater and potential quality and quantity problems. Each of the alternative strategies shall be evaluated in terms of feasibility, effectiveness, cost, time and difficulty to implement, and degree of consistency with local comprehensive plans and water management programs such as the coordinated water system plan, the water supply reservation program, and others. The alternative management strategies shall address water conservation, conflicts with existing water rights and minimum instream flow requirements, programs to resolve such conflicts, and long-term policies and construction practices necessary to protect existing water rights and subsequent facilities installed in accordance with the groundwater management area program and/or other water right procedures.

(5) A recommendations section containing those management strategies chosen from the alternatives section that are recommended for implementation. The rationale for choosing these strategies as opposed to the other alternatives identified shall be given;

(6) An implementation section comprised of:

(a) A detailed work plan for implementing each aspect of the groundwater management strategies as presented in the recommendations section. For each recommended management action, the parties responsible for initiating the action and a schedule for implementation shall be identified. Where possible, the implementation plan should include specifically worded statements such as model ordinances, recommended governmental policy statements, interagency agreements, proposed legislative changes, and proposed amendments to local comprehensive plans, coordinated water system plans, basin management programs, and others as appropriate;

(b) A monitoring system for evaluating the effectiveness of the program;

(c) A process for the periodic review and revision of the groundwater management program.

Appendix B – Regulatory Authority

The water molecules in the ground beneath the GWMA fall within the regulatory structure of the federal Safe Drinking Water Act and Washington Department of Health regulations (as "drinking water") and Washington's Water Pollution Control Act and Water Resources Act (as "groundwater"). Those molecules' potential contribution to surface water quality makes the federal Clean Water Act and surface water authorities assigned to the Washington State Department of Ecology by the Water Pollution Control Act also apply.

Safe Drinking Water Act

The EPA has broad authority, under Section 1421 of the Safe Drinking Water Act, 42 U.S.C. 300g-1(b)(1)(A), (B), to establish national primary drinking water standards, "if the Administrator determines that . . . the contaminant may have an adverse effect on the health of persons;" "is known to occur . . . in public water systems with a frequency and at levels of public health concern;" or there is "a meaningful opportunity for health risk reduction for persons served by public water systems."

For each contaminant that the Administrator determines to regulate under subparagraph (B), the Administrator shall publish maximum contaminant level goals and promulgate, by rule, national primary drinking water regulations under this subsection (42 U.S.C. 300g-1(b)(1)(E)).

EPA sets legal limits on over 90 contaminants in drinking water. The legal limit for a contaminant reflects the level that protects human health and that water systems can achieve using the best available technology. EPA rules also set water testing schedules and methods that water systems must follow. The EPA set the maximum contaminant level for nitrate, nitrite and total nitrate, and nitrite in 40 CFR § 141.62:

Contaminant	MCL (mg/L)
(7) Nitrate	10 (as Nitrogen)
(8) Nitrite	1 (as Nitrogen)
(9) Total Nitrate and Nitrite	10 (as Nitrogen)

EPA may approve states to assume primary enforcement authority under the Safe Drinking Water Act. Washington's drinking water quality standard for nitrate is 10 milligrams per liter (mg/L), or 10 parts per million.

When drinking water in private wells contains or is likely to contain a contaminant that may present an imminent and substantial endangerment, such as nitrate, EPA may take an emergency action under the SDWA, Section 1431. EPA must first determine that the state and local authorities have not taken action to protect the health of such persons. An emergency action pursuant to SDWA Section 1431 may include any order that may be necessary to protect the health of persons, including ordering the collection of samples to investigate the sources of the contamination. In addition, where appropriate, EPA may issue orders to require the provision of alternative water supplies. EPA may also judicially enforce its orders, through action seeking civil penalties for each day of such violation. If violation of EPA's orders is "willful," EPA may seek criminal penalties of fines or imprisonment for not more than three years (42 U.S.C. § 300g-2(b)). Citizens may also seek protection of underground sources of drinking water, under 42 USC 300j-8, so as to mandate EPA regulatory or litigative action.

The EPA may also designate sole source drinking water aquifers under Section 1427 of the Safe Drinking Water Act, 42 U.S.C. 300h.

State Department of Health

The Washington State Department of Health is authorized to adopt regulations "to protect public health" (RCW 43.20.050(2)). These may include rules for Group A public water systems, as necessary, to assure safe and reliable public drinking water and to protect the public health. Those rules set requirements regarding: (i) The design and construction of public water system facilities, including proper sizing of pipes and storage for the number and type of customers; (ii) Drinking water quality standards, monitoring requirements, and laboratory certification requirements; (iii) Public water system management and reporting requirements; (iv) Public water system planning and emergency response requirements; (v) Public water system operation and maintenance requirements; (vi) Water quality, reliability, and management of existing but inadequate public water systems; and (vii) Quality standards for the source or supply, or both source and supply, of water for bottled water plants.

The DOH also sets rules for Group B public water systems, as defined in RCW 70.119A.020. These rules establish minimum requirements for the initial design and construction of a public water system and "rules and standards for prevention, control, and abatement of health hazards and nuisances related to the disposal of human and animal excreta and animal remains" (RCW 42.30.050 (2) (b), (c)).

The Department of Health requires that nitrate levels (concentrations) (as N) in Group A public water systems not exceed the maximum contaminant level ("MCL") of 10 mg/L, and that nitrite levels (concentrations) not exceed the MCL of 1 mg/L (WAC 246-290-310(3) (Table 4)). The requirements for Group B public water systems are the same (WAC 246-291-170 (2)(b)). Nitrate and nitrite are "primary inorganic contaminants" and the MCL for nitrate and nitrite

are "primary MCLs." When primary MCLs are exceeded by a public water system the water purveyor must "determine the cause of the contamination" and "take action as directed by the Department of Health" (WAC 246-290-320(1)(b)(iii)).

WAC 246-290-300 requires public water systems to sample for many contaminants, including nitrate, on a regular basis. Public water systems with nitrate levels over 10 mg/L must notify the people who receive water from them (WAC 246-290-320).

Clean Water Act

Surface water quality in Washington is regulated by the federal Clean Water Act (33 U.S.C. 1342, et seq.) and Washington's Water Quality Standards for Surface Waters (Chapter 173-201A), which are authorized by the State Water Pollution Control Act (Chapter 90.48).

The Clean Water Act makes it unlawful to discharge any pollutant from a point source into waters of the U.S. unless a National Pollutant Discharge Elimination System (NPDES) permit is obtained (33 U.S.C. 1342). The NPDES permitting authority has been delegated to the Department of Ecology (See 33 U.S.C. 1342 (b); RCW 90.48.260). The Department exercises this delegated authority, together with its authority under the Water Pollution Control Act, in issuing NPDES permits and State Waste Discharge Permits (SWDPs) (pursuant to WAC 273-226-030). Ecology's water quality standards are used to establish effluent limits in NPDES permits and SWDPs.

Ecology's water quality standards and SWDPs apply to both point source activities and nonpoint source activities. Point source activities are activities where a source of pollution can be readily distinguished, such as the industrial discharge of waste onto or into the ground. State law requires point sources to operate under permits that set conditions for discharges. These permits may be issued to a specific entity with conditions designed to protect water quality.

A "point source" is "any discernible, confined, and discrete conveyance, including, but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture." (WAC 273-226-030 (21))

"Nonpoint sources" are more diffuse in nature. They often consist of many small pollutant sources that have a cumulative effect, like highway runoff, on-site septic systems in developed areas, and application of pesticides or nutrients in both agricultural and urban areas. Some nonpoint sources are managed through the development of siting and design standards.

Groundwater contamination may affect surface water quality. Under §303(d) of the Clean Water Act, states are required to develop lists of impaired waters. These are waters for which technology-based regulations and other required controls are not stringent enough to meet the

water quality standards set by the state. The law requires that states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDL) for these waters. A TMDL is a calculation of the maximum amount of a pollutant that a water body can receive and still safely meet water quality standards. A TMDL is generally administered by establishing limits on the discharge of pollutant materials otherwise permitted under the NPDES or state regulatory programs.

Washington's Water Pollution Control Act and Water Resources Act

Groundwater quality in Washington is regulated by the Groundwater Quality Standards (Chapter 173-200 WAC) which are authorized by the state Water Pollution Control Act (Chapter 90.48 RCW) and Water Resources Act (Chapter 90.54 RCW). Discharges to groundwater are regulated through a variety of permitting mechanisms which are authorized by the Water Pollution Control Act (Chapter 90.48. RCW). These permitting regulations include State Waste Discharge Permits, which may be issued as General Permits.

The Water Pollution Control Act, Chapter 90.48 RCW makes it "unlawful for any person to throw, drain, run, or otherwise discharge into any of the waters of this state, or to cause, permit or suffer to be thrown, run, drained, allowed to seep or otherwise discharged into such waters any organic or inorganic matter that shall cause or tend to cause pollution of such waters" (RCW 90.48.080).

The Department of Ecology (Ecology) is the primary agency in Washington State responsible for implementation of this mandate. Ecology has adopted Chapter 173-200 WAC, Water Quality Standards for Groundwaters. The standards include "water quality criteria" (numerical limits for specific contaminants that apply to all groundwaters in the state). WAC 173-200-040 (2) (Table 1) establishes that Nitrate concentrations in groundwater may not exceed 10 mg/L.

The standards apply to all groundwaters of the state that occur in a saturated zone (generally at or below the water table) or stratum beneath the surface of land or below a surface water body. The groundwater standards do not apply in the root zone of saturated soils where agricultural pesticides and nutrients have been applied at agronomic rates for agricultural purposes, but only if those contaminants will not cause pollution of groundwaters below the root zone (WAC 173-200-010(3)(a)). In other words (removing the double negative), the standards do apply in saturated root zones if pollution is caused in groundwaters below.

Ecology's water quality standards incorporate an "antidegradation policy," an otherwise existing part of state water quality law (WAC 173-200-030). This policy precludes degradation which would harm existing or future beneficial uses of groundwater (drinking water, irrigation and support of wildlife habitat). Ecology has antidegradation implementation procedures that explain what needs to be done for an antidegredation analysis. The standards provide numeric values, which must not be exceeded to protect the beneficial use of drinking water.

General permits issued by the Department of Ecology (either as a combined NPDES and SWDP or as a state only SWDP) may be issued to a group of entities with common discharge characteristics and conditions (WAC 273-226-020). Permits issued under Chapter 273-226 WAC are designed to satisfy the requirements for discharge permits under Sections 307 and 402(b) of the federal Water Pollution Control Act (33 U.S.C. §1251) and the state law governing water pollution control (Ch. 90.48 RCW) (WAC 273-226-020). If eligible, a point source must obtain general permit coverage before discharging to surface or ground waters or the point source may be found to be in violation of state or federal law for discharging without a permit.

General permits establish standards for management. General permits are issued for fixed terms not exceeding five years from the effective date. Point source facility operators must apply to Ecology for coverage under a general permit (WAC 227-226). All permittees covered under a general permit must submit a new application for coverage under a general permit or an application for an individual permit at least 90 days prior to the expiration date of the general permit under which the permittee is covered. When a permittee has made timely and sufficient application for the renewal of coverage under a general permit, an expiring general permit remains in effect and enforceable until the application has been denied, a replacement permit has been issued by Ecology, or the expired general permit has been terminated by Ecology. Coverage under an expired general permit for permittees who fail to submit a timely and sufficient application shall expire on the expiration date of the general permit (WAC 173-226-200).

A general permit may be modified, revoked and reissued, or terminated, during its term if information is obtained by Ecology which indicates that cumulative effects on the environment from dischargers covered under the general permit are unacceptable (WAC 173-226-230 (1)(d)). Ecology may require any discharger to apply for and obtain an individual permit, or to apply for and obtain coverage under another more specific general permit. Also, any interested person may petition Ecology to require a discharger authorized by a general permit to apply for and obtain an individual permit (WAC 173-226-240 (2), (3)).

Ecology may revoke, or "terminate coverage under a general permit," where terms or conditions of the general permit are violated, conditions change such that either temporary or permanent reduction or elimination of permitted discharges is required, or Ecology determines that the permitted activity endangers human health, safety, or the environment, or contributes to water or sediment quality standards violations (WAC 173-226-240 (1) (a), (c), and (d)).

Washington's Water Pollution Control Act authorizes Ecology to "bring any appropriate action, in law or equity, including action for injunctive relief . . . as may be necessary to carry out the provisions" of that Act (RCW 90.48.037), including its prohibition of the discharge of

organic or inorganic matter that may cause pollution of ground or surface water (RCW 90.48.080).

Violations of maximum concentrations may be addressed by enforcement "through all legal, equitable, and other methods available to the department including, but not limited to: issuance of state waste discharge permits, other departmental permits, regulatory orders, court actions, review and approval of plans and specifications, evaluation of compliance with all known, available, and reasonable methods of prevention, control, and treatment of a waste prior to discharge, and pursuit of memoranda of understanding between the department and other regulatory agencies" (WAC 173-200-100 (3)).

If Ecology determines that a potential to pollute the groundwater exists, it may request a permit holder or responsible person to prepare and submit a groundwater quality evaluation program for its approval. Each evaluation program must be based on soil and hydrogeologic characteristics and be capable of assessing impacts on groundwater at the "point of compliance." The evaluation program approved by Ecology may include (a) groundwater monitoring for a specific activity; (b) groundwater monitoring at selected sites for a group of activities; (c) monitoring of the vadose zone; (d) evaluation and monitoring of effluent quality; (e) evaluation within a treatment process; or (f) evaluation of management practices (WAC 173-200-080 (2)). The "point of compliance" is the location where the "enforcement limit," is "measured and shall not be exceeded" (WAC 173-200-060 (1)). The "enforcement limit" is established in accordance with WAC 173-200-050.

Ecology may also designate a groundwater "special protection area" if it determines that the groundwater in an area requires "special consideration or increased protection because of one or more unique characteristics" (WAC 173-200-090 (1)). These unique characteristics are then to be taken into consideration by Ecology when regulating activities, developing regulations, guidelines and policies and when prioritizing department resources for groundwater quality protection programs (WAC 173-200-090 (2)). Characteristics to guide designation of a special protection area are set forth in the rule (WAC 173-200-090 (2)). Designation of special protection areas must be in the public interest (WAC 173-200-090 (5)(b)).

Well Construction

In Washington State, the construction of groundwater wells was first required to be reported in 1972. Consequently, the Washington State Department of Ecology (Ecology) well database includes only those wells constructed after 1972, and those wells identified in information supporting water right claims, permits or certifications predating 1972. A reasonable estimate of wells within Yakima County that are identified in Ecology's well database is 45,000. Some portion of that is located within the Groundwater Management Area.

Groundwater wells typically have a life of about 40 years. This is due to: mechanical failure, deterioration of material (primarily steel well casings), settling of casings within ground materials,

change in aquifer conditions (mineralization, scale deposits within casing). In most instances, it is cheaper to drill a new well than to repair an old one (Richardson).

Not all wells have the same risk of failure, or if abandoned the same risk to the public health and welfare. Wells differ in design, construction, diameter of casing, depth of casing, depth to water, water chemistry, etc. Wells constructed pursuant to regulatory standards have less risk of failure, even if "abandoned." "Dug wells," those wells constructed by digging a pit in the ground in order to collect water near ground surface, either with or without a small-diameter casing hammered into the ground from the bottom of the pit have the greatest risk of failure and risk to the public health and welfare. In addition to potential groundwater contamination from dug wells, people and animals can fall into these wells (Richardson).

"Vaulted" wells also present a significant risk of groundwater contamination, whether in use or abandoned. A "vaulted" well is essentially a dug well with a concrete reinforcement of the sides, or bottom, of the pit, creating a "vault". Water can collect in vaults which may migrate down the well casement, or along the annulus (the circular void between the well casing and the ground material through which the well was drilled) of the well casing. Wells with casing top elevations at or near ground level (as opposed to raised above ground level), or cut off below ground level, also present risk of groundwater contamination, due to possible "overtopping" of surface contamination into the well casing. Similar risk occurs where the well casing has no cap. Otherwise properly constructed wells may present risk of groundwater contamination if they have not been "sealed." Sealing is accomplished through the infusion of bentonite clay or cement into the casing annulus for a distance sufficient to prevent surface water intrusion into the subsurface (Richardson).

Deeper wells generally have larger diameters than shallower wells. Industrial, public water system, or irrigation wells are more likely to have larger diameter wells than single-user domestic wells. Unused irrigation wells may be less likely to be discovered because of change of land use or crop choice (Richardson).

Abandoned wells or wells that have not been decommissioned are often located by purchasers of property, parties who may become liable upon foreclosure of real estate financing instruments (banks), and reviewing entities (e.g., county planning officials) when reviewing proposals for change of parcel definitions (short plats, site plans for building permits) (Richardson).

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act (RCRA) (Pub. L. No. 94-590, 90 Stat 2795, 42 U.S.C. §§6901 – 6987, 9001 – 9010) contains both regulatory standards and remedial provisions to achieve goals of conservation, reducing waste disposal, and minimizing the present and future threat to human health and the environment. RCRA provides a comprehensive national

regulatory structure for the management of nonhazardous solid wastes (subtitle D, 42 U.S.C. §§ 6941/y-6949a) and hazardous solid wastes (subtitle C, 42 U.S.C. §§ 6921/y-6939b). "Solid waste" is defined as "any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities . . . ." 42 U.S.C. §6903(27)

Materials are discarded if they are either abandoned or recycled or are inherently waste-like. 40 C.F.R. § 261.2. Materials are "disposed" if they are discharged, deposited, injected, dumped, spilled, leaked or otherwise placed into or on land or water such that it may enter into the environment or be emitted into the air or discharged into any waters, including groundwaters 42 U.S.C. §6903(3). Agricultural wastes, including manures, crop residues, or commercial fertilizers applied to the soil in amounts greater than can be used as fertilizers or soil conditioners may be the disposal of solid waste.

Washington's Right to Farm Law

Washington State's right to farm law, RCW 7.48.300-320, was first enacted in 1979, with the purpose of protecting agricultural activities conducted on farm and forest lands from nuisance lawsuits. As a consequence, "agricultural activities conducted on farmland and forest practices, if consistent with good agricultural and forest practices and established prior to surrounding nonagricultural and nonforestry activities, are presumed to be reasonable and shall not be found to constitute a nuisance" (RCW 7.48.305 (1)). The defense does not apply however if "the activity or practice has a substantial adverse effect on public health and safety." "Agricultural activities and forest practices undertaken in conformity with all applicable laws and rules are presumed to be good agricultural and forest practices not adversely affecting the public health and safety" (RCW 7.48.305 (2)). The Yakima County Code protects the right to farm in similar terms to the state statute (Ch. 6.22, YCC).

In 2005, Washington's right to farm law was amended to provide for full recovery of costs of litigation in the defense of nuisance suits where the right to farm law was a successful defense (RCW 7.48.315).

Interagency Cooperation

Ecology and WSDA signed a Memorandum of Understanding (MOU) in 2003 to guide coordination and cooperation between the two agencies for dairies, CAFOs and other animal feeding operations. A key element of the MOU is that WSDA inspectors must provide field inspections and technical assistance to Ecology for CAFO and other AFO related water quality activities. The two agencies continue to coordinate on livestock and manure related complaints and in implementing the CAFO permit. An updated MOU was signed in 2011. The MOU can be found at:
http://agr.wa.gov/FP/Pubs/docs/MOUAgricultureEcology2011Final.pdf

Under the MOU, Ecology is responsible to EPA for Clean Water Act compliance for AFOs and CAFOs. Ecology maintains authority under Ch. 90.48 RCW to take compliance actions on any livestock operations where human health or environmental damage has or may occur due to potential or actual discharges, for pasture or rangeland based operations, for manure spreading operations when it is determined the manure was not applied by a dairy, for non-dairy AFOs, CAFOs and permitted CAFOs, and ultimately for permitted dairies. Where compliance actions are against non-permitted dairies, Ecology recognizes WSDA as lead. When Ecology is involved in investigations and compliance actions against non-permitted dairies, they will discuss the compliance actions with WSDA to ensure that timely compliance actions are sufficient to protect human health and the environment. Ecology is responsible for the approval of best management practices used to show compliance with water quality standards. Ecology must provide available monitoring data and trend analysis for livestock-related pollutants to WSDA upon request. Ecology's TMDL process must involve WSDA as a stakeholder if livestock issues are anticipated.

The Ecology/WSDA MOU requires that both agencies provide the other all livestock-related records that either may possess as necessary to fulfill state and federal requirements for livestock under the Clean Water Act (MOU ¶ C.2), and that the two agencies will coordinate in response to public disclosure requests for AFOs, CAFOs and dairies (MOU ¶ C.4).

WSDA is responsible for implementing Ch. 90.64 RCW and is required to follow Ch. 43.05 RCW. WSDA is responsible for inspections and may initiate compliance actions on permitted dairies, but must notify Ecology if there is a discharge to waters of the state and provide a Recommendation for Enforcement. WSDA is responsible for inspections, complaint response and warning letters for all non-dairy permitted CAFOs. Ecology is responsible for complaint response for non-dairy AFOs and CAFOs but WSDA may respond for initial complaint response if resources are available and may write warning letters. WSDA must coordinate, but seldom becomes involved with Ecology when compliance actions beyond warning letters are necessary for non-dairy AFOs and CAFOs or permitted CAFOs. WSDA must enter complaint inspections and warning letters on non-permitted AFOs and CAFOs into Ecology's PARIS database.

Natural Resources Conservation Service (NRCS) offers voluntary financial and technical assistance programs to eligible landowners and agricultural producers to help them manage natural resources in a sustainable manner. Those under contract with NRCS to participate in voluntary programs must adhere to relevant standards for funded projects. Current financial assistance programs in Washington State include:

- Agricultural Management Assistance (AMA): helps agricultural producers use conservation to manage risk and solve natural resource issues through natural resources conservation.

- Conservation Stewardship Program (CSP): helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns.
- Environmental Quality Incentives Program (EQIP): provides financial and technical assistance to agricultural producers in order to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, reduced soil erosion and sedimentation or improved or created wildlife habitat.

Yakima County's Role in Groundwater Quality Protection

Yakima County's role in groundwater quality protection is enabled by Washington's Growth Management Act (GMA) and the State Environmental Policy Act (SEPA).

Growth Management Act
The GMA, primarily codified in Ch. 36.70A RCW, requires counties and cities planning under the act to adopt comprehensive plans and development regulations consistent with the GMA. The GMA establishes goals to guide the development and adoption of comprehensive plans and development regulations of those counties, like Yakima, that are required or choose to plan under RCW 36.70A.040. Relevant goals include:

(5) Encourage economic development . . . that is consistent with adopted comprehensive plans, promote economic opportunity for all citizens of this state, especially for unemployed and for disadvantaged persons, promote the retention and expansion of existing businesses and recruitment of new businesses, recognize regional differences impacting economic development opportunities, and encourage growth in areas experiencing insufficient economic growth, all within the capacities of the state's natural resources, public services, and public facilities.

(8) Maintain and enhance natural resource-based industries, including . . . agricultural . . . industries. Encourage the conservation of . . . productive agricultural lands, and discourage incompatible uses.

(10) Protect the environment and enhance the state's high quality of life, including air and water quality, and the availability of water. RCW 36.70A.020

The GMA requires that:

> Each comprehensive plan shall include a plan, scheme, or design for each of the following: A land use element designating the proposed general distribution and general location and extent of the uses of land, where appropriate, for agriculture, timber production, housing, commerce, industry, recreation, open spaces, general aviation airports, public utilities, public facilities, and other land uses. The land use element shall include population densities, building intensities, and estimates of

future population growth. The land use element shall provide for protection of the quality and quantity of groundwater used for public water supplies." (RCW 36.70A.070(1))

The GMA identifies both agriculture and groundwater quality as protectable resources. GMA recognizes the importance of rural lands and rural character to Washington's economy, its people, and its environment. Rural lands and rural-based economies enhance the economic desirability of the state, help to preserve traditional economic activities, and contribute to the state's overall quality of life (RCW 36.70A.011). The statute also recognizes that, in order to retain and enhance the job base in rural areas, rural counties must have flexibility to create opportunities for business development. Rural counties must have the flexibility to retain existing businesses and allow them to expand. Not all business developments in rural counties require an urban level of services. Many businesses in rural areas fit within the definition of rural character.

When defining the county's rural element, a county should foster land use patterns and develop a local vision of rural character that will: help preserve rural-based economies and traditional rural lifestyles; encourage the economic prosperity of rural residents; foster opportunities for small-scale, rural-based employment and self-employment; permit the operation of rural-based agricultural, commercial, recreational, and tourist businesses that are consistent with existing and planned land use patterns; be compatible with the use of the land by wildlife and for fish and wildlife habitat; foster the private stewardship of the land and preservation of open space; and enhance the rural sense of community and quality of life (RCW 36.70A.070(5)).

RCW 36.70A.030 (15) defines "Rural character" as the:

"Patterns of land use and development established by a county in the rural element of its comprehensive plan:

(a) In which open space, the natural landscape, and vegetation predominate over the built environment;

(b) That foster traditional rural lifestyles, rural-based economies, and opportunities to both live and work in rural areas;

(c) That provide visual landscapes that are traditionally found in rural areas and communities;

(d) That are compatible with the use of the land by wildlife and for fish and wildlife habitat;

(e) That reduce the inappropriate conversion of undeveloped land into sprawling, low-density development;

(f) That generally do not require the extension of urban governmental services; and

(g) That are consistent with the protection of natural surface water flows and groundwater and surface water recharge and discharge areas.

"Rural development" means: development outside the urban growth area and outside agricultural, forest, and mineral resource lands designated pursuant to RCW 36.70A.170. Rural development can consist of a variety of uses and residential densities, including clustered residential development, at levels that are consistent with the preservation of rural character and the requirements of the rural element. Rural development does not refer to agriculture or forestry activities that may be conducted in rural areas (RCW 36.70A.030 (16)).

"Rural governmental services" include: those public services and public facilities historically and typically delivered at an intensity usually found in rural areas, and may include domestic water systems, fire and police protection services, transportation and public transit services, and other public utilities associated with rural development and normally not associated with urban areas" (RCW 36.70A.030 (17)).

Yakima County enacted its Comprehensive Plan (*Plan 2015*) in 1997. On June 27, 2017, the Board of County Commissioners approved Ordinance 4-2017, adopting an updated Comprehensive Plan, *Horizon 2040* (Yakima County 2017). In both plans, three separate chapters – 2) Natural Setting, 5) Land Use, and 9) Utilities – include goals and policies related to water quality. *Horizon 2040*'s goals and policies are implemented through various titles of Yakima County Code. Yakima County's zoning code, YCC Title 19[3], applies to all of unincorporated Yakima County. Table 19.10.020-1 lists the zoning classifications applicable throughout the unincorporated areas. Table 19.14-1 lists which specific land uses are allowed within particular zoning districts. Each permitted use is subject to a particular level of review: Type 1 – permitted; Type 2 – administrative review; Type 3 – conditional; Type 4 – quasi-judicial review (YCC 19.30.030).

Yakima County's Agriculture (AG) Zoning District is by far the most prevalent use district in the Lower Yakima Valley, followed by the Remote/Extremely Limited Development Potential (R/ELDP) district on the ridges and along the Yakima River, Valley Rural (VR) on the Valley floor, and some Rural Transitional (RT) Zoning Districts near the cities and towns. The AG zone allows a broad array of agricultural uses under Type 1 review, including: Animal Feeding Operations, land application of soil amendments or agricultural by-products~~waste~~ at agronomic rates. CAFOs are allowed in the AG and R/ELDP zones under Type 2 review and by Type 3 hearing review in the VR. New or expanding CAFOs, feedlots, and other agricultural uses may be subject to environmental review under the State Environmental Policy Act (SEPA) depending upon the size of the proposal and whether the project falls below SEPA's flexible exemption thresholds.

The Growth Management Act requires counties to designate critical areas (RCW 36.70A.060(2), 170(d)). "Critical areas" include the following areas and ecosystems: (a) wetlands; (b) areas with a critical recharging effect on aquifers used for potable water; (c)

fish and wildlife habitat conservation areas; (d) frequently flooded areas; and (e) geologically hazardous areas. "Fish and wildlife habitat conservation areas" do not include such artificial features or constructs as irrigation delivery systems, irrigation infrastructure, irrigation canals, or drainage ditches that lie within the boundaries of and are maintained by a port district or an irrigation district or company (RCW 36.70A.030(5). "Development regulations" may be established for critical areas so as to prohibit or refine permitted uses under existing zoning requirements (RCW 36.70A.172(1)).

As amended by Yakima County Ordinance 13-2007, the Yakima County Code now addresses regulation of land use within critical areas in Ch. 16C. Application of that chapter to agricultural activities defined in YCC 16C.01.050(3)(a) is limited due to the provisions of RCW 36.70A 700-760 (YCC Title 19 became effective October 1, 2015, replacing YCC Titles 15 and 15A, pursuant to Yakima County Ordinance 7-2013). Regulation of agricultural activities on designated agricultural and rural lands is retained in Ch. 16A. Critical areas subject to the Shoreline Management Program are addressed in YCC Ch. 16D.

RCW 36.70A.700 through .760 establish a "Voluntary Stewardship Program" (VSP) under which counties may choose to adopt a voluntary practices approach in lieu of protecting critical areas in areas used for agricultural activities through development regulations adopted under RCW 36.70A.060. Yakima County adopted the voluntary practices approach by ordinance. This approach involves the establishment of a "watershed group" to develop a "work plan to protect critical areas while maintaining the viability of agriculture in the watershed" (RCW 36.70A.720 (1)).

The Growth Management Act requires local jurisdictions to designate and protect areas with a critical recharging effect on aquifers used for potable water, or areas where a drinking aquifer is vulnerable to contamination that would affect the potability of the water (RCW 36.70A and YCC 16C.09.01 (1)).

A "critical aquifer recharge area" is an area "with a critical recharging effect on aquifers used for potable water, including areas where an aquifer that is a source of drinking water is vulnerable to contamination that would affect the potability of the water, or is susceptible to reduced recharge" (WAC 365-190-030 (3)).

Regulations of the Washington Department of Commerce provide that:

(2) The quality and quantity of groundwater in an aquifer is inextricably linked to its recharge area. Where aquifers and their recharge areas have been studied, affected counties and cities should use this information as the basis for classifying and designating these areas. Where no specific studies have been done, counties and cities may use existing soil and surface geologic information to determine where recharge areas exist. To determine the threat to groundwater quality, existing land use activities and their potential to lead to contamination should be evaluated.

(3) Counties and cities must classify recharge areas for aquifers according to the aquifer vulnerability. Vulnerability is the combined effect of hydrogeological susceptibility to contamination and the contamination loading potential. High vulnerability is indicated by land uses that contribute directly or indirectly to contamination that may degrade groundwater, and hydrogeologic conditions that facilitate degradation. Low vulnerability is indicated by land uses that do not contribute contaminants that will degrade groundwater, and by hydrogeologic conditions that do not facilitate degradation. Hydrological conditions may include those induced by limited recharge of an aquifer. Reduced aquifer recharge from effective impervious surfaces may result in higher concentrations of contaminants than would otherwise occur (WAC 365-190-100).

Yakima County has prohibited certain uses in critical aquifer recharge areas (YCC. 16C.09.07). Currently, those limitations include:

(1) Landfills. Landfills, including hazardous or dangerous waste, municipal solid waste, special waste, wood waste and inert and demolition waste landfills;

(2) Underground Injection Wells. Class I, III and IV wells and subclasses 5F01, 5D03, 5F04, 5W09, 5W10, 5W11, 5W31, 5X13, 5X14, 5X15, 5W20, 5X28, and 5N24 of Class V wells;

(3) Wood Treatment Facilities. Wood treatment facilities that allow any portion of the treatment process to occur over permeable surfaces (both natural and manmade);

(4) Storage, Processing, or Disposal of Radioactive Substances. Facilities that store, process, or dispose of radioactive substances;

(5) Mining. Hard rock; and sand and gravel mining, unless located within the mineral resource designation; and

(6) Other Prohibited Uses or Activities:

(a)Activities that would significantly reduce the recharge to aquifers currently or potentially used as a potable water source;

(b)Activities that would significantly reduce the recharge to aquifers that are a source of significant base flow to a regulated stream.

"Susceptible Groundwater Management Areas," defined as "areas that have been designated as moderately or highly vulnerable or susceptible in an adopted groundwater management program developed pursuant to Chapter 173-100," are among those designated Critical Aquifer Recharge Areas (CARAs) (YCC 16C.09.02(3)). The Lower Yakima Valley Groundwater Management Area is currently developing such a program, but it has not yet been "adopted."

Unless the VSP work plan to protect critical areas contemplated by RCW 36.70A.720 (1) is first put in place, and adopted within the groundwater management program, those provisions of the Growth Management Act requiring establishment of development regulations within CARAs would not apply to agricultural activities within the CARA. Again, application of the critical areas aspects of the Growth Management Act to agricultural activities defined in YCC 16C.01.050(3)(a) is limited due to the provisions of RCW 36.70A 700-760.

The county commission may also "create one or more aquifer protection areas for the purpose of funding the protection, preservation, and rehabilitation of subterranean water" (RCW 36.36.020). The creation of an aquifer protection area is subject to the vote of residents within a proposed area. Fees imposed within a designated CARA may be used to address:

(1) The preparation of a comprehensive plan to protect, preserve, and rehabilitate subterranean water, including groundwater management programs adopted under Chapter 90.44 RCW. This plan may be prepared as a portion of a county sewerage and/or water general plan pursuant to RCW 36.94.030;

(2) The construction of facilities for: (a) The removal of waterborne pollution; (b) water quality improvement; (c) sanitary sewage collection, disposal, and treatment; (d) storm water or surface water drainage collection, disposal, and treatment; and, (e) the construction of public water systems;

(3) The proportionate reduction of special assessments imposed by a county, city, town, or special district in the aquifer protection area for any of the facilities described in subsection (2) of this section;

(4) The costs of monitoring and inspecting on-site sewage disposal systems or community sewage disposal systems for compliance with applicable standards and rules, and for enforcing compliance with these applicable standards and rules in aquifer protection areas created after June 9, 1988; and,

(5) The costs of: (a) Monitoring the quality and quantity of subterranean water and analyzing data that is collected; (b) ongoing implementation of the comprehensive plan developed under subsection (1) of this section; (c) enforcing compliance with standards and rules relating to the quality and quantity of subterranean waters; and (d) public education relating to protecting, preserving, and enhancing subterranean waters (RCW 36.36.040).

Yakima County's Zoning Ordinance also implements a number of *Horizon 2040*'s policies intended to reduce the number of individual wells approved in the higher density zones.

Washington State Environmental Policy Act

Washington State's Environmental Policy Act (SEPA), Chapter 43.21C RCW, requires state agencies and local governments to consider the environmental implications of potential actions. It is like the National Environmental Policy Act, enacted by Congress in 1970. Using a checklist of environmental factors, governmental officials must consider the threshold question whether a potential action has "a probable significant, adverse environmental impact" (RCW 43.21C.031 (a)). If not, an environmental assessment or determination of non-significance may be published. If so, then an environmental impact statement is required. The environmental impact disclosure process imposed by these requirements is used by local governments exercising their police power in zoning, subdivision, or other permitting actions to identify factors militating toward denial of specific development proposals or conditions that may be attached to the approval of those proposals.

When the Yakima County Planning Department receives an application for approval of a particular activity, it circulates a completed checklist of environmental factors to other governmental agencies with jurisdiction of the potential activities in order to solicit their expertise with respect to the anticipated action. Whenever those agencies suggest concerns, those concerns may be incorporated as a basis to deny or impose conditions upon approval of the proposed action.

Yakima Health District

The board of the Yakima County Health District consists of seven members, including three members of the Yakima County Board of County Commissioners and two elected officials of the cities and towns within Yakima County who are appointed by their legislative bodies and two citizens from within Yakima County with an interest in public health appointed by county commissioners (YCC 6.04.010).

The Health District approves the acceptability of site conditions for installation and construction of onsite septic systems. WAC 246-272A-0015(5) requires that the Yakima Health District prepare a written plan to provide guidance to Yakima County regarding development and management activities for all onsite septic systems within the county. At a minimum, the plan should include a description of the Yakima Health District's capacity to provide education and operation and maintenance information for all types of systems in use within the county; a description of how the local health officer will remind and encourage homeowners to complete the operation and maintenance inspection required by WAC 246-272A-0270; and, a description of its capacity to adequately fund its onsite septic system plan.

The Yakima Health District inspects about 50 percent of newly constructed wells, seeking proper bentonite or other sealing, tags, etc. It determines the GPS coordinates of each inspected well and reports the same to the Ecology.

WAC 246-272A-0015(9) authorizes the Health District to adopt its own rules for septic systems more stringent than rules adopted by the State DOH, provided that they are approved by DOH.

Regulations Pertaining to Particular Sources

Crops Supporting Livestock Operations

WSDA's regulations implementing the Dairy Nutrient Management Act, Ch. 16-611 WAC, require dairy producers to maintain records to demonstrate that applications of nutrients to crop land are within acceptable agronomic rates. Soil analysis should include annual postharvest soil nitrate nitrogen analysis; triennial soil analysis that includes organic matter; pH, ammonium nitrogen; phosphorus, potassium; and electrical conductivity. Nutrient analysis is required for all sources of organic and inorganic nutrients including, but not limited to, manure and commercial fertilizer supplied for crop uptake. Manure and other organic sources of nutrients must be analyzed annually for organic nitrogen, ammonia nitrogen, and phosphorus. WSDA conducts on-site inspections of dairies and reviews their records a minimum of every 18 months. Any significant operational change requires an updated dairy nutrient management plan. Dairies are subject to complaint inspections by WSDA, Ecology, and EPA at all times. There is no equivalent requirement for non-dairy agricultural producers.

Nutrient application records should include field identification and year of application, crop grown in each field where the application occurred, crop nutrient needs based on expected crop yield, nutrient sources available from residual soil nitrogen including contributions from soil organic matter, previous legume crop, and previous organic nutrients applied, date of applications, method of application, nutrient sources, nutrient analysis, amount of nitrogen and phosphorus applied and available for each source, total amount of nitrogen and phosphorus applied to each field each year; and the weather conditions twenty-four hours prior to and at time of application (WAC 16-611-020 (2)).

Tree Fruit and Vegetable Crops

There are no groundwater-specific regulations specifically addressing production of tree fruit and vegetable crops

Fertilizers

Bulk commercial fertilizer distributors are required by RCW 15.54.275 to be licensed. They are also required by RCW 15.54.362 to report the number of net tons of fertilizer distributed within the state during six-month periods (January to June, July to December) (annual report permitted if less than 100 tons). 220,909 tons (200,406,000 kg) of commercial fertilizer was purchased in Washington State in 2011. As the statute does not require that the report be subdivided by county, region or groundwater management area, there is no specific information with which to evaluate the amount of commercial fertilizer sold within the GWMA. "Bulk fertilizer" is commercial fertilizer distributed in a nonpackage form such as tote bags, tanks, trailers, spreader trucks, and railcars. Fertilizers are required to meet the nutrient value guaranteed by the fertilizer manufacturer. There is no requirement that agricultural producers be licensed to apply commercial or any other fertilizer. Unmanipulated animal and vegetable manures, organic waste-derived materials and biosolids are not commercial fertilizer (WAC 16-200-701).

Regulations pertaining to "chemigation" (Ch. 16-202 WAC) do not pertain to "fertigation," the application of commercial fertilizer through irrigation water delivery systems. "Chemigation" is the application of any substance a pesticide, plant or crop protectant, or system maintenance compound applied with irrigation water (WAC 16-202-1002 (17)). All pesticide laws apply to chemigation. Pesticides cannot be applied with an open surface, gravity irrigation system unless allowed by the product label.

The Director of the Department of Agriculture may adopt regulations for the appropriate use and disposal of commercial fertilizers for the protection of groundwater (RCW 15.54.800). Although "deep percolation" ("the movement of water downward through the soil profile below a plant's effective rooting zone") is defined by WSDA regulations, WAC 16-202-1002 (23), the regulations do not specifically prohibit deep percolation.

There are no federal, state, or local regulations specifically pertaining to the application of nitrogen-based fertilizer to agricultural crops, so long as they are applied at an agronomic rate so long as it does not pollute groundwaters below the root zone (WAC 173-200 100-(3)). Manure applied as fertilizer is a "nutrient" under Washington State's Dairy Nutrient Management Act (Ch. 90.64 RCW) "'Nutrient' means any organic waste produced by dairy cows or a dairy farm operation" (RCW 90.64.010 (11)). The 2017 CAFO general permit specifically requires that application of nitrogen-based fertilizers not pollute the groundwater.

Livestock Operations

Washington's Dairy Nutrient Management Act (DNMA) (Ch. 90.64 RCW) authorizes WSDA to "determine if a dairy-related water quality problem requires immediate corrective action under the Washington state water pollution control laws, chapter 90.48 RCW, or the Washington state water quality standards adopted under chapter 90.48 RCW" (RCW 90.64.050 (1)(d)). Dairies that are licensed to sell Grade A milk and who generate large quantities of animal waste that can pollute surface water and ground water must have an "approved" Nutrient Management Plan (NMP) on site within six months of licensing. NMP's must be implemented within two years after licensing (RCW 90.64.026 (7)). The purpose of such plan is to prevent the discharge of livestock nutrients to surface and ground waters of the state.

The DNMA authorizes local conservation districts to "provide technical assistance to producers in developing and implementing a dairy nutrient management plan;" and to "review, approve, and certify dairy nutrient management plans that meet the minimum standards" (RCW 90.64.070 (1)(d),(e)). An employee of the South Yakima Conservation District often writes the NMP. "Approved" means the local conservation district has determined that the facility's plan to manage nutrients meets all the elements identified on a checklist established by the Washington Conservation Commission. "Certified" means the local conservation district has determined all plan elements are in place and implemented as described in the plan. To be certified, both the dairy operator and an authorized representative of the local conservation district must sign the plan. Dairies whose NPDES permits require dairy nutrient management plans need not be

otherwise "certified." "Farm Plans," developed and approved by local conservation districts for farmers, must include "livestock nutrient management measures" (RCW 89.08.560). Local conservation districts also provide dairies with technical assistance and planning services with which to implement nutrient management plans.

Local Conservation Districts are authorized to provide dairies and other farms with technical assistance and planning services (RCW 89.08.560) and are required to approve and certify all NMPs. "Farm Plans" developed by conservation districts for farmers must include "livestock nutrient management measures" (RCW 89.08.560). The South Yakima Conservation District often writes the NMPs for dairy farms and later certifies them.

The primary goal of an NMP is to protect water quality from nutrient discharges. The required elements of an NMP specified by the State Conservation Commission include the collection, storage, transfer and application of manure, waste feed and litter, and any potentially contaminated runoff at the site. Plans should focus on management of nitrogen, and phosphorus as well as preventing bacteria and other pollutants, such as sediment, from reaching surface or ground water. Excess nutrients must be exported off site.

The elements of a dairy nutrient management plan may include methods and technologies of the nature prescribed by the Natural Resources Conservation Service, a department of the U.S. Department of Agriculture (RCW 90.64.026(3)).

Nutrient management plans are required to be maintained on the farm for review by WSDA inspectors. The DNMA requires that all dairies be inspected for implementation of their nutrient management plans and to ensure protection of waters of the state. Most dairies keep their NMP and associated sampling data on location.

WSDA's regulations implementing the DNMA are published at chapter 16-611 WAC. WAC 16-611-010 defines "agronomic rate" as "the application of nutrients to supply crop or plant nutrient needs to achieve realistic yields and minimize the movements of nutrients to surface and ground waters." The same section defines "Nutrient" as "any product or combination of products used to supply crops with plant nutrients including, but not limited to, manure or commercial fertilizer." The phrase "transfer of manure" is defined as "the transfer of manure, litter or process wastewater to other persons when the receiving facility is in direct control of application acreage, rate or time, and transfer rate and time.

Producers must maintain records to demonstrate that applications of nutrients to crop land are within acceptable agronomic rates. Those records should demonstrate that applications of nutrients to the land were within acceptable agronomic rates. Soil analysis should include annual postharvest soil nitrate nitrogen analysis; triennial soil analysis that includes organic matter; pH, ammonium nitrogen; phosphorus, potassium; and electrical conductivity. Nutrient analysis is required for all sources of organic and inorganic nutrients including, but not limited to, manure

and commercial fertilizer supplied for crop uptake. Manure and other organic sources of nutrients must be analyzed annually for organic nitrogen, ammonia nitrogen, and phosphorus.

The Dairy Nutrient Management Act requires that manure application and transfer records, including imports or exports, be maintained by dairies that transfer ownership of manure to others. Nutrient application records should include field identification and year of application, crop grown in each field where the application occurred, crop nutrient needs based on expected crop yield, nutrient sources available from residual soil nitrogen including contributions from soil organic matter, previous legume crop, and previous organic nutrients applied, date of applications, method of application, nutrient sources, nutrient analysis, amount of nitrogen and phosphorus applied and available for each source, total amount of nitrogen and phosphorus applied to each field each year; and the weather conditions twenty-four hours prior to and at time of application. Manure transfer records, including imports or exports should include date of manure transfer, amount of nutrients transferred, the name of the person supplying and receiving the nutrients, and a nutrient analysis of manure transferred. Irrigation water management records should include field identification and the total amount of irrigation water applied to each field each year.

The elements of an NMP must include methods and technologies of the nature prescribed by the Natural Resources Conservation Service (NRCS), a department of the U.S. Department of Agriculture RCW 90.64.026(3)). NRCS provides technical assistance to farmers and other private landowners and managers. NRCS has six mission goals: 1) high quality productive soils, 2) clean and abundant water, 3) healthy plant and animal communities, 4) clean air, 5) an adequate energy supply, and 6) working farms and ranchlands.

NRCS helps landowners develop conservation plans and provides advice on the design, layout, construction, management, operation, maintenance, and evaluation of recommended, voluntary conservation practices. NRCS activities include farmland protection, upstream flood prevention, emergency watershed protection, urban conservation, and local community projects designed to improve social, economic, and environmental conditions. NRCS conducts soil surveys, conservation needs assessments, and the National Resources Inventory to provide a basis for resource conservation planning activities.

NRCS conservation practice standards contain information on why and where the practice is applied, and sets forth the minimum quality criteria that must be met during the use of that practice. State conservation practice standards are available through the Field Office Technical Guide (FOTG). NRCS believes that nutrient management for the protection of groundwater, although different on each farm, is best accomplished through best management practices beginning with those stated in Standards 590, 449 and 313.

Ch. 90.64 RCW does not require that the best management practices recommended by the NRCS be followed, but allows the use of "alternative methods and standards and specifications" of the NRCS (RCW 90.64.016 (3)). Nutrient Management Plans are required

to be maintained on the farm for review by inspectors. The DNMA requires that all dairies be inspected for implementation of their Nutrient Management Plans and to ensure protection of waters of the state. Most dairies keep their NMP and associated sampling data on location.

The DNMA does not authorize the WSDA to compel nutrient management consistent with NMPs. Representatives of the WSDA state that most "enforcement" is accomplished through the "soft enforcement" efforts that the Department accomplishes through its administrative activities (visitation and advice) under its Dairy Nutrient Management Program (Prest).

Although "farm plans" are not subject to disclosure under Washington's public records law, (RCW 42.56.270 (17)), plans, records, and reports obtained by state and local agencies from dairies, animal feeding operations, and concentrated animal feeding operations not required to apply for a NPDES permit are disclosable under Washington's public records law (Ch. 42.56 RCW), but only in ranges that provide meaningful information to the public while ensuring confidentiality of business information regarding: (1) number of animals; (2) volume of livestock nutrients generated; (3) number of acres covered by the plan or used for land application of livestock nutrients; (4) livestock nutrients transferred to other persons; and (5) crop yields. The ranges of the information required to be disclosed by the public disclosure law (Ch. 42.56 RCW) are set forth in the WSDA's rules implementing that law and Ch. 90.64 RCW, WAC 16-06-210 (29).

The WSDA's mission under the DNMA is to "protect water quality from livestock nutrient discharges" and to "help maintain a healthy agricultural business climate." The WSDA encourages compliance by providing technical assistance as a first step as required by RCW 43.05, but when that is not successful the WSDA has authority under both RCW 90.64 and RCW 90.48 and has informal (warning letters and notices of correction) and formal (civil penalties and orders) enforcement tools available.

In 2013 – 2014, WSDA issued 17 notices of correction, one order, and 11 notices of penalty for discharges of pollutants to surface waters, statewide, as well as 122 warning letters and 27 notices of correction for potential to pollute (including failures in record keeping). WSDA usually begins with informal enforcement, using warning letters and notices of correction, then proceeding to formal enforcement through civil penalty or administrative order. Most penalties include a settlement process including reduction in penalty, requirements to adopt specific management practices, to abstain from discharge and collection of entire penalty in the event of non-performance.

Concentrated Animal Feeding Operations

The Clean Water Act's regulations (40 CFR, Part 122) define dairies with 700 or more animals and feedlots with 1,000 or more animals as Large Concentrated Animal Feeding Operations (CAFO). Large CAFOs are defined as point sources of water pollution if they can or do discharge to surface waters, becoming subject to the National Pollutant Discharge Elimination System (NPDES) requirement for permit. However, unlike other point sources that have

continuous or regular discharges to surface waters, CAFOs are not considered to automatically have a surface water discharge. Consequently, they may be required to obtain an NPDES CAFO permit only if they have a discharge or potential to discharge. The Ecology administers the CAFO permit, decides when a facility is required to apply for a permit and is responsible for enforcing the permit.

The Washington Department of Ecology issued two CAFO permits under its general permitting authority (Chapter 173-226 WAC) in January 2017 (effective March 3, 2017) (Ecology 2017). (A National Pollutant Discharge Elimination System and State Waste Discharge General Permit for Concentrated Animal Feeding Operations (combined permit) and a State Waste Discharge General Permit (state only)). The state and combined permits regulate the discharge of pollutants such as manure, litter, or process wastewater from CAFOs into waters of the state.

The permits conditionally authorize the permittees to discharge, but only in a manner that does not cause or contribute to a violation of water quality standards. The permittees are prohibited from discharging manure, litter, feed, process wastewater, other organic by-products, or water that has come into contact with manure, litter, feed process wastewater, or other organic by-products, to surface waters of the state from the production area with a few exceptions.

The permittees must implement measures to address the pollution prevention performance objectives listed in special conditions of the permit. Livestock may not be allowed to come into contact with surface waters or conduits to surface waters. Each calendar year, the permittees must develop a field-specific nutrient budget for each land application field they will control to which they plan to apply manure, litter, process wastewater, or other organic by-products (Ecology 2017).

The permittees must have all sources of manure, litter, process wastewater, and other organic by-products sampled and analyzed prior to land application and at least twice more, spaced evenly throughout the land application season, to account for seasonal variation in nutrient concentration (e.g., dilution due to rainfall or concentration from evaporation) (Ecology 2017).

The permittees must land apply manure, litter, process wastewater, or other organic byproducts in accordance with their yearly field nutrient budgets and at the appropriate rates and times to comply with permit conditions. If the permittees generate more manure, litter, process wastewater, or other organic by-products than the land application fields available to the permittees can appropriately utilize according to their yearly field nutrient budgets, the permittees must find other avenues of appropriately utilizing the excess manure, litter, process wastewater, or other organic by-products (e.g., export, composting) (Ecology 2017).

Lands to which manure, litter, process wastewater, and other organic byproducts have been applied must be sampled in spring and fall. The permittees must manage the application irrigation water so that the amount of water applied from precipitation and irrigation does not

exceed the water holding capacity in the top two feet of soil, thereby preventing the downward movement of nitrate.

The permittees must use field discharge management practices on their land-application fields to limit discharge of manure, litter, process wastewater, and other organic by-products to down-gradient surface waters or to conduits to surface or ground water.

The permittees are permitted to "export" manure, i.e., to relinquish control of how the manure is used. When exporting manure, the permittees must provide the most recent manure, litter, process wastewater, or other organic by-product nutrient analysis to the recipient as part of export. The permittees must keep records of its manure exports.

Waste Storage Facilities (Lagoons)
Under the 2017 CAFO permit, the permittee must have adequate storage space for the manure, litter, process wastewater, feed, and any other sources of pollutants on site during the storage period for the area where the CAFO is located. Lagoons and other liquid storage structures built, expanded, or having major refurbishment e.g., complete emptying and re-compaction to restore the earthen liner done after the issuance of this permit must achieve a permeability of $1x10^{-6}$ cm/s without consideration for manure sealing and there must be a minimum of two feet of vertical separation between the bottom of the lagoon (measured from the outside of the earthen liner) and the water table, including seasonal high water table. Lagoons must be inspected, maintained as to structure and volume, and permanently decommissioned when closed. Existing lagoons are required to be assessed.

Pens and Composting Areas
Management practices are advisable on the site of CAFO pens, such as maintaining an intact layer between the cattle and the underlying ground to inhibit leaching through the surface of the pen, changes in precipitation and evapotranspiration from season to season, and animal density rates. Particulate matter practices require that the pens maintain a certain percentage of moisture to reduce dust emissions.

Water Applications
There are no federal, state or local regulations specifically pertaining to the application of irrigation water to agricultural crops. State water law generally precludes wasting water (RCW 90.03.005). Water may only be used for "beneficial use," the opposite of which is "waste."

Residential Onsite Sewage Systems (ROSS)
"Septage" is "the mixture of solid wastes, scum, sludge and liquids pumped from within septic tanks, pump chambers, holding tanks and other OSS components" (WAC 246-271A-0010). The total nitrogen content of septage generated in the GWMA varies under individual circumstances. An area-wide average is not available.

WAC 246-272A-0270 provides that the owner of an OSS is responsible for its operation, monitoring, maintaining, repairing, altering or expanding an OSS. The owner must also assure that an evaluation of a simple gravity septic system's components happens at least once every three years and that an evaluation of all other systems occurs every year. The solids and scum must be pumped from the septic system by an approved pumper generally every three to five years or whenever necessary (EPA 2002). The septic system must not be covered by structures or impervious material. Surface drainage must be trained away from the septic system. The soil above the drain field should not be compacted by vehicles or livestock. It is advisable to inform prospective buyers about the septic system. Most septic systems are now pumped prior to transfer of title to the property.

The location, design, installation, operation, maintenance, and monitoring of OSS is regulated by Chapter 246-272A WAC. The chapter is intended to coordinate with other statutes and rules for the design of OSS under Chapter 18.210 RCW and Chapter 196-33 WAC.

A local board of health must apply to the state DOH to approve local regulations. They must be at least as stringent as the regulations of the state department WAC 246-272A-0015 (9), (10). Yakima County does not have additional regulations.

Permitting for septic systems is done by the Yakima Health District. That agency is also authorized by WAC 246-272A-0015 (5) to "develop a written plan that will provide guidance to the local jurisdiction regarding development and management activities for all OSS within the jurisdiction." The elements of the plan are listed in the WAC.

The amount of land necessary for the installation of an onsite sewage (septic) tank varies depending upon soil type. Table X in WAC 246-272A-0320 establishes the minimums. Table V in WAC 246-272A-0220 describes the soil types. A site is required to meet certain ground absorption parameters, pass a percolation test, in order to qualify for a permit to install a septic system. If the ground does not have a certain absorption rate, it does not qualify for a septic system.

TABLE 1 – (WAC 246-272A-0320) MINIMUM LAND AREA REQUIREMENT SINGLE FAMILY RESIDENCE OR UNIT VOLUME OF SEWAGE

Type of Water Supply	Soil Type (defined by WAC 246-272A-0220)					
	1	2	3	4	5	6
Public	0.5 acre 2.5 acres	12,500 sq. ft.	15,000 sq. ft.	18,000 sq. ft.	20,000 sq. ft.	22,000 sq. ft.
Individual, on each lot	1.0 acre 2.5 acres	1 acre	1 acre	1 acre	2 acres	2 acres

TABLE 2 – (WAC 246-272A-220)

Soil Type	Soil Textural Classifications
1	Gravelly and very gravelly coarse sands, all extremely gravelly soils excluding soil types 5 and 6, all soil types with greater than or equal to 90 percent rock fragments.
2	Coarse sands.
3	Medium sands, loamy coarse sands, loamy medium sands.
4	Fine sands, loamy fine sands, sandy loams, loams.
5	Very fine sands, loamy very fine sands; or silt loams, sandy clay loams, clay loams and silty clay loams with a moderate or strong structure (excluding platy structure).
6	Other silt loams, sandy clay loams, clay loams, silty clay loams.
7 Unsuitable for treatment or dispersal	Sandy clay, clay, silty clay, strongly cemented or firm soils, soil with a moderate or strong platy structure, any soil with a massive structure, any soil with appreciable amounts of expanding clays.

The minimum liquid volume for a septic tank serving a single-family residence containing three or fewer bedrooms is 900 gallons. A septic tank serving a single-family residence containing four bedrooms may be 1,000 gallons. Each bedroom after that requires an additional 250 gallons of septic capacity. The actual size of each ROSS within the GWMA is unknown.

The local health officer may require the owner of a failing OSS located within 200 feet of a public sewer service to hook up to that system WAC 246-272A-0025. Design specifications for OSS tanks are located at WAC 246-272C.

Large Onsite Sewer Systems (LOSS)
Regulations for large on-site sewage (septic) systems (LOSS) are found at WAC 264-272B. LOSS are inventoried with the Department of Ecology as UIC wells (WAC 173-218-040) under a memorandum agreement between Ecology and DOH.

Biosolids
Ecology's biosolid program is coordinated with health districts. Land application of biosolids requires pre-approval of application rates that are based upon agronomic crop requirements. Permittees receive coverage under a statewide general permit. Permit coverage is mandated for those who produce and/or land apply biosolids. Ecology's regulatory program incorporates site specific approvals with specific testing and analysis procedures, development of land

application plans that prescribe specific practices and prohibitions, and a review and approval process for land application of the wastewater solids. Land application may only occur on permitted sites with pre-established buffers and setbacks.

Residential Lawn Fertilizers
There are no known laws or regulations regarding homeowner maintenance of residential lawns. There are also no known laws or regulations regarding municipal maintenance of parks or grounds.

Hobby Farms
There are no known laws or regulations regarding maintenance of animals or herbaceous material on hobby farms.

Underground Injection Wells
Part C of the federal Safe Drinking Water Act (SDWA), 42 U.S.C. §300h-3, regulates underground injection wells (UIC). Washington's UIC program is administered by the Department of Ecology. Its UIC regulations are found at WAC 173-218. The program is approved by the EPA pursuant to SDWA §1422, 40 CFR 147.2400. The program regulates the injection of fluids underground for storage, enhanced recovery, in the context of Class II, and disposal to prevent the contamination of underground sources of drinking water. Injection activities may be authorized by rule or permit. The regulations establish a non-endangerment standard designed to ensure that injected fluids do not cause or contribute to the movement of a contaminant into an underground source of drinking water if the presence of that contaminant may cause or contribute to the exceedance of a drinking water standard ("MCL") or otherwise adversely affect the health of persons (40 CFR 144.12, WAC 173-18-080).

Abandoned Wells
An "abandoned well" is one "that is unmaintained or is in such disrepair that it is unusable or is a risk to public health and welfare" (RCW 18.104.020 (1)).

Wells no longer in use are required by law to be "decommissioned" (RCW 18.104.020 (3)). WAC 173-160-381 describes the processes that must be used to decommission wells. A permit must be obtained before decommissioning may occur (RCW 18.104.030).

Appendix C – The Nitrogen Cycle

Nitrogen is a dynamic element. It exists in many forms, and undergoes many complex transformations in the environment. The aggregate of these transformations is known as the nitrogen cycle (Figure C-1). The nitrogen cycle is a series of biological processes that are influenced by climatic conditions, the physical and chemical properties of soils, and management of the land.

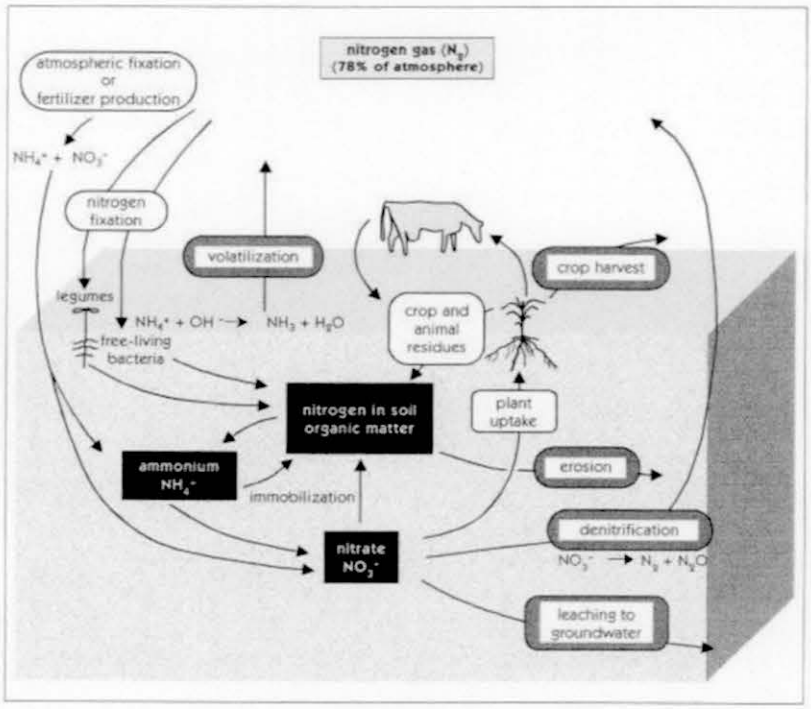


Figure C-1. Nitrogen Cycle (University of Western Australia, 2013).

Plants require nitrogen to grow. Nitrogen can be supplied to plants through the application of commercial fertilizer, animal manure or other organic wastes. The amount and type of nitrogen supplied is dependent on the source. The nitrogen forms that are immediately available for a

plant to use are ammonium and nitrate. Commercial fertilizers typically contain these two forms. Manure is primarily comprised of organic nitrogen and ammonium. Organic nitrogen must first be converted to an inorganic form (either ammonium or nitrate) before it can be taken up through roots and used by plants. When plants die, the organic matter becomes part of the soil, it is converted by bacteria, used by plants, and then reverts back to organic matter.

Nitrogen Forms

Table C-1 describes the different forms of nitrogen.

Table C-1. Nitrogen Forms.

Nitrogen Form	Chemical Formula	Description
Nitrogen gas Nitrous Oxide	N_2 N_2O	The atmosphere contains 78 percent nitrogen gas. Nitrogen gas must be transformed into usable forms before it is available for plant uptake.
Organic Nitrogen	Various forms	Organic nitrogen is the dominant form of nitrogen in manure. Organic nitrogen originates in living material; it is present in animal and human wastes and decomposing plant material. Organic nitrogen is not usable by plants directly; it must first be converted to an inorganic form (ammonium, nitrate).
Ammonia	NH_3	Ammonia can be present in either a liquid or gas state. Ammonia can escape from the surface of the soil under certain conditions. Anhydrous ammonia is the basic nitrogen form found in commercial fertilizers.
Ammonium	NH_4^+	Ammonium is an inorganic form of nitrogen and is available for plant uptake. Attenuation in soils occurs through cation exchange complexes.
Nitrite	NO_2^-	Nitrite is an intermediate product in the conversion of ammonium to nitrate (nitrification). It is usually present in low quantities but is toxic to plants.
Nitrate	NO_3^-	Nitrate is an inorganic form of nitrogen and is available for plant uptake. Nitrate is very soluble in water and highly mobile.

(Killpack and Buchholz, 1993)

Nitrogen Transformation Processes

Table C-2 describes the transformations that convert nitrogen into its different forms. (Killpack and Buchholz, 1993)

Table C-2. Nitrogen Transformation Processes.

Nitrogen Process	Forms	Description
Nitrogen Fixation	N_2 => NH_4^+	Nitrogen fixation is the process that allows plants to convert nitrogen gas from the atmosphere into a form usable for growth. Industrial fixation is the manmade process of creating fertilizers.
Mineralization (Ammonification)	Organic nitrogen => NH_4^+	Mineralization is the conversion of organic nitrogen to ammonium. Bacteria are necessary in this process. Mineralization increases as microbial activity increases, which is directly related to soil temperature and water content.
Immobilization		Immobilization occurs when nitrate or ammonium present in the soil is used by bacteria to build proteins. These actively growing bacteria immobilize some soil N and break down soil organic matter to release N during the growing season. There is often a net gain of N during the growing season, because the additional N in the residue will be the net gain after immobilization-mineralization processes.
Nitrification	NH_4^+ => NO_2^- NO_2^- => NO_3^-	Nitrification is the conversion of ammonium to nitrite, and nitrite to nitrate. Nitrification is a biological process which increases rapidly in warm, wet aerobic conditions. Nitrification slows when soil temperatures decrease below 50°F.
Denitrification	NO_3^- => N gas	Denitrification is the conversion of nitrate to atmospheric forms of nitrogen. Denitrification is a bacterial process and occurs in anaerobic zones typically created by saturated soils and the presence of organic matter. Denitrifying bacteria use nitrate instead of oxygen in their metabolic process.
Volatilization	NH_3 => N gas.	Volatilization is the loss of gaseous ammonia to the atmosphere. Volatilization can occur from manure and fertilizer products containing urea. Ammonia is an intermediate form of nitrogen during the process in which urea is transformed to ammonium.

(O'Leary et al., 2002; University of Western Australia, 2013)

Processes that Affect Nitrogen Fate and Transport

Table C-3 summarizes the physical, chemical, and biological processes that result in gains and losses of nitrogen, which occur as part of the nitrogen cycle. These processes directly affect the fate and transport of nitrogen in the environment.

When nitrogen inputs to the soil system exceed outputs (crop needs), there is a possibility that excessive amounts of nitrate may leach to groundwater or runoff to surface water. Minimizing impacts to groundwater quality can be achieved through sound management practices. Understanding the characteristics of nitrogen in the environment can help efficiently manage nitrogen in land treatment systems.

Table C-3. Processes and conditions that affect nitrogen fate and transport

Nitrogen Process	Result	Description
Attenuation	Retained in soil	The effect of all processes that reduce contaminant concentrations. Ammonium is a positively charged ion which allows it to be immobilized by binding to negatively charged soil and soil organic matter. Ammonium does not move downward in soils unless all the cation exchange sites are saturated.
Leaching	Loss to groundwater	Leaching is a physical process in which nitrate moves with soil water. Nitrate is a negatively charged ion and is not attenuated by negatively charged soils particles. Nitrate is water soluble and, once it migrates below the root zone, may leach to groundwater.
Run-off	Loss to surface water	Runoff to surface water occurs when fields are frozen or saturated and nitrogen cannot infiltrate into the soil pores. Water ponds and moves downhill towards drains, ditches, or surface water.
Consumption	Loss	Consumption of nitrogen by plants and other organisms occurs while nitrogen is retained in the root zone.
Decomposition	Loss	Any portion of a plant that is left after harvest, including roots and nodules, supplies N to the soil system. When the plant material decomposes, N is released.
Precipitation	Gain	Small amounts of N are added to the soil from precipitation.
Addition of Fertilizers or Manure	Gain of N to soil	Direct additions of manure, wastewater, or commercial fertilizers to crops.
Crop Removal	Loss	Crop removal during harvest accounts for the majority of the N that leaves the soil system.
Soil Organic Matter	Gain of nitrate. Loss of organic nitrogen	Decomposition of organic matter proceeds at a slow rate and releases approximately 20 lb N/acre/year for each percent of organic matter.

(O'Leary et al., 2002; University of Western Australia, 2013)

Appendix D – Physical Basin Characteristics

The following appendix is a more detailed description of the physical basin characteristics of the Lower Yakima Valley.

Physical Basin Characteristics

The Yakima River Basin is located in south-central Washington. This area includes three Washington State Water Resource Inventory Areas (WRIA 37, 38, and 39), part of the Yakama Nation lands, three ecoregions (Cascades, Eastern Cascades, and Columbia Basin), and crosses four counties: Klickitat, Kittitas, Yakima, and Benton (USGS 2006a). Almost all of Yakima County and more than 80 percent of Kittitas County lie within the basin. About 50 percent of Benton County is in the basin. Less than 1 percent of the basin lies in Klickitat County, principally in an unpopulated upland area.

Within the Yakima Basin there are six structural sedimentary basins. The delineated sedimentary basins are (from north to south) the Roslyn, Kittitas, Selah-Wenas, Yakima (Ahtanum-Moxee), Toppenish, and Benton Sedimentary Basins. The GWMA includes only parts of the Toppenish and Benton Sedimentary Basins.

The Toppenish Sedimentary Basin is fully contained within Yakima County. It is bordered by Ahtanum Ridge to the north, Toppenish Ridge to the south, and the Benton Sedimentary Basin to the east. It is bisected by the Wapato Syncline. Only the southeastern corner of the Toppenish Sedimentary Basin, northeast of the Yakima River, is included in the GWMA boundaries.

The Benton Sedimentary Basin is bordered on the south by the Horse Heaven Hills. The northeast boundary generally follows the northern flank of the Cold Creek Syncline. The western boundary abuts the eastern boundary of the Toppenish Sedimentary Basin and a small section of the Yakima Sedimentary Basin. Only the western portion (approximately a third) of the Benton Sedimentary Basin is within the GWMA boundaries.

Geology

The primary geologic features discussed include the stratigraphic units of the Columbia River Basalt Group, the Ellensburg Formation, and the Lower Yakima Valley Fill. The structural feature known as the Yakima Fold Belt is described as well.

Columbia River Basalt Group

The Columbia River Basalt Group (CRBG) is a thick sequence of Miocene eruptive basalts estimated to be several thousand feet thick and interbedded with a few minor sedimentary strata. It overlays the basalt bedrock unit of the Yakima region. The CRBG covers an area of more

than 59,000 square miles (Beeson and Tolan 1990) and spans parts of Washington, Oregon, and Idaho. It is subdivided into three primary formations: the Saddle Mountains Basalt, the Wanapum Basalt, and the Grande Ronde Basalt (USGS 2009a; GSI 2009a, 2011). The Saddle Mountains Basalt is often exposed at the surface, with thicknesses ranging from 180 to 800 feet and averaging more than 500 feet in the Yakima Basin. The Wanapum Basalt can be over 800 feet thick. The Grande Ronde Basalt underlies the Wanapum Basalt. These formations are further subdivided into several dozen members and hundreds of flows.

The Saddle Mountains Basalt is often visible at the bounding upland ridges of the Toppenish Basin such as the Rattlesnake Mountains, Ahtanum Ridge, Toppenish Ridge, and the Horse Heaven Hills. It is made up of several flows, including the Umatilla Member, the Wilbur Creek Member, the Asotin Member (13 million years ago), the Weissenfels Ridge Member, the Esquatzel Member, the Elephant Mountain Member (10.5 million years ago), the Bujford Member, the Ice Harbor Member (8.5 million years ago), and the Lower Monumental Member (6 million years ago). The underlying Wanapum Unit averages 600 feet thick. These units are separated by the Mabton Interbed, with an average thickness of 70 feet (USGS 2009a).

Basalt is a dense rock, having a fine texture precluding identification of crystals without magnification. Basalt is resistant to erosion and weathering and is a notable cliff-forming rock. Fresh, unweathered surfaces are black or dark gray; weathered surfaces range in color from gray to reddish brown. Basalt consists principally of small crystals of calcic labradorite, pyroxene, and olivine in a dense matrix of sodic labradorite, augite, and volcanic glass. Magnetite and apatite are common accessory minerals. Calcite, siderite, zeolites, opal, and chalcedony are common in veins and vesicles in the basalt (USGS 1962).

At the end of the Miocene Epoch, approximately 5.3 million years ago, an extended plain of basaltic lava covered most of eastern Washington (USGS 1962, 2009a). The basaltic lava flows were extruded from fissures located in the eastern part of the Columbia Plateau (USGS 1962), most likely near Hells Canyon, Oregon; these extrusions probably continued intermittently into the Pliocene Epoch (5.3–2.6 million years ago), covering sedimentary deposits, forming new basins of deposition, and changing stream courses (USGS 1962). This sequence of volcanic flows resulted in the Columbia Basin Basalt Group, now underlying southeastern Washington and extending into Oregon and Idaho (USGS 1962). The individual flows range in thickness from a few feet to more than 100 feet. The total basalt thickness in the central part of the plateau is estimated to be greater than 10,000 feet (USGS 1990b), and the maximum thickness in the Yakima River basin is more than 8,000 feet (USGS 1962).

Extrusions and flows of volcanic material now within the CRBG formation occurred intermittently over millions of years. Individual flow layers range from less than 20 to more than 200 feet in thickness. Individual flows may differ considerably in thickness from place to place (USGS 1962). Enough time elapsed between extrusions to allow considerable weathering of the uppermost frothy surfaces of lava flows and to allow development of thin soil zones, which

were later buried by subsequent flows (USGS 1962). Bubbles of gases emitted from the solidifying molten lava created zones of abundant gas cavities (vesicles). The vesicles are sometimes filled with secondary minerals deposited by water percolating through the rocks. The vesicles are separated from each other by the encasing solid rock, except where they have been fractured or deeply weathered (USGS 1962).

The Ellensburg Formation

At the west side of the basaltic lava plain, approximately where the present Cascade Mountains now stand, intense volcanic activity occurred before the period of basaltic lava extrusion ended. This volcanic activity was at an elevation somewhat higher than the lava plain but probably lower than the present Cascades. The debris created by this volcanic activity in those ancestral Cascade Mountains was the source of the Ellensburg Formation: sedimentary materials that were deposited upon the lava plain, transported by eastward flowing streams or aeolian processes moving ash and pumice (USGS 1962). The majority of the volcanic materials were deposited upon the lava plain after these flows ceased and the Cascades continued to rise (USGS 1962, 1999a).

The Ellensburg Formation consists of 85 to 95 percent semi-consolidated clay, silt, and sand with only 5 to 15 percent gravel and conglomerate. It often appears as sedimentary interbeds found between the various CRBG formations, members, and flow units. These interbeds vary in nature and composition, typically ranging between 1 and 100 feet thick. The color is predominantly gray, tan, and buff, although there are a few relatively thin rusty-brown sand and gravel strata. The clay and silt parts are massive at most places, but excellent bedding and shaley parting also are found. Some sand and gravel strata are cross-bedded, with thicknesses of the individual beds ranging from a few feet to more than 100 feet; strata of clay, silt, and fine sand usually are somewhat thicker than strata of the coarser materials (USGS 1962). "More than 1,000 feet of course-grained volcanoclastic sediment has accumulated over many parts of the Yakima River Basin" (USGS 1999a).

The Ellensburg Formation is mostly tough and hard, although some sand and gravel strata are weakly cemented. The silt and sand are composed chiefly of pumice, volcanic ash, quartz, and scattered feldspar and hornblende particles. Clay-size particles consist mostly of finely divided pumice and ash. The gravel contains large amounts of tuff and a distinctive purple or gray tuffaceous hornblende andesite. Cementing material is mostly argillaceous (containing clay). Minor amounts of diorite, quartzite, and various granitic and metamorphic rock types also are found locally in the gravel; basaltic fragments are rare (USGS 1962).

Lower Yakima Valley Fill

A variety of fine and coarse-grained sediments exists within the Toppenish Basin, overlying the Ellensburg Formation and included in the underlying major basalt flows (USGS 2009a). These sediments pinch out along the flanks of the ridges. They include the Touchet Beds, loess, thick alluvial sands, and gravels deposited by rivers and streams, including those within the Ellensburg

Formation, and other unconsolidated and weakly consolidated valley fill comprising glacial, glacio-fluvial, lacustrine, and alluvium deposits resulting from catastrophic glacial outburst floods that inundated the lower Yakima River Basin (USGS 1962, 1990b, 1999a, 2009a).

About 16,000 years ago these glacial outburst floods created Lake Lewis, a temporary lake in what is today the Lower Yakima Valley. The waters from periodic cataclysmic floods from the glacial Lake Missoula, pluvial Lake Bonneville, and perhaps from subglacial outbursts backed up through the constriction formed by the Wallula Gap in the Horse Heaven Hills, forming the lake; water also backed up further downstream on the Columbia River between Washington and Oregon, delaying the lake's drainage. The water remained for undefined periods before draining through Wallula Gap, permitting surface loess and basalt materials collected in the flood's transit southeast from the Spokane area to settle to the lake's bottom. This settled material formed at least some of the fine-grained gravelly and sandy materials extant today on the valley bottom of the Yakima River within the GWMA (Figure 6). Lake Lewis intermittently reached an elevation of about 1,200 feet (370 m) above today's sea level before draining to the Columbia through Wallula Gap (Carson and Pogue 1996; Alt 2001; Bjornstad 2006).

The Yakima Fold Belt

The GWMA lies within the Yakima River Basin within the Yakima Fold Belt. The fold belt is a highly folded and faulted region underlain by various consolidated rocks ranging in age from the Precambrian Supereon to the Cenozoic Era's Miocene Epoch, and unconsolidated materials and volcanic rocks of the Quaternary Period's Pleistocene Epoch. Dominant geologic structures in the Yakima Fold Belt in the western part of the Columbia Plateau are long, narrow, east-west to east-southeasterly trending anticlinal ridges with intervening broad synclinal basins; the combination essentially partitions the groundwater flow system. The anticlinal ridges function as groundwater flow barriers (USGS 2009a; Vaccaro 2016).

The folding that created the anticlines and synclines within the Yakima region was the consequence of tectonic compression (McCaffrey et al. 2016), initially of the sedimentary rocks now underlying the Columbia River Basalt Group; this compression probably began during the latter part of the Cenozoic Era, during the Pliocene Epoch. The Ellensburg sedimentary material was still accumulating during this time. Earlier explanations suggested that the folding was likely related to the Cascade uplift and subsidence of the center of the lava body approaching from the southeast (Foxworthy 1962). The folding proceeded slowly enough that the Yakima River could continue to erode its channel (Union Gap) as the Ahtanum Ridge anticline rose (Foxworthy 1962). The Ahtanum Ridge and the Rattlesnake Hills are part of the same anticline (Alt and Hyndman 2007). The Toppenish Ridge is another anticline, forming the southern boundary of the Toppenish Basin.

As the folding continued, the sedimentary material previously deposited on what became the anticlinal ridges was eroded off and carried down into the centers of the synclinal basins. This process accounts in part for the great thickness of the Ellensburg formation (USGS 1962).

Groundwater Recharge

Vaccaro (2016) studied recharge in the context of water availability for potential rural residential development and identified two domains within the GWMA: Rattlesnake Hills and Mabton. The Rattlesnake Hills Domain (246 sq. mi.) includes the relevant lands south of the Moxee Drain and east and north of the Yakima River (left bank). The eastern boundary of the domain is the boundary between Yakima and Benton Counties. The Mabton Domain (40.9 sq. mi.) includes the area north of Horse Heaven Hills (defined by the ridgeline) east of the Yakama Nation boundary, south of the Yakima River and west of the Yakima–Benton county line. These two domains include the GWMA. The Rattlesnake Hills Domain was divided into two sectors: one below the Roza Irrigation District canal (Sector 1), the other above that canal (Sector 2). The Mabton Domain was not further divided (Vaccaro 2016).

Sector 1 [of the Rattlesnake Hills Domain] (194 square miles) includes the irrigation districts present on Rattlesnake Hills such as Sunnyside Valley, Roza and Union Gap. The delivery and use of surface water in the irrigation districts provide a source of recharge (more than 10 inches per year and in some areas more than 20 inches per year (USGS 2007a) to the system. The sector includes the cities of Zillah, Sunnyside, Granger, and Grandview. Except for the northern and eastern part of the sector, the area is typified by basin fill deposits generally over 200 feet thick. That is, basin fill deposits over more than two thirds of this sector are almost everywhere greater than 200 feet, and over about one half of the sector they are greater than 400 feet. In the smaller, southeastern part of the sector, the deposits are thinner and future residential wells may need to be finished into the Saddle Mountains unit. Most of the existing wells may need to be finished in the basin fill deposits and much of the future pumpage in this sector would occur from these deposits except along the peripheral boundary with sector 2 or where the basin fill deposits thin toward the east. Future wells near the boundary between the two sectors likely would be needed to be drilled deeper than wells downslope. Groundwater-level hydrographs indicate stable water levels in these deposits. The groundwater levels for the units indicate that future withdrawals from the basin fill deposits would have minimal, if any affect, on the deeper Wanapum and Grande Ronde units.

Recharge over most of th[e] area [in the Mabton Domain north of the 700 foot water level contour for the Saddle Mountains unit [described by] Vaccaro and others (USGS 2009a)] is more than 10 inches per year because of the influence of surface water irrigation [from the Roza Irrigation District] (Vaccaro 2016).

Appendix E – Education and Public Outreach

The following plan was developed when the GWAC first formed. The committee recognized that it was critical to let affected residents know about the state of water in the Lower Yakima Valley, the potential health risks, and what they could do about it.

Introduction

The following outreach plan will help guide the Lower Yakima Valley Groundwater Advisory Committee (GWAC) carry out its public involvement efforts during the development of the GWMA program. The two-year outreach plan will educate audiences about the risk of nitrates in groundwater, invite participation in the GWAC's work, and solicit feedback in the GWMA development. It will also set the stage for future outreach efforts following implementation of the GWMA program.

The plan was developed by the GWAC's Education and Outreach (EPO) subcommittee, which was comprised of GWAC members, GWAC agency affiliates and citizen volunteers. The list is included as Appendix (A).

The subcommittee worked over several months to develop the strategy; key to this effort was ensuring that the plan will allow flexibility over the two years that the GWMA program itself is developed. That separate and concurrent effort will likely offer new data, program feedback and other variables that will require a dynamic and flexible outreach plan.

Following the subcommittee's creation of the draft plan, it was reviewed and approved by the GWAC committee on December 12, 2012.

GWAC and EPO Goals and Objectives

The Outreach Plan will support the GWAC's goal, *The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards.*

In addition, the EPO developed its own goal statement: *The GWMA Education and Public Outreach Plan will inform and educate the public about nitrate groundwater contamination and its health and environmental impacts, promote GWMA activities, and encourage engagement in the process by the community and key stakeholders.*

Overarching Objectives

The overarching objectives developed to carry out the plan goals include:

1. Educating at-risk audiences about the risks of elevated nitrate to human health and how to protect themselves from that risk;
2. Informing audiences about the GWAC planning process; and
3. Inviting participation in the development of the GWMA program

Target Audiences

The EPO plan will target four larger audiences, each with its own diverse audience subsets:

1. Internal audiences
    a. Agency Leadership
    b. Policymakers & Legislative Staff
    c. Yakama Nation Leadership
2. General Public
    a. Private well users and at risk-populations in the GWMA
    b. Other residents within the GWMA
    c. Media
3. Underserved/English as a Second Language Residents
    a. Private well users and at-risk populations in the GWMA
    b. Other residents within the GWMA
    c. Spanish-Language Media
4. Special Interests
    a. Large employers in the GWMA
    b. Environmental & Ag Industry Associations
    c. Social Justice Organizations

The detailed list of the target audiences is included as Appendix (B).

Strategy

The plan will address the specific needs of the diverse target audiences by responding to 1) the information and/or educational needs of each audience; 2) providing bilingual (English and Spanish) information and 3) using audience-specific outreach tools to convey key messages. This will be accomplished through a coordinated outreach campaign using a variety of English/Spanish outreach tools: a project website, interagency networking and coordination, print materials and mailings, local media, public events and festivals.

Underserved/English As a Second Language (ESL) Audiences

The EPO will directly reach out to the underserved and ESL audiences, especially those at high risk from nitrate contamination using targeted media and outreach work. Key "messengers" include Spanish language media, large employers, women's groups, the faith community, University of Washington Pacific Northwest Agricultural Safety and Health Center (PNASH), El Projecto Bienestar, and others in the GWMA program area. They will be provided English/Spanish outreach materials and will be invited to spread the word about the program.

The EPO will seek outreach opportunities such as Cinco de Mayo festivals, Hispanic Awareness Month activities, Tribal Housing Summits, and local health care community events.

Yakama Nation and Spanish-language radio and TV will be invited to participate in outreach through public radio talk shows, PSA's and commercial ad spots.

Role of the GWAC Members in the EPO

GWAC members will also play a central role in education and outreach efforts. Members are expected to provide regular GWAC updates to their constituencies, identify and help coordinate outreach opportunities within their own organizations, and convey feedback to the EPO. They will also be invited to participate in, and to help solicit volunteers for, outreach efforts.

As the oversight body of the EPO, the GWAC will also provide ongoing guidance to the EPO through recommendations, feedback and course corrections during the development of the GWMA program.

Outreach Tools

The following is a highlight of recommended outreach tools; a comprehensive list is included as Appendix (B).

GWMA Website

The GWMA website will serve as the central clearinghouse for the GWAC and the GWMA development. It will invite audience participation in the process, offer access to educational and self-help materials, provide information exchange between the GWAC and the public, and solicit feedback on the outreach strategy and the GWMA development.

Outreach materials (correspondence, fact sheets, flyers) will direct audiences to the website, and provide an additional means for audiences to access resources and to receive updates. The website may be viewed at www.yakimacounty.us/gwma.

Bilingual educational and outreach materials

Outreach materials (flyers, posters, mailings, survey instruments) will be made available in both English and Spanish. Based on feedback from previous outreach efforts, materials will convey the plan's key messages in a simple, easy to read format.

Evaluation Measures

A consistent survey instrument will be developed and used with each audience contact (through the website, at events, etc.). The purpose will be to solicit feedback on outreach efforts and their effectiveness, and to evaluate participants' current understanding of the issues, their awareness of the GWAC and their degree of involvement with the GWMA development.

A detailed list of evaluation measures is included as Appendix (B).

Key Milestones: 2013-2014

The key milestones for the outreach plan reflect an ongoing cycle of preparation and outreach, followed by review and evaluation and a subsequent report back to the GWAC. This dynamic approach allows the strategy to remain relevant over time and under changing conditions. It also ensures that the GWAC has sufficient information to provide meaningful input, or to make course corrections or suggestions as it develops the GWMA program.

The EPO Milestones are included as Appendix (C).

(B1) Internal Audiences- Agency Leadership	OBJECTIVES	OUTREACH TOOLS	EVALUATION MEASURES
Yakima County & Benton County Health Districts Benton County Planning, Permitting, Surface Water Conservation Districts Department of Agriculture Department of Health Department of Ecology EPA Public Water Systems Cities & Towns Yakima Valley Conference of Governments	Communicate with agencies about the GWAC planning process; inform and educate stakeholders regarding nitrate contamination and its effects. Coordinate outreach efforts with other agencies to maximize effectiveness and distribution.	GWAC Agency representatives are expected to report regularly back to their respective leadership, using face-to-face meetings, fact sheets, talking points, or informal presentations on a "need to know" basis. Use internal agency venues (brown bag lunches, Ed meetings, etc.) to announce program and provide periodic updates. Frequency: semi-annually or as dictated by agency opportunities. Use agencies' existing outreach (newsletters, website:, Facebook, tweets, etc.) to announce GWAC's work and to provide updates. Use e-mail distribution list for general updates. Offer presentations and/or displays at professional conferences, annual meetings, etc. Frequency: semiannually or as dictated by agency and conference opportunities	Number of new participating agencies Number of face-to-face meetings Number of fact sheets developed Number of talking points/presentations developed Number of outreach recommendations received & implemented Amount/character of audience feedback Number of e-mail contacts received Number of updates sent via e-mail list Number and character of comments, questions, suggestions and praise. Number of agency/organization requests to be involved in GWMA Structured interviews with key stakeholders to measure understanding of issues, degree of involvement with GWMA

(B2) Internal Audiences- Policymakers & Legislative Staff	OBJECTIVES	OUTREACH TOOLS	EVALUATION MEASURES
County Commissions (Benton & Yakima) Governor's Office 13, 14, 15 & 16 Legislative District Leadership State Agency Heads (AG, Ecology, Health) Fourth Congressional District (Doc Hastings)	Keep policymakers apprised of GWAC efforts and its relevance to public health Obtain political support for GWMA at multiple leadership levels and across affiliations Cultivate policymaker support as a vehicle to obtain additional funding Develop and maintain a reputation as an effective, science-based collaborative effort to protect human health	Send introduction letters to policymakers announcing the GWAC, the GWMA program and to invite participation in the effort. Frequency: once; followed by periodic "red letter" updates, e-mails, etc. Brief leadership and/or legislative staff using face-to-face meetings supplemented with support materials (fact sheets, links to website, etc.) Frequency: once; followed by periodic updates	Number of mailings Number of e-mails Number of inquiries, or follow-up contacts initiated by policymaker or legislative staff Structured interviews with key stakeholders to measure understanding of issues, degree of involvement with GWMA Amount/quality of direct support (funding, legislative action) received

(B3) Internal Audiences- Tribal Leadership	OBJECTIVES	OUTREACH TOOLS	EVALUATION MEASURES
Yakama Nation General Council Yakima Nation Tribal Council	Keep tribal leadership apprised of the GWAC's efforts Seek to develop a collaborative outreach program between the Lower Valley GWMA and the Yakama Nation's efforts.	Provide similar policymaker outreach tools (introduction letter/fact sheet, offer to make presentations to leaderships, etc.) to Nation's GWAC representative. Frequency: as guided by Nation's GWAC representative. Provide materials and presence of the Tribal Housing Summit, Treaties, and other community events. Frequency: semiannually, or as invited to participate. Offer to provide presentations and/or materials to schools. Frequency: as invited to participate.	Similar to policymaker outreach - focus on counting and documenting outreach efforts. Number/type of invitations from tribal leadership to engage in collaborative outreach.

(B-4) Target Audience-General Public	OBJECTIVES	OUTREACH TOOLS	EVALUATION MEASURES
Residents served by private wells in the GWMA. Benton and Yakima County Residents (general public) Media Healthcare Providers School Districts Higher Education	Provide information to private well users on nitrate self-help and groundwater quality protection measures. Educate public audiences about groundwater, risks of elevated nitrate to human health and the GWAC and GWMA program. Invite participation in the development of the GWMA program. Develop and maintain a reputation as an effective, science-based, non-regulatory effort to protect human health	Involve area media in events and GWAC updates using news releases, fact sheets and invitations to events. Host community water testing and education events in various target neighborhoods most likely to have high nitrate in drinking water. Frequency: 2-4 times annually. Direct mailings. Bilingual door-to-door campaign in the GWMA. Create and maintain a "groundwater message hotline" for resource and referral purposes. Create posters, fliers and table tents for distribution throughout the community and at key community events.	Amount and character of media coverage Number of community events Number of participants at events Number of drinking water samples processed Number of resident requests for assistance or follow-up Number of households contacted Number of residents requesting additional information Structured interviews with key stakeholders to measure understanding of issues, protection measures taken, degree of awareness of GWAC and/or or GWMA.

(B5) Target Audience-Underserved/English As Second Language	OBJECTIVES	OUTREACH TOOLS	EVALUATION MEASURES
Residents served by private wells in the GWMA. Benton and Yakima County Residents (general public) Spanish-language Media Healthcare & Social Service Providers School Districts Higher Education	Reach out to non-English speakers to educate and involve them in the GWAC planning efforts. Provide education on the health risks of nitrates and self-help measure's to non-English speakers through targeted media, large employers and healthcare and social service providers. Invite participation in the development of the GWMA program. Develop and maintain a reputation as an effective, science-based, non-regulatory effort to protect human health	Involve Spanish-area media in events and outreach using paid ads, PSAs, and radio talk shows. Coordinate with healthcare and social service providers, churches, U of W and Projecto Bienestar to provide education and to evaluate communication measures. Offer targeted educational outreach and community water testing at Cinco de Mayo, Hispanic awareness month festivals etc. in neighborhoods most likely to have high nitrate in drinking water. Frequency: 2-4 times annually. Direct mailings. Bilingual door-to door campaign in the GWMA. Create and maintain a "groundwater message hotline" for resource and referral purposes. Create posters, fliers and table tents for distribution at large employers in the GWMA and throughout the community.	Amount and character of media coverage Number of community events Number of participants at events Number of drinking water samples processed Number of resident requests for assistance or follow-up Number of households contacted Number of residents requesting additional information Structured interviews with key stakeholders to measure understanding of issues, protection measures taken, degree of awareness of GWAC and/or or GWMA.

(B6) Target Audience-Special Interests	OBJECTIVES	OUTREACH TOOLS	EVALUATION MEASURES
Agricultural Groups (Dairy Federation, Farm Bureau, Fertilizer Groups, Hop Growers, Mint Growers, Irrigated Ag Producers) Centers for Disease Control (CDC) Center for Environmental Law & Policy Faith-based Groups Farm Workers Clinic Large Employers Environmental & Social Justice Organizations Women's Groups Yakama Nation	Inform targeted special interest groups of the GWAC planning process and programs. Educate targeted special interest groups about relevant measures to protect groundwater from nitrate levels that exceed drinking water standards. Provide education to targeted special interest groups on the health risks of nitrates and self-help measures. Develop and maintain a reputation as an effective, science-based, non-regulatory effort to protect human health	Distribute outreach materials (posters, fliers) to special interest groups. Offer speaker presentations at regularly scheduled meetings. Develop and maintain social media sites, e- newsletters etc. targeting special interest audiences. Network with regional dairy women and other industry representatives.	Number of materials requested and/or distributed Number of presentations requested Number of participants at events Amount/character of audience feedback Number of e- social media contacts received Number of updates sent via e-mail list Number and character of comments, questions, and praise. Structured interviews with key stakeholders to measure understanding of issues, degree of awareness of the GWMA and its purpose

Accomplishments Chronology

Lower Yakima Valley Groundwater Management Area

Education & Public Outreach Accomplishments Timeline

2012-2017

2012

1. EPO develops the Education and Public Outreach (EPO) Plan as required under WAC 173-100-090 (1) Groundwater advisory committee.
2. December 12, 2012 - GWAC approves the outreach plan; Yakima County submits it to the Department of Ecology.

*2013 - EPO Implements Education and Outreach Plan

3. EPO creates GWAC logo options for GWAC consideration.
4. March 13, 2013 - GWAC approves a GWMA logo, which is used for all subsequent outreach materials, including but not limited to the website, letterhead, news releases, outreach flyers, program banner, and billboards.
5. **Public Awareness Survey (English & Spanish).** GWAC contracts with Heritage University to conduct **bilingual** door-to-door surveys in the GWMA. EPO designs survey to gauge the public's awareness of the nitrate issue and its potential health impacts. (Work included but was not limited to creating the survey content **(English & Spanish)** and packets, mapping the areas to be surveyed, training 16 Heritage University **bilingual** students to conduct the survey, troubleshooting issues, conducting quality control of the survey methods, and entering data into a spreadsheet.)
    a. **Outreach results:** 300 Direct **Bilingual** Contacts (direct mail, in person, flyers) to households in the GWMA.
    b. 136 surveys completed
    c. **Spanish/English** news releases issued to media (pre-and post-survey).
    d. EPO issues survey results in English/**Spanish** and posts to the website.
6. **Health provider outreach.** Over 200 healthcare providers receive nitrate-related health information and a survey asking them if they have observed symptoms of methemoglobinemia in their maternal or infant patients (English).
7. July 18- Commissioner Rand Elliott and Andy Cervantes make a presentation to the Central Family Medicine Residency Program on the GWMA and nitrates.
8. September - EPO creates script for—and GWAC/EPO member Andy Cervantes participates in—an **Hispanic Affairs Commission "Connect with Your**

Government" Spanish-language statewide radio talk show to increase awareness about the GWMA

9. **December -** Commissioner Elliott gives a presentation on the GWMA, and seeks support of the upcoming well assessment survey, to the Community Advisory Board for **El Proyeto Bienestar**
10. **December-High Risk Well Assessment Survey Phase I (English/Spanish)** EPO Creates a survey instrument and develops an outreach campaign for a well assessment survey in the target area. (Wrote and released **bilingual** materials including PSA's, a direct mail piece, GWAC Chair letter to area newspapers; explored ministerial outreach to churches)
11. **GWMA website.** EPO develops and launches a community website that offers information about the committee, its meetings and information on nitrate-related topics.

*2014-

12. January-EPO issues a news release announcing the GWAC's accomplishments
13. EPO updates the website and maintains it in "real time" from its inception to the present (English)
14. EPO continues **(English/Spanish)** outreach for High Risk Well Assessment Survey Phase I

April 7 - issues an **(English/Spanish)** news release announcing that the survey deadline has been extended

15. New Mom Campaign (English/Spanish)
    a. EPO develops and obtains GWAC approval for new mom messages to be distributed in hospitals and clinics.
    b. EPO prints and distributes over 2000 English/**Spanish** new mom flyers to hospitals, clinicians and at health fairs and community events (including but not limited to Zillah Days and Granger Agricultural bilingual event)
    c. **EPO seeks and obtains partnership with the University of Washington's** Pediatric Environmental Health Specialty Unit (PEHSU) to collaborate on the New Mom campaign
        i. PEHSU conducts clinician trainings in Yakima and Lower Valley to raise clinician awareness of nitrate issue, resources and treatment
        ii. PEHSU obtains authorization to offer Continuing Education Units (CEU) to participating healthcare providers.
        iii. PEHSU creates and distributes Clinician Training video
        iv. Nitrate/new mom materials posted to PEHSU's national website
16. **GWAC educational materials**: EPO creates and obtains GWAC approval of GWAC slide deck (GWAC background information and nitrate education series); posted to website

17. **May - Deep Soil Sampling Launched.** EPO partners with Irrigated Ag working group to promote program.
18. May 2 - EPO issues a **bilingual** news release reminding households of the May 31 deadline to participate in Phase I Free Well Testing.

19. Phase I of the (English/Spanish) High Risk Well Assessment Sampling Surveys is completed (172 Total)

    a. **Outreach: Bilingual** outreach included multiple presentations to Sunnyside Workforce clients, talk show **participation** on **Spanish** (KDNA) and English radio stations, paid advertisement on **Spanish** and English-language radio, 600 **Spanish**-English direct mail pieces, and GWAC Chair editorial outreach published in area English and **Spanish** papers.

20. GWAC approves a two-year outreach budget developed by the EPO

TOTAL $267,000:

- Abandoned Wells and Septic System Maintenance $76,000
- Educational Outreach Campaigns $54,000
- Wellhead Risk Assessment Surveys-Phase 2 $100,000
- Redesign and Maintain GWMA Website $12,000
- Community Outreach Surveys $25,000

21. EPO releases the High Risk Well Assessment results.
22. EPO prints and distributes 2000 double-sided English/**Spanish** New Mom Flyers at health fairs in Prosser, Yakima and other outlets.

*2015 –

23. EPO rebuilds and launches the new GWMA website
24. High Risk Well Assessment Follow-up (English/Spanish)
    EPO communicates test results, prevention messages and GWAC information to high risk well assessment participants (171 unique mail pieces in English and **Spanish**)
25. EPO evaluates and reports back to the GWAC regarding the Phase I High Risk Well Assessment results. They agree that the data show a great need for well owners to be familiar with their wells, and to test their wells more frequently.
26. EPO announces Phase II Well Assessment survey. EPO's goal is to complete 200 sampling surveys.
    EPO agrees to use Phase I methodology for messaging in Phase II. Targets: areas of known high nitrate, areas where little nitrate data exists. Direct mail list is increased from 600 (Phase I) to 1000 in Phase II.

27. Phase II **(English/Spanish)** outreach continues. December-EPO evaluates its outreach methods (direct mail, radio advertising, flyers and newspaper coverage.) Response from survey participants indicates that direct mail is the most cost-effective method of eliciting participation. Accordingly, EPO plans a second direct-mail release in January 2016.

*2016

28. County sends 115 **(English/Spanish)** results letters to recent well assessment participants with their certified lab results and educational materials. January-350 additional household invitation letters are sent.
29. January and March-**(English/Spanish)** news releases inviting well assessment participation are released.
30. March 31-Phase II high risk well assessment survey closes.
31. April-the County mails the last round of **(English/Spanish)** results letters to the Phase II well assessment participants with their certified lab results and educational materials. The letters included **(English/Spanish)** handouts on nitrate, coliform, and private well and septic system maintenance.
32. EPO Completes Phase II of the High Risk Well Assessment Sampling Surveys (289) for a total of 466 completed surveys (Phase I-177 + Phase II- 289).
    a. **Outreach: Bilingual** outreach included multiple presentations to Sunnyside Workforce clients, talk show participation on **Spanish** and English radio stations, paid advertisement on **Spanish** and English-language radio, 600 Spanish-English direct mail pieces, and GWAC Chair editorial outreach published in area English and **Spanish** papers.
    b. **Follow-up (English/Spanish)** County communicates test results, prevention messages, septic system maintenance and GWAC information to high risk well assessment participants (289 unique mail pieces in English and **Spanish**)
33. *GWAC/EPO participate in five Spanish-language Fred Hutch-sponsored health fairs (Sunnyside, Mabton, Zillah, Granger and Toppenish) between May and August 2016. Volunteers make **bilingual**, one-on-one contact with approximately 250 lower Valley residents.
    (English/Spanish) Information on private wells, nitrate in groundwater, new mom flyers is distributed to visitors.
    Visitors are also asked to complete the GWAC's **(English/Spanish)** public survey.

Residents on private wells are offered **(English/Spanish)** nitrate test step strips for a "do-it-yourself" drinking water test. Self-addressed stamped envelopes are included with the test strips so people can return their test results directly to Yakima County.

34. EPO develops, presents and receives GWAC approval to launch a "Test Your Well" English/**Spanish billboard** campaign in the Lower Yakima Valley.

35. December - first (English/Spanish) billboard goes live in the LYV GWMA.

*2017

36. January - Second of two (English/Spanish) "Test Your Well" Billboards Goes Live
37. EPO creates, translates and posts five **(English/Spanish) "What You Can Do"** flyers to the GWMA website.
38. EPO Launches a (English/Spanish) "What You Can Do to Protect Well Water Campaign
(in response to wide-spread local flooding, especially in the unincorporated community of Outlook) March & April 2017

- **(English/Spanish)** "What You Can Do to Protect Well Water" flyers "(English/Spanish) and test trips distributed door-To-door in Outlook (Yakima Health District).
- **(English/Spanish)** 12,000 What You Can Do to Protect Well Water flyers inserted in the Sunnyside Daily Sun News on March 29, 2017
- **(English/Spanish)** 10,700 flyers inserted in the Spanish-language *El Sol* weekly publication on March 30, 2017
- **Spanish-language** KDNA news show participation – April 4, 2017 (Andy Cervantes and Ignacio Marquez)
- KIT interview-March 30, 2017 (Commissioner Rand Elliott)
- April 29- **(English/Spanish)** flyers (using a **Spanish-speaking EPO member)** distributed at the Sunnyside Walmart store

39. PEHSU (English/Spanish) New Mom Flyers
200 **(English/Spanish)** flyers are distributed to the Toppenish Community Hospital (restock order)
40. EPO Requests Working Groups to Complete an EPO Questionnaire
EPO asks all working groups to answer EPO's questions related to their mission, accomplishments, discoveries, target audiences and messages.
The purpose of this exercise is to help the EPO develop a short-and long-term (post adoption) Communications and Outreach Plan for the GWAC's consideration.
This information is compiled in a summary distributed to the GWAC.

41. June - EPO begins to develop its alternatives recommendations for the GWMA program.

- EPO requests GWAC assistance to identify specific messages and outreach it would like conducted.

Appendix F – Deep Soil Sampling

In 2014, the GWMA authorized a Deep Soil Sampling Initiative (DSS) to collect nitrate soil samples across a variety of irrigated agriculture activities. The project design was based on recommendations developed by the GWMA's Irrigated Agriculture Working Group and has been documented in a quality assurance project plan (PGG 2014c). The goal of the initiative was to create a "snapshot" of current soil nitrate conditions corresponding to the range of irrigated agricultural actives in the basin. By collecting generic samples from a variety of existing agricultural operations, the goal was to identify base conditions that could be used to further refine the conceptual model of irrigated agriculture's contribution of nutrients to the subsurface environment. Because participation in the initiative was voluntary and sample sites and results were anonymized, this type of assessment is qualitative, and not necessarily quantitative.

The objectives of the sampling were to provide:

- Baseline data on the nitrogen content (nitrate, ammonium, and organic matter) of soils underlying a variety of soil, crop, and irrigation systems representing a cross-section of agricultural activities.
- An initial assessment of current nitrogen and water management practices for each sampled field, along with a snapshot of soil nitrogen availability.

Programmatic goals included generating:

- Foundational information for a technically based education program and
- Insights about project design, implementation, technical challenges and costs that could guide subsequent projects.

The DSS included four rounds of sampling starting in the fall of 2014 and running through the spring of 2016. Samples were collected in the fall and spring of each year. Over the course of the two years, four rounds of sampling were conducted and 175 sites were sampled with soil collected at one foot intervals (down to six feet). All samples were analyzed for nitrate (NO_3 as N) and ammonium (NH_4 as N). Organic matter was analyzed from samples collected at one foot.

For each field sampled, a survey was to be completed that tracked:

- The amount and types of nitrogen applied over recent years,
- Types of crops with estimates of the yield, and
- Irrigation practices associated with each field.

Under the study design, grower participation was voluntary and anonymous. Each field location, data and ownership were assigned to a generic sample number. While study participants received copies of the sample results, the project data was anonymized with only generic field information being reported. Neither specific locations nor ownership data were included in the results. Each sampling round was independent of previous rounds, and unique sample numbers were assigned in each round. The DSS Sampling Plan (PGG 2014c) outlines the procedures used to coordinate the site selection, field sample collection, and laboratory reporting requirements. The work was completed under contracts with the South Yakima Conservation District (SYCD) and Landau and Associates with the bulk of the coordination and reporting under the auspices of the SYCD. The cost of sampling and analysis was paid for by the GWMA.

A complete summary of the Deep Soil Sample results are included in this appendix under Deep Soil Sampling Data. Sample results are entered by year and site/field, with each site identified by a unique ID. A summary of the field data (field survey data) is included along with the soil analysis. The 175 sample sets reflect a wide array of agricultural activities ranging from annual row crops to orchards and reflect an equally diverse set of irrigation practices. Quality Assurance and Quality Control procedures for the Initiative are outlined in the quality assurance project plan (PGG 2014c). Also included in that report are copies of the user survey (field survey), sample collection, and field analysis forms (field soil survey).

Outcomes and Challenges

The quality of information on the historical practices varied greatly over the study. Some owners were able to provide detailed information about prior year practices (over the previous 3 – 4 years) while others provided no information beyond the current year. There is a wealth of qualitative information that could be mined for further analysis, but because of the diversity of sites and impact of the limitations identified below, a comprehensive and quantitative analysis of this initial data set is not an option.

The field soil survey data appears to have been consistently collected and analyzed. Each set provided real soil nutrient information to the operator that they could use to evaluate their on-site practices; however, there are at least three factors tied to the design and operation of the initiative that limit the use of the data to make broad observations about impact of current operations across the GWMA. These limiting factors include:

- Lack of longitudinal sampling. (The same sites were not necessarily sampled repeatedly over the four rounds. If a site was sampled multiple times, the site reference, and anonymized data set obscured that fact.)
- Field survey data (user practices) were not consistently recorded. The field soil sample analysis was not explicitly tied to a completed and returned field site survey (user practices). As a result, there are sites with soil data that do not have complete survey data. Further, it is not clear that the same level of accuracy and rigor were applied to all field surveys.

- Even though the survey was voluntary, subsidized, and the public data anonymized, SYCD was faced with the challenge of recruiting participants. The public perception and fear that the collected data could be tied back to a specific site, and used in subsequent enforcement or legal challenges appears to have had a chilling effect on the volunteer pool.

None of these factors by themselves are fatal flaws, but their collective impact has limited the quantitative value of the data collected in this initial effort. However, a significant amount of data was collected and the qualitative observations speak to the original goals of the study. Two such reviews were initiated by members of the GWMA's Data Management Workgroup (Data Workgroup). These preliminary reviews were presented to the Data Workgroup, and a summary was reported to the GWAC. These presentations are included in this appendix under the section titled Analytical Data Analysis (Redding) and Analytical Data and Survey Data Analysis (Mendoza). In both Ms. Redding's and Ms. Mendoza's work, the findings are preliminary and qualitative; however, their work was able to highlight areas for discussions with the grower community, provide focus for further work, and identify opportunities for educational outreach on operational, irrigation, and fertilization practices.

Melanie Redding (Data Workgroup Chair) provided a summary of the full soil sample dataset. Her analysis focused on how nitrate values were expressed in the subsurface by depth and to a lesser extent by season. For this review, each sample site was considered a random point. She did not consider cropping or irrigation information from the field surveys and only looked at the analytical soil data. Specifically the review focused on the cumulative nitrate concentrations as they relate to average, shallow, and deep roots zones. The strength of her analysis is that it treated all sample sites as random within a geographic area. With that assumption, she was able to focus on the analytical results for each round of sampling as independent data points. This analysis did not attempt to factor in the subjective site survey data. As a result, it provided a large sample set and a snapshot of subsurface nitrate values that existed during the sample seasons. This type of analysis can be used as a base for comparison against future rounds that may be undertaken. It also highlights what current nitrate loading levels could look like at "typical" root zone levels in the GWMA.

Jean Mendoza (Data Workgroup Member and GWMA Advisory Committee member) took a different approach to reviewing the DSS data. She broke the data into spring and fall sample sets, which allowed her to combine seasonal data across the two years (fall = 2014 and 2015; spring = 2015 and 2016). This provided a larger sample set that any single year would provide. She then compared fall and spring values highlighting apparent seasonal differences. Like Ms. Redding's work, Ms. Mendoza treated all samples within a seasonal set as random. While there are likely a combination of hydrologic and operational factors that could impact seasonal soil nitrate, this initial sample set can quantify that (See discussion of limitations above). Ms. Mendoza's qualitative observations of seasonal soil nitrate levels provide a basis to begin looking

at operational issues and practices that might exacerbate or mitigate subsurface nutrient levels. Further discussions with the grower community could provide the context and understanding of "typical" operations linked to certain irrigation practices.

In her analysis, she considered gross seasonality but also looked at broad cropping and irrigation practices as potentially significant influences on the resulting soil nitrate values. Her analysis of the subset of data on fields that were double cropped and planted with triticale and corn silage shows the type of analysis that could be done in the future with targeted longitudinal samples set buttressed with consistent and complete field user data. The conclusions are qualitative because under this type of analysis, the sample sets were small and not longitudinal. The differences between sites and site-specific practices can significantly impact one data point versus another. The type of information needed to correct for those factors was not consistently captured in this initial project (DSS). With limited sample sets, it is difficult to differentiate between data points that may be outliers and those that are significant endpoints within the data set.

The analysis of the DSS data is considered informational only. Any clarification or questions can be directed to the author.

Going Forward

The work done by Ms. Redding and Ms. Mendoza provides insights into how a study like the DSS could be improved to better meet the original goals and objectives. Such work would be valuable as part of a long term GWMA program serving as a "safe" feedback mechanism to the grower community regarding the effectiveness of current management practices and their potential impact on subsurface nitrogen loading. However, any future work would need to address the limitations and challenges identified by this initial work. Specifically, some considerations include:

- Better correlation between field soil sample data and field survey data.
    - Tying soil sampling and analysis to complete and submitted field user survey.
    - Providing follow-up with users by a third party on incomplete field survey data forms.
- Tie participation and subsidies (sampling costs) to longitudinal sampling (multiple samples over time at the same site).
- Collaborate with a research organization to provide stability, expertise, and capacity to manage a multi-year program as well as detailed analysis of data as it is collected.
- Re-emphasize the "safety" and utility of the anonymized sampling protocols.

If longitudinal samples are incorporated into the study design along with more complete and consistent field survey data, the number of sample sites could be smaller and/or targeted on specific crops, cropping patters and or irrigation practices. This would expand the educational potential of the work with the agricultural community by developing a dynamic and ongoing "laboratory" that can draw attention to best management practices.

Deep Soil Sampling Data

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

1001

Acres	4
Soil Testing?	10/31/2014
Test Frequency	NO
Irrigation Type	Solid Set Above Canopy
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	8
2 ft	3
3 ft	3
4 ft	3
5 ft	5
6 ft	3
TOTAL	25
NH4-N	28
ORGANIC	1.87

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	0	0	0	0	0	0	0	Pasture					
2013	0	0	0	0	0	0	0	Pasture					
2012	0	0	0	0	0	0	0	Pasture					
2011	0	0	0	0	0	0	0	Pasture					

Comments: Just 4 to 5 head of Cattle

Current Crop	
Crop Year	2014
Condition	Fair

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	6	
B	S	M	2	
C	S	M	4.2	
D	S	M	5.5	
E				

1002

Acres	50
Soil Testing?	10/29/2014
Test Frequency	YES
Irrigation Type	Biannually
Irrigation Schedule	Wheel Lines
Hour Sets	Routine Schedule
Irrigation years	2
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	285
2 ft	124
3 ft	115
4 ft	
5 ft	
6 ft	
TOTAL	524
NH4-N	11
ORGANIC	2.4

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	337.5	0	100	0	0	0	438	Triticale	5	Tons			
2013	112.5	0	100	0	0	0	213	Wheat	65	Bushels			
2012	0	0	0	0	0	0	0						
2011	0	0	0	0	0	0	0						

Comments:

Current Crop	
Crop Year	2014
Condition	Fair Planned

Soil: 121 - Scoon Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M		3
B	S	M		2.5
C	S	M		2
D	S	M		2
E				

1003

Acres	25
Soil Testing?	10/29/2014
Test Frequency	YES
Irrigation Type	Annually
Irrigation Schedule	Drip
Hour Sets	Routine Schedule
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	65
2 ft	6
3 ft	3
4 ft	
5 ft	
6 ft	
TOTAL	74
NH4-N	5
ORGANIC	1.43

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	0	0	50	0	0	0	50	Cherries	8	Tons			
2013	0	0	30	0	0	0	30	Cherries	4	Tons			
2012	0	0	0	0	0	0	0						
2011	0	0	0	0	0	0	0						

Comments:

Current Crop	
Crop Year	2014
Condition	Fair

Soil: 120 - Scoon Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M		3.2
B	S	M		3.2
C	S	M		1.5
D	S	M		2.6
E				

1004

Acres	40
Soil Testing?	10/30/2014
Test Frequency	YES
Irrigation Type	Pivot
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	177
2 ft	79
3 ft	63
4 ft	69
5 ft	42
6 ft	50
TOTAL	480
NH4-N	16
ORGANIC	2.06

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	0	0	250	0	0	0	250	Corn Silage	25	Tons	Triticale	6	Tons
2013	0	0	250	0	0	0	250	Corn Silage	25	Tons	Triticale	6	Tons
2012	0	0	250	0	0	0	250	Corn Silage	25	Tons	Triticale	6	Tons
2011	0	0	250	0	0	0	250	Corn Silage	25	Tons	Triticale	6	Tons

Comments:

Current Crop	
Crop Year	2014
Condition	Fair

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.5	
B	S	M	4.1	
C	S	M	3.2	
D	S	M	3.5	
E				

1005

Acres	15
Soil Testing?	10/30/2014
Test Frequency	YES
Irrigation Type	Annually to Biannually
Irrigation Schedule	Rill Irrigation and Hand Lines w/ Impacts
Hour Sets	Routine Schedule
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	25
2 ft	3
3 ft	3
4 ft	3
5 ft	3
6 ft	4
TOTAL	41
NH4-N	20
ORGANIC	2.21

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	0	0	0	0	0	0	0	Mint	70	Lbs.			
2013	0	0	12	0	0	0	12	Corn Silage	35	Tons			
2012	0	0	12	0	0	0	12	Corn Silage	35	Tons			
2011	0	0	12	0	0	0	12	Corn Silage	35	Tons			

Comments: The field has gotten manured for awhile. Solids are composted and spread as needed. Pond water is diluted down to irrigate with. No liquid sample taken.

Current Crop	
Crop Year	2014
Condition	Good Actual

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M		
B	S	M		
C	S	M		
D	S	M		
E				

Page 1 of 37

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

1006

Acres	15
	10/30/2014
Soil Testing?	NO
Test Frequency	
Irrigation Type	Wheel Lines
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	24
Irrigation years	5
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	45
2 ft	4
3 ft	3
4 ft	3
5 ft	4
6 ft	3
TOTAL	62
NH4-N	20
ORGANIC	2.17

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History: Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016							0				
2015							0				
2014	0	0	100	0	0	0	100				
2013	0	0	100	0	0	0	100	Alfalfa	9 Tons		
2012	0	0	100	0	0	0	100	Alfalfa	10 Tons		
2011	0	0	100	0	0	0	100	Alfalfa	10 Tons		

Comments: 50 pounds of N in spring and 50 pounds of N after second cutting

Current Crop	
Crop Year	
2014	
Condition	
Fair	Actual

Soil: 179 - Warden Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH	M, D, D	1.5	
B	S, SH	M, M	5	5.5
C	S	M	4.5	5
D	S	M	5	5
E				

1007

Acres	7
	10/30/2014
Soil Testing?	NO
Test Frequency	
Irrigation Type	Solid Set Below Canopy
Irrigation Schedule	
Hour Sets	
Irrigation years	10
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	3
2 ft	3
3 ft	3
4 ft	3
5 ft	
6 ft	
TOTAL	12
NH4-N	8
ORGANIC	1.09

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History: Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016							0				
2015							0				
2014	0	0	0	0	0	0	0	Crop Failure			
2013	0	0	0	0	0	0	0	Crop Failure			
2012	0	0	0	0	0	0	0	Cherries	2 Tons		
2011	0	0	0	0	0	0	0	Crop Failure			

Comments: Only leaf feed applied during crop year

Current Crop	
Crop Year	
2014	
Condition	
Good	Actual

Soil: 179 - Warden Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, SH	M, D	3.5	4
B	SH	D	1.9	1.9
C	S, SH	M, D		3
D	S, SH	M, D		3.5
E				

1008

Acres	45
	10/30/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Drip
Irrigation Schedule	Have coil moisture but use boots on ground
Hour Sets	
Irrigation years	19
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	246
2 ft	73
3 ft	14
4 ft	3
5 ft	
6 ft	
TOTAL	336
NH4-N	37
ORGANIC	1.39

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History: Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016							0				
2015							0				
2014	0	0	0	0	0	0	0	Wine Grapes			
2013	0	0	0	0	0	0	0	Wine Grapes			
2012	0	0	0	0	0	0	0	Wine Grapes			
2011	0	0	0	0	0	0	0	Wine Grapes			

Comments: 9 acres of problem field raw manure application in adjacent acres subs into our wine grape rows

Current Crop	
Crop Year	
2014	
Condition	
Poor	Actual

Soil: 10 - Burke Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	D, M, D		3.1
B	S, S	M, D	3.3	3.3
C	S	M		3
D	S, S, S	M, D, M	4	4
E				

1009

Acres	10
	10/31/2014
Soil Testing?	NO
Test Frequency	
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	99
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	12
2 ft	3
3 ft	40
4 ft	81
5 ft	
6 ft	
TOTAL	136
NH4-N	10
ORGANIC	1.64

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History: Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016							0				
2015							0				
2014	0	0	80	0	0	0	80				
2013	0	0	80	0	0	0	80	Concord Grapes	8 Tons		
2012	0	0	80	0	0	0	80	Concord Grapes	8 Tons		
2011	0	0	80	0	0	0	80	Concord Grapes	8 Tons		

Comments

Current Crop	
Crop Year	
2014	
Condition	
Good	Actual

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	M, D	3.2	3.4
B	S, S	M, D	2.8	3.2
C	S, S	M, D	3.4	3.4
D	S, S	M, D		3.6
E				

1010

Acres	2
	10/31/2014
Soil Testing?	NO
Test Frequency	
Irrigation Type	Solid Set Above Canopy
Irrigation Schedule	Routine Schedule
Hour Sets	6
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	50
2 ft	112
3 ft	6
4 ft	
5 ft	
6 ft	
TOTAL	168
NH4-N	17
ORGANIC	1.47

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History: Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016							0				
2015							0				
2014	0	0	0	0	0	0	0	Pasture			
2013	0	0	0	0	0	0	0	Pasture			
2012	0	0	0	0	0	0	0	Pasture			
2011	0	0	0	0	0	0	0	Pasture			

Comments: 4 to 6 Head of cattle

Current Crop	
Crop Year	
2014	
Condition	

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M		2
B	S	M	2	2.8
C	S	M		2
D	S	M	2.6	2.6
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

1011

Acres	27
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	FALL 2014
	10/31/2014

NO3 (#N/ACRE)	
1 ft	57
2 ft	141
3 ft	295
4 ft	269
5 ft	93
6 ft	50
TOTAL	905
NH4-N	40
ORGANIC	3.18

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	90	0	0	0	0	0	90
2013	90	0	0	0	0	0	90
2012	90	0	0	0	0	0	90
2011	90	0	0	0	0	0	90

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Silage	30	Tons			
Wheat	110	Bushels			
Corn Silage	30	Tons			
Wheat	100	Bushels			

Current Crop	
Crop Year	2014
Condition	Good Actual

Soil: 179 - Warden Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH	M, M, M	3.7	4
B	S, S, SH	M, M, M	5	
C	S, S, SH, S, SH, S	M, M, M, M, M	5.5	
D	S, S, SH	M, M, M	2	2
E				

1012

Acres	10
Soil Testing?	NO
Test Frequency	
Irrigation Type	None
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	FALL 2014
	11/4/2014

NO3 (#N/ACRE)	
1 ft	53
2 ft	60
3 ft	102
4 ft	
5 ft	
6 ft	
TOTAL	215
NH4-N	9
ORGANIC	3.06

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0

Comments: Fallow for last 10 years; Pre 2003 was in apples.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Fallow			
Fallow			
Fallow			
Fallow			

Current Crop	
Crop Year	2014
Condition	

Soil: 179 - Warden Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, SH, SH, SH, SH, SH	M, D, D, D, D, D	2.3	3
B	S, SH, SH, SH	M, D, D, D	2.1	2.5
C	S, SH, SH	M, D, D	1.2	1.5
D	S, SH, SH	M, D, D	1.2	2.7
E				

1013

Acres	6
Soil Testing?	NO
Test Frequency	
Irrigation Type	Drip
Irrigation Schedule	As Needed
Hour Sets	
Irrigation years	10
Event	FALL 2014
	11/4/2014

NO3 (#N/ACRE)	
1 ft	68
2 ft	9
3 ft	4
4 ft	6
5 ft	
6 ft	
TOTAL	87
NH4-N	30
ORGANIC	3.09

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	150	0	0	0	150
2013	0	0	150	0	0	0	150
2012	0	0	150	0	0	0	150
2011	0	0	150	0	0	0	150

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Pears	40	Bins			
Pears	35	Bins			

Current Crop	
Crop Year	2014
Condition	Fair

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.2	3.4
B	S	M	2.9	3.3
C	S	M	1.8	1.8
D	S	M	1.4	
E				

1015

Acres	40
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	10
Event	FALL 2014
	11/5/2014

NO3 (#N/ACRE)	
1 ft	271
2 ft	125
3 ft	266
4 ft	97
5 ft	94
6 ft	77
TOTAL	930
NH4-N	18
ORGANIC	2.26

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	300	0	0	0	300
2013	0	0	300	0	0	0	300
2012	0	0	300	0	0	0	300
2011	0	0	300	0	0	0	300

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Silage	40	Tons			
Corn Silage	40	Tons			
Corn Silage	40	Tons			
Corn Silage	40	Tons			

Current Crop	
Crop Year	2014
Condition	Good

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	4.1	5.5
B	S	M	5.6	
C	S	M	4.7	
D	S	M	4.3	
E				

1016

Acres	40
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	
Event	FALL 2014
	11/5/2014

NO3 (#N/ACRE)	
1 ft	94
2 ft	19
3 ft	27
4 ft	36
5 ft	73
6 ft	124
TOTAL	373
NH4-N	16
ORGANIC	1.71

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	300	0	0	0	300
2013	0	0	300	0	0	0	300
2012	0	0	260	0	0	0	260
2011	0	0	260	0	0	0	260

Comments: Split Application of N

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Silage	40	Tons			
Corn Silage	40	Tons			
Corn Silage	40	Tons			
Corn Silage	40	Tons			

Current Crop	
Crop Year	2014
Condition	Good

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.9	
B	S	M	5.4	
C	S	M	4.3	
D	S	M	3.7	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

1017

Acres	11/5/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	20
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	133
2 ft	14
3 ft	12
4 ft	14
5 ft	20
6 ft	9
TOTAL	202
NH4-N	11
ORGANIC	1.52

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	300	0	0	0	300
2013	0	0	300	0	0	0	300
2012	0	0	300	0	0	0	300
2011	0	0	300	0	0	0	300

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Corn Silage	8	Tons		
Corn Silage	8	Tons		
Corn Silage	8	Tons		
Corn Silage	8	Tons		

Current Crop	
Crop Year	
2014	
Condition	
Good	Actual

Soil: 171 - Wanser Loamy Fine Sand

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH, S	Dp, Dp, M, Dp	1.4	
B	S, SH, S	Dp, M, Dp	2.2	
C	S, SH, S	Dp, M, Dp	2.3	
D	S, S, SH	Dp, Dp, M	2.4	
E				

1018

Acres	11/5/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	20
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	155
2 ft	55
3 ft	32
4 ft	35
5 ft	52
6 ft	100
TOTAL	429
NH4-N	10
ORGANIC	1.64

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	300	0	0	0	300
2013	0	0	300	0	0	0	300
2012	0	0	300	0	0	0	300
2011	0	0	300	0	0	0	300

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Corn Grain	8	Tons		
Corn Grain	8	Tons		
Corn Grain	8	Tons		
Corn Grain	8	Tons		

Current Crop	
Crop Year	
2014	
Condition	
Good	Actual

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH	M, M, M	3.6	5.5
B	S, S, SH	M, M, M	2.5	
C	S, S, SH	M, M, M	2.3	
D	S, S, SH	M, M, M	2.2	5
E				

1019

Acres	10
	11/5/2014
Soil Testing?	NO
Test Frequency	
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	12
Irrigation years	1
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	10
2 ft	7
3 ft	4
4 ft	5
5 ft	9
6 ft	27
TOTAL	62
NH4-N	9
ORGANIC	1.29

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	100	0	0	0	100
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Barley	55	Bushels		
Alfalfa	8	Tons		

Current Crop	
Crop Year	
2014	
Condition	
Fair	Actual

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, D, D	3.5	
B	S	M	3.3	
C	S	M	4.3	
D	S, S, S	M, D, M	4.6	
E				

1020

Acres	45
	11/7/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	10
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	93
2 ft	276
3 ft	208
4 ft	78
5 ft	38
6 ft	23
TOTAL	716
NH4-N	23
ORGANIC	2.32

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	100	0	0	0	100
2013	0	0	100	0	0	0	100
2012	0	0	300	0	0	0	300
2011	0	0	300	0	0	0	300

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Wheat	100	Bushels		
Wheat	100	Bushels		
Corn	8	Tons		
Corn	8	Tons		

Current Crop	
Crop Year	
2014	
Condition	
Good	Planned

Soil: 173 - Warden Fine Sandy Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S	M, M, D, M	3.4	
B	S, S, S, S	M, M, D, M	5.8	
C	S	M	4.2	
D	S	M	5.2	
E				

1021

Acres	30
	11/7/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	315
2 ft	33
3 ft	99
4 ft	17
5 ft	40
6 ft	15
TOTAL	519
NH4-N	23
ORGANIC	2.15

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	100	0	0	0	100
2013	0	200	100	0	0	0	300
2012	0	200	0	0	0	0	200
2011	0	200	0	0	0	0	200

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Corn Grain	28	Bushels		
Corn Grain	28	Bushels		
Corn Grain	28	Bushels		

Current Crop	
Crop Year	
2014	
Condition	
Fair	

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S, SH	M, M, M, M, Dp	3.1	
B	S, S, SH, SH	M, M, Dp, Dp	4.1	
C	S, S, SH, SH	M, M, Dp, Dp	4.3	
D	S	M	2.4	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

1022

Acres	20
	11/6/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Wheel Lines
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	2
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	16
2 ft	10
3 ft	17
4 ft	15
5 ft	21
6 ft	33
TOTAL	112
NH4-N	11
ORGANIC	1.53

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	0	0	100	0	0	0	100	Hay	10	Tons			
2013	0	0	100	0	0	0	100	Hay	9	Tons			
2012	0	0	100	0	0	0	100	Wheat	100	Bushels			
2011	0	0	100	0	0	0	100	Hay	8	Tons			

Comments

Current Crop	
Crop Year	
2014	
Condition	
Fair	

Soil: 57 - Hezel Loamy Fine Sand 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, M, W	3.7	
B	S, S, S	M, M, W	4.7	
C	S, S, S	M, M, W	3	
D	S, S, S	M, M, W	2.6	
E				

1023

Acres	20
	11/6/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	2
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	28
2 ft	53
3 ft	152
4 ft	81
5 ft	59
6 ft	66
TOTAL	439
NH4-N	11
ORGANIC	1.19

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	75	0	300	0	0	0	375	Corn Grain	8	Tons			
2013	75	0	300	0	0	0	375	Corn Grain	8	Tons			
2012	75	0	300	0	0	0	375	Corn Grain	5	Tons			
2011	75	0	300	0	0	0	375	Corn Grain	5	Tons			

Comments

Current Crop	
Crop Year	
2014	
Condition	
Good	Actual

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.5	
B	S	M	5.1	
C	S	M	4.2	
D	S	M	3.5	
E				

1024

Acres	40
	11/6/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	4
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	22
2 ft	21
3 ft	19
4 ft	34
5 ft	121
6 ft	57
TOTAL	274
NH4-N	19
ORGANIC	2.4

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	75	0	300	0	0	0	375	Corn	8	Tons			
2013	75	0	300	0	0	0	375	Corn	8	Tons			
2012	75	0	300	0	0	0	375	Corn	8	Tons			
2011	75	0	300	0	0	0	375	Corn	8	Tons			

Comments

Current Crop	
Crop Year	
2014	
Condition	
Fair	

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.3	
B	S	M	3.1	
C	S	M	2.2	
D	S	M	2.6	
E				

1025

Acres	20
	11/6/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	215
2 ft	18
3 ft	13
4 ft	4
5 ft	32
6 ft	4
TOTAL	286
NH4-N	8
ORGANIC	1.34

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	0	0	180	0	0	0	180	Hops	0	Tons			
2013	0	0	180	0	0	0	180	Hops	1	Tons			
2012	0	0	180	0	0	0	180	Hops	1	Tons			
2011	0	0	140	0	0	0	140	Hops	1	Tons			

Comments: Split application on fields; 200 lbs. N to start grow season and side dress 100 lbs throughout rest of season

Current Crop	
Crop Year	
2014	
Condition	
Fair	Actual

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.8	
B	S	M	1.3	
C	S	M	1.8	
D	S	M	2.6	
E				

1026

Acres	51
	11/6/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Rill Irrigation
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	314
2 ft	10
3 ft	7
4 ft	7
5 ft	7
6 ft	3
TOTAL	348
NH4-N	22
ORGANIC	1.33

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016							0						
2015							0						
2014	0	0	150	0	0	0	150	Hops	1	Tons			
2013	0	0	150	0	0	0	150	Hops	1	Tons			
2012	0	0	0	0	0	0	0	Hops	1	Tons			
2011	0	0	0	0	0	0	0	Hops	1	Tons			

Comments

Current Crop	
Crop Year	
2014	
Condition	
Fair	

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, SH	M, M	4.3	
B	S, SH	M, M	3.8	
C	S, SH	M, M	3.6	
D	S, SH	M, M	3.8	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

1027

Acres	50
	11/6/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	7
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	115
2 ft	121
3 ft	99
4 ft	67
5 ft	114
6 ft	66
TOTAL	582
NH4-N	23
ORGANIC	1.94

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	100	0	0	0	100
2013	0	0	300	0	0	0	300
2012	0	0	100	0	0	0	100
2011	0	0	100	0	0	0	100

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Alfalfa	10	Tons		
Corn Grain	8	Tons		
Wheat	95	Bushels		
Wheat	120	Bushels		

Current Crop	
Crop Year	
2014	
Condition	
Good	Actual

Soil: 171 - Wanser Loamy Fine Sand

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, SH	D, M, M, M	4.2	
B	S	M	4.3	
C	S	M	4.5	
D	S	M	3.5	
E				

1028

Acres	25
	11/7/2014
Soil Testing?	NO
Test Frequency	
Irrigation Type	Solid Set Below Canopy
Irrigation Schedule	Routine Schedule
Hour Sets	12
Irrigation years	25
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	11
2 ft	3
3 ft	3
4 ft	3
5 ft	3
6 ft	3
TOTAL	26
NH4-N	16
ORGANIC	1.39

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Apples			
Apples			
Apples			
Apples			

Current Crop	
Crop Year	
2014	
Condition	
Poor	Planned

Soil: 143 - Starbuck-Rock Outcrop Complex 0-45% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, SH, S, SH, S, SH	M, M, M, Dp, Dp, Dp, Dp, Dp	4.3	
B	S, S, S, SH, S	M, M, M, Dp, Dp	4.2	
C	S, S, S, S, SH	M, M, M, Dp, Dp	4.2	
D	S, S, S, SH, S	M, M, Dp, Dp, Dp	4.1	
E				

1029

Acres	25
	11/7/2014
Soil Testing?	NO
Test Frequency	
Irrigation Type	Solid Set Below Canopy
Irrigation Schedule	Routine Schedule
Hour Sets	12
Irrigation years	25
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	8
2 ft	3
3 ft	11
4 ft	4
5 ft	3
6 ft	3
TOTAL	32
NH4-N	10
ORGANIC	1.17

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Apples			
Apples			
Apples			
Apples			

Current Crop	
Crop Year	
2014	
Condition	
Poor	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH, SH, SH	M, M, Dp, Dp, Dp	5.5	
B	S, S, SH, SH, SH, S	M, M, Dp, Dp, Dp, M	5.9	
C	S, S, S, S, SH, SH, SH	M, M, M, M, Dp, Dp, Dp	5.2	
D	S, S, SH, SH, SH	M, M, Dp, Dp, Dp	5.1	
E				

1030

Acres	40
	11/7/2014
Soil Testing?	YES
Test Frequency	Every 4 Years
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	8
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	113
2 ft	57
3 ft	8
4 ft	6
5 ft	7
6 ft	6
TOTAL	197
NH4-N	31
ORGANIC	2.86

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0

Comments: Bio Solids applied 7 years ago, no fertilizer of any kind has been applied for 6 growing seasons. Crop advisor told producer that the Nitrogen is bound up in the first foot.

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Sudan Grass				
Alfalfa	10	Tons		
Alfalfa	10	Tons		
Alfalfa	10	Tons		

Current Crop	
Crop Year	
2014	
Condition	
Fair	

Soil: 66 - Kittitas Silt Loam

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	5.7	
B	S	M	5.6	
C	S	M	5.8	
D	S	M	4.9	
E				

1031

Acres	80
	11/7/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	568
2 ft	601
3 ft	760
4 ft	
5 ft	
6 ft	
TOTAL	1929
NH4-N	12
ORGANIC	2.34

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	90	0	0	0	0	0	90
2013	90	0	0	0	0	0	90
2012	90	0	0	0	0	0	90
2011	90	0	0	0	0	0	90

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Corn	5	Tons		
Corn Grain	4	Tons		
Wheat	70	Bushels		
Corn Grain	4	Tons		

Current Crop	
Crop Year	
2014	
Condition	
Good	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	M, D	2.4	2.7
B	S, S	M, D	1.8	2.4
C	S, S	M, D	1.8	1.8
D	S, S	M, D	1.9	1.9
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

1032

Acres	80
	11/7/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	25
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	50
2 ft	268
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	318
NH4-N	19
ORGANIC	2.28

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	90	0	60	0	0	0	150
2013	90	0	0	0	0	0	90
2012	90	0	0	0	0	0	90
2011	90	0	0	0	0	0	90

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Wheat	90	Bushels			
Corn Grain	5	Tons			
Corn Grain	5	Tons			
Corn Grain	4	Tons			

Current Crop	
Crop Year	
2014	
Condition	
Good	Actual

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	M, D	1.6	2
B	S, S	M, D	1.8	1.8
C	S, S	M, D	1.5	1.7
D	S, S	M, D	1.9	1.9
E				

1033

Acres	80
	11/7/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	110
2 ft	28
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	138
NH4-N	25
ORGANIC	2.96

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	90	0	0	0	0	0	90
2013	90	0	0	0	0	0	90
2012	90	0	0	0	0	0	90
2011	90	0	0	0	0	0	90

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Grain	4	Tons			
Wheat	100	Bushels			
Corn Grain	5	Tons			
Corn Grain	4	Tons			

Current Crop	
Crop Year	
2014	
Condition	
Fair	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.6	2
B	S	M	2	2
C	S	M	2	2
D	S	M	2	2
E				

1034

Acres	80
	11/7/2014
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Solid Set Above Canopy
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	25
Event	FALL 2014

NO3 (#N/ACRE)	
1 ft	285
2 ft	55
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	340
NH4-N	17
ORGANIC	2.62

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014	90	0	120	0	0	0	210
2013	90	0	0	0	0	0	90
2012	90	0	0	0	0	0	90
2011	90	0	0	0	0	0	90

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Grain	5	Tons			
Corn Grain	6	Tons			
Corn Grain	4	Tons			
Wheat	60	Bushels			

Current Crop	
Crop Year	
2014	
Condition	
Good	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.2	1.8
B	S	M	0.9	1.4
C	S	M	1	1.5
D	S	M	1	1.7
E				

2035

Acres	40
	4/28/2015
Soil Testing?	YES
Test Frequency	Annually in Fall
Irrigation Type	Pivot
Irrigation Schedule	Observe Crop
Hour Sets	
Irrigation years	10
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	55
2 ft	56
3 ft	56
4 ft	103
5 ft	110
6 ft	93
TOTAL	473
NH4-N	108
ORGANIC	3.04

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	434	0	0	0	434
2014	50	0	391	0	0	0	441
2013	50	0	317	0	0	0	367
2012	50	0	430	0	0	0	480
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	6	Tons			
Triticale	6	Tons	Corn Silage	28	Tons
Triticale	6	Tons	Corn Silage	28	Tons
Triticale	6	Tons	Corn Silage	28	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	4.2	
B	S	M	5.2	
C	S	M	4.5	
D	S	M	4.5	
E				

2036

Acres	33
	4/28/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Linear Move
Irrigation Schedule	Observe Crop
Hour Sets	
Irrigation years	6
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	90
2 ft	47
3 ft	31
4 ft	23
5 ft	12
6 ft	6
TOTAL	209
NH4-N	65
ORGANIC	2.37

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	50	0	434	0	0	0	484
2014	0	0	166	0	0	0	166
2013	0	0	434	0	0	0	434
2012	0	0	435	0	0	0	435
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	6	Tons			
Triticale	6	Tons	Corn Silage	28	Tons
Triticale	6	Tons	Corn Silage	28	Tons
Triticale	6	Tons	Corn Silage	28	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	5.5	
B	S	M	5.2	
C	S	M	4.8	
D	S	M	5.6	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2037

Acres	38
Sampling Date	4/28/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Observe Crop
Hour Sets	
Irrigation years	10
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	50
2 ft	106
3 ft	226
4 ft	183
5 ft	149
6 ft	72
TOTAL	786
NH4-N	93
ORGANIC	1.9

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	50	0	434	0	0	0	484
2014	0	0	391	0	0	0	391
2013	0	0	434	0	0	0	434
2012	0	0	435	0	0	0	435
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	6	Tons			
Triticale	6	Tons	Corn Silage	28	Tons
Triticale	6	Tons	Corn Silage	28	Tons
Triticale	6	Tons	Corn Silage	28	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 173 - Warden Fine Sandy Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S-SH	D-M	3.2	
B	S-SH	D-M	4.3	
C	S-SH	D-M	3.5	
D	S-SH	D-M		
E				

2038

Acres	17
Sampling Date	4/28/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Wheel Lines
Irrigation Schedule	Observe Crop
Hour Sets	
Irrigation years	15
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	116
2 ft	137
3 ft	108
4 ft	45
5 ft	17
6 ft	7
TOTAL	430
NH4-N	44
ORGANIC	3.46

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	40	0	0	0	0	0	40
2014	120	0	0	0	0	0	120
2013	150	0	0	0	0	0	150
2012	150	0	0	0	0	0	150
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	6	Tons			
Triticale	6	Tons			
Triticale	6	Tons			
Triticale	6	Tons			

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 140 - Sinloc Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, SH, SH	D-M, M, M	2.3	4
B	S, SH, SH	D-M, M, M	2.2	
C	S, SH, SH, SH	D-M, M, Dp, Dp	2.5	
D	S, SH, SH	D-M, M, Dp		
E				

2039

Acres	40
Sampling Date	4/29/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Observe Crop
Hour Sets	
Irrigation years	2
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	45
2 ft	104
3 ft	93
4 ft	131
5 ft	314
6 ft	360
TOTAL	1047
NH4-N	13
ORGANIC	2.12

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	198	0	0	0	0	0	198
2014	306	0	0	0	0	0	306
2013	216	0	0	0	0	0	216
2012	288	0	0	0	0	0	288
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	8	Tons			
Alfalfa	8	Tons			
Alfalfa	8	Tons			
Alfalfa	8	Tons			

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D-M	3.5	
B	S, SH	D-M, M	3.5	
C	S, SH, SH	D-M, M, M	4.9	
D	S, SH	D-M, M	5.6	
E				

2040

Acres	33
Sampling Date	4/29/2015
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Shovel Method
Hour Sets	
Irrigation years	15
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	41
2 ft	25
3 ft	13
4 ft	36
5 ft	88
6 ft	68
TOTAL	271
NH4-N	26
ORGANIC	3.09

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	200	0	0	0	0	0	200
2014	0	0	0	0	0	0	0
2013	204	0	0	0	0	0	204
2012	200	0	0	0	0	0	200
2011							0

Comments: LIQUID APPLIED THRU PIVOT

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	9	Tons			
Triticale	9	Tons	Corn Silage	26	Tons
Triticale	9	Tons	Corn Silage	22	Tons
Triticale	8	Tons	Corn Silage	25	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH	D, M, M	3.6	
B	S, S, S, SH	D, M, D, M	4.8	
C	S, SH, S	D, M, M	5.9	
D	S	M	3.8	
E				

2041

Acres	72
Sampling Date	4/29/2015
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Shovel Method
Hour Sets	
Irrigation years	7
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	4
2 ft	3
3 ft	3
4 ft	4
5 ft	6
6 ft	12
TOTAL	32
NH4-N	9
ORGANIC	1.46

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	34	50	0	0	0	0	84
2013	180	0	0	0	0	0	180
2012	180	0	0	0	0	0	180
2011							0

Comments: Liquid is injected

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	11	Tons			
Triticale	7	Tons	Corn Silage	24	
Triticale	10	Tons	Corn Silage	31	
Triticale	10	Tons	Corn Silage	30	

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D	4.5	
B	S	D	3	
C	S	D	3.6	
D	S	D		
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2042

Acres	18
Sampled	4/29/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Wheel Lines
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	12
Irrigation years	20
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	29
2 ft	28
3 ft	12
4 ft	7
5 ft	8
6 ft	5
TOTAL	89
NH4-N	32
ORGANIC	2.03

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: NO NITROGEN APPLIED OF ANY KIND LAST 3 YEARS

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	7 Tons		
Alfalfa	2 Tons		
Triticale	5 Tons	Sudan Grass	5 Tons
Triticale	5 Tons	Sudan Grass	5 Tons

Current Crop	
Crop Year	2015
Condition	Poor
	Planned

Soil: 138 - Sinloc Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.7	
B	S	M	2.8	
C	S	M	3	
D	S	M	3.9	
E				

2043

Acres	40
Sampled	4/29/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Wheel Lines
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	20
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	32
2 ft	16
3 ft	6
4 ft	3
5 ft	13
6 ft	16
TOTAL	86
NH4-N	35
ORGANIC	3.09

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	195	0	0	0	0	195
2012	0	0	0	0	0	0	0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	6 Tons		
Alfalfa	8 Tons		
Alfalfa	4 Tons		
Triticale	5 Tons		

Current Crop	
Crop Year	2015
Condition	Good
	Planned

Soil: 138 - Sinloc Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S	M, Dp, W, W	1.9	
B	S, S, S	M, Dp, W	3.7	
C	S, S, S	M, Dp, W	2.6	
D	S, S, S	M, Dp, W	2.7	
E				

2044

Acres	33
Sampled	4/30/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	29
2 ft	152
3 ft	457
4 ft	623
5 ft	706
6 ft	409
TOTAL	2376
NH4-N	31
ORGANIC	3.4

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: No Nutrients added during last 4 years

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	8 Tons		
Alfalfa	7 Tons		
Alfalfa	9 Tons		
Alfalfa	6 Tons		

Current Crop	
Crop Year	2015
Condition	Good
	Planned

Soil: 92 - Outlook Silt Loam

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.9	
B	S	M	1.5	
C	S	M	5	
D	S	M	5.4	
E				

2045

Acres	44
Sampled	4/30/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Wheel Lines
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	20
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	29
2 ft	4
3 ft	20
4 ft	22
5 ft	13
6 ft	31
TOTAL	119
NH4-N	25
ORGANIC	2.37

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: No nutrients added since fall of 2011

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	8 Tons		
Alfalfa	8 Tons		
Alfalfa	9 Tons		
Alfalfa	5 Tons		

Current Crop	
Crop Year	2015
Condition	Good
	Planned

Soil: 138 - Sinloc Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH, S	D, M, M, M	3.1	
B	S, S, SH, S	D, M, M, M	3	
C	S, S, SH, S	D, M, M, M	3.4	
D	S, S, SH, S, SH, S	D, M, M, M, M, M	4.7	
E				

2046

Acres	
Sampled	4/30/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Wheel Lines
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	20
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	36
2 ft	88
3 ft	95
4 ft	70
5 ft	65
6 ft	72
TOTAL	426
NH4-N	33
ORGANIC	2.67

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	100	0	0	0	0	100
2014	0	500	0	0	0	0	500
2013	0	500	0	0	0	0	500
2012	0	500	0	0	0	0	500
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	5 Tons		
Triticale	5 Tons	Sudan Grass	10 Tons
Triticale	5 Tons	Sudan Grass	10 Tons
Triticale	5 Tons	Sudan Grass	10 Tons

Current Crop	
Crop Year	2015
Condition	Fair
	Planned

Soil: 139 - Sinloc Silt Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH, S	D, M, M, M	2.9	
B	S, S, SH, S	D, M, M, M	1.8	
C	S, S, SH, S	D, M, M, M	1.9	
D	S, S, SH	D, M, M	1.3	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2047

Acres	45
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	120
Irrigation years	10
Event	SPRING 2015
	4/30/2015

NO3 (#N/ACRE)	
1 ft	113
2 ft	466
3 ft	913
4 ft	951
5 ft	626
6 ft	252
TOTAL	3321
NH4-N	21
ORGANIC	3.11

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	150	0	0	0	0	0	150
2014	300	0	0	0	0	0	300
2013	300	0	0	0	0	0	300
2012	300	0	0	0	0	0	300
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	10 Tons		
Alfalfa	9 Tons		
Alfalfa	10 Tons		
Alfalfa	6 Tons		

Current Crop	
Crop Year	
2015	
Condition	
Fair	Planned

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	SH, SH, SH, SH, S, SH	M, M, M, M, D, M	5.9	
B	SH, SH, SH, S	M, M, M, D	5.3	
C	SH	M	2	2
D	SH	M	2	3
E				

2048

Acres	150
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Wheel Lines
Irrigation Schedule	Routine Schedule
Hour Sets	12
Irrigation years	15
Event	SPRING 2015
	4/30/2015

NO3 (#N/ACRE)	
1 ft	144
2 ft	73
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	217
NH4-N	17
ORGANIC	3.51

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: Liquid Manure was applied twice per year. Records are unavailable for #/acre of N

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	5 Tons		
Alfalfa	7 Tons		
Alfalfa	7 Tons		
Alfalfa	7 Tons		

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 120 - Scoon Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.6	1.6
B	S	M	1.4	1.5
C	S	M	1.4	1.5
D	S	M	1.7	1.8
E				

2049

Acres	35
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	DAILY
Irrigation years	1
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	84
2 ft	8
3 ft	11
4 ft	8
5 ft	45
6 ft	8
TOTAL	164
NH4-N	19
ORGANIC	1.55

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	50	0	0	0	50
2013	0	0	60	0	0	0	60
2012	0	0	45	0	0	0	45
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	30 Tons		
Corn Grain	8 Tons		
Corn Silage	8 Tons		
Corn Silage	28 Tons		

Current Crop	
Crop Year	
2015	
Condition	
Good	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	4.7	
B	S	M	4.2	
C	S	M	5.9	
D	S	M	4.2	
E				

2050

Acres	55
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	8
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	18
2 ft	9
3 ft	21
4 ft	43
5 ft	61
6 ft	51
TOTAL	203
NH4-N	25
ORGANIC	2.95

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	80	0	0	0	80
2013	0	0	0	0	0	0	0
2012	0	0	45	0	0	0	45
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	8 Tons		
Triticale	8 Tons	Corn Silage	30
Triticale	8 Tons	Corn Silage	30
Triticale	8 Tons	Corn Silage	30

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.2	4
B	S	M	2.7	4
C	S	M	5.3	
D	S	M	3.4	
E				

2051

Acres	50
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Wheel Lines
Irrigation Schedule	Routine Schedule
Hour Sets	Daily
Irrigation years	
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	14
2 ft	3
3 ft	3
4 ft	3
5 ft	3
6 ft	3
TOTAL	29
NH4-N	25
ORGANIC	2.32

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	75	0	0	0	75
2014	0	0	180	0	0	0	180
2013	0	0	150	0	0	0	150
2012	0	0	135	0	0	0	135
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Pasture			
Pasture			
Pasture			
Pasture			

Current Crop	
Crop Year	
2015	
Condition	
Good	

Soil: 140 - Sinloc Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.4	
B	S	M	4.2	
C	S	M	4.4	
D	S	M	4.3	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2052

Acres	130
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Shovel Method
Hour Sets	
Irrigation years	12
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	59
2 ft	
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	59
NH4-N	16
ORGANIC	2.16

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	400	0	0	0	0	0	400
2013	400	0	0	0	0	0	400
2012	400	0	0	0	0	0	400
2011							0

Comments: Nutrients applied thru pivot

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	7 Tons		
Triticale	6 Tons	Corn Silage	29 Tons
Triticale	6 Tons	Corn Silage	31 Tons
Triticale	6 Tons	Corn Silage	26 Tons

Current Crop	
Crop Year	2015
Condition	Good / Actual

Soil: 120 - Scoon Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D	1	1
B	S	D	1.2	1.2
C	S	D	0.8	1
D	S	D		1
E				

2053

Acres	110
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Shovel Method
Hour Sets	
Irrigation years	15
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	84
2 ft	58
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	142
NH4-N	11
ORGANIC	1.59

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	400	0	0	0	0	0	400
2013	400	0	0	0	0	0	400
2012	400	0	0	0	0	0	400
2011							0

Comments: Nutrients applied thru pivot

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	7 Tons		
Triticale	6 Tons	Corn Silage	29 Tons
Triticale	6 Tons	Corn Silage	31 Tons
Triticale	6 Tons	Corn Silage	26 Tons

Current Crop	
Crop Year	2015
Condition	Good / Actual

Soil: 122 - Scoon Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D	0.9	1
B	S	D	1.5	1.5
C	S	D	1.5	1.5
D	S	D	1	1
E				

2054

Acres	15
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Solid Set Above Canopy
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	15
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	133
2 ft	40
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	173
NH4-N	22
ORGANIC	2.52

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	240	0	0	0	0	0	240
2014	200	0	0	0	0	0	200
2013	200	0	100	0	0	0	300
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Wheat	110 Bushels		
Corn Grain	35 Bushels		
Alfalfa	3 Tons	Corn Silage	32 Tons
Alfalfa	9 Tons		

Current Crop	
Crop Year	2015
Condition	Good / Planned

Soil: 132 - Shano Lilt Loan 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2	2
B	S	M	1.9	2
C	S	M	1.9	2
D	S	M	2	2
E				

2055

Acres	15
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Solid Set Above Canopy
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	15
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	75
2 ft	
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	75
NH4-N	62
ORGANIC	4.24

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	240	0	0	0	0	0	240
2014	200	0	0	0	0	0	200
2013	200	0	100	0	0	0	300
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Wheat	110 Bushels		
Corn Silage	35 Tons		
Alfalfa	2 Tons	Corn Silage	32 Tons
Alfalfa	8 Tons		

Current Crop	
Crop Year	2015
Condition	Good / Planned

Soil: 120 - Scoon Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1	1
B	S	M	0.8	1
C	S	M	0.7	0.9
D	S	M	0.9	0.9
E				

2056

Acres	40
Soil Testing?	YES
Test Frequency	Annually in Fall
Irrigation Type	Wheel Lines
Irrigation Schedule	Shovel Method
Hour Sets	12-24
Irrigation years	11
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	25
2 ft	151
3 ft	50
4 ft	14
5 ft	8
6 ft	10
TOTAL	258
NH4-N	21
ORGANIC	2.39

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	60	0	0	0	60
2014	0	0	50	0	0	0	50
2013	0	0	50	0	0	0	50
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	7 Tons		
Squash			
Squash			

Current Crop	
Crop Year	2015
Condition	Good / Actual

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.2	
B	S	M	4.2	
C	S	M	2.5	
D	S	M	3.2	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2057

Acres	12
Soil Testing?	YES
Test Frequency	
Irrigation Type	Drip
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	37
2 ft	21
3 ft	21
4 ft	3
5 ft	
6 ft	
TOTAL	82
NH4-N	10
ORGANIC	1.03

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: No Nutrients Applied

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Wine Grapes	5	Tons			
Wine Grapes	5	Tons			
Wine Grapes	2	Tons			

Current Crop	
Crop Year	
2015	
Condition	
Fair	Planned

Soil: 132 - Shano Lilt Loan 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.6	4
B	S	M	4	4
C	S	M	3.3	3.8
D	S	M	3.7	3.7
E				

2058

Acres	35
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	15
Event	SPRING 2015
	5/3/2015

NO3 (#N/ACRE)	
1 ft	119
2 ft	986
3 ft	892
4 ft	694
5 ft	407
6 ft	287
TOTAL	3385
NH4-N	16
ORGANIC	1.92

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	270	0	0	0	0	0	270
2014	342	0	0	0	0	0	342
2013	342	0	0	0	0	0	342
2012	342	0	0	0	0	0	342
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	7	Tons			
Triticale	7	Tons	Corn Silage	25	Tons
Triticale	7	Tons	Corn Silage	27	Tons
Triticale	6	Tons	Corn Silage	27	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 174 - Warden Fine Sandy Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.8	
B	S	M	4.2	
C	S, S, SH	M, M, M	3.3	
D	S, S, SH, S	M, M, M, M	4.7	
E				

2059

Acres	41
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	
Hour Sets	
Irrigation years	1
Event	SPRING 2015
	5/5/2015

NO3 (#N/ACRE)	
1 ft	33
2 ft	23
3 ft	28
4 ft	18
5 ft	
6 ft	
TOTAL	102
NH4-N	9
ORGANIC	2.83

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	40	0	0	0	40
2014	0	0	260	0	0	0	260
2013	0	0	200	0	0	0	200
2012	0	0	250	0	0	342	592
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	6	Tons			
Corn Silage	33	Tons			
Corn Silage	29	Tons			
Corn Silage	31	Tons			

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 37 - Finley Silt Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, D, D	1.7	1.7
B	S, S, S, S,	M, D, D, D	2.5	4
C	S, S, S	M, D, D	1.3	1.7
D	S, S, S, S,	M, D, D, D	2.7	4
E				

2060

Acres	19
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	SPRING 2015
	5/5/2015

NO3 (#N/ACRE)	
1 ft	171
2 ft	50
3 ft	201
4 ft	24
5 ft	68
6 ft	7
TOTAL	521
NH4-N	6
ORGANIC	1.72

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	225	0	0	0	225
2013	0	0	240	0	0	0	240
2012	0	0	275	0	0	0	275
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Mint	150	Lbs.			
Corn Silage	30	Tons			
Corn Silage	32	Tons			
Mint	68	Lbs.			

Current Crop	
Crop Year	
2015	
Condition	
Good	Planned

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.3	
B	S, S, S, S, S, S	M, M, M, M, Dp, M	2.6	
C	S, S, S, S, S, S	M, M, M, M, Dp, M	2.7	
D	S, S, SH, S, SH, S	M, M, M, M, M, M	1.6	
E				

2061

Acres	
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2015
	5/5/2015

NO3 (#N/ACRE)	
1 ft	5
2 ft	3
3 ft	10
4 ft	4
5 ft	
6 ft	
TOTAL	22
NH4-N	9
ORGANIC	1.78

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: No Survey Returned

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	

Current Crop	
Crop Year	
Condition	

Soil: 125 - Scooteney Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D	1.5	4
B	S	D	1.8	3.9
C	S	D	1.6	4
D	S	D	1.6	3.8
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2062

Acres	5/5/2015
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	5
2 ft	6
3 ft	11
4 ft	14
5 ft	10
6 ft	
TOTAL	46
NH4-N	7
ORGANIC	0.84

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: No Survey Returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop: Crop Year: Condition:

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D	1	4
B	S, SH	D, M	1.2	3.9
C	S	D	2.9	5.2
D	S	D	1.1	4
E				

2063

Acres	69 5/5/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	
Hour Sets	
Irrigation years	10
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	227
2 ft	337
3 ft	424
4 ft	528
5 ft	
6 ft	
TOTAL	1516
NH4-N	24
ORGANIC	3.94

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	306	0	0	0	0	306
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: No manure applied for last 3 years. In 2012 accidental over application of commecial nitrogen caused excess N in soil.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	5 Tons	Corn Silage	35 Tons
Triticale	5 Tons	Corn Silage	31 Tons
Triticale	5 Tons	Corn Silage	31 Tons

Current Crop: Crop Year: 2015 Condition: Good Planned

Soil: 142 - Starbuck Silt Loam 2-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH	D, D, M	3.8	4
B	S, S, SH	D, D, M	1.9	4
C	S, S, SH	D, D, M	2.6	4.1
D	S, S, SH	D, D, M	3.5	4
E				

2064

Acres	30 5/5/2015
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Observe Crop
Hour Sets	
Irrigation years	10
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	52
2 ft	26
3 ft	43
4 ft	26
5 ft	
6 ft	
TOTAL	147
NH4-N	19
ORGANIC	3.21

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	324	0	0	0	0	0	324
2014	63	0	0	0	0	0	63
2013	63	0	0	0	0	0	63
2012	63	0	0	0	0	0	63
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	6 Tons	Corn Silage	35 Tons
Triticale	6 Tons	Corn Silage	33 Tons
Triticale	6 Tons	Corn Silage	33 Tons

Current Crop: Crop Year: 2015 Condition: Good Planned

Soil: 142 - Starbuck Silt Loam 2-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.1	4
B	S	M	3	3.9
C	S	M	3.6	4.2
D	S	M	3.6	4
E				

2065

Acres	30 5/6/2015
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	
Irrigation years	15
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	213
2 ft	304
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	517
NH4-N	15
ORGANIC	2.59

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	225	0	0	0	0	0	225
2014	475	0	75	0	0	0	550
2013	475	0	100	0	0	0	575
2012	390	0	100	0	0	0	490
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Triticale	10 Tons	Corn Silage	33 Tons
Triticale	10 Tons	Corn Silage	35 Tons
Triticale	12 Tons	Corn Silage	33 Tons

Current Crop: Crop Year: 2015 Condition: Good Actual

Soil: 132 - Shano Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	M, D	2	2
B	S, S	M, D	1.9	1.9
C	S	M	2	2
D	S	M	2	2
E				

2066

Acres	155 5/8/2015
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	
Irrigation years	9
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	44
2 ft	182
3 ft	193
4 ft	
5 ft	
6 ft	
TOTAL	419
NH4-N	24
ORGANIC	3.23

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	200	0	0	0	0	0	200
2014	450	0	0	0	0	0	450
2013	425	0	0	0	0	0	425
2012	450	0	50	0	0	0	500
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	8 Tons		
Triticale	8 Tons	Corn Silage	30 Tons
Triticale	9 Tons	Corn Silage	29 Tons
Triticale	7 Tons	Corn Silage	26 Tons

Current Crop: Crop Year: 2015 Condition: Good Actual

Soil: 120 - Scoon Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D-M	2	2
B	S	D-M	2	2
C	S	D-M	2.8	2.9
D	S	D-M	1.6	1.7
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2067

Acres	83
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	
Irrigation years	7
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	19
2 ft	97
3 ft	197
4 ft	115
5 ft	40
6 ft	27
TOTAL	495
NH4-N	18
ORGANIC	1.56

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	90	0	0	0	90
2014	180	0	200	0	0	0	380
2013	180	0	200	0	0	0	380
2012	20	0	200	0	0	0	220
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	7	Tons			
Triticale	7	Tons	Corn Silage	32	Tons
Triticale	10	Tons	Corn Silage	31	Tons
Triticale	7	Tons	Corn Silage	25	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S, S, S, S, S	D, D-M, M, D-M, M, M, D-M, M	5.3	
B	S, S, S, S, S, S	D, D-M, M, D-M, M, M	3.9	
C	S, S, S, S, S, S	D, D-M, M, D-M, M, D-M	4.1	
D	S, S, S, S, SH, S, S, S, S	D-M, M, D-M, M, D-M, M, D-M	5.3	
E				

2068

Acres	75
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	
Irrigation years	9
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	7
2 ft	35
3 ft	137
4 ft	115
5 ft	
6 ft	
TOTAL	294
NH4-N	13
ORGANIC	1.71

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	250	0	0	0	0	0	250
2014	0	0	75	0	0	0	75
2013	240	0	150	0	0	0	390
2012	250	0	175	0	0	0	425
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	7	Tons			
Triticale	7	Tons	Corn Silage	31	Tons
Triticale	7	Tons	Corn Silage	31	Tons
Triticale	7	Tons	Corn Silage	29	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 58 - Hezel Loamy Fine Sand 2-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S,	D, M, M, M	3	4
B	S	M	3	4
C	S	M	2.5	4
D	S	M	3	4
E				

2069

Acres	83
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Linear Move
Irrigation Schedule	Routine Schedule 1 inch every 3 to 4 days
Hour Sets	
Irrigation years	10
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	24
2 ft	9
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	33
NH4-N	22
ORGANIC	2.17

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	164	0	0	0	0	0	164
2013	0	315	70	0	0	0	385
2012	0	0	150	0	0	0	150
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Alfalfa	8	Tons			
Alfalfa	7	Tons	Corn Silage	35	Tons
Triticale	12	Tons	Corn Silage	35	Tons
Triticale	12	Tons			

Current Crop	
Crop Year	
2015	
Condition	
Good	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2	2
B	S	M	1	1
C	S	M	2	2
D	S	M	1.9	1.9
E				

2070

Acres	110
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Linear Move
Irrigation Schedule	Routine Schedule 1 inch every 3 to 4 days
Hour Sets	
Irrigation years	10
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	37
2 ft	26
3 ft	63
4 ft	83
5 ft	51
6 ft	38
TOTAL	298
NH4-N	9
ORGANIC	0.98

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	60	0	100	0	0	0	160
2014	60	135	100	0	0	0	295
2013	0	0	270	0	0	0	270
2012	0	132	0	0	0	0	132
2011							0

Comments: Commercial N put through pivot throughout the year.

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	15	Tons			
Triticale	15	Tons	Corn Silage	35	Tons
Triticale	15	Tons	Corn Silage	35	Tons
Triticale	15	Tons	Corn Silage	35	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 19 - Cleman Very Fine Sandy Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, D, D	6	
B	S, S, S, S,	M, D, D, D	5.8	
C	S	M	5.8	
D	S	M	5.6	
E				

2071

Acres	35
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	41
2 ft	68
3 ft	31
4 ft	36
5 ft	77
6 ft	100
TOTAL	353
NH4-N	16
ORGANIC	1.34

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	150	0	0	0	0	0	150
2014	150	0	80	0	0	0	230
2013	150	0	0	0	0	0	150
2012	150	0	100	0	0	0	250
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Alfalfa	10	Tons			
Corn Silage	35	Tons			
Alfalfa	10	Tons			
Triticale & Grass	22	Tons			

Current Crop	
Crop Year	
2015	
Condition	
Good	Planned

Soil: 58 - Hezel Loamy Fine Sand 2-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2	4
B	S	M	3	4
C	S	M	3	4
D	S	M	4	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2072

Acres	40
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Wheel Lines
Irrigation Schedule	Routine Schedule
Hour Sets	12
Irrigation years	
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	39
2 ft	20
3 ft	21
4 ft	15
5 ft	21
6 ft	24
TOTAL	140
NH4-N	19
ORGANIC	1.03

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	45	0	0	0	0	0	45
2014	100	0	0	0	0	0	100
2013	150	0	0	0	0	0	150
2012	100	0	0	0	0	0	100
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Alfalfa	10	Tons			
Alfalfa	9	Tons			
Grass	21	Tons			
Grass	20	Tons			

Current Crop	
Crop Year	2015
Condition	
Good	Planned

Soil: 58 - Hezel Loamy Fine Sand 2-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3	3.2
B	S	M	3.5	3.5
C	S	M	6	
D	S	M	3	3
E				

2073

Acres	120
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	36
2 ft	35
3 ft	31
4 ft	38
5 ft	
6 ft	
TOTAL	140
NH4-N	27
ORGANIC	2.42

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	150	0	80	0	0	0	230
2014	150	0	100	0	0	0	250
2013	150	0	100	0	0	0	250
2012	150	0	0	0	0	0	150
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Alfalfa	10	Tons			
Alfalfa	9	Tons			
Alfalfa	10	Tons			
Alfalfa	10	Tons			

Current Crop	
Crop Year	2015
Condition	
Good	Planned

Soil: 179 - Warden Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, M, D	3.2	3.4
B	S, S, S	M, M, D	2.4	2.9
C	S, S, S	M, M, D	3.3	3.5
D	S, S, S	M, M, D	3.1	3.9
E				

2074

Acres	20
Soil Testing?	Yes
Test Frequency	Annually
Irrigation Type	Wheel Lines
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	
Irrigation years	
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	75
2 ft	55
3 ft	68
4 ft	97
5 ft	94
6 ft	26
TOTAL	415
NH4-N	26
ORGANIC	2.51

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	177	0	0	0	0	0	177
2013	177	0	0	0	0	0	177
2012	106	0	0	0	0	0	106
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Alfalfa	8	Tons			
Alfalfa	8	Tons			
Alfalfa	8	Tons			

Current Crop	
Crop Year	2015
Condition	
Good	

Soil: 37 - Finley Silt Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	6	
B	S	M	3.7	
C	S	M	3.4	
D	S, S, SH, H	M, M, M, M	2.6	4.5
E				

2075

Acres	30
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Big Gun
Irrigation Schedule	Shovel Method
Hour Sets	
Irrigation years	
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	160
2 ft	40
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	200
NH4-N	55
ORGANIC	2.72

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	130	0	0	0	0	0	130
2013	30	0	0	0	0	0	30
2012	0	0	0	0	0	0	0
2011							0

Comments: Nutrients applied with injector

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	10	Tons			
Corn Silage	25	Tons			
Triticale	2	Tons			
Sudan Grass	7	Tons			

Current Crop	
Crop Year	2015
Condition	
Good	Actual

Soil: 40 - Finley Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1	1
B	S	M	2	2
C	S	M	1.5	1.5
D	S, EH	M, M	1.2	2
E				

2076

Acres	37
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	SPRING 2015
	5/8/2015

NO3 (#N/ACRE)	
1 ft	182
2 ft	87
3 ft	150
4 ft	73
5 ft	248
6 ft	30
TOTAL	770
NH4-N	14
ORGANIC	1.49

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	200	0	0	0	200
2013	0	0	200	0	0	0	200
2012	0	0	200	0	0	0	200
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Mint	150	Lbs.			
Corn Silage	28	Tons			
Corn Silage	33	Tons			
Corn Silage	35	Tons			

Current Crop	
Crop Year	2015
Condition	
Good	Planned

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2	
B	S	M	2	
C	S	M	1.5	
D	S	M	1.5	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2077

Acres	40
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	Observe Crop
Hour Sets	
Irrigation years	14
Event	SPRING 2015
5/8/2015	

NO3 (#N/ACRE)	
1 ft	26
2 ft	22
3 ft	26
4 ft	25
5 ft	35
6 ft	41
TOTAL	175
NH4-N	16
ORGANIC	1.81

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	0	0	100	0	0	0	100
2013	0	0	100	0	0	0	100
2012	0	0	100	0	0	0	100
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	8	Tons			
Triticale	6	Tons	Corn Silage	35	Tons
Triticale	6	Tons	Corn Silage	35	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Planned

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3	
B	S	M	4	
C	S	M	3	
D	S	M	2	
E				

2078

Acres	40
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Pivot
Irrigation Schedule	shovel method
Hour Sets	
Irrigation years	14
Event	SPRING 2015
5/8/2015	

NO3 (#N/ACRE)	
1 ft	49
2 ft	89
3 ft	86
4 ft	156
5 ft	172
6 ft	111
TOTAL	663
NH4-N	27
ORGANIC	2.62

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0		0	0	0	0
2014	0	0	100	0	0	0	100
2013	0	0	100	0	0	0	100
2012	0	0	100	0	0	0	100
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield
Triticale	8	Tons		
Triticale	6	Tons	Corn Silage	35
Triticale	6	Tons	Corn Silage	35

Current Crop	
Crop Year	
2015	
Condition	
Good	Planned

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, Dp, M	2.5	
B	S, S, S	M, Dp, M	2	
C	S, S, S, S, S	M, Dp, M, W, M	2.2	
D	S, S, S	M, Dp, W	1.5	
E				

2079

Acres	55
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Visual in spring; routine in summer
Hour Sets	
Irrigation years	20
Event	SPRING 2015
5/8/2015	

NO3 (#N/ACRE)	
1 ft	9
2 ft	66
3 ft	127
4 ft	173
5 ft	98
6 ft	108
TOTAL	581
NH4-N	17
ORGANIC	2.62

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	20	0	0	0	0	0	20
2014	20	0	250	0	0	0	270
2013	20	0	200	0	0	0	220
2012	20	0	200	0	0	0	220
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	8	Tons			
Triticale	8	Tons	Corn Silage	30	Tons
Triticale	8	Tons	Corn Silage	30	Tons
Triticale	8	Tons	Corn Silage	30	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, SH, S, S, SH	M, M, M, M, M, M	3.5	
B	S, S, SH	M, M, M	5.1	
C	S, S, SH	M, M, M	5.8	
D	S, S, S, SH, S, SH	M, M, M, M, M, M	5.2	
E				

2080

Acres	104
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Pivot
Irrigation Schedule	Visual in spring; routine in summer
Hour Sets	
Irrigation years	15
Event	SPRING 2015
5/8/2015	

NO3 (#N/ACRE)	
1 ft	15
2 ft	15
3 ft	27
4 ft	44
5 ft	
6 ft	
TOTAL	101
NH4-N	17
ORGANIC	2.63

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	35	0	0	0	0	0	35
2014	35	0	250	0	0	0	285
2013	35	0	200	0	0	0	235
2012	35	0	200	0	0	0	235
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	8	Tons			
Triticale	8	Tons	Corn Silage	30	Tons
Triticale	8	Tons	Corn Silage	30	Tons
Triticale	8	Tons	Corn Silage	30	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.5	4
B	S	M	2	2
C	S	M	1.5	2
D	S	M	1.5	2
E				

2081

Acres	13
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Rill Irrigation and hand line
Irrigation Schedule	Routine Schedule
Hour Sets	12
Irrigation years	10
Event	SPRING 2015
5/8/2015	

NO3 (#N/ACRE)	
1 ft	75
2 ft	48
3 ft	40
4 ft	42
5 ft	32
6 ft	24
TOTAL	261
NH4-N	35
ORGANIC	2.45

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	457	0	0	0	0	0	457
2013	403	0	0	0	0	0	403
2012	367	0	0	0	0	0	367
2011							0

Comments: N split applications; Rill used for corn in July and August. Hand lines rest of year.

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	7	Tons			
Triticale	7	Tons	Corn Silage	29	Tons
Triticale	7	Tons	Corn Silage	29	Tons

Current Crop	
Crop Year	
2015	
Condition	
Good	Planned

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.5	
B	S	M	3.5	
C	S	M	3	
D	S	M	4	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

2082

Acres	57
	5/8/2015
Soil Testing?	YES
Test Frequency	Biannually
Irrigation Type	Rill Irrigation and hand line
Irrigation Schedule	Routine Schedule
Hour Sets	12
Irrigation years	10
Event	SPRING 2015

NO3 (#N/ACRE)	
1 ft	41
2 ft	22
3 ft	55
4 ft	70
5 ft	58
6 ft	74
TOTAL	320
NH4-N	25
ORGANIC	3.36

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015	0	0	0	0	0	0	0
2014	370	0	0	0	0	0	370
2013	414	0	0	0	0	0	414
2012	571	0	0	0	0	0	571
2011							0

Comments: N split applications; Rill used for corn in July and August. Hand lines rest of year.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	7 Tons		
Triticale	7 Tons	Corn Silage	29 Tons
Triticale	7 Tons	Corn Silage	29 Tons

Current Crop: Crop Year 2015; Condition: Good / Planned

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, SH	M, Dp	1.8	
B	S, SH	M, Dp	2.5	
C	S, SH	M, Dp	2.8	
D	S, SH	M, Dp	2.5	
E				

3083

Acres	8
	10/13/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Wheel-line
Irrigation Schedule	Shovel Method
Hour Sets	
Irrigation years	20
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	417
2 ft	412
3 ft	118
4 ft	72
5 ft	77
6 ft	22
TOTAL	1118
NH4-N	56
ORGANIC	2.96

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	100	0	0	0	0	100
2014	150	0	0	0	0	0	150
2013	150	0	0	0	0	0	150
2012	0	0	0	0	0	0	0
2011							0

Comments: In spring the liquid manure is about 9 pounds per 1000 gallons. During irrigation season water is blended down to under 1 pound per 1000 gallons.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Barley	3 Tons	Barley Hay	2 Tons
Alfalfa	10 Tons		
Alfalfa	10 Tons		

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, SH	M,M	1.2	
B	S, S, SH	M, Dp, M	1.8	
C	S, SH, SH	M, M, Dp	1.5	
D	S, SH, SH	M, M, DP	2.2	
E				

3084

Acres	55
	10/13/2015
Soil Testing?	NO
Test Frequency	Not in last two years
Irrigation Type	Wheel-line
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	24
Irrigation years	1
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	14
2 ft	5
3 ft	3
4 ft	3
5 ft	6
6 ft	5
TOTAL	36
NH4-N	30
ORGANIC	2.72

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	0	0	200	0	0	0	200
2013	0	0	200	0	0	0	200
2012	0	0	200	0	0	0	200
2011							0

Comments: Nutrients applied in spring.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Pasture	2 Tons		
Triticale	8 Tons	Corn Silage	27 Tons
Triticale	8 Tons	Corn Silage	28 Tons

Current Crop: Crop Year 2015; Condition: Good / Actual

Soil: 176 - Warden Silt Loam 0 to 2 percent slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	M, Dp	3	
B	S, S, S	M, Dp, Dp	0.8	
C	S, S, S	M, Dp, Dp	0.6	
D	S, SH	M, Dp	0.6	
E				

3085

Acres	20
	10/14/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Solid Set Above Canopy
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	24
Irrigation years	3
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	110
2 ft	108
3 ft	73
4 ft	80
5 ft	266
6 ft	108
TOTAL	745
NH4-N	10
ORGANIC	1.56

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	113	300	0	0	0	413
2014	0	0	100	0	0	0	100
2013	0	0	100	0	0	0	100
2012	0	0	0	0	0	0	0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Corn Silage	30 Tons		
Grapes	9 Tons		
Grapes	8 Tons		

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M		
B	S	M	0.9	
C	S	M	0.7	
D	S	M		
E				

3086

Acres	38
	10/14/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	check the field
Hour Sets	
Irrigation years	15
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	139
2 ft	30
3 ft	33
4 ft	56
5 ft	47
6 ft	29
TOTAL	334
NH4-N	14
ORGANIC	1.76

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	20	0	225	0	0	0	245
2014	60	0	225	0	0	0	285
2013	60	0	225	0	0	0	285
2012	0	0	0	0	0	0	0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	8 Tons		
Triticale	8 Tons	Corn Silage	25 Tons
Triticale	8 Tons	Corn Silage	25 Tons
Triticale	8 Tons	Corn Silage	25 Tons

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, D, D	2	
B	S, S, S	M, D, D	1.5	
C	S, S, S	M, D, D	1.2	
D	S, S, S	M, D, D	1.5	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3087

Acres	15
	10/14/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24 one time a month
Irrigation years	10
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	31
2 ft	12
3 ft	26
4 ft	44
5 ft	19
6 ft	6
TOTAL	138
NH4-N	7
ORGANIC	2.11

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	266	0	0	0	0	266
2014	0	266	0	0	0	0	266
2013	0	266	0	0	0	0	266
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016	Alfalfa	10	Tons			
2015	Alfalfa	10	Tons			
2014	Sudan Grass	10	Tons	Triticale	10	Tons
2013	Sudan Grass	10	Tons	Triticale	10	Tons

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, SH	M, D, M, M	2.2	
B	S, S, S	M, D, M	1.8	
C	S, S	M, D	2.5	5
D	S, S	M, D	2.1	4
E				

3088

Acres	10
	10/14/2015
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	1x per month
Irrigation years	100
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	65
2 ft	11
3 ft	22
4 ft	9
5 ft	24
6 ft	6
TOTAL	137
NH4-N	24
ORGANIC	2.27

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: No nutrients applied last 5 years

Cropping History

	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016						
2015	Alfalfa	9	Tons			
2014	Alfalfa	8	Tons			
2013	Alfalfa	7	Tons			
2012	Alfalfa	8	Tons			

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, SH, SH	D, Dp, W	3.3	
B	S, SH, SH	D, Dp, W	5.3	
C	S, SH, SH	D, Dp, W	1.4	
D	S, SH, SH	D, Dp, W	1.9	
E				

3089

Acres	20
	10/14/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24 twice a month
Irrigation years	1
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	207
2 ft	276
3 ft	290
4 ft	166
5 ft	130
6 ft	80
TOTAL	1149
NH4-N	29
ORGANIC	2.49

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	100	0	0	0	0	0	100
2014	100	0	0	0	0	0	100
2013	100	0	0	0	0	0	100
2012	0	0	0	0	0	0	0
2011							0

Comments: Manure application in spring

Cropping History

	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016	Alfalfa	9	Tons			
2015	Barley	4	Tons			
2014	Corn Grain	6	Tons			
2013	Corn Grain	6	Tons			

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 139 - Sinloc Silt Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S, S	M, Dp, Dp, Dp, Dp	2.8	
B	S, S, S, S, S	M, Dp, Dp, Dp, Dp	3	
C	S, S, S, S, S	M, Dp, Dp, Dp, Dp	2.7	
D	S, S, S,	M, Dp, Dp	1.8	
E				

3090

Acres	33
	10/14/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	25
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	51
2 ft	28
3 ft	25
4 ft	42
5 ft	40
6 ft	33
TOTAL	219
NH4-N	36
ORGANIC	2.29

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	350	0	0	0	0	350
2014	0	350	0	0	0	0	350
2013	0	350	0	0	0	0	350
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016	Alfalfa	9	Tons			
2015	Triticale	10	Tons	Sudan Grass	6	Tons
2014	Triticale	9	Tons	Sudan Grass	7	Tons
2013	Triticale	10	Tons	Sudan Grass	7	Tons

Current Crop	
Crop Year	
2016	
Condition	
Fair	Planned

Soil: 140 - Sinloc Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	M, Dp	1.9	
B	S, S	M, Dp	1.8	
C	S, S	M, Dp	1.6	
D	S, S	M, Dp	1.1	
E				

3091

Acres	45
	10/15/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	5 day sets
Irrigation years	10
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	86
2 ft	43
3 ft	46
4 ft	56
5 ft	19
6 ft	4
TOTAL	254
NH4-N	25
ORGANIC	2.41

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	150	0	0	0	0	0	150
2015	300	0	0	0	0	0	300
2014	300	0	0	0	0	0	300
2013	300	0	0	0	0	0	300
2012	0	0	0	0	0	0	0
2011							0

Comments: Split applications - 150 lbs thru pivot point in spring, 150 lbs thru pivot point in fall

Cropping History

	Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
2016	Alfalfa	9	Tons			
2015	Alfalfa	8	Tons			
2014	Alfalfa	9	Tons			
2013	Alfalfa	10	Tons			

Current Crop	
Crop Year	
2016	
Condition	
Fair	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	6	
B	S	M	6	
C	S	M	4	4
D	S	M	2.5	4
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3092

Acres	36
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	20
Event	FALL 2015
	10/15/2015

NO3 (#N/ACRE)	
1 ft	22
2 ft	8
3 ft	9
4 ft	3
5 ft	3
6 ft	3
TOTAL	48
NH4-N	14
ORGANIC	2.15

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: No nutrients have been added since 2012

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	8 Tons		
Alfalfa	8 Tons		
Alfalfa	7 Tons		
Alfalfa	9 Tons		

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 138 - Sinloc Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	M, Dp	2	
B	S, S, S	M, Dp, Dp	1.8	
C	S, S, S, S	M, Dp, Dp, Dp	2	
D	S, S, S	M, Dp, Dp	2	
E				

3093

Acres	80
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check the soil
Irrigation years	6
Event	FALL 2015
	10/15/2015

NO3 (#N/ACRE)	
1 ft	16
2 ft	3
3 ft	3
4 ft	4
5 ft	6
6 ft	7
TOTAL	39
NH4-N	19
ORGANIC	1.63

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	50	0	0	0	50
2014	0	0	50	0	0	0	50
2013	0	0	50	0	0	0	50
2012	0	0	0	0	0	0	0
2011							0

Comments: N is applied in the spring

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	10 Tons		
Alfalfa	10 Tons		
Alfalfa	10 Tons		
Alfalfa	10 Tons		

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S	M, M, Dp, Dp	1.8	
B	S, S, S, S	M, M, Dp, Dp	1.9	
C	S, S, S, S	M, M, Dp, Dp	2	
D	S, S, S, S	M, M, Dp, Dp	1.5	
E				

3094

Acres	35
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check Soil
Irrigation years	16
Event	FALL 2015
	10/15/2015

NO3 (#N/ACRE)	
1 ft	467
2 ft	644
3 ft	776
4 ft	726
5 ft	576
6 ft	565
TOTAL	3754
NH4-N	50
ORGANIC	2.85

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	190	0	0	0	0	0	190
2015	320	0	0	0	0	0	320
2014	360	0	0	0	0	0	360
2013	342	0	0	0	0	0	342
2012	0	0	0	0	0	0	0
2011							0

Comments: Liquid manure is applied twice a year. Split Application. In current year, only 1 application has occurred.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	7 Tons		
Triticale	8 Tons	Corn Silage	27 Tons
Triticale	7 Tons	Corn Silage	27 Tons
Triticale	7 Tons	Corn Silage	25 Tons

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 175 - Warden fine silty loan 8 to 15 percent slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2	
B	S	M	1.8	
C	S	M	1.6	
D	S	M	1	
E				

3095

Acres	75
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Pivot
Irrigation Schedule	Only 1 irrigation to sprout triticale
Hour Sets	
Irrigation years	
Event	FALL 2015
	10/15/2015

NO3 (#N/ACRE)	
1 ft	60
2 ft	90
3 ft	140
4 ft	178
5 ft	
6 ft	
TOTAL	468
NH4-N	17
ORGANIC	1.92

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: This field has had a history of manure application for double cropping. The property changed ownership and application records and yield records were not available.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Triticale	Tons	Corn Silage	Tons
Triticale	Tons	Corn Silage	Tons
Triticale	tons		

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 57 - Hezel Loamy Fine Sand 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, M, Dp	1.4	
B	S, S, S	M, M, Dp	0.8	4
C	S, S	M, Dp	0.9	4
D	S, S, S	M, M, Dp	2.8	4
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3096

Acres	16
	10/16/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	2
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	27
2 ft	8
3 ft	10
4 ft	17
5 ft	47
6 ft	19
TOTAL	128
NH4-N	44
ORGANIC	2.06

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	0	0	251	0	0	0	251
2013	0	225	0	0	0	0	225
2012	0	0	0	0	0	0	0
2011							0

Comments: No nutirents appllied in 2015

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	9	Tons			
Triticale	7	Tons	Sudan Grass	7	Tons
Triticale	8	Tons	Sudan Grass	7	Tons
Triticale	7	Tons	Corn Silage	24	Tons

Current Crop	
Crop Year	2016
Condition	
Good	Planned

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S, S, S	M, M, M, M, Dp, M	2.9	
B	S, S, S, S, S	M, M, Dp, M, Dp	3	
C	S, S, S, S, S, S, S, S	M, M, M, Dp, M, Dp, M, Dp	2.4	
D	S, S, S, S, S, S	M, M, M, Dp, M, Dp	3	
E				

3097

Acres	60
	10/16/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check Soil
Irrigation years	7
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	336
2 ft	363
3 ft	335
4 ft	263
5 ft	113
6 ft	64
TOTAL	1474
NH4-N	28
ORGANIC	2.18

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	170	0	0	170
2014	0	0	0	170	0	0	170
2013	0	0	0	170	0	0	170
2012	0	0	0	0	0	0	0
2011							0

Comments: Bio solids applied in spring

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	9	Tons			
Triticale	9	Tons	Corn Silage	28	Tons
Triticale	9	Tons	Corn Silage	28	Tons
Triticale	9	Tons	Corn Silage	28	Tons

Current Crop	
Crop Year	2016
Condition	
Good	Planned

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, SH, S, S	M, M, M, M, M, M	1.4	
B	S, S, S, SH, S, S	M, M, M, M, M, M	1.1	
C	S, S, SH, S, S	M, M, M, M, M	1.5	
D	S, S, S, SH, S, S	M, M, M, M, M, M	1.7	
E				

3098

Acres	35
	10/16/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	20
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	35
2 ft	11
3 ft	16
4 ft	12
5 ft	24
6 ft	15
TOTAL	113
NH4-N	40
ORGANIC	1.46

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	100	0	0	0	100
2014	0	0	100	0	0	0	100
2013	0	0	100	0	0	0	100
2012	0	0	0	0	0	0	0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Wheat	9	Tons			
Wheat	9	Tons	Sudan Grass	4	Tons
Wheat	9	Tons	Sudan Grass	4	Tons

Current Crop	
Crop Year	2015
Condition	
Good	Actual

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.5	
B	S	M	2.1	
C	S	M	2.3	
D	S	M	2.8	
E				

3099

Acres	40
	10/16/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check the Soil
Irrigation years	30
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	179
2 ft	151
3 ft	77
4 ft	54
5 ft	90
6 ft	56
TOTAL	607
NH4-N	15
ORGANIC	1.65

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	200	0	0	0	200
2014	0	0	200	0	0	0	200
2013	0	0	200	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Silage	28	Tons			
Corn Silage	28	Tons			
Corn Silage	28	Tons			

Current Crop	
Crop Year	2015
Condition	
Fair	Actual

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S, S	D, M, M, M, M	2	
B	S, S, S, S, S	D, M, M, M, M	2	
C	S, S, S, S, S, S	D, M, M, M, M, M	2.4	
D	S, S, S, S, S	D, M, M, M, M	2.2	
E				

3100

Acres	35
	10/18/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	Check the soil
Irrigation years	
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	79
2 ft	41
3 ft	68
4 ft	76
5 ft	61
6 ft	27
TOTAL	352
NH4-N	22
ORGANIC	1.4

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	200	0	0	0	200
2014	0	0	200	0	0	0	200
2013	0	0	200	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Silage	30	Tons			
Corn Silage	30	Tons			
Corn Silage	30	Tons			

Current Crop	
Crop Year	2015
Condition	
Good	Actual

Soil: 174 - Warden Fine Sandy Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.4	
B	S	M	3.3	
C	S	M	3.3	
D	S	M	3.7	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3101

Acres	20
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	12
Irrigation years	20
Event	FALL 2015
	10/18/2015

NO3 (#N/ACRE)	
1 ft	54
2 ft	9
3 ft	5
4 ft	7
5 ft	22
6 ft	18
TOTAL	115
NH4-N	46
ORGANIC	2.38

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016	0	0	0	0	0	0	0				
2015	0	0	0	0	0	0	0	Grazing Pasture			
2014	0	0	0	0	0	0	0	Grazing Pasture			
2013	0	0	60	0	0	0	60	Grazing Pasture			
2012	0	0	0	0	0	0	0	Grazing Pasture			
2011							0				

Comments: 120 mature milking cows 6 hours a day

Current Crop	
Crop Year	2015
Condition	Good

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.4	
B	S	M	1.3	
C	S	M	1.3	
D	S	M	1.8	
E				

3102

Acres	55
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check the soil
Irrigation years	7
Event	FALL 2015
	10/18/2015

NO3 (#N/ACRE)	
1 ft	46
2 ft	17
3 ft	13
4 ft	52
5 ft	
6 ft	
TOTAL	128
NH4-N	27
ORGANIC	2.89

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016	0	0	0	0	0	0	0	Alfalfa	10 Tons		
2015	10	0	0	0	0	0	10	Alfalfa	10 Tons		
2014	0	0	0	0	0	0	0	Triticale	8 Tons	Sudan Grass	6 Tons
2013	0	0	0	0	48	0	48	Corn Silage	29 Tons	Triticale	8 Tons
2012	0	0	0	0	0	0	0				
2011							0				

Comments: The 8 ton per acre compost application = 48 lbs of N applied per acre; No nutirents applied in 2014.

Current Crop	
Crop Year	2016
Condition	Good Planned

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.3	4
B	S	M	1	4
C	S	M	1.2	4
D	S	M	1.8	4
E				

3103

Acres	65
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Wheel-line
Irrigation Schedule	Sprinklers
Hour Sets	24
Irrigation years	25
Event	FALL 2015
	10/20/2015

NO3 (#N/ACRE)	
1 ft	12
2 ft	4
3 ft	7
4 ft	5
5 ft	7
6 ft	3
TOTAL	38
NH4-N	19
ORGANIC	1.73

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016	0	0	0	0	0	0	0				
2015	30	0	0	0	0	0	30	Grass hay	2 Tons	Cows	
2014	30	0	0	0	0	0	30	Grass hay	2 Tons	Cows	
2013	30	0	0	0	0	0	30	Grass hay	2 Tons	Cows	
2012	30	0	0	0	0	0	30	Grass hay	2 Tons	Cows	
2011							0				

Comments: Split application; 15 lbs N per Acre in Spring, 15 lbs N per Acre in fall

Current Crop	
Crop Year	2015
Condition	Good Actual

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S, S, S	M, M, M, M, M, M	1.9	
B	S, S, S, SH, S, S, S	M, M, M, M, M, M, M	1.9	
C	S, S, S, S, S, S	M, M, M, M, M, M	1.8	
D	S, S, S, S, S	M, M, M, M, M	2.5	
E				

3104

Acres	80
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	20
Event	FALL 2015
	10/20/2015

NO3 (#N/ACRE)	
1 ft	17
2 ft	3
3 ft	3
4 ft	3
5 ft	
6 ft	
TOTAL	26
NH4-N	28
ORGANIC	2.42

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016	0	0	0	0	0	0	0				
2015	30	0	0	0	0	0	30				
2014	30	0	0	0	0	0	30	Grass Hay	2 Tons	Cows	
2013	30	0	0	0	0	0	30	Grass Hay	2 Tons	Cows	
2012	30	0	0	0	0	0	30	Grass Hay	2 Tons	Cows	
2011							0				

Comments: Split application; 15 lbs N per Acre in Spring, 15 lbs N per Acre in fall; Because of drought, no hay was made in the 2015 Season. Only 100 beef cows in August grazed off pasture.

Current Crop	
Crop Year	2015
Condition	Fair Just Graz

Soil: 120 - Scoon Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	SH, SH, SH, SH	M, M, Dp, Dp	2.2	3.2
B	SH, SH	M, M	2.9	3.1
C	SH, SH, SH	M, M, Dp	2.3	3
D	SH, SH, SH	M, M, Dp	2.2	3.6
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3105

Acres	20
	10/21/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	Check soil
Irrigation years	30
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	371
2 ft	58
3 ft	18
4 ft	9
5 ft	20
6 ft	68
TOTAL	544
NH4-N	67
ORGANIC	1.83

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	200	0	0	0	0	200
2014	0	200	0	0	0	0	200
2013	0	200	0	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Comments: Nutrients applied in the spring; Note irrigation - uses Rill on Corn and Wheel-line for triticale

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Corn Silage	30 Tons		
Corn Silage	25 Tons		
Corn Silage	28 Tons		

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, Fl, Fl, Fl	M, Dp, Dp, Dp	1.4	
B	S, Fl, Fl, Fl, S	M, Dp, Dp, Dp, M	1.7	
C	S, Fl, Fl, Fl, Fl, Fl	M, Dp, Dp, Dp, Dp, Dp	1.3	
D	S, Fl, Fl, Fl, Fl, Fl	M, Dp, Dp, Dp, Dp, Dp	1.3	
E				

3106

Acres	35
	10/21/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check Soil
Irrigation years	14
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	316
2 ft	445
3 ft	465
4 ft	248
5 ft	256
6 ft	222
TOTAL	1952
NH4-N	15
ORGANIC	0.95

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	150	0	0	0	0	0	150
2015	300	0	0	0	0	0	300
2014	300	0	0	0	0	0	300
2013	300	0	0	0	0	0	300
2012	0	0	0	0	0	0	0
2011							0

Comments: Split application 150 lbs N in Spring 150 lbs N in Fall

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Triticale	9 Tons	Corn Silage	37 Tons
Triticale	8 Tons	Corn Silage	41 Tons
Triticale	10 Tons	Corn Silage	36 Tons

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S, Fl, Fl	M, M, M, M, M, M	1.4	
B	S, S, S, S, Fl, FVI	M, M, M, M, M, M	3.2	
C	S, S, S, S, Fl, FVI	M, M, M, M, M, M	3.4	
D	S, S, S, S, VFl	M, M, M, M, M	3.1	
E				

3107

Acres	35
	10/21/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Blank
Hour Sets	
Irrigation years	10
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	96
2 ft	70
3 ft	164
4 ft	182
5 ft	120
6 ft	44
TOTAL	676
NH4-N	22
ORGANIC	2.48

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	127	0	0	0	0	0	127
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: Only one year of history available, but there is a known history of annual manure application

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Corn Silage	26 Tons		

Current Crop	
Crop Year	
2016	
Condition	
Fair	Planned

Soil: 138 - Sinloc Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, Fl, S	M, M, M, Dp	3.2	
B	S, S, Fl, S	M, M, M, Dp	2.8	
C	S, S, Fl, S	M, M, M, Dp	3.2	
D	S, S, Fl, S	M, M, M, Dp	3.3	
E				

3108

Acres	24
	10/21/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Watch the corn
Hour Sets	
Irrigation years	10
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	311
2 ft	465
3 ft	612
4 ft	684
5 ft	247
6 ft	264
TOTAL	2583
NH4-N	27
ORGANIC	2.66

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	21	0	0	0	0	0	21
2015	82	0	150	0	0	0	232
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: 82 lbs N thru pivot onto triticale in spring, 150 N thru pivot for corn crop. Only one year history available but field has had a history of annual manure application.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Triticale	8 Tons	Corn Silage	28 Tons

Current Crop	
Crop Year	
2016	
Condition	
Fair	Planned

Soil: 138 - Sinloc Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	M, M	2.5	
B	S, Fl, S, S	M, M, M, M	3.4	
C	S, Fl, VFl, S	M, M, M, M	1.4	
D	S, Fl, VFl, Fl, S	M, M, M, M, M	3	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3109

Acres	36
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Wheel Lines
Irrigation Schedule	Blank
Hour Sets	
Irrigation years	10
Event	FALL 2015

10/21/2015

NO3 (#N/ACRE)	
1 ft	82
2 ft	60
3 ft	223
4 ft	238
5 ft	56
6 ft	100
TOTAL	759
NH4-N	12
ORGANIC	1.48

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	31	0	0	0	0	0	31
2015	29	0	150	0	0	0	179
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	10	Tons			
Triticale	8	Tons	Corn Silage	29	Tons

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 174 - Warden Fine Sandy Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	4.5	
B	S	M	2.6	
C	S	M	3.5	4
D	S	M	3.8	4
E				

Comments: All nutrients applied thru the pivot. Only one year history available, but field has a known history of having manure applied on a annual basis.

3110

Acres	32
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check soil
Irrigation years	11
Event	FALL 2015

10/22/2015

NO3 (#N/ACRE)	
1 ft	93
2 ft	100
3 ft	125
4 ft	154
5 ft	283
6 ft	413
TOTAL	1168
NH4-N	34
ORGANIC	2.19

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	100	0	0	0	0	0	100
2015	280	0	60	0	0	0	340
2014	300	0	125	0	0	0	425
2013	280	0	50	0	0	0	330
2012	0	0	0	0	0	0	0
2011							0

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	11	Tons			
Triticale	12	Tons	Corn Silage	38	Tons
Triticale	11	Tons	Corn Silage	34	Tons
Triticale	12	Tons	Corn Silage	30	Tons

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, FI	M, M, M	4.9	
B	S, S, FI	M, M, M	3.5	
C	S, S, FI	M, M, M	4.3	
D	S, S, FI, S	M, M, M, M	4.2	
E				

Comments: Split application of liquid manure, half in fall and half in spring

3111

Acres	40
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	check soil
Irrigation years	10
Event	FALL 2015

10/22/2015

NO3 (#N/ACRE)	
1 ft	35
2 ft	45
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	80
NH4-N	24
ORGANIC	1.59

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	170	0	0	0	0	0	170
2015	300	0	0	0	0	0	300
2014	300	0	0	0	0	0	300
2013	300	0	75	0	0	0	375
2012	0	0	0	0	0	0	0
2011							0

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	10	Tons			
Triticale	12	Tons	Corn Silage	18	Tons
Triticale	18	Tons	Corn Silage	30	Tons
Triticale	15	Tons	Corn Silage	33	Tons

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 121 - Scoon Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, HA	M, M	1.2	1.6
B	S, HA	M, M	1.1	1.1
C	S, HA	M, M	1.2	1.5
D	S	M	0.9	1
E				

Comments: Split application of liquid manure 150 lbs in fall 150 lbs in spring

3112

Acres	66
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	check soil
Irrigation years	8
Event	FALL 2015

10/22/2015

NO3 (#N/ACRE)	
1 ft	39
2 ft	73
3 ft	87
4 ft	95
5 ft	47
6 ft	38
TOTAL	379
NH4-N	22
ORGANIC	1.87

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	75	0	0	0	0	0	75
2015	75	0	85	0	0	0	160
2014	75	0	40	0	0	0	115
2013	75	0	0	0	0	0	75
2012	0	0	0	0	0	0	0
2011							0

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	10	Tons			
Triticale	12	Tons	Corn Silage	36	Tons
Triticale	10	Tons	Corn Silage	32	Tons
Triticale	11	Tons	Corn Silage	30	Tons

Current Crop: Crop Year 2016; Condition: Good / Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.4	
B	S	M	1.7	
C	S	M	3.4	
D	S	M	2.2	5.7
E				

Comments: Liquid manure fall application on triticale commerical N side dress with corn planting

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3113

Acres	74
	10/22/2015
Soil Testing?	YES
Test Frequency	Twice a Year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check Soil
Irrigation years	8
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	49
2 ft	150
3 ft	308
4 ft	308
5 ft	340
6 ft	280
TOTAL	1435
NH4-N	19
ORGANIC	1.71

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	75	0	0	0	0	0	75
2014	75	0	0	0	0	0	75
2013	75	0	45	0	0	0	120
2012	75	0	0	0	0	0	75
2011							0

Comments: Liquid manure fall application

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Alfalfa	10	Tons			
Alfalfa	10	Tons			
Triticale	10	Tons	Alfalfa	4	Tons
Triticale	11	Tons	Corn Silage	30	Tons

Current Crop	
Crop Year	2016
Condition	
Good	Planned

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, Fl, Si	M, M, M, M, M	6	
B	S, S, S, Fi, S, S	M, M, M, M, M, M	5.2	
C	S, S, S	M, M, M	5	5
D	S, S, S	M, M M	4	4
E				

3114

Acres	36
	10/22/2015
Soil Testing?	YES
Test Frequency	Once a Year - Fall
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	8-Day Rotation
Irrigation years	100
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	131
2 ft	22
3 ft	36
4 ft	18
5 ft	28
6 ft	31
TOTAL	266
NH4-N	10
ORGANIC	1.55

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	100	0	0	0	0	100
2014	0	150	0	0	0	0	150
2013	0	200	0	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Silage	34	Tons			
Corn Silage	35	Tons			
Corn Silage	31	Tons			
Corn Silage	27	Tons			

Current Crop	
Crop Year	2015
Condition	
Good	Actual

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, Fl, S, S, L	D, M, M, M, M, M	1.8	
B	S, S, Fl, L, Fl, L, S, L	D, M, M, M, M, M, M, M	3.3	
C	S, S, Fl, S, Fl	D, M, M, M, M	2.4	
D	S, S, S, L, S, Fl	D, M, M, M, M, M	3.4	
E				

3115

Acres	40
	10/22/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	10
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	82
2 ft	90
3 ft	149
4 ft	111
5 ft	192
6 ft	195
TOTAL	819
NH4-N	14
ORGANIC	1.67

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	150	0	0	0	0	0	150
2015	300	0	0	0	0	0	300
2014	300	0	0	0	0	0	300
2013	300	0	75	0	0	0	375
2012	0	0	0	0	0	0	0
2011							0

Comments: Split application of liquid manure, 150 lbs N in spring, 150 lbs N in fall

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	10	Tons			
Triticale	10	Tons	Sorgummilo	18	Tons
Triticale	18	Tons	Corn Silage	30	Tons
Triticale	14	Tons	Corn Silage	33	Tons

Current Crop	
Crop Year	2016
Condition	
Good	Planned

Soil: 179 - Warden Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, Fl, S	M, M, M	1.9	4
B	S, Fl, S, Fl, S, Fl	M, M, M, M, M, M	3.2	
C	S, S, Fl, S, Fl, VFl, S	M, M, M, M, M, M, M	2.9	
D	S, S, Fl, S, S, S, VFl	M, M, M, M, M, M, M	2.5	
E				

3116

Acres	30
	10/25/2015
Soil Testing?	YES
Test Frequency	One a Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Look at Crop and Soil
Hour Sets	
Irrigation years	65
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	271
2 ft	489
3 ft	113
4 ft	56
5 ft	55
6 ft	49
TOTAL	1033
NH4-N	23
ORGANIC	3.04

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	50	0	150	0	0	0	200
2014	50	0	150	0	0	0	200
2013	50	0	150	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Grain	180	Bushels			
Corn Grain	180	Bushels			
Corn Grain	180	Bushels			
Corn Silage	25	Tons			

Current Crop	
Crop Year	2015
Condition	
Good	Actual

Soil: 176 - Warden Silt Loam 0 to 2 percent slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.9	
B	S	M	2.2	
C	S	M	3.7	
D	S	M	2.7	
E				

3117

Acres	36
	10/25/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Solid Sets
Irrigation Schedule	Blank
Hour Sets	
Irrigation years	5
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	51
2 ft	301
3 ft	573
4 ft	400
5 ft	
6 ft	
TOTAL	1325
NH4-N	9
ORGANIC	1.67

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: This is an organic grape vineyard. We use vetch legume with triticale as a cover crop and the vetch does nitrogen fixing.

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Grapes	6	Tons			
Grapes	6	Tons			
Grapes	9	Tons			
Grapes	6	Tons			

Current Crop	
Crop Year	2015
Condition	
Fair	Actual

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	D, M, M	3.9	4
B	S, S, S	D, M, M	3.6	4
C	S, S, S, S, S	D, M, M, M, M	2.3	4
D	S, S, S, S, S	D, M, M, M, M	1.8	4
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3118

Acres	45
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Solid Sets
Irrigation Schedule	Check the soil
Hour Sets	
Irrigation years	25
Event	FALL 2015

10/25/2015

NO3 (#N/ACRE)	
1 ft	87
2 ft	51
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	138
NH4-N	14
ORGANIC	3.06

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	70	0	0	0	70
2014	0	0	50	0	0	0	50
2013	0	0	50	0	0	0	50
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Apples	53 Bins		
Apples	55 Bins		
Apples	50 Bins		
Apples	50 Bins		

Current Crop	
Crop Year	2015
Condition	Good

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D	1.8	1.8
B	S	D	1.8	1.8
C	S	D	1.9	1.9
D	S	D	1.7	1.7
E				

3119

Acres	15
Soil Testing?	YES
Test Frequency	Every 2 Years
Irrigation Type	Solid Sets
Irrigation Schedule	Check Soil
Hour Sets	
Irrigation years	10
Event	FALL 2015

10/25/2015

NO3 (#N/ACRE)	
1 ft	20
2 ft	213
3 ft	260
4 ft	213
5 ft	559
6 ft	580
TOTAL	
NH4-N	11
ORGANIC	1.49

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	50	0	0	0	50
2014	0	0	50	0	0	0	50
2013	0	0	50	0	0	0	50
2012	0	0	0	0	0	0	0
2011							0

Comments: Previous farmer 40 years ago had a history of excessive nitrogen application according to current farmer

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Grapes	10 Tons		
Grapes	6 Tons		
Grapes	4 Tons		
Grapes	10 Tons		

Current Crop	
Crop Year	2015
Condition	Good Actual

Soil: 179 - Warden Silt Loam 8-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, FI	M, M, D	5.3	5.8
B	S, S	M, M	3.2	4
C	S, S	M, M	3.3	3.8
D	S, S, FI, L	M, M, M, M	3	4
E				

3120

Acres	35
Soil Testing?	YES
Test Frequency	Every Other Year
Irrigation Type	Solid Sets
Irrigation Schedule	Check soil
Hour Sets	
Irrigation years	10
Event	FALL 2015

10/25/2015

NO3 (#N/ACRE)	
1 ft	13
2 ft	143
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	156
NH4-N	12
ORGANIC	1.35

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	50	0	0	0	50
2014	0	0	50	0	0	0	50
2013	0	0	50	0	0	0	50
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Grapes	10 Tons		
Grapes	8 Tons		
Grapes	4 Tons		
Grapes	10 Tons		

Current Crop	
Crop Year	2015
Condition	Good Actual

Soil: 180 - Warden Silt Loam 15-30% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.4	1.4
B	S	M	1.8	2
C	S	M	1.6	1.9
D	S	M	1.1	2
E				

3121

Acres	40
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	
Irrigation years	17
Event	FALL 2015

10/25/2015

NO3 (#N/ACRE)	
1 ft	275
2 ft	193
3 ft	162
4 ft	137
5 ft	202
6 ft	272
TOTAL	1241
NH4-N	32
ORGANIC	2.91

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	137	0	0	0	0	0	137
2013	293	0	0	0	0	0	293
2012	0	0	0	0	0	0	0
2011							0

Comments: No nutirents applied in 2015. 2013 split application - 117 pounds in Spring and 176 pounds in fall.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	8 Tons		
Triticale	7 Tons	Corn Silage	29 Tons
Triticale	7 Tons	Corn Silage	29 Tons
Triticale	7 Tons	Corn Silage	29 Tons

Current Crop	
Crop Year	2016
Condition	Good Planned

Soil: 139 - Sinloc Silt Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.2	
B	S	M	1.5	
C	S	M	4.5	
D	S	M	4.6	
E				

3122

Acres	80
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	30
Event	FALL 2015

10/25/2015

NO3 (#N/ACRE)	
1 ft	101
2 ft	20
3 ft	14
4 ft	3
5 ft	16
6 ft	4
TOTAL	158
NH4-N	23
ORGANIC	2.07

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	215	0	0	0	215
2014	0	0	60	0	0	0	60
2013	0	0	140	0	0	0	140
2012	0	0	0	0	0	0	0
2011							0

Comments: Comment on Sprinklers - For triticale sprinkles 24 hour sets for corn move ditches every 2 hours. Rill forever sprinklers started 5 years ago. Rill for corn, sprinklers for triticale.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	8 Tons		
Triticale	9 Tons	Corn Silage	25 Tons
Corn Silage	28 Tons		
Corn Silage	30 Tons		

Current Crop	
Crop Year	2016
Condition	Good Planned

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, FI, FI, FI, S	M, M, Dp, W, M	1.2	
B	S, FI, FI, FI, S	M, M, Dp, W, M	1.1	
C	S, FI, FI, FI, S	M, M, Dp, W, M	1.4	
D	S, FI, FI, FI, S	M, M, Dp, W, M	1.1	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3123

Acres	40
	10/25/2015
Soil Testing?	YES
Test Frequency	Once a Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Every 8 days
Hour Sets	
Irrigation years	100
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	435
2 ft	27
3 ft	74
4 ft	31
5 ft	99
6 ft	28
TOTAL	694
NH4-N	47
ORGANIC	2.28

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016	0	0	0	0	0	0	0				
2015	200	0	0	0	0	0	200	Corn Silage	30 Tons		
2014	200	0	0	0	0	0	200	Corn Silage	26 Tons		
2013	200	0	0	0	0	0	200	Corn Silage	27 Tons		
2012	0	0	0	0	0	0	0	Corn Silage	26 Tons		
2011							0				

Comments: Every year

Current Crop	
Crop Year	
2015	
Condition	
Fair	Actual

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S	M, M, M, W	2.4	
B	S, S, S	M, M, W	2.4	
C	S, S, S	M, M, W	2.6	
D	S, S, S	M, M, W	1.6	
E				

3124

Acres	20
	10/25/2015
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Rill/Surface Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	6x a year water
Irrigation years	
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	13
2 ft	6
3 ft	3
4 ft	4
5 ft	4
6 ft	6
TOTAL	36
NH4-N	81
ORGANIC	2.95

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016	0	17	0	0	0	0	17	Pasture			
2015	0	17	0	0	0	0	17	Pasture			
2014	0	17	0	0	0	0	17	Pasture			
2013	0	17	0	0	0	0	17	Pasture			
2012	0	17	0	0	0	0	17	Pasture			
2011							0				

Comments: Only manure is from cows - .42 lbs of N per day per animal pair; 40 pair year around

Current Crop	
Crop Year	
2015	
Condition	
Fair	

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, FI	M, M, Dp-W	1	
B	S, S, FI	M, M, Dp-W	3.4	
C	S, S, FI	M, M, Dp-W	2.6	
D	S, S, FI, FI	M, M, M, Dp-W	1.8	
E				

3125

Acres	35
	10/25/2015
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	16
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	8
2 ft	4
3 ft	3
4 ft	
5 ft	
6 ft	
TOTAL	15
NH4-N	20
ORGANIC	0.9

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016	0	0	0	0	0	0	0	Alfalfa	10 Tons		
2015	0	0	210	0	0	0	210	Alfalfa	10 Tons		
2014	0	0	210	0	0	0	210	Alfalfa	9 Tons		
2013	0	0	210	0	0	0	210	Alfalfa	10 Tons		
2012	0	0	0	0	0	0	0				
2011							0				

Comments: Split application of N to the field

Current Crop	
Crop Year	
2015	
Condition	
Fair	

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, M, M	1.6	3
B	S, L, S	M, M, M	3.1	3.1
C	S, S, FI, S	M, M, M, M	2	2
D	S, S, FI, S	M, M, M, M	1.6	2
E				

3126

Acres	16
	10/27/2015
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	Check soil
Irrigation years	1
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	246
2 ft	104
3 ft	92
4 ft	126
5 ft	134
6 ft	140
TOTAL	842
NH4-N	30
ORGANIC	1.91

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total	Cropping History Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
2016	40	0	0	0	0	0	40	Triticale	10 Tons		
2015	160	0	80	0	0	0	240	Triticale	10 Tons	Corn Silage	37 Tons
2014	40	0	0	0	0	0	40	Alfalfa	9 Tons		
2013	40	0	0	0	0	0	40	Alfalfa	10 Tons		
2012	0	0	0	0	0	0	0				
2011							0				

Comments: Split application of commercial N

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S	M, M, Dp, W	2.7	
B	S, S, S, S	M, M, Dp, W	2.5	
C	S, S, S, S	M, M, Dp, W	1.7	
D	S, S, S, S	M, M, Dp, W	2	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3127

Acres	10/27/2015
Soil Testing?	Blank
Test Frequency	N/A
Irrigation Type	Wheel-line
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	34
2 ft	22
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	56
NH4-N	13
ORGANIC	2.27

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	40	0	0	0	0	0	40
2014	40	0	0	0	0	0	40
2013	40	0	0	0	0	0	40
2012	0	0	0	0	0	0	0
2011							0

Comments: Liquid manure applied thru wheel lines to field in Spring

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	Tons		
Alfalfa	9 Tons		
Alfalfa	10 Tons		
Alfalfa	8 Tons		

Current Crop	
Crop Year	2016
Condition	Good

Soil: 173 - Warden Fine Sandy Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.8	2
B	S	M	1.3	2
C	S	M	1.6	2
D	S	M	1	1
E				

3128

Acres	30
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	257
2 ft	11
3 ft	22
4 ft	10
5 ft	95
6 ft	
TOTAL	395
NH4-N	12
ORGANIC	1.61

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	100	0	0	0	100
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: Records were not available for yield of year 14 and 13 also fertilizer records were not available for year 14 or 13

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	35 Tons		
Corn Silage	35 Tons		
Corn Silage	Tons		
Corn Silage	Tons		

Current Crop	
Crop Year	2015
Condition	Good Actual

Soil: 174 - Warden Fine Sandy Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S	M, M, Dp	0.6	5
B	S, S, S	M, M, Dp	0.9	4
C	S, S, S, S, S	M, M, Dp, M, Dp	1.3	
D	S, S, S	M, M, Dp	1.4	5.2
E				

3129

Acres	30
Soil Testing?	YES
Test Frequency	Once a Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	check soil
Hour Sets	
Irrigation years	30
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	28
2 ft	8
3 ft	17
4 ft	6
5 ft	7
6 ft	3
TOTAL	69
NH4-N	22
ORGANIC	2.49

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	300	0	0	0	300
2014	0	0	300	0	0	0	300
2013	0	0	300	0	0	0	300
2012	0	0	0	0	0	0	0
2011							0

Comments: 150 in Spring another 150 after cutting

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Mint	190 Lbs.		
Mint	165 Lbs.		
Mint	165 Lbs.		
Mint	165 Lbs.		

Current Crop	
Crop Year	2015
Condition	Good Actual

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S	M, M, M, M	2.5	
B	S, S, S	M, M, M	2	
C	S, S, S, S, S	M, M, M, M, Dp	1.4	
D	S, S, S, S, S	M, M, M, M, Dp	1.1	
E				

3130

Acres	16
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Hand-line
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	3
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	18
2 ft	7
3 ft	6
4 ft	3
5 ft	
6 ft	
TOTAL	34
NH4-N	10
ORGANIC	1.91

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0
2012	0	0	0	0	0	0	0
2011							0

Comments: This farm applied 20 tons of manure per acre in Fall of 2011 before alfalfa was planted. It was on est. 200 lbs of N applied per acre. When not in alfalfa it is a rill irrigated corn field.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	10 Tons		
Alfalfa	10 Tons		
Alfalfa	11 Tons		
Alfalfa	10 Tons		

Current Crop	
Crop Year	2016
Condition	Good Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.6	4
B	S	M	1.4	4
C	S	M	4	4
D	S	M	3.3	4
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3131

Acres	35
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	100
Event	FALL 2015
	10/28/2015

NO3 (#N/ACRE)	
1 ft	97
2 ft	25
3 ft	33
4 ft	14
5 ft	12
6 ft	11
TOTAL	192
NH4-N	58
ORGANIC	2.72

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	250	100	0	0	0	350
2014	0	60	100	0	0	0	160
2013	0	0	100	0	0	0	100
2012	0	0	0	0	0	0	0
2011							0

Comments: All nutrients applied in Spring

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	30 Tons		
Corn Silage	30 Tons		
Corn Silage	30 Tons		
Corn Silage	30 Tons		

Current Crop	
Crop Year	2015
Condition	
Good	Actual

Soil: 138 - Sinloc Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S	M, M, Dp, Dp	1.5	
B	S, S, S, S, S	M, M, Dp, Dp, Dp	1.2	
C	S, S, S, S, S, S	M, M, Dp, Dp, M, Dp	2.1	
D	S, S, S, S	M, M, Dp, Dp	2.8	
E				

3132

Acres	20
Soil Testing?	YES
Test Frequency	Once a Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Check soil
Hour Sets	
Irrigation years	100
Event	FALL 2015
	10/28/2015

NO3 (#N/ACRE)	
1 ft	308
2 ft	43
3 ft	78
4 ft	14
5 ft	43
6 ft	8
TOTAL	494
NH4-N	13
ORGANIC	1.78

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	100	100	0	0	0	200
2014	0	100	100	0	0	0	200
2013	0	100	100	0	0	0	200
2012	0	100	100	0	0	0	200
2011							0

Comments: All nutrients applied in spring

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	28 Tons		
Corn Silage	30 Tons		
Corn Silage	25 Tons		
Corn Silage	27 Tons		

Current Crop	
Crop Year	2015
Condition	
Fair	Actual

Soil: 58 - Hezel Loamy Fine Sand 2-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S	D, M	3.1	4
B	S, S, S	D, M, M	2.8	
C	S, S, S	D, M, M	3.1	
D	S, S, S	D, M, M	3.2	
E				

3133

Acres	30
Soil Testing?	YES
Test Frequency	Once a Year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Check soil
Hour Sets	
Irrigation years	100
Event	FALL 2015
	10/28/2015

NO3 (#N/ACRE)	
1 ft	170
2 ft	97
3 ft	53
4 ft	24
5 ft	67
6 ft	59
TOTAL	470
NH4-N	16
ORGANIC	1.9

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	100	100	0	0	0	200
2014	0	100	100	0	0	0	200
2013	0	100	100	0	0	0	200
2012	0	100	100	0	0	0	200
2011							0

Comments: All nutrients applied in spring

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	24 Tons		
Corn Silage	27 Tons		
Corn Silage	32 Tons		
Corn Silage	27 Tons		

Current Crop	
Crop Year	2015
Condition	
Fair	Actual

Soil: 58 - Hezel Loamy Fine Sand 2-15% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S, S, S, S	M, M, M, M	2.6	
B	S, S, S	M, M, M	1.8	
C	S, S, S	M, M, M	2.9	
D	S, S, S, S, S	M, M, M, M, Dp	1.6	
E				

3134

Acres	30
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Pivot
Irrigation Schedule	Shovel
Hour Sets	
Irrigation years	3
Event	FALL 2015
	10/29/2015

NO3 (#N/ACRE)	
1 ft	10
2 ft	14
3 ft	76
4 ft	74
5 ft	46
6 ft	48
TOTAL	268
NH4-N	11
ORGANIC	1.42

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	80	0	0	0	80
2014	0	0	180	0	0	0	180
2013	0	0	180	0	0	0	180
2012	0	0	0	0	0	0	0
2011							0

Comments: Yield for 2015 not recorded

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Mint	200 Lbs.		
Mint	Lbs.		
Corn	35 Bushels		
Corn Grain	8 Tons		

Current Crop	
Crop Year	2016
Condition	
Good	Planned

Soil: 57 - Hezel Loamy Fine Sand 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.3	4
B	S	M	2.5	4
C	S	M	2	4
D	S	M	2.1	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3135

Acres	28
	10/29/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Pivot
Irrigation Schedule	Observe Crop
Hour Sets	
Irrigation years	3
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	225
2 ft	233
3 ft	219
4 ft	125
5 ft	
6 ft	
TOTAL	802
NH4-N	20
ORGANIC	2.14

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	50	200	0	0	0	250
2014	0	0	250	0	0	0	250
2013	0	0	200	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Comments: Previously commercial N was broadcast on by now it is applied thru the growing season thru the pivot

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Grain	28 Tons		
Corn Silage	28 Tons		
Corn Grain	7 Tons		
Corn Grain	7 Tons		

Current Crop	
Crop Year	
2015	
Condition	
Good	Actual

Soil: 57 - Hezel Loamy Fine Sand 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.2	4
B	S	M	1.5	4
C	S	M	1.1	3.2
D	S	M	1.3	4
E				

3136

Acres	15
	10/29/2015
Soil Testing?	Blank
Test Frequency	N/A
Irrigation Type	Rill Irrigation
Irrigation Schedule	Blank
Hour Sets	
Irrigation years	50
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	50
2 ft	6
3 ft	4
4 ft	3
5 ft	10
6 ft	8
TOTAL	81
NH4-N	20
ORGANIC	1.85

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	300	0	0	0	300
2014	0	0	300	0	0	0	300
2013	0	0	300	0	0	0	300
2012	0	0	0	0	0	0	0
2011							0

Comments: 150 in spring, fly on 50lbs June 1st, July 10 add

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Mint	Lbs.		
Mint	185 Lbs.		
Mint	195 Lbs.		
Mint	180 Lbs.		

Current Crop	
Crop Year	
2016	
Condition	

Soil: 173 - Warden Fine Sandy Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.4	
B	S	M		
C	S	M	2	
D	S	M		
E				

3137

Acres	5
	10/29/2015
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	50
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	56
2 ft	3
3 ft	7
4 ft	3
5 ft	7
6 ft	3
TOTAL	79
NH4-N	71
ORGANIC	1.75

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	300	0	0	0	300
2014	0	0	300	0	0	0	300
2013	0	0	300	0	0	0	300
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Mint	188 Lbs.		
Mint	188 lbs		
Mint	188 Lbs.		
Mint	188 Lbs.		

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 173 - Warden Fine Sandy Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.4	
B	S	M	2.4	
C	S	M	2.1	
D	S	M	1.9	
E				

3138

Acres	30
	10/29/2015
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	Check soil to start
Irrigation years	100
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	15
2 ft	3
3 ft	7
4 ft	4
5 ft	43
6 ft	4
TOTAL	76
NH4-N	12
ORGANIC	0.84

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	75	0	0	0	75
2014	0	0	75	0	0	0	75
2013	0	0	75	0	0	0	75
2012	0	0	0	0	0	0	0
2011							0

Comments: Field has been in grapes since 1949

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Grapes	15 Tons		
Grapes	11 Tons		
Grapes	18 Tons		
Grapes	12 Tons		

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 176 - Warden Silt Loam 0 to 2 percent slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2	4
B	S	M	2.2	4
C	S	M	1.8	
D	S	M	2.6	4
E				

3139

Acres	60
	10/29/2015
Soil Testing?	NO
Test Frequency	N/A
Irrigation Type	Solid Sets
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	10
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	5
2 ft	6
3 ft	30
4 ft	32
5 ft	
6 ft	
TOTAL	73
NH4-N	10
ORGANIC	1.13

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	75	0	0	0	75
2014	0	0	75	0	0	0	75
2013	0	0	75	0	0	0	75
2012	0	0	0	0	0	0	0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Grapes	15 Tons		
Grapes	11 Tons		
Grapes	18 Tons		
Grapes	12 Tons		

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.6	4
B	S	M	1.8	4
C	S	M	1.7	4
D	S	M	3.2	4
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

3140

Acres	20
	10/29/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Drip
Irrigation Schedule	once system is on rotate thru year
Hour Sets	
Irrigation years	15
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	300
2 ft	4
3 ft	40
4 ft	17
5 ft	127
6 ft	5
TOTAL	493
NH4-N	22
ORGANIC	1.42

Comments

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	200	0	0	0	200
2014	0	0	200	0	0	0	200
2013	0	0	200	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Hops	2 Tons		
Hops	1 Tons		
Hops	1 Tons		
Hops	1 Tons		

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.4	
B	S	M	2.5	
C	S	M	2.7	
D	S	M	2	
E				

3141

Acres	20
	10/29/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Drip
Irrigation Schedule	once system is on rotate thru year
Hour Sets	
Irrigation years	15
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	950
2 ft	59
3 ft	596
4 ft	57
5 ft	1344
6 ft	1204
TOTAL	4210
NH4-N	22
ORGANIC	2.25

Comments

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	200	0	0	0	200
2014	0	0	200	0	0	0	200
2013	0	0	200	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Hops	2 Tons		
Hops	1 Tons		
Hops	1 Tons		
Hops	1 Tons		

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2	
B	S	M	2.8	
C	S	M	2.1	5
D	S	M	2.2	4
E				

3142

Acres	20
	10/29/2015
Soil Testing?	YES
Test Frequency	Once per Year
Irrigation Type	Drip
Irrigation Schedule	once system is on rotate thru year
Hour Sets	
Irrigation years	15
Event	FALL 2015

NO3 (#N/ACRE)	
1 ft	820
2 ft	44
3 ft	149
4 ft	56
5 ft	
6 ft	
TOTAL	1069
NH4-N	12
ORGANIC	1.85

Comments

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	0	0	0	0	0	0	0
2015	0	0	200	0	0	0	200
2014	0	0	200	0	0	0	200
2013	0	0	200	0	0	0	200
2012	0	0	0	0	0	0	0
2011							0

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Hops	2 Tons		
Hops	2 Tons		
Hops	2 Tons		
Hops	2 Tons		

Current Crop	
Crop Year	
2016	
Condition	
Good	Planned

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.1	4
B	S	M	2.9	4
C	S	M	3.1	4
D	S	M	2.8	4
E				

4143

Acres	20
	4/26/2016
Soil Testing?	YES
Test Frequency	Yearly
Irrigation Type	Drip
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	5
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	129
2 ft	290
3 ft	174
4 ft	66
5 ft	30
6 ft	9
TOTAL	698
NH4-N	13
ORGANIC	1.46

Comments

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016			0				0
2015			75				75
2014			100				100
2013			100				100
2012							0
2011							0

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Apples	16.1 Tons		
Apples	2.1 Tons		
None			
None			

Current Crop	
Crop Year	
2016	
Condition	
Fair	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.4	
B	S	M	1.8	
C	S	M	2.6	4
D	S	M	1.4	
E				

4144

Acres	20
	4/26/2016
Soil Testing?	YES
Test Frequency	Annually
Irrigation Type	Micro Sprinklers
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	8
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	33
2 ft	20
3 ft	17
4 ft	
5 ft	
6 ft	
TOTAL	70
NH4-N	16
ORGANIC	1.93

Comments

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016			60				60
2015			75				75
2014			100				100
2013			100				100
2012							0
2011							0

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Cherries	60 Tons		
Cherries	66.3 Tons		
Cherries	68 Tons		
Cherries	33 Tons		

Current Crop	
Crop Year	
2016	
Condition	
Fair	Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,S,SH,S	M	2.6	3
B	S,S,SH	M	1.9	2
C	S,S,SH,S	M	2.5	2.5
D	S,S,SH	M	1.6	1.8
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

4145

Acres	35
Soil Testing?	4/26/2016
Test Frequency	
Irrigation Type	Wheel Lines
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	15
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	13
2 ft	4
3 ft	3
4 ft	3
5 ft	
6 ft	
TOTAL	23
NH4-N	22
ORGANIC	1.54

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016			0				0
2015			0				0
2014			0				0
2013			200				200
2012							0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Alfalfa	9 Tons		
Alfalfa	7 Tons		
Wheat	145 Bushels		

Current Crop	
Crop Year	2016
Condition	Good Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	4	4
B	S	M	3.2	4
C	S	M,M,M,D	3.9	4
D	S	M,M,D,M	4	4
E				

4146

Acres	
Soil Testing?	4/27/2016
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	35
2 ft	
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	35
NH4-N	9
ORGANIC	1.64

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: Survey Was not Returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop	
Crop Year	
Condition	

Soil: 120 - Scoon Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1	1.1
B	S	M	0.9	0.9
C	S	M	0.9	1
D	S	M	0.7	0.9
E				

4147

Acres	
Soil Testing?	4/27/2016
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	54
2 ft	51
3 ft	96
4 ft	197
5 ft	323
6 ft	
TOTAL	
NH4-N	13
ORGANIC	1.82

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: Survey was not returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop	
Crop Year	
Condition	

Soil: 121 - Scoon Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	3.1	3.5
B	S	M	5	5
C	S	M	2.2	3.5
D	S	M	1.9	2.8
E				

4148

Acres	
Soil Testing?	4/27/2016
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	41
2 ft	39
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	80
NH4-N	36
ORGANIC	2.95

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: Survey was not returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop	
Crop Year	
Condition	

Soil: 121 - Scoon Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.4	1.4
B	S	M	1.1	1.2
C	S	M	1.3	1.3
D	S	M	0.9	0.9
E				

4149

Acres	35
Soil Testing?	4/27/2016
Test Frequency	YES
Irrigation Type	Two times per year
Irrigation Schedule	Pivot
Hour Sets	Routine Schedule
Irrigation years	1
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	122
2 ft	59
3 ft	67
4 ft	42
5 ft	67
6 ft	175
TOTAL	532
NH4-N	17
ORGANIC	1.58

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: Page two of survey not available

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	25 Tons		
Corn Silage	26.5 Tons		
Corn Silage	29 Tons	Triticale	9 Tons
Corn Silage	23 Tons		

Current Crop	
Crop Year	2016
Condition	Fair Planned

Soil: 140 - Sinloc Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,S,SH,S	M	0.5	
B	S,HA,S,S,	M	1.7	5
C	S,SH,S,S,S	M	1.8	
D	S,SH,S	M	1.6	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

4150

Acres	40
	4/27/2016
Soil Testing?	YES
Test Frequency	Two times per year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	2
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	189
2 ft	109
3 ft	148
4 ft	200
5 ft	178
6 ft	91
TOTAL	915
NH4-N	22
ORGANIC	2.04

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: Page two of survey not available

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Silage	25	Tons			
Corn Silage	26.5	Tons			
Corn Silage	29	Tons	Triticale	9	Tons
Corn Silage	23	Tons			

Current Crop	
Crop Year	
2016	
Condition	
Fair	Planned

Soil: 32 - Esquatzel Silt Loam 0-2%Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,S,SH	D,M,Dp	1.3	
B	S,S,SH	D,M,Dp	0.9	
C	S,S,SH	D,M,Dp	1.3	
D	S,S,SH	D,M,Dp	1	
E				

4151

Acres	8
	4/27/2016
Soil Testing?	NO
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	37
2 ft	10
3 ft	6
4 ft	4
5 ft	5
6 ft	3
TOTAL	65
NH4-N	16
ORGANIC	1.19

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No tillage practices. This area has never been farmed or irrigated. Sample taken to see if nitrates were present to ground that has never been farmed in the low lying area of the Outlook area and close to the Granger Drain.

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	

Current Crop	
Crop Year	
Condition	

Soil: 140 - Sinloc Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	5.1	
B	S	M	4.4	
C	S	M	4.2	
D	S	M	3.8	
E				

4152

Acres	40
	4/28/2016
Soil Testing?	YES
Test Frequency	Once per year
Irrigation Type	Pivot
Irrigation Schedule	Soil Moisture Sensors - 1st year
Hour Sets	
Irrigation years	4
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	25
2 ft	106
3 ft	319
4 ft	279
5 ft	256
6 ft	219
TOTAL	1204
NH4-N	26
ORGANIC	2.63

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: 2016 crop yield is from first cutting. No nutrients applied from 2013 thru 2016.

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Alfalfa	72	Bushels			
Alfalfa	8	Tons			
Alfalfa	8	Tons			
Alfalfa	8	Tons			

Current Crop	
Crop Year	
2016	
Condition	
Fair	Actual

Soil: 140 - Sinloc Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.5	
B	S	M	5.2	
C	S	M	3.3	
D	S	M	6	
E				

4153

Acres	20
	4/28/2016
Soil Testing?	YES
Test Frequency	
Irrigation Type	Wheel Lines
Irrigation Schedule	
Hour Sets	
Irrigation years	15
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	17
2 ft	9
3 ft	21
4 ft	21
5 ft	5
6 ft	10
TOTAL	83
NH4-N	17
ORGANIC	2.62

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No nutrients applied 2013 thru 2016.

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Alfalfa					
Alfalfa green cho	20	Tons			
Alfalfa green cho	20	Tons			
Alfalfa green cho	10	Tons			

Current Crop	
Crop Year	
2016	
Condition	
Good	

Soil: 178 - Warden Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,S,S,L	M,M,D,D	4.8	
B	S,S,S,L	M,M,D,D	3.9	4
C	S,S,S,L	M,M,D,D		4
D	S	M	3	3
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

4154

Acres	20
Soil Testing?	YES
Test Frequency	Yearly
Irrigation Type	Drip
Irrigation Schedule	Routine Schedule - visual
Hour Sets	
Irrigation years	13
Event	SPRING 2016
	4/28/2016

NO3 (#N/ACRE)	
1 ft	157
2 ft	345
3 ft	100
4 ft	9
5 ft	11
6 ft	4
TOTAL	626
NH4-N	14
ORGANIC	1.99

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016			200				200
2015			200				200
2014			150				150
2013			150				150
2012							0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Hops	1.0 Tons		
Hops	1.5 Tons		
Hops	1.5 Tons		
Hops	1.5 Tons		

Current Crop	
Crop Year	2016
Condition	Good / Planned

Soil: 176 - Warden Silt Loam 0 to 2 percent slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,SH,S,S,S	M	4	
B	S	M	3	
C	S,S,S,L,S,L,S	M,M,M,D,M,D,M		
D	S,SH,S	M		
E				

4155

Acres	18
Soil Testing?	YES
Test Frequency	Yearly
Irrigation Type	Drip
Irrigation Schedule	Routine Schedule - visual
Hour Sets	
Irrigation years	30
Event	SPRING 2016
	4/28/2016

NO3 (#N/ACRE)	
1 ft	71
2 ft	76
3 ft	35
4 ft	21
5 ft	17
6 ft	18
TOTAL	238
NH4-N	6
ORGANIC	1.23

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016			150				150
2015		140					140
2014			200				200
2013			200				200
2012							0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Hops	1.2 Tons		
Hops	1 Tons		
Hops	1 Tons		
Hops	1 Tons		

Current Crop	
Crop Year	2016
Condition	Good / Planned

Soil: 176 - Warden Silt Loam 0 to 2 percent slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,FI,S	M	3.1	
B	S,FI,S,FI	M,M,M,Dp	2.3	
C	S,FI,S	M	2.6	
D	S,FI,S	M	4.3	
E				

4156

Acres	20
Soil Testing?	YES
Test Frequency	yearly
Irrigation Type	Drip
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	4
Event	SPRING 2016
	4/28/2016

NO3 (#N/ACRE)	
1 ft	84
2 ft	174
3 ft	110
4 ft	21
5 ft	59
6 ft	63
TOTAL	511
NH4-N	10
ORGANIC	1.22

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016			150				150
2015			200				200
2014			200				200
2013			200				200
2012							0
2011							0

Comments

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Hops	1.5 Tons		
Hops	1 Tons		
Hops	1 Tons		
Hops	1 Tons		

Current Crop	
Crop Year	2016
Condition	Good / Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,FI,S,VFI,FI	M,M,M,M,W	3.7	
B	S,VFI,S,FI	M,M,M,W	1.5	
C	S,S,FI	M,M,W	5.2	
D	S,S,S,FI	M,M,M,W	4	
E				

4157

Acres	36
Soil Testing?	YES
Test Frequency	Once each fall
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	24
Irrigation years	
Event	SPRING 2016
	4/29/2016

NO3 (#N/ACRE)	
1 ft	123
2 ft	166
3 ft	157
4 ft	123
5 ft	97
6 ft	66
TOTAL	732
NH4-N	18
ORGANIC	2.08

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016			150				150
2015			190				190
2014			225				225
2013			240				240
2012							0
2011							0

Comments: Started irrigating using a pump back system 3 years ago. In 2016 irrigated almost exclusively with tail water. Adding soil moisture probes this year.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	35 Tons		
Corn Silage	36.7 Tons		
Corn Silage	32 Tons		
Corn Silage	30 Tons		

Current Crop	
Crop Year	2016
Condition	Good / Planned

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.5	
B	S	M	2.6	
C	S	M	3.4	
D	S	M	3.3	
E				

4158

Acres	76
Soil Testing?	YES
Test Frequency	Annual in fall
Irrigation Type	Pivot
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	
Irrigation years	
Event	SPRING 2016
	4/29/2016

NO3 (#N/ACRE)	
1 ft	12
2 ft	5
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	17
NH4-N	38
ORGANIC	2.18

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	85		240				325
2015			240				240
2014			225				225
2013			300				300
2012							0
2011							0

Comments: Plan on adding more moisture probes and base station; Hiring an agronomist.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	35 Tons		
Corn Silage	37 Tons	Triticale	6.4 Tons
Corn Silage	29 Tons	Triticale	8.6 Tons
Corn Silage	37 Tons	Triticale	6.4 Tons

Current Crop	
Crop Year	2016
Condition	Good / Planned

Soil: 37 - Finley Silt Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D,M	1	1
B	S	D,M	1	1.8
C	S	D,M	1	1
D	S	D,M	1	1.3
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

4159

Acres	40
Soil Testing?	YES
Test Frequency	Annually in fall
Irrigation Type	Pivot
Irrigation Schedule	Soil Moisture Sensors
Hour Sets	
Irrigation years	
Event	SPRING 2016
	4/29/2016

NO3 (#N/ACRE)	
1 ft	34
2 ft	16
3 ft	36
4 ft	27
5 ft	7
6 ft	9
TOTAL	129
NH4-N	40
ORGANIC	2.41

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	60		240				300
2015			240				240
2014			238				238
2013			250				250
2012							0
2011							0

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Corn Silage	35	Tons			
Corn Silage	37.4	Tons	Triticale	5.3	Tons
Corn Silage	29	Tons	Triticale	6.6	Tons
Corn Silage	28	Tons	Triticale	8.1	Tons

Comments: Plan on adding more moisture sensors and hiring an agronomist.

Current Crop	
Crop Year	2016
Condition	Good Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2	
B	S	M	2.4	4
C	S	M	5.2	
D	S	M	2	4
E				

4160

Acres	
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016
	4/29/2016

NO3 (#N/ACRE)	
1 ft	9
2 ft	
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	9
NH4-N	19
ORGANIC	1.79

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	

Comments: No survey returned

Current Crop	
Crop Year	
Condition	

Soil: 37 - Finley Silt Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1	1
B	S	M	1	1
C	S	M	1	1
D	S	M	1	1
E				

4161

Acres	75
Soil Testing?	YES
Test Frequency	Twice each year
Irrigation Type	Pivot
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	25
Event	SPRING 2016
	4/29/2016

NO3 (#N/ACRE)	
1 ft	66
2 ft	9
3 ft	6
4 ft	5
5 ft	8
6 ft	8
TOTAL	102
NH4-N	39
ORGANIC	2.59

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	140		120				260
2015	0		217				217
2014	250		150				400
2013	200		150				350
2012							0
2011							0

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	
Triticale	9	Tons			
Triticale	12	Tons	Corn Silage	30	Tons
Triticale	12	Tons	Corn Silage	28	Tons
Triticale	10	Tons	Corn Silage	30	Tons

Comments: Manure applications for 2013 and 2014 were split - half in spring and half in fall

Current Crop	
Crop Year	
Condition	

Soil: 173 - Warden Fine Sandy Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,S,F	M,M,D	4.1	
B	S,S,S,F,S	M,M,M,D,M	2.5	
C	S,S,S,S,F	M,M,D,M,D	4.4	
D	S	M,M,M,D,M	5.6	
E				

4162

Acres	
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016
	4/29/2016

NO3 (#N/ACRE)	
1 ft	14
2 ft	4
3 ft	3
4 ft	3
5 ft	3
6 ft	63
TOTAL	30
NH4-N	30
ORGANIC	1.66

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Cropping History

Crop 1	Crop 1 Yield		Crop 2	Crop 2 Yield	

Comments: No Survey Returned

Current Crop	
Crop Year	
Condition	

Soil: 173 - Warden Fine Sandy Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,F,S,S,F	M	5.6	
B	S,F,S,F	M	3.8	
C	S,F,S,F	M	3.3	
D	S,S,F,S	M	5.1	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

4163

Acres	4/29/2016
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	11
2 ft	5
3 ft	13
4 ft	4
5 ft	38
6 ft	3
TOTAL	74
NH4-N	19
ORGANIC	1

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No Survey Returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop | Crop Year | Condition

Soil: 141 - Sinloc Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,Fl,L,L	M,D,D,D	3.9	
B	S,Fl	M,D	4	
C	S,Fl	M,D	4	
D	S,Fl	M,D	3.4	
E				

4164

Acres	4/29/2016
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	6
2 ft	3
3 ft	3
4 ft	5
5 ft	16
6 ft	14
TOTAL	47
NH4-N	12
ORGANIC	1.54

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No Survey Returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop | Crop Year | Condition

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M,M,D,M	4	
B	S	M,M,D,M	4.3	
C	S	M,M,D,M	2.6	
D	S	M,M,D,M	3.2	
E				

4165

Acres	4/29/2016
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	4
2 ft	51
3 ft	4
4 ft	4
5 ft	6
6 ft	
TOTAL	69
NH4-N	10
ORGANIC	1.47

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No Survey Returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop | Crop Year | Condition

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,S,Fl,Fl	M	3.3	4.6
B	S,S,Fl,Fl	M	3.3	4
C	S,S,Fl	M	3.8	4
D	S	M	3.6	4
E				

4166

Acres	5/3/2016
Soil Testing?	YES
Test Frequency	Twice per year
Irrigation Type	Sprinklers
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	1
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	27
2 ft	9
3 ft	11
4 ft	16
5 ft	23
6 ft	21
TOTAL	107
NH4-N	31
ORGANIC	1.45

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	180						180
2015							0
2014							0
2013							0
2012							0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Triticale	10 Tons		
Grapes			
Grapes			
Grapes			

Current Crop: 2016 | Condition: Good | Actual

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D,M,M	1.7	
B	S	D,M,M	1.2	
C	S	D,M,M	2.1	
D	S	D,M,M	1.9	
E				

4167

Acres	20 5/3/2016
Soil Testing?	YES
Test Frequency	Twice each year
Irrigation Type	Rill Irrigation - furrow
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	97
2 ft	81
3 ft	88
4 ft	13
5 ft	
6 ft	
TOTAL	279
NH4-N	68
ORGANIC	1.39

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016	240						240
2015	280						280
2014							0
2013							0
2012							0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	30 Tons		
Corn Silage	30 Tons	Triticale	8 Tons

Current Crop: 2016 | Condition: Good | Actual

Soil: 172 - Warden Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S,S,S,SH	D,M,D,M	1.8	4
B	S,S,S,SH	D,M,D,M	1.5	4
C	S,S,S,SH	D,M,D,M	1.1	4
D	S,S,SH	D,M,M	1.2	4
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

4168

Acres	5/3/2016
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	52
2 ft	
3 ft	
4 ft	
5 ft	
6 ft	
TOTAL	52
NH4-N	21
ORGANIC	3.2

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No survey returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop	
Crop Year	
Condition	

Soil: 121 - Scoon Silt Loam 5-8% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	D	0.8	1
B	S	D	0.6	1.1
C	S	D	1.1	1.1
D	S	D	0.4	1
E				

4169

Acres 35	5/4/2016
Soil Testing?	YES
Test Frequency	Once each year
Irrigation Type	Drip
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	10
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	191
2 ft	377
3 ft	285
4 ft	82
5 ft	37
6 ft	7
TOTAL	979
NH4-N	16
ORGANIC	1.91

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016			20				20
2015			20		30		50
2014			20		30		50
2013			20		100		120
2012							0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Hops	1 Tons		
Hops	1 Tons		
Hops	0.8 Tons		
Hops	0.9 Tons		

Current Crop	
Crop Year	2016
Condition	Good Planned

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.2	
B	S	M		
C	S	M	0.7	
D	S	M	0.8	
E				

4170

Acres 20	5/4/2016
Soil Testing?	YES
Test Frequency	Once each year
Irrigation Type	Rill Irrigation
Irrigation Schedule	
Hour Sets	
Irrigation years	10
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	134
2 ft	98
3 ft	46
4 ft	25
5 ft	52
6 ft	19
TOTAL	374
NH4-N	34
ORGANIC	2.04

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: Applied one cover of liquid manure 2013 through 2016. One cover of solid Manure 2014. Don't know the amount of N applied.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Corn Silage	18 Tons		
Corn Silage	20.5 Tons		
Corn Silage	19 Tons		
Corn Silage	17 Tons		

Current Crop	
Crop Year	2016
Condition	Good

Soil: 177 - Warden Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M,M,Dp	2.5	
B	S	M,M,Dp	2.8	
C	S	M,M,Dp	2.9	
D	S	M,M,Dp,Dp	2.7	
E				

4171

Acres	5/4/2016
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	29
2 ft	6
3 ft	16
4 ft	22
5 ft	29
6 ft	27
TOTAL	129
NH4-N	13
ORGANIC	1.3

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No Survey Returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop	
Crop Year	
Condition	

Soil: 95 - Quincy Loamy Fine Sand 0-10% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	4.3	
B	S	M	4.5	
C	S	M	4.4	
D	S	M	3.6	
E				

4172

Acres	5/4/2016
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	25
2 ft	11
3 ft	3
4 ft	3
5 ft	3
6 ft	19
TOTAL	64
NH4-N	15
ORGANIC	2.02

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No Survey Returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop	
Crop Year	
Condition	

Soil: 92 - Outlook Silt Loam

Hole	Consistency	Moisture	Roots	Refusal
A	S	M,M,Dp	1.7	
B	S	M,M,Dp	1.2	
C	S	M,M,Dp		
D	S	M,M,Dp	1.4	
E				

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE — Groundwater Management Area (GWMA)

Deep Soil Sampling

4173

Acres	5/4/2016
Soil Testing?	
Test Frequency	
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	141
2 ft	541
3 ft	311
4 ft	121
5 ft	
6 ft	
TOTAL	1114
NH4-N	24
ORGANIC	2.64

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No Survey Returned

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield

Current Crop	
Crop Year	
Condition	

Soil: 91 - Outlook Fine Sandy Loam

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	2.7	4.3
B	S	M	2.1	4
C	S	M	1.8	4
D	S	M	1.5	3.9
E				

4174

Acres	16
Soil Testing?	YES
Test Frequency	Once each year
Irrigation Type	Drip
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	1
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	117
2 ft	142
3 ft	29
4 ft	11
5 ft	27
6 ft	8
TOTAL	334
NH4-N	11
ORGANIC	0.81

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016		140					140
2015							0
2014							0
2013							0
2012							0
2011							0

Comments:

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Hops	1 Tons		
Grapes			
Grapes			
Grapes			

Current Crop	
Crop Year	2016
Condition	Fair Planned

Soil: 125 - Scooteney Silt Loam 2-5% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M	1.7	
B	S	M	1.4	
C	S	M		4
D	S	M	2.1	4
E				

4175

Acres	10
Soil Testing?	YES
Test Frequency	Once each year
Irrigation Type	
Irrigation Schedule	
Hour Sets	
Irrigation years	
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	427
2 ft	766
3 ft	664
4 ft	242
5 ft	281
6 ft	169
TOTAL	2549
NH4-N	12
ORGANIC	0.69

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No nutrients applied for at least the last 3 years. No manure applied for over 10 years. Field gets subby when SVID canal fills up in spring and dries out when canal shuts off.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Asparagus			
Asparagus			
Asparagus			
Asparagus			

Current Crop	
Crop Year	2016
Condition	Good

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M,Dp,Dp,w,w	1	
B	S	Dp,Dp,Dp,W	1.2	
C	S	Dp,Dp,Dp,W	0.9	
D	S	Dp,Dp,Dp,W	1.1	
E				

4176

Acres	20
Soil Testing?	YES
Test Frequency	Once each year
Irrigation Type	Rill Irrigation
Irrigation Schedule	Routine Schedule
Hour Sets	
Irrigation years	100
Event	SPRING 2016

NO3 (#N/ACRE)	
1 ft	36
2 ft	233
3 ft	160
4 ft	172
5 ft	143
6 ft	54
TOTAL	798
NH4-N	16
ORGANIC	1.12

Fertilzer Applications (#N/Acre)

Year	Liquid Manure	Solid Manure	Com.	Bio	Comp	Other	Total
2016							0
2015							0
2014							0
2013							0
2012							0
2011							0

Comments: No nutrients applied for at least the last 3 years. No manure applied for over 10 years. Field gets subby when SVID canal fills up in spring and dries out when canal shuts off.

Cropping History

Crop 1	Crop 1 Yield	Crop 2	Crop 2 Yield
Asparagus			
Asparagus			
Asparagus			
Asparagus			

Current Crop	
Crop Year	2016
Condition	Good

Soil: 18 - Cleman Very Fine Sandy Loam 0-2% Slopes

Hole	Consistency	Moisture	Roots	Refusal
A	S	M,M,W,W,W	1.3	
B	S	M,M,W,W,W	1.2	
C	S	Dp,M,W,W,W	0.8	
D	S	Dp,M,W,W,W	0.9	
E				

Analytical Data Analysis

Analysis of the deep soil analytical data was conducted by Melanie Redding, chair of the data workgroup.

Deep Soil Sampling (DSS)
In the Lower Yakima Valley GWMA

Melanie Redding, Hydrogeologist,
Washington State Department of Ecology
May, 2018

Deep Soil Sampling was conducted in the Lower Yakima Valley. This effort was initiated and funded by the Groundwater Management Area Committee. Sample sites were selected voluntarily and all locations remain anonymous. Samples were collected from 175 fields at one foot intervals down to six feet below land surface, and these samples were collected over four seasons (fall 2014, spring 2015, fall 2015, and spring 2016). All samples were analyzed for nitrate (NO_3 as N), ammonium (NH_4 as N) and organic matter from samples collected at the one foot depth.

Limitations of Data

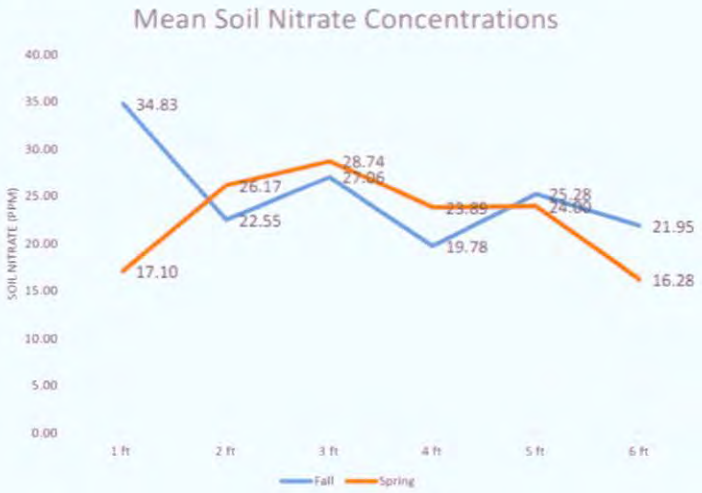
- Since all locations are anonymous it is not possible to determine if a site was sampled more than once during the project.
- Survey data was also collected at the time of sampling, including amount of nitrogen applied over recent years, type of nitrogen, type of crops grown, irrigation practices, and crop yield.
- At a recent GWAC meeting, it was decided not to use crop survey data collected for the Nitrogen Availability Assessment since there were questions about its accuracy. Since it is impossible to validate anonymous survey data, this data was omitted from the evaluation process.
- This evaluation focuses only on the analytical data and not the survey data.
- There is no way to determine trends over time, how nitrate is moving through the soil column, or how different sources of nitrogen affect residual soil nitrate.
- This information cannot be extrapolated to be representative of the entire Lower Yakima Valley.
- This data represents a snapshot in time.
- Quality Assurance – assure all data used is credible.
    - The ammonium data collected in the Fall 2015 had an RPD of 55% for the sample with lower ammonium concentrations. PGG cautions that during this sampling event lower concentration ammonium results may be biased high.

Fall vs. Spring

Mean soil nitrate concentrations for all fall samples compared to all spring samples.

- Two lines are closely aligned for all depths except in the first foot.
- The first foot spring soil nitrate is an average of 18 ppm lower than fall soil nitrate.
- The differences for all other depths are between 1 ppm and 6 ppm.

Figure 1.



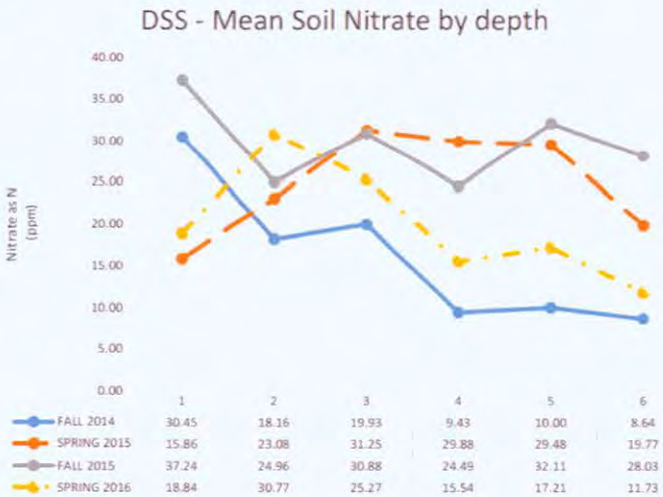
	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft	Total Cumulative
Fall	34.83	22.55	27.06	19.78	25.28	21.95	130.15
Spring	17.10	26.17	28.74	23.89	24.00	16.28	111.26
difference	17.74	-3.62	-1.68	-4.11	1.28	5.67	18.89

mean ppm (parts per million)

Mean soil nitrate concentrations for each depth are compared for each sampling event (fall 2014, spring 2015, fall 2015, and spring 2016).

- Fall 2014
  - The mean for all depths is ≤ 30 ppm.
  - The shape of both Fall lines are similar, but 2014 is consistently lower than 2015.
  - The highest mean concentration occurs within the 1 foot sample.
  - The lowest mean concentration for all sampling events occurs in the fall 2014 in the 6 ft depth.
  - Within the 1 foot sample, the means of both fall samples are close to twice the concentration of both the spring mean concentrations.
- Spring 2015
  - The mean for all depths is ≤ 31 ppm.
  - The highest mean concentration occurs with the 1 foot sample.
- Fall 2015
  - The highest mean of all sampling events and all depths occurred in the fall 2015 in the 1 foot depth at 37 ppm.
  - The mean is elevated (≥ 30 ppm) in the 1 foot, 3 foot, and 5 foot depths.
- Spring 2016
  - The mean for all depths ≤ 30 ppm.

Figure 2.



Maximum soil nitrate concentration for each depth compared for each sampling event.

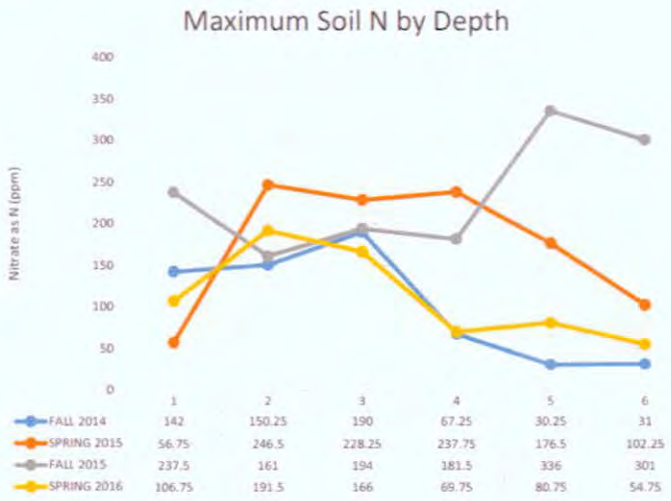
- Fall 2014
  - The maximum concentrations are elevated (≥ 30 ppm) for all depths. These values range from 190 ppm at the 3 foot depth to 30 ppm in the 5 and 6 foot depths.
  - There are no consistent patterns with the fall maximum concentrations or the spring maximum concentrations.
  - The maximum fall concentrations were both greater than the spring maximum concentrations in the 1st foot sample.
  - Collectively, it appears that concentrations are elevated in the 2 foot and 3 foot samples (150 to 250 ppm).
- Spring 2015
  - The maximum concentrations are elevated (≥ 30 ppm) for all depths.
- Fall 2015
  - The maximum concentrations are elevated (≥ 30 ppm) for all depths ranging from 161 ppm to 336 ppm.

4

- Fall 2015 had the highest measured soil nitrate value during this study of 336 ppm in the 5 foot sample.

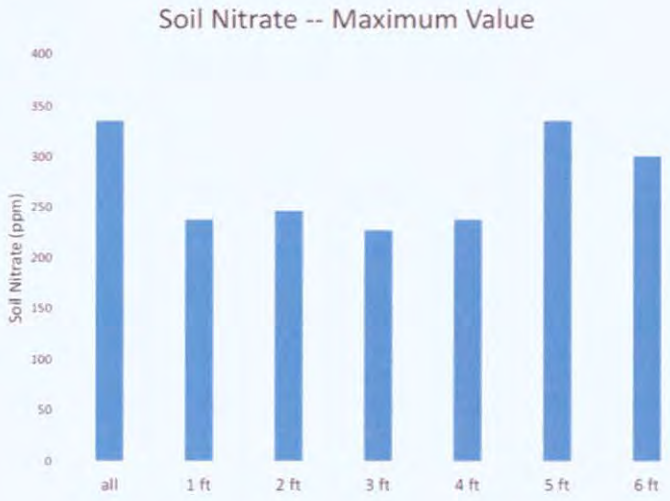
- Spring 2016
  - The maximum concentrations are elevated (≥ 30 ppm) for all depths.

Figure 3.



The maximum soil nitrate concentration for each depth exceeded 200 ppm. Every depth had a maximum soil nitrate concentration which exceeded 200 ppm. The maximum concentrations were greatest in the 5 ft (336 ppm) and 6 ft (301 ppm).

Figure 4.



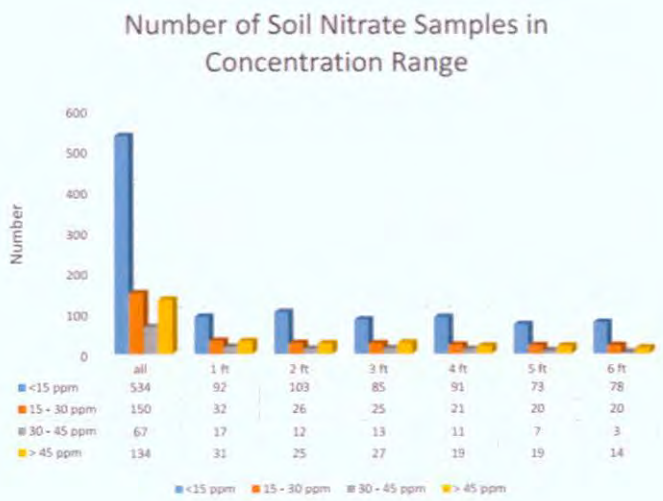
6

Depth

The number of soil nitrate which are in four different concentration brackets; < 15 ppm, 15 – 30 ppm, 30 – 45 ppm, and > 45 ppm. This graph compares all depths. The first set of bars in figure 5 represents the entire data set.

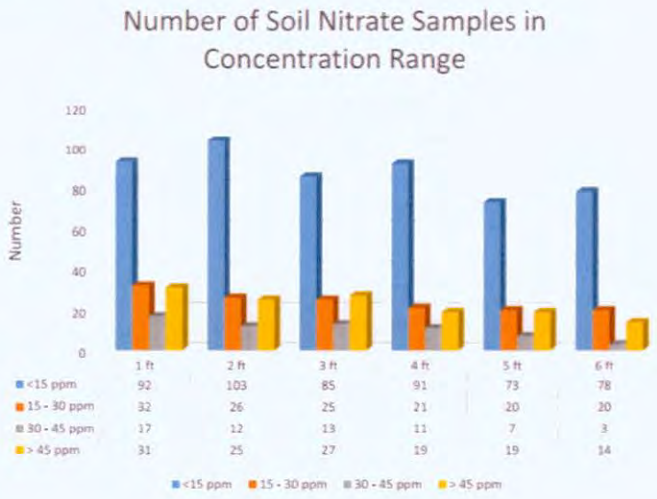
- The majority of soil nitrate samples were < 15 ppm for the entire data set and for each depth.
- All depths had soil nitrate samples which were in the 30 – 45 ppm and > 45 ppm ranges.

Figure 5.



	all	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft
<15 ppm	534	92	103	85	91	73	78
15 - 30 ppm	150	32	26	25	21	20	20
30 - 45 ppm	67	17	12	13	11	7	3
> 45 ppm	134	31	25	27	19	19	14

Figure 6.

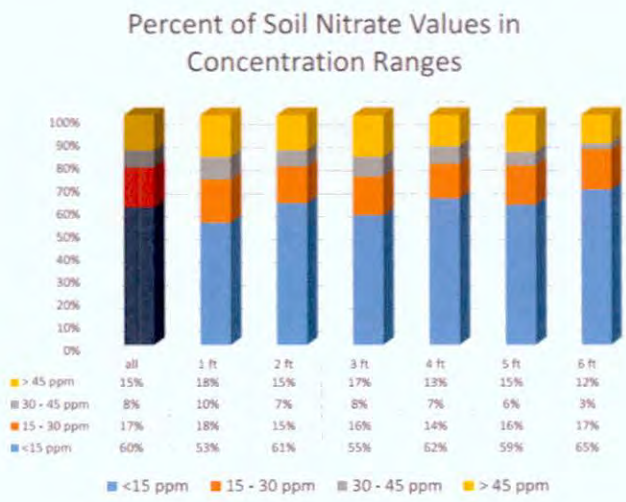

Number of Soil Nitrate Samples in Concentration Range
Number
120
100
80
60
40
20
0
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft
<15 ppm 92 103 85 91 73 78
15 - 30 ppm 32 26 25 21 20 20
30 - 45 ppm 17 12 13 11 7 3
> 45 ppm 31 25 27 19 19 14
<15 ppm
15 - 30 ppm
30 - 45 ppm
> 45 ppm

8

Figure 7 shows the percent of soil nitrate samples that occurred in each of the concentration categories for each depth. The first bar represents the entire data set.

- Again, this figure illustrates that 60% of all soil samples had nitrate concentrations < 15 ppm.
- And 23% of all soil samples were > 30 ppm.
- The percentages are fairly consistent across all depths.
  - < 15 ppm ranged from 53% to 65%
  - > 30 ppm ranged from 28% to 15%

Figure 7.



Distribution by sampling event and depth

These figures show the concentration distribution for each depth for each sample. The first four graphs are divided by sampling event. The last graph has all samples collectively. These graphs allow a comparison of where the highest and lowest nitrate concentrations are found for each sample.

Figure 8.

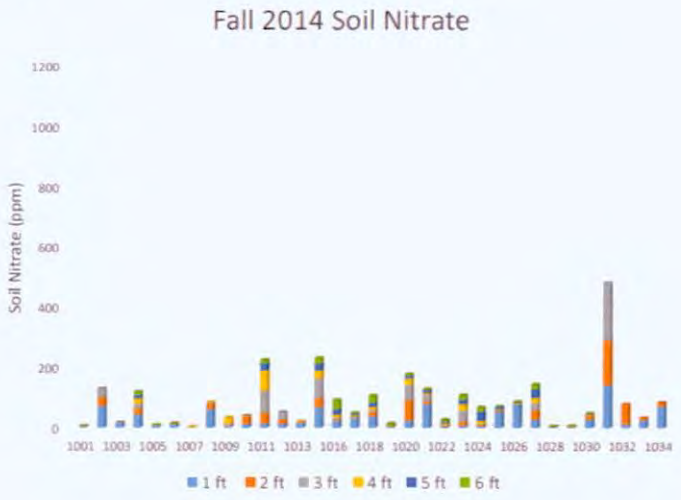
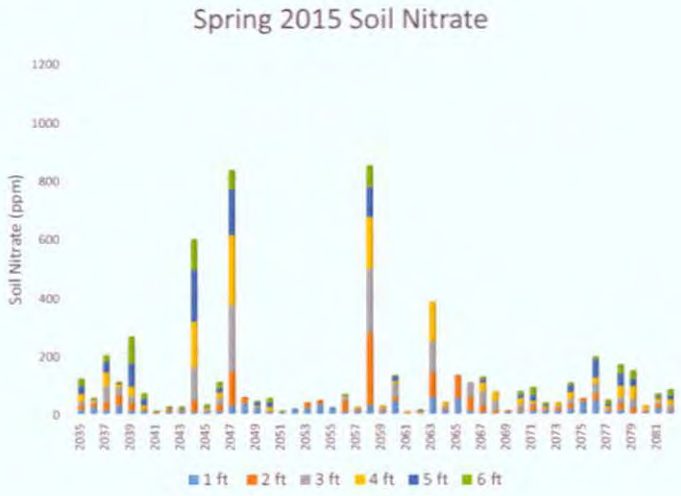
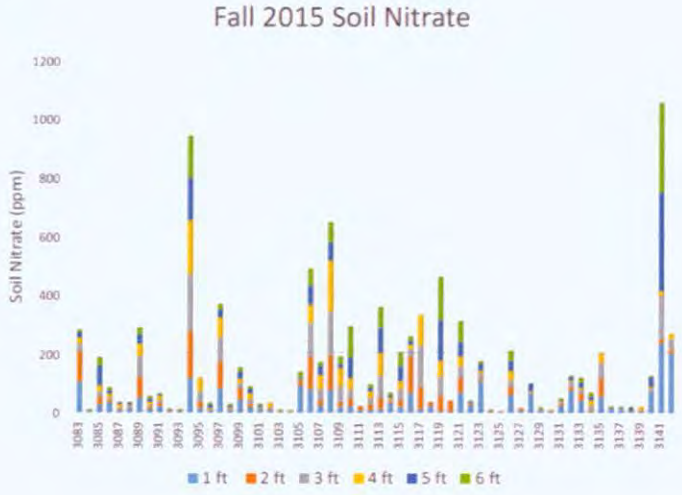


Figure 9.


Spring 2015 Soil Nitrate
Soil Nitrate (ppm)
1200
1000
800
600
400
200
0
2035
2037
2039
2041
2043
2045
2047
2049
2051
2053
2055
2057
2059
2061
2063
2065
2067
2069
2071
2073
2075
2077
2079
2081
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft

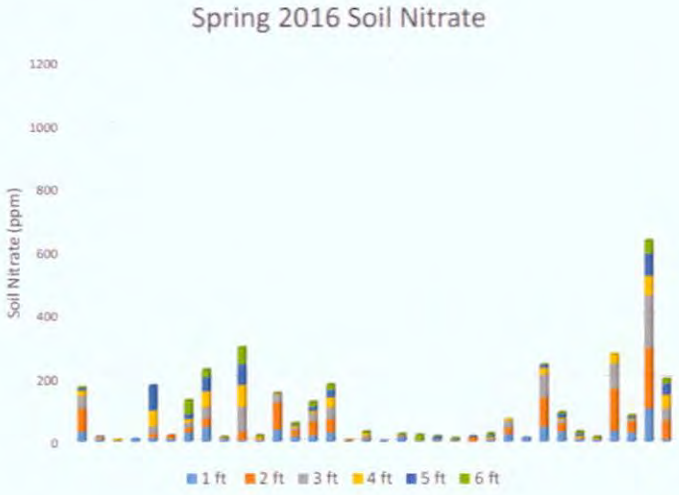
11

Figure 10.


Fall 2015 Soil Nitrate
Soil Nitrate (ppm)
1200
1000
800
600
400
200
0
3083
3085
3087
3089
3091
3093
3095
3097
3099
3101
3103
3105
3107
3109
3111
3113
3115
3117
3119
3121
3123
3125
3127
3129
3131
3133
3135
3137
3139
3141
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft

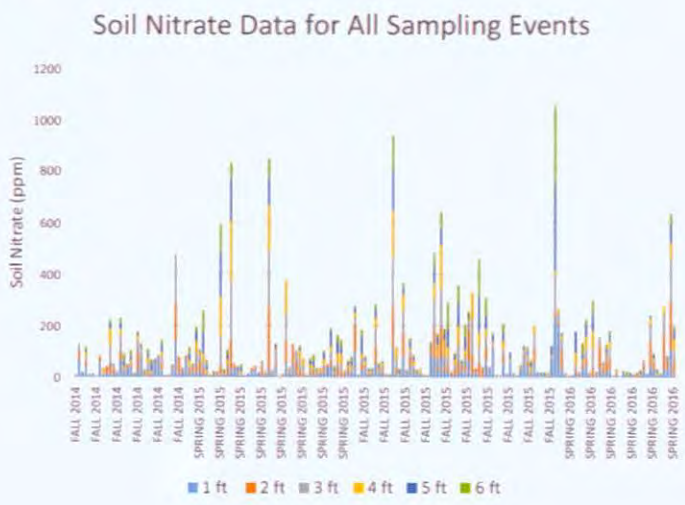
12

Figure 11.


Spring 2016 Soil Nitrate
Soil Nitrate (ppm)
1200
1000
800
600
400
200
0
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft

13

Figure 12.


Soil Nitrate Data for All Sampling Events
Soil Nitrate (ppm)
1200
1000
800
600
400
200
0
FALL 2014
SPRING 2015
FALL 2015
SPRING 2016
1 ft
2 ft
3 ft
4 ft
5 ft
6 ft

Nitrate relative to the root zone

Figure 13.

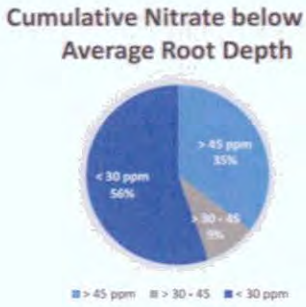
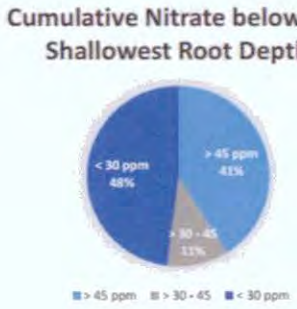
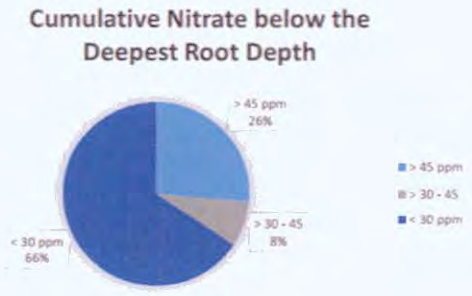


Figure 14.



15

Figure 15.


Cumulative Nitrate below the Deepest Root Depth
> 45 ppm 26%
> 30 - 45 8%
< 30 ppm 66%
> 45 ppm
> 30 - 45
< 30 ppm

16

Summary Statistics

	Soil Nitrate (NO3 as N) (ppm)						
	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft	Total Cumulative
	FALL 2014						
mean	30.45	18.16	19.93	9.43	10.00	8.64	85.73
median	17.00	7.00	3.88	3.50	8.00	5.75	68.50
max	142.00	150.25	190.00	67.25	30.25	31.00	482.25
min	0.75	0.75	0.75	0.75	0.75	0.75	3.00
n	33.00	33.00	30.00	25.00	21.00	21.00	33.00
Δ	141.25	149.50	189.25	66.50	29.50	30.25	479.25
	SPRING 2015						
mean	15.86	23.08	31.25	29.88	29.48	19.77	119.69
median	10.25	10.88	11.63	10.50	14.50	8.63	59.38
max	56.75	246.50	228.25	237.75	176.50	102.25	846.25
min	1.00	0.75	0.75	0.75	0.75	0.75	5.50
n	48.00	46.00	40.00	39.00	31.00	30.00	48.00
Δ	55.75	245.75	227.50	237.00	175.75	101.50	840.75
	FALL 2015						
mean	37.24	24.96	30.88	24.49	32.11	28.03	155.00
median	20.13	10.50	12.38	13.00	11.75	7.50	83.50
max	237.50	161.00	194.00	181.50	336.00	301.00	1052.50
min	1.25	0.75	0.75	0.75	0.75	0.75	3.75
n	60.00	60.00	56.00	55.00	47.00	46.00	59.00
Δ	236.25	160.25	193.25	180.75	335.25	300.25	1048.75
	SPRING 2016						
mean	18.83824	30.76613	25.26724	15.54464	17.21	11.72826	99
median	9.75	12.75	9	5.25	7.25	4.75	32.25
max	106.75	191.5	166	69.75	80.75	54.75	637.25
min	1	0.75	0.75	0.75	0.75	0.75	2.25
n	34	31	29	28	25	23	33
Δ	105.75	190.75	165.25	69	80	54	635

Sites where all concentrations are < 30 ppm			
	number	total	percent
Fall 2014	16	33	48%
Spring 2015	29	48	60%
Fall 2015	29	60	48%
Spring 2016	20	34	59%

Sites where the cumulative nitrate ≥200 ppm			
	number	total	percent
Fall 2014	3	33	9%
Spring 2015	5	48	10%
Fall 2015	16	60	27%
Spring 2016	5	34	15%

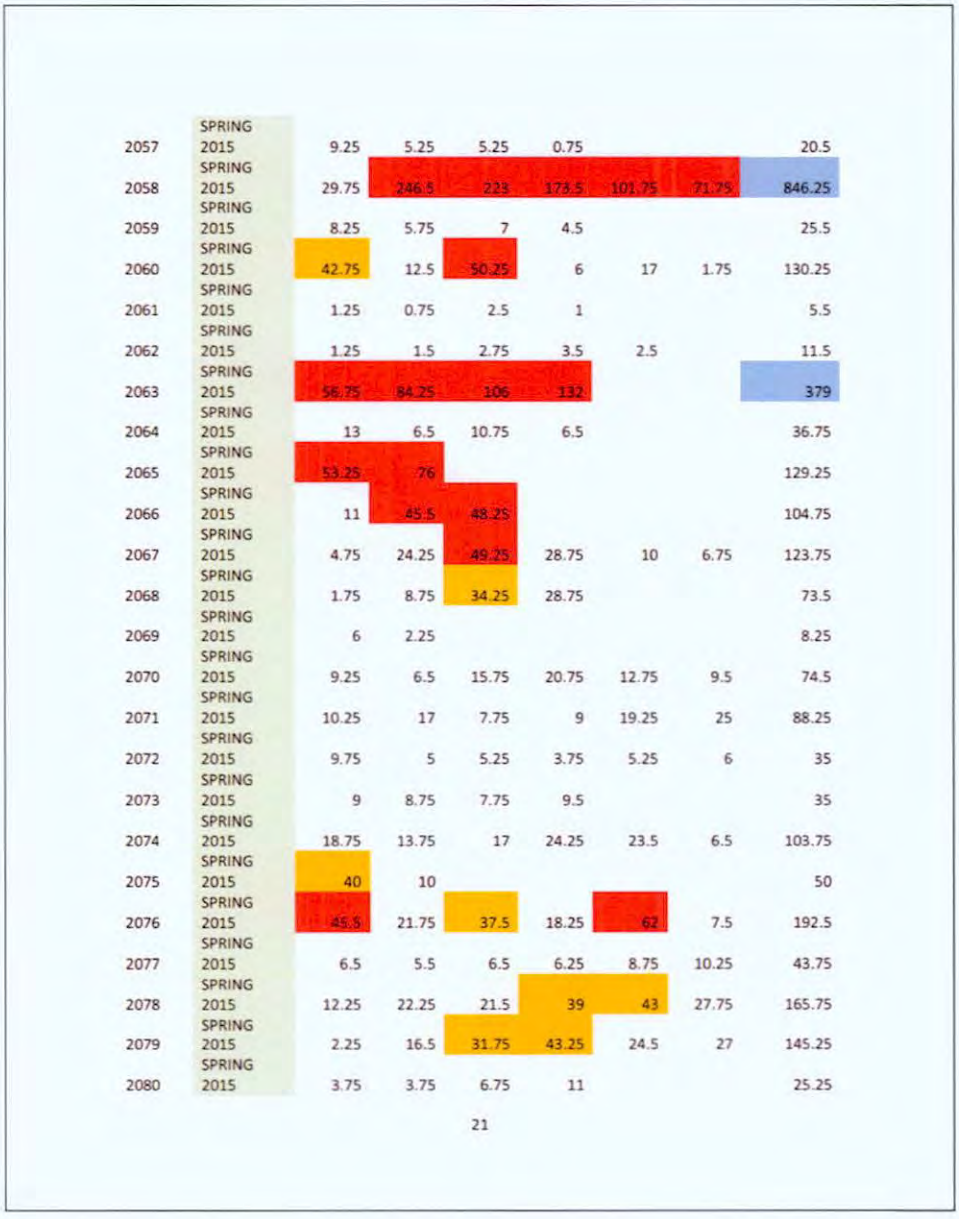
Sites where ≥45 ppm is present			
	number	total	percent
Fall 2014	10	33	30%
Spring 2015	11	48	23%
Fall 2015	25	60	42%
Spring 2016	9	34	26%

Additionally, there are 4 sites where soil nitrate concentrations exceeded 45 ppm at all depths.

And there are 6 sites where soil nitrate concentrations exceeded 30 ppm at all depths.

Site		Soil Nitrate (NO3 as N)						
		ppm						
ID	Time	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft	Total Cumulative
1001	FALL 2014	2	0.75	0.75	0.75	1.25	0.75	6.25
1002	FALL 2014	71.25	31	28.75				131
1003	FALL 2014	16.25	1.5	0.75				18.5
1004	FALL 2014	44.25	19.75	15.75	17.25	10.5	12.5	120
1005	FALL 2014	6.25	0.75	0.75	0.75	0.75	1	10.25
1006	FALL 2014	11.25	1	0.75	0.75	1	0.75	15.5
1007	FALL 2014	0.75	0.75	0.75	0.75			3
1008	FALL 2014	61.5	18.25	3.5	0.75			84
1009	FALL 2014	3	0.75	10	20.25			34
1010	FALL 2014	12.5	28	1.5				42
1011	FALL 2014	14.25	35.25	73.75	67.25	23.25	12.5	226.25
1012	FALL 2014	13.25	15	25.5				53.75
1013	FALL 2014	17	2.25	1	1.5			21.75
1015	FALL 2014	67.75	31.25	66.5	24.25	23.5	19.25	232.5
1016	FALL 2014	23.5	4.75	6.75	9	18.25	31	93.25
1017	FALL 2014	33.25	3.5	3	3.5	5	2.25	50.5
1018	FALL 2014	38.75	13.75	8	8.75	13	25	107.25
1019	FALL 2014	2.5	1.75	1	1.25	2.25	6.75	15.5
1020	FALL 2014	23.25	69	52	19.5	9.5	5.75	179
1021	FALL 2014	78.75	8.25	24.75	4.25	10	3.75	129.75
1022	FALL 2014	4	2.5	4.25	3.75	5.25	8.25	28
1023	FALL 2014	7	13.25	38	20.25	14.75	16.5	109.75
1024	FALL 2014	5.5	5.25	4.75	8.5	30.25	14.25	68.5
1025	FALL 2014	53.75	4.5	3.25	1	8	1	71.5
1026	FALL 2014	78.5	2.5	1.75	1.75	1.75	0.75	87
1027	FALL 2014	28.75	30.25	24.75	16.75	28.5	16.5	145.5
1028	FALL 2014	2.75	0.75	0.75	0.75	0.75	0.75	6.5
1029	FALL 2014	2	0.75	2.75	1	0.75	0.75	8
1030	FALL 2014	28.25	14.25	2	1.5	1.75	1.5	49.25
1031	FALL 2014	142	150.25	190				482.25
1032	FALL 2014	12.5	67					79.5
1033	FALL 2014	27.5	7					34.5
1034	FALL 2014	71.25	13.75					85

ID	Time	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft	Total Cumulative
2035	SPRING 2015	13.75	14	14	25.75	27.5	23.25	118.25
2036	SPRING 2015	22.5	11.75	7.75	5.75	3	1.5	52.25
2037	SPRING 2015	12.5	26.5	56.5	45.75	37.25	18	196.5
2038	SPRING 2015	29	34.25	27	11.25	4.25	1.75	107.5
2039	SPRING 2015	11.25	26	23.25	32.75	78.5	90	261.75
2040	SPRING 2015	10.25	6.25	3.25	9	22	17	67.75
2041	SPRING 2015	1	0.75	0.75	1	1.5	3	8
2042	SPRING 2015	7.25	7	3	1.75	2	1.25	22.25
2043	SPRING 2015	8	4	1.5	0.75	3.25	4	21.5
2044	SPRING 2015	7.25	38	114.25	155.75	176.5	102.25	594
2045	SPRING 2015	7.25	1	5	5.5	3.25	7.75	29.75
2046	SPRING 2015	9	22	23.75	17.5	16.25	18	106.5
2047	SPRING 2015	28.25	116.5	228.25	237.75	156.5	83	830.25
2048	SPRING 2015	36	18.25					54.25
2049	SPRING 2015	21	2	2.75	2	11.25	2	41
2050	SPRING 2015	4.5	2.25	5.25	10.75	15.25	12.75	50.75
2051	SPRING 2015	3.5	0.75	0.75	0.75	0.75	0.75	7.25
2052	SPRING 2015	14.75						14.75
2053	SPRING 2015	21	14.5					35.5
2054	SPRING 2015	33.25	10					43.25
2055	SPRING 2015	18.75						18.75
2056	SPRING 2015	6.25	37.75	12.5	3.5	2	2.5	64.5



2057	SPRING 2015	9.25	5.25	5.25	0.75			20.5
2058	SPRING 2015	29.75	246.5	223	173.5	101.75	71.75	846.25
2059	SPRING 2015	8.25	5.75	7	4.5			25.5
2060	SPRING 2015	42.75	12.5	50.25	6	17	1.75	130.25
2061	SPRING 2015	1.25	0.75	2.5	1			5.5
2062	SPRING 2015	1.25	1.5	2.75	3.5	2.5		11.5
2063	SPRING 2015	56.75	84.25	106	132			379
2064	SPRING 2015	13	6.5	10.75	6.5			36.75
2065	SPRING 2015	53.25	76					129.25
2066	SPRING 2015	11	45.5	48.25				104.75
2067	SPRING 2015	4.75	24.25	49.25	28.75	10	6.75	123.75
2068	SPRING 2015	1.75	8.75	34.25	28.75			73.5
2069	SPRING 2015	6	2.25					8.25
2070	SPRING 2015	9.25	6.5	15.75	20.75	12.75	9.5	74.5
2071	SPRING 2015	10.25	17	7.75	9	19.25	25	88.25
2072	SPRING 2015	9.75	5	5.25	3.75	5.25	6	35
2073	SPRING 2015	9	8.75	7.75	9.5			35
2074	SPRING 2015	18.75	13.75	17	24.25	23.5	6.5	103.75
2075	SPRING 2015	40	10					50
2076	SPRING 2015	45.5	21.75	37.5	18.25	62	7.5	192.5
2077	SPRING 2015	6.5	5.5	6.5	6.25	8.75	10.25	43.75
2078	SPRING 2015	12.25	22.25	21.5	39	43	27.75	165.75
2079	SPRING 2015	2.25	16.5	31.75	43.25	24.5	27	145.25
2080	SPRING 2015	3.75	3.75	6.75	11			25.25

21

2081	SPRING 2015	18.75	12	10	10.5	8	6	65.25
2082	SPRING 2015	10.25	5.5	13.75	17.5	14.5	18.5	80



ID	Time	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft	Total Cumulative
3083	FALL 2015	104.25	103	29.5	18	19.25	5.5	279.5
3084	FALL 2015	3.5	1.25	0.75	0.75	1.5	1.25	9
3085	FALL 2015	27.5	27	18.25	20	66.5	27	186.25
3086	FALL 2015	34.75	7.5	8.25	14	11.75	7.25	83.5
3087	FALL 2015	7.75	3	6.5	11	4.75	1.5	34.5
3088	FALL 2015	16.25	2.75	5.5	2.25	6	1.5	34.25
3089	FALL 2015	51.75	69	72.5	41.5	32.5	20	287.25
3090	FALL 2015	12.75	7	6.25	10.5	10	8.25	54.75
3091	FALL 2015	21.5	10.75	11.5	14	4.75	1	63.5
3092	FALL 2015	5.5	2	2.25	0.75	0.75	0.75	12
3093	FALL 2015	4	0.75	0.75	1	1.5	1.75	9.75
3094	FALL 2015	116.75	161	194	181.5	144	141.25	938.5
3095	FALL 2015	15	22.5	35	44.5			117
3096	FALL 2015	6.75	2	2.5	4.25	11.75	4.75	32
3097	FALL 2015	84	90.75	83.75	65.75	28.25	16	368.5
3098	FALL 2015	8.75	2.75	4	3	6	3.75	28.25
3099	FALL 2015	44.75	37.75	19.25	13.5	22.5	14	151.75
3100	FALL 2015	19.75	10.25	17	19	15.25	6.75	88
3101	FALL 2015	13.5	2.25	1.25	1.75	5.5	4.5	28.75
3102	FALL 2015	11.5	4.25	3.25	13			32
3103	FALL 2015	3	1	1.75	1.25	1.75	0.75	9.5
3104	FALL 2015	4.25	0.75	0.75	0.75			6.5
3105	FALL 2015	92.75	14.5	4.5	2.25	5	17	136
3106	FALL 2015	79	111.25	116.25	62	64	55.5	488
3107	FALL 2015	24	17.5	41	45.5	30	11	169
3108	FALL 2015	77.75	116.25	153	171	61.75	66	645.75
3109	FALL 2015	20.5	15	55.75	59.5	14	25	189.75
3110	FALL 2015	23.25	25	31.25	38.5	70.75	103.25	292
3111	FALL 2015	8.75	11.25					20
3112	FALL 2015	9.75	18.25	21.75	23.75	11.75	9.5	94.75
3113	FALL 2015	12.25	37.5	77	77	85	70	358.75
3114	FALL 2015	32.75	5.5	9	4.5	7	7.75	66.5
3115	FALL 2015	20.5	22.5	37.25	27.75	48	48.75	204.75
3116	FALL 2015	67.75	122.25	28.25	14	13.75	12.25	258.25
3117	FALL 2015	12.75	75.25	143.25	100			331.25
3118	FALL 2015	21.75	12.75					34.5
3119	FALL 2015	5	53.25	65	53.25	139.75	145	
3120	FALL 2015	3.25	35.75					39
3121	FALL 2015	68.75	48.25	40.5	34.25	50.5	68	310.25
3122	FALL 2015	25.25	5	3.5	0.75	4	1	39.5
3123	FALL 2015	108.75	6.75	18.5	7.75	24.75	7	173.5

3124	FALL 2015	3.25	1.5	0.75	1	1	1.5	9
3125	FALL 2015	2	1	0.75				3.75
3126	FALL 2015	61.5	26	23	31.5	33.5	35	210.5
3127	FALL 2015	8.5	5.5					14
3128	FALL 2015	64.25	2.75	5.5	2.5	23.75		98.75
3129	FALL 2015	7	2	4.25	1.5	1.75	0.75	17.25
3130	FALL 2015	4.5	1.75	1.5	0.75			8.5
3131	FALL 2015	24.25	6.25	8.25	3.5	3	2.75	48
3132	FALL 2015	77	10.75	19.5	3.5	10.75	2	123.5
3133	FALL 2015	42.5	24.25	13.25	6	16.75	14.75	117.5
3134	FALL 2015	2.5	3.5	19	18.5	11.5	12	67
3135	FALL 2015	56.25	58.25	54.75	31.25			200.5
3136	FALL 2015	12.5	1.5	1	0.75	2.5	2	20.25
3137	FALL 2015	14	0.75	1.75	0.75	1.75	0.75	19.75
3138	FALL 2015	3.75	0.75	1.75	1	10.75	1	19
3139	FALL 2015	1.25	1.5	7.5	8			18.25
3140	FALL 2015	75	1	10	4.25	31.75	1.25	123.25
3141	FALL 2015	237.5	14.75	149	14.25	336	301	1052.5
3142	FALL 2015	205	11	37.25	14			267.25

ID	Time	1 ft	2 ft	3 ft	4 ft	5 ft	6 ft	Total Cumulative
4143	SPRING 2016	32.25	72.5	43.5	16.5	7.5	2.25	174.5
4144	SPRING 2016	8.25	5	4.25				17.5
4145	SPRING 2016	3.25	1	0.75	0.75			5.75
4146	SPRING 2016	8.75						8.75
4147	SPRING 2016	13.5	12.75	24	49.25	80.75		
4148	SPRING 2016	10.25	9.75					20
4149	SPRING 2016	30.5	14.75	16.75	10.5	16.75	43.75	133
4150	SPRING 2016	47.25	27.25	37	50	44.5	22.75	228.75
4151	SPRING 2016	9.25	2.5	1.5	1	1.25	0.75	16.25
4152	SPRING 2016	6.25	26.5	79.75	69.75	64	54.25	301
4153	SPRING 2016	4.25	2.25	5.25	5.25	1.25	2.5	20.75
4154	SPRING 2016	39.25	86.25	25	2.25	2.75	1	156.5
4155	SPRING 2016	17.75	19	8.75	5.25	4.25	4.5	59.5
4156	SPRING 2016	21	43.5	27.5	5.25	14.75	15.75	127.75
4157	SPRING 2016	30.75	41.5	39.25	30.75	24.25	16.5	183
4158	SPRING 2016	3	1.25					4.25
4159	SPRING 2016	8.5	4	9	6.75	1.75	2.25	32.25
4160	SPRING 2016	2.25						2.25
4161	SPRING 2016	16.5	2.25	1.5	1.25	2	2	25.5
4162	SPRING 2016	3.5	1	0.75	0.75	0.75	15.75	7.5
4163	SPRING 2016	2.75	1.25	3.25	1	9.5	0.75	18.5
4164	SPRING 2016	1.5	0.75	0.75	1.25	4	3.5	11.75

4165	SPRING 2016	1	12.75	1	1	1.5		17.25
4166	SPRING 2016	6.75	2.25	2.75	4	5.75	5.25	26.75
4167	SPRING 2016	24.25	20.25	22	3.25			69.75
4168	SPRING 2016	13						13
4169	SPRING 2016	47.75	94.25	71.25	20.5	9.25	1.75	244.75
4170	SPRING 2016	33.5	24.5	11.5	6.25	13	4.75	93.5
4171	SPRING 2016	7.25	1.5	4	5.5	7.25	6.75	32.25
4172	SPRING 2016	6.25	2.75	0.75	0.75	0.75	4.75	16
4173	SPRING 2016	35.25	135.25	77.75	30.25			278.5
4174	SPRING 2016	29.25	35.5	7.25	2.75	6.75	2	83.5
4175	SPRING 2016	106.75	191.5	166	80.5	70.25	42.25	637.25
4176	SPRING 2016	9	58.25	40	43	35.75	13.5	199.5

QA synopsis:

Nitrate:

Blind samples were submitted to the soils analytical lab with each round of sampling. Two samples were selected; one with a known nitrate concentration between 10 and 15 mg/Kg, and the other greater than 50 mg/Kg. All analyzed results were within the +/- 20% relative percent difference as specified in the QAPP.

Organic Matter and Ammonium:

Blind samples were submitted to the soils analytical lab with each round of sampling. There were evaluation criteria specified in the QAPP. Pacific Groundwater Group states in their evaluations of the blind sampling:

Although bias is suggested by the larger RPD percentage (in some cases) for ammonium and organic matter, these results are explained by the unavoidable variability which naturally occurs. This variability can occur due to heterogeneity which is typically present in soils. Further the North American Proficiency Testing (NAPT) program standards are median values calculated from analyses performed by multiple labs, therefore some lab and natural variabili6ty in the samples is expected and is statistically documented by the NAPT program. Natural variability may also occur in association with sample handling practices. A RPD of +/- 20% is typically used by labs for laboratory standard samples, with theoretically have no natural variability. Therefore, it is reasonable to expect that these samples which have natural variability could have RPDs that exceed +/- 20%.

Qualified soil data:

The ammonium data collected in the Fall 2015 had an RPD of 55% for the sample with lower ammonium concentrations. PGG cautions that during this sampling event lower concentration ammonium results may be biased high.

Analytical Data and Survey Data Analysis

Jean Mendoza evaluated the entire data set including the analytical data and the survey data collected from the farmer. She also conducted a second evaluation specifically focusing on fields planted in triticale.

Summary Analysis

Lower Yakima Valley Deep Soil Sampling Summary Analysis

By Jean Mendoza

August 2017

Between the fall of 2014 and the spring of 2016 the Lower Yakima Valley (LYV) Groundwater Management Area (GWMA) conducted four rounds of deep soil sampling (DSS) on agricultural land in the GWMA target area. All fields were voluntarily submitted and anonymously recorded. Soil sampling was done under contract by the South Yakima Conservation District and Landau Associates.

Purposes of the DSS as stated in *Deep Soil Sampling Plan Lower Yakima Valley Groundwater Management Area, March 2014* were:

1) Providing baseline data regarding the nitrogen content (nitrate, ammonium, and organic matter) of soils underlying a variety of soil, crop, and irrigation systems that represent a cross-section of agricultural activities.
2) Provide an initial assessment of current nitrogen and water management practices in place today and in the past.
3) Provide information regarding availability of soil nitrogen to crops.
4) Provide the foundation for a technically based education program.
5) Provide information about project design, practical realities, time requirements and costs that can be used in developing subsequent project scopes.

There has been no analysis of the collected data. This summary is an attempt by one member of the GWMA advisory committee to begin that process. This summary indicates that analysis is possible for a limited number of crops – triticale, alfalfa & corn silage. These were the majority of the crops in the study – 60% of crops in fall samplings and 78% of crops in spring samplings.

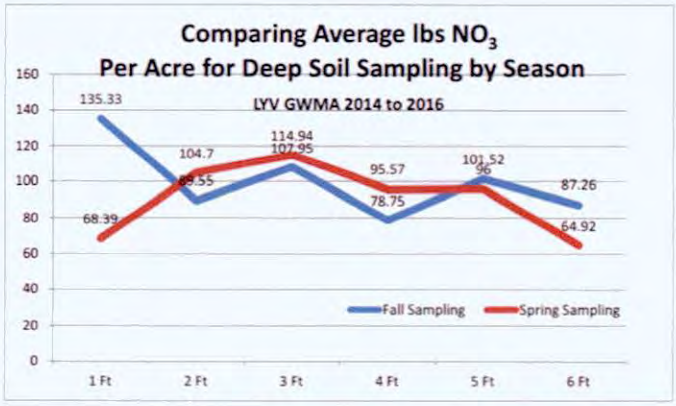
Summary of Data Parameters

There is a difference between the nitrate levels in the soil samples from the fall testing and the spring testing. This could be due to winter moisture that drives nitrates downward in the soil column. It could be due to differences in the fields and nature of the crops that were tested in each season.

Table 1. Average Nitrate Levels for Fall & Spring DSS

Seasonal Averages	1 Ft #N/Acre	2 Ft #N/Acre	3 Ft #N/Acre	4 Ft #N/Acre	5 Ft #N/Acre	6 Ft #N/Acre	Total #N/Acre	Ammonia #N/Acre	Organic Matter
Fall (N = 93)	135.33	89.55	107.95	78.75	101.52	87.26	531.78	22.7	2.01%
Spring (N = 82)	68.39	104.7	114.94	95.57	96	64.92	448.41	23.8	2.13%

Graph 1.



There are results for 93 fields in the fall sampling and 82 fields in the spring sampling for a total of 175. Part or all of the survey results are missing for 17 of the sites in the spring 2016 study. Analysis by crop, crop yield, fertilizations practices and irrigation type for the 2016 spring testing was calculated for those samples with available information. Soil information was available for all samples.

Average acreage per field was 34.23 acres for the fall testing and 45.61acres for the spring testing.

Total acreage: According to the Washington State Department of Agriculture (WSDA) there are about 96,380 acres of land in agriculture in the GWMA target area. Survey results were obtained for 6,091 acres or 6% of those fields. Acreage was missing for 3 of the fields in the fall samplings and 16 fields in the spring samplings. We do not know if any fields were tested twice and we do not know the locations of the fields.

Soil testing had been done by 74% of the growers in the fall survey and 99% of the growers in the spring survey with 3 unknown in the fall and 15 unknown in the spring. Those fields that were not routinely tested had lower nitrate levels. This indicates that many farmers know where they should be testing.

Irrigation types were:

- Rill = 21 fields or 23% for fall sampling and 7 fields or 11% for spring sampling with 17 unknown in the spring
- Sprinkler = 66 fields or 73% for fall sampling and 51fields or 78% for spring sampling with 17 unknown in the spring
- Drip = 5 fields or 3% for fall samplings and 7 fields or 11% for spring sampling with 17 unknown in the spring
- No irrigation = 1 field or 1% for the fall sampling

Crop history was provided for the past four to five years for most fields. Some fields were planted in only one crop throughout that time period while others were planted with multiple crops. This complicates the analysis. Unless otherwise stated the crop listed for each sample and analysis is the most recently harvested crop under the category *Crop #1* in the DSS spreadsheets. Remember that previous crops impact the nitrogen levels in soils.

Percentage of crops in the DSS is described below in Table 2. WSDA's percentage of crops in the GWMA target area is in parentheses. WSDA data is taken from Attachment 2, *Summary of Proposed Allocation Process.* Most DSS fields in triticale were double cropped in silage corn. Perhaps WSDA only counted triticale as a crop when it was the only crop on a field. This would account for WSDA's low estimate of land in triticale.

Table 2. Percentage of Crops in the LYV GWMA DSS

Fall	% of Crops in the Sampling	N	Spring	% of Crops in the Sampling	N
Triticale	22% (WSDA 1%)	20	Triticale	46% (WSDA 1%)	31
Alfalfa	15% (WSDA 7%)	14	Alfalfa	19% (WSDA 7%)	13
Corn Silage	14% (WSDA 19% for silage + grain)	13	Corn Silage	12% (WSDA 19% for silage + grain)	8
Corn Grain	10% (WSDA 19% for silage + grain)	9	Hops	7% (Hops 5%)	5
Grapes	6% (WSDA 11%)	6	Asparagus	3% (WSDA 1%)	2
Hops	5% (WSDA 5%)	5	Mint	3% (WSDA 1%)	2
Mint	5% (WSDA 1%)	5	Wheat	3% (WSDA 2%)	2
Pasture	5% (WSDA 6%)	5	Apples	1% (WSDA 17%)	1
Wheat	4% (WSDA 2%)	4	Cherries	1 % (WSDA 7%)	1
Apples	3% (WSDA 17%)	3	Pasture	1% (WSDA 6%)	1
Hay	3% (WSDA 1%)	3	Wine Grapes	1% (WSDA 5%)	1
Cherries	2% (WSDA 7%)	2	None	1%	1
Barley	1% (WSDA < 1%)	1			
Fallow	1%	1			
Pears	1% (WSDA 4%)	1			
Sudan Grass	1% (WSDA 1%)	1			
Wine Grapes	1% (WSDA 5%)	1			
Double Crop	24%	22	Double Crop	46%	31
Multiple Crops	30%	28	Multiple Crops	25%	17

Based on these numbers it is possible to draw limited conclusions regarding triticale, alfalfa and corn silage for the fields in this data set of voluntary samples. This descriptive analysis begins on page 8. Statistical analysis for significance begins on page 37.

Fertilization Practices were:

- Liquid Manure = 29 fields (31%) for fall sampling and 36 fields (55%) for spring
- Solid Manure = 18 fields (19%) for fall sampling and 10 fields (15%) for spring
- Commercial Fertilizer = 59 fields (63%) for fall sampling and 36 fields (55%) for spring sampling
- Biosolids = 1 field (1%) for fall sampling and 0% for spring sampling
- Compost = 2 fields (2%) for fall sampling and 0% for spring sampling
- Other = 3 fields (3%) for fall sampling and 1 field (2%) for spring sampling
- 23 fields or 25% of the fall sampling received more than one type of fertilizer
- 23 fields or 35% of the spring sampling received more than one type of fertilizer

Leaching estimates were obtained using the *Capacity of the Most Limiting Layer to Transmit Water (Ksat)* classifications found on the Natural Resource Conservation Services (NRCS) *Soils Website* at https://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx.

Ksat soil classes for this analysis were:

- Very Low to Moderately Low =5 fields or 5% for fall, 9 fields or 11% for spring and 14 fields or 8% overall
- Moderately High to High = 78 fields or 84% for fall, 68 fields or 83% for spring and 146 fields or 83% overall.
- High to Very High = 10 fields or 11% for fall, 15 fields or 6% for spring and 25 fields or 9% overall

See Attachment 3 for a listing of the soil types and classifications in the DSS. None of the sampled fields fell into other classes.

Most frequent soil types listed in the DSS spread sheet were:

Fall -

- Warden Silt Loam 2-5% Slopes (Moderately High to High) - 24% (22)
- Quincy Loamy Fine Sand 0-10% Slopes (Moderately High to High) - 9% (8)
- Warden Silt Loam 5-8% Slopes (Moderately High to High) - 9% (8)
- Ezquatel Silt Loam 0-2% Slopes (Moderately High to High) - 8% (7)
- Warden Silt Loam 8-15% Slopes (Moderately High to High) - 6% (6)

Spring –

- Warden Silt Loam 2-5% Slopes (Moderately High to High) – 15% (12)
- Cleman Very Find Sandy Loam 0-2% Slopes (Moderately High to High) – 12%(10)
- Warden Fine Sandy Loam 0-2% Slopes (Moderately High to High) – 7%(6)
- Scoon Silt Loam 2-5% Slopes (Very Low to Moderately Low) – 6% (5)
- Sinloc Silt Loam 2-5% Slopes (Moderately High to High) – 6% (5)

Deep Soil Sampling Plan

Prior to implementation of the LYV GWMA DSS planners from the Irrigated Ag Work Group presented the advisory committee with an estimated breakdown of categories for the GWMA target area. (Attachment 2 – *Summary of Proposed Allocation Process*) These groupings were:

1. Crops by root depths:
   - More than 4 Ft – alfalfa, asparagus, tree fruits & hops ~42% of total crops
   - 2.5 Ft to 4 Ft – corn, wheat, grains/triticale, sorghum/Sudan, pasture, grapes ~54% of total crops
   - Less than 2.5 Ft – mint ~1% of total crops
   - Miscellaneous ~3% of total crops

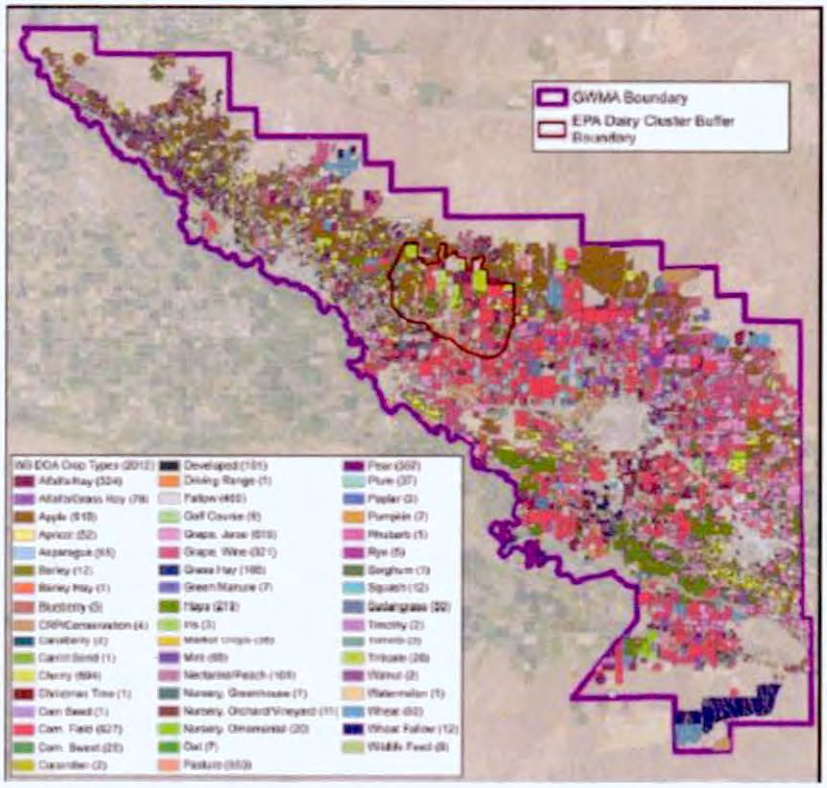
2. Irrigation Types
   - None, none + anything, unknown ~6% of area irrigation
   - Drip, micro sprinkler, drip + anything ~13% of area irrigation
   - Sprinklers, sprinklers + anything, hand ~63% of area irrigation
   - Flood, rill, rill + sprinkler ~ 16% of area irrigation

3. Leaching Potentials (percentages unknown)
   - Low
   - Medium
   - High
   - Possibly a fourth category – medium to high

The plan was to calculate total acreage for each of 36 to 96 categories and to rank categories according to acreage. Analysists would determine which categories were most prevalent in the GWMA target area. They would sample 6 fields from each of the most prevalent, 4 fields from each of the next highest grouping and 3 fields from each of the next highest grouping. There would be no sampling from approximately half of the combinations with low prevalence.

In order to determine the percentage of GWMA land in each category someone would use the WSDA map of GWMA area crops below and search the NRCS Web Soils site to determine soil type for each parcel. These calculations were apparently not done.

Map 1. WSDA Crop Map for the GWMA Target Area



Comparison of the Plan with the Collected DSS Data

For purposes of this comparison the number of categories is reduced to 27 possible combinations: (Irrigation = 3) x (Crops = 3) x (Leaching = 3).

Irrigation

The plan states there is rill irrigation on 16% of the target area. 19% of the fields in the study had rill irrigation

The plan states there is sprinkler irrigation on 63% of the fields in the target area. 74% of the fields in the study had sprinkler irrigation

The plan states there is drip irrigation on 13% of the fields in the target area. 7% of the fields in the study had drip irrigation

There is no irrigation on 6% of the fields in the target area and about 1% of the fields in the study had none. That category is omitted in this analysis of the DSS

Crops by Rooting Depth

The plan states that 1% of the crops in the target area have roots < 2.5 Ft deep. About 5% of the fields in the study had crops (mint) in this category

The plan states that 54% of the crops in the target area have roots 2.5 Ft to 4 Ft. About 66% of the fields in the study had crops in this category.

The plan states that 42% of the crops in the target area have roots > 4 Ft. About 29% of the fields in the study had crops in this category

Analysis of DSS by crops is complicated by double cropping. Most of the DSS fields planted in triticale and corn silage were double cropped. Double cropping was done on 24% of the fields in the fall soil sampling and 46% of the crops in the spring soil sampling

Crops in the DSS are not always typical of the crops grown in the area. For example 2.5% of the fields in the DSS were planted in apples but 19% of the cropland in the area is actually planted in apples according to the WSDA. For example 17% of the fields in the DSS were planted in alfalfa but 7% of the cropland in the area is actually planted in alfalfa according to the WSDA. The composition of the > 4 Ft root depth group in the DSS includes both of these crops and is especially not typical of the area.

Leaching Potential
In the collected data the DSS leaching potential categories were:

- Very low to moderately low – 6% of fields
- Moderately high to high – 84% of fields
- High to very high – 10% of fields

We do not know the actual percentages of leaching categories in the GWMA target area.

Results for Most Prevalent Categories in the DSS

The DSS gathered data for 15 out of the 27 categories.

Table 3. LYV GWMA DSS Categories with Soil Testing Results

Irrigation	Root Depth	Leaching Potential	Number of fields in the DSS	% of DSS Fields
Rill	< 2.5 Ft	Moderately High, Moderately High to High	6	4%
Rill	2.5 Ft to 4 Ft	Moderately High, Moderately High to High	19	12%
Rill	2.5 Ft to 4 Ft	High to Very High	1	1%
Rill	> 4 Ft	Moderately High, Moderately High to High	3	2%
Rill	> 4 Ft	High to Very High	1	1%
Sprinkler	< 2.5 Ft	Moderately High, Moderately High to High	2	1%
Sprinkler	2.5 Ft to 4 Ft	Very Low to Moderately Low	8	5%
Sprinkler	2.5 Ft to 4 Ft	Moderately High, Moderately High to High	65	40%
Sprinkler	2.5 Ft to 4 Ft	High to Very High	12	7%
Sprinkler	> 4 Ft	Moderately High, Moderately High to High	31	19%
Sprinkler	> 4 Ft	High to Very High	2	1%
Drip	2.5 Ft to 4 Ft	Very Low to Moderately Low	1	1%
Drip	2.5 Ft to 4 Ft	Moderately High, Moderately High to High	1	1%
Drip	> 4 Ft	Very Low to Moderately Low	1	1%
Drip	> 4 Ft	Moderately High, Moderately High to High	9	6%

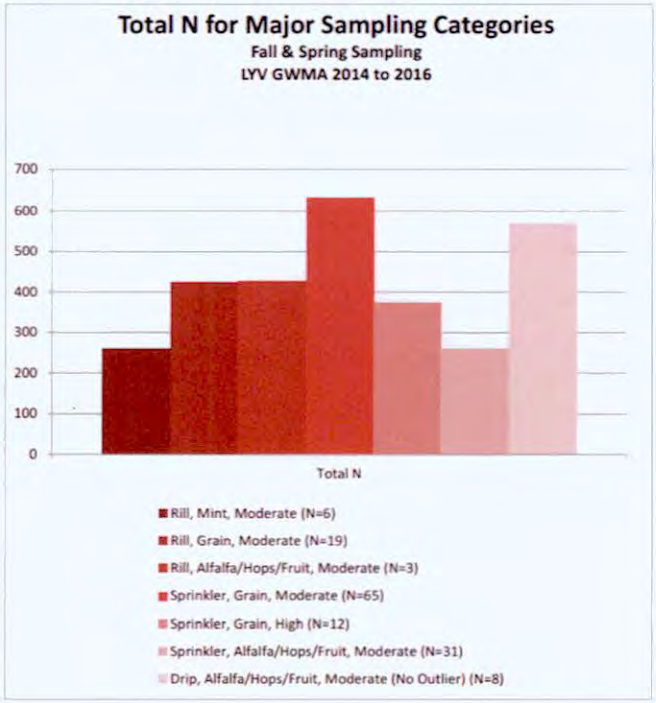
Here are the average readings for nitrates in the soil for the categories with more than three samples. The bar graph that follows shows the calculated total nitrogen for these major groups. Note that early refusal of the auger results in fewer samples and a lower total N. For this reason the category "Sprinkler, Grain, Low" was omitted from the bar graph since that grouping had no measurements below 3 ft.

Table 4. Average NO_3 Levels by Sampling Category for LYV GWMA DSS

Category	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total N
Rill, Mint, Moderate (N=6)	85.33	26.17	63.67	18.67	57.17	9.17	260.17
Rill, Grain, Moderate (N=19)	157.95	74.42	69.74	47.37	52.88	33.69	425.16
Rill, Alfalfa/Hops/Fruit, Moderate (N = 3)	138.33	84.67	63	62.67	58	21	427.67
Sprinkler, Grain, Low (N=8)	92.88	80.83	103.67		Early Refusal		
Sprinkler, Grain, Moderate (N=65)	101.09	130.69	145.08	124.88	111.7	102.77	631.43
Sprinkler, Grain, High (N=12)	102.5	61.5	89.1	60	62.67	50.44	373.08
Sprinkler, Alfalfa/Hops/Fruit, Moderate (N = 31)	60.83	35.72	53.56	53.67	65.67	37.75	260.72
Drip, Alfalfa/Hops/Fruit, Moderate with Outlier (N = 9) *	287.44	168.56	164.67	36.56	217.86	187.57	972.44
Drip, Alfalfa/Hops/Fruit, Moderate without Outlier (N = 8)	204.63	182.25	110.75	34	30.17	18.17	567.75

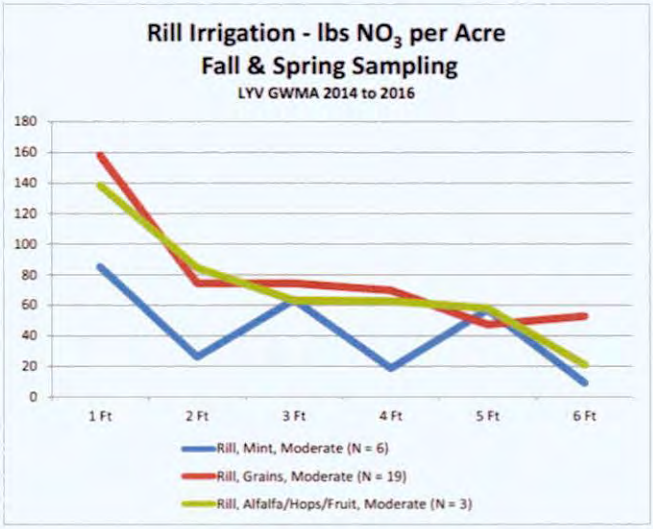
* Field #3141 had extremely high nitrate levels at the 5 ft and 6 ft levels. At this depth the readings cannot be explained by the parameters in the study. This field was excluded from the analysis on this page, but not from later analyses.

Graph 2. Total Nitrogen for Major Sampling Categories LYV GWMA DSS



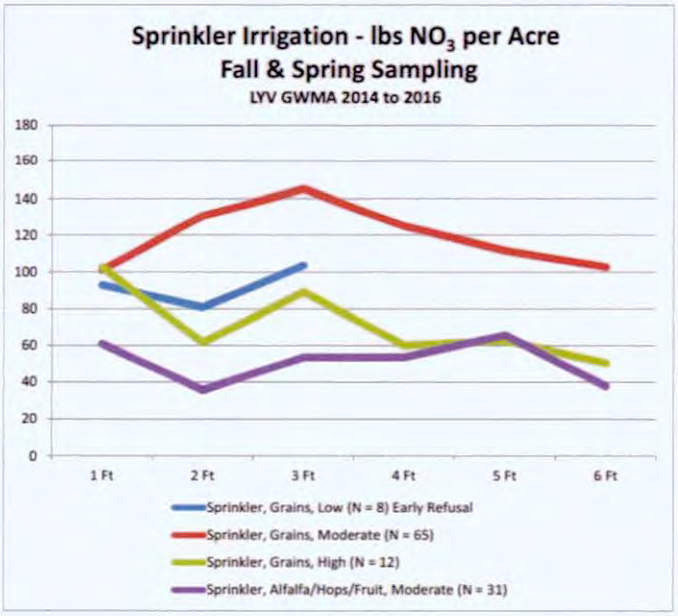
Following are graphs that provide easy viewing of common factors in the 15 groupings.

Graph 3.



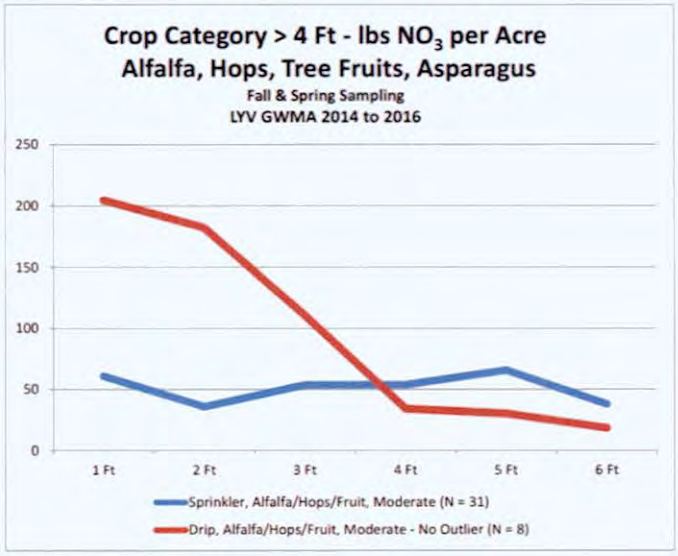
11

Graph 4.


Sprinkler Irrigation - lbs NO_3 per Acre
Fall & Spring Sampling
LYV GWMA 2014 to 2016
180
160
140
120
100
80
60
40
20
0
1 Ft
2 Ft
3 Ft
4 Ft
5 Ft
6 Ft
Sprinkler, Grains, Low (N = 8) Early Refusal
Sprinkler, Grains, Moderate (N = 65)
Sprinkler, Grains, High (N = 12)
Sprinkler, Alfalfa/Hops/Fruit, Moderate (N = 31)

12

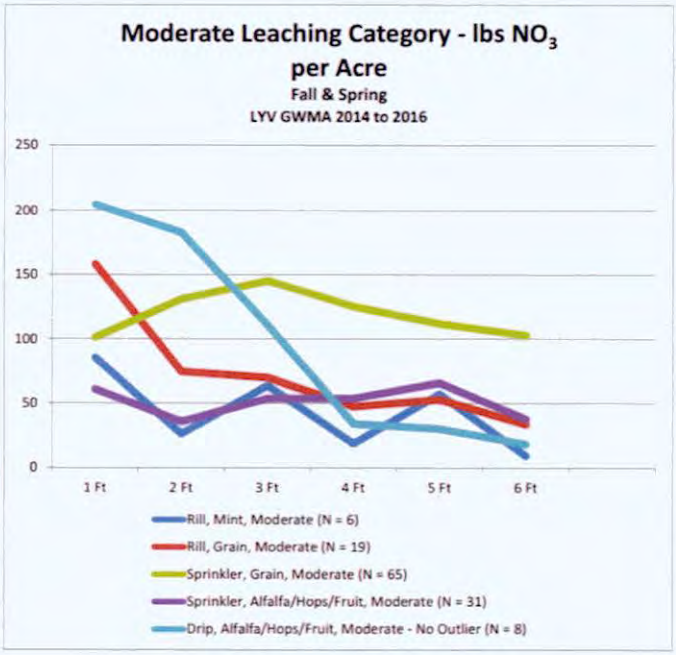
Graph 5.



Note change in scale

13

Graph 6.



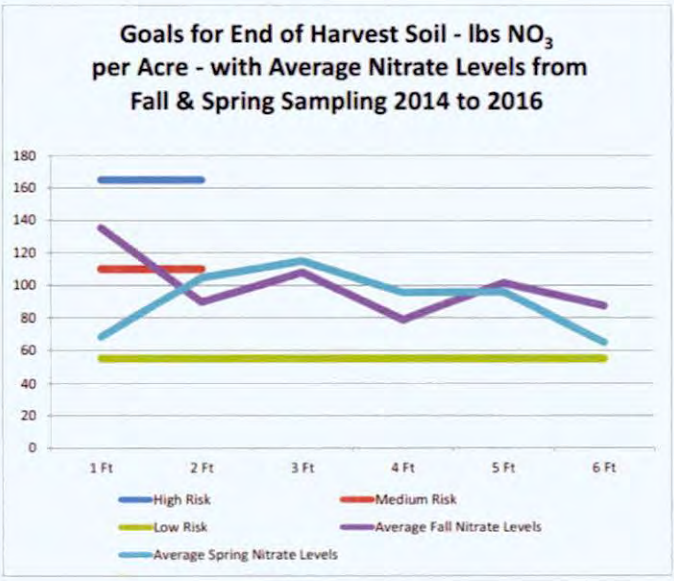
Descriptive Analysis of the DSS Data

Based on the number of samples available certain groupings of data in the DSS lend themselves to limited analysis. In the pages that follow there is discussion of data for the crops: alfalfa, alfalfa + other, triticale & corn silage. There is limited discussion of other crops: grapes, hops, mint, grain corn, & wheat. There is analysis of the impact of double cropping, fertilizer practices and root depth. This study is not sufficiently sophisticated to analyze combinations of factors. The results apply only to the data in the DSS and should only be applied to the entire GWMA target area with caution. Spring and fall data collections are analyzed separately in most of the analyses that follow.

DSS Goals: Suggested goals for end of harvest soil testing at the two foot level in Eastern Washington can be adapted from the WA State General NPDES permit for Concentrated Animal Feeding Operations. (Ecology, 2017). According to this document there is low risk when end of harvest nitrate levels at two feet are < 55 # per acre, medium risk when levels are 55# per acre to 110 # per acre, high risk when levels are 110 # per acre to 165 # per acre and very high risk when levels are > 165 # per acre.

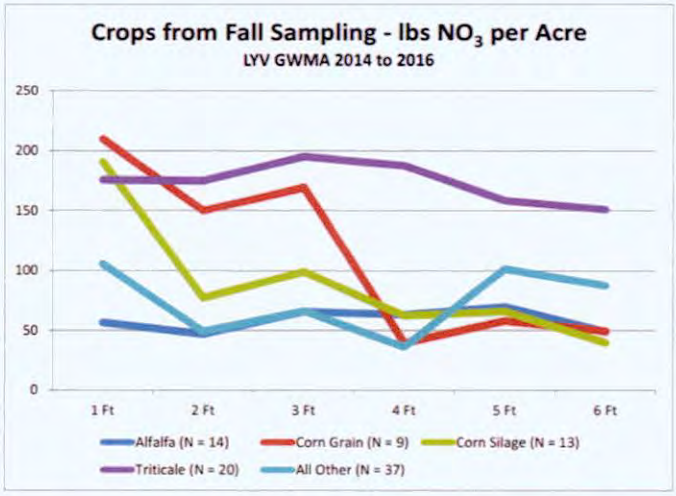
Here is a graphic representation with the average nitrate levels from fall and spring DSS testing in the LYV GWMA target area:

Graph 7.



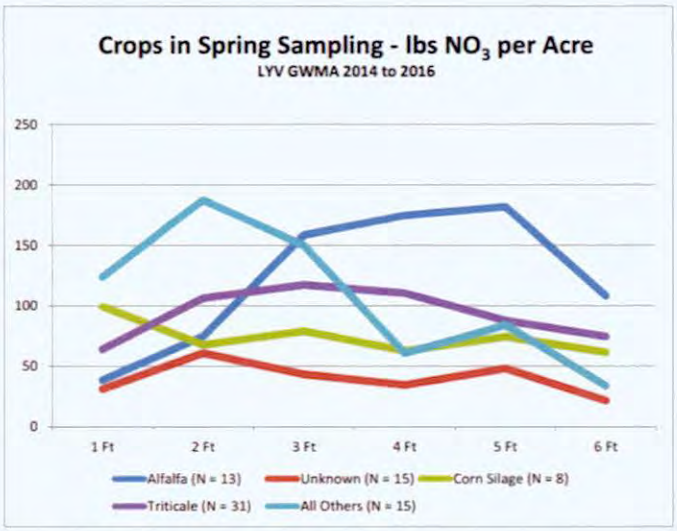
Major Categories: The majority crops in the fall sampling were triticale (n=20), alfalfa (n = 14), corn silage (n=13), corn grain (n=9) and all others (n=37). The majority crops in the spring sampling were triticale (n=31), unknown (n=15), alfalfa (n=13), corn silage (n=8) and all others (n=15).

Graph 8.



16

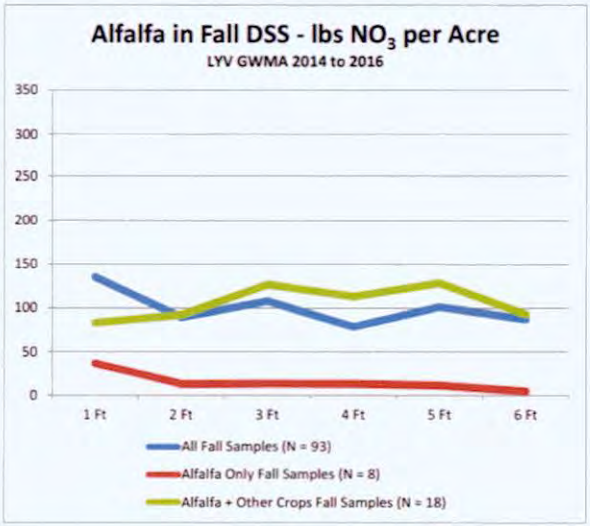
Graph 9.



Alfalfa: Analysis of the data for alfalfa from the fall samplings strongly suggests that when alfalfa is the only crop planted on a field for several years, then nitrate levels tend to be low. When other crops are rotated onto the field then nitrate levels tend to be higher. Fertilization practices naturally have a strong influence.

17

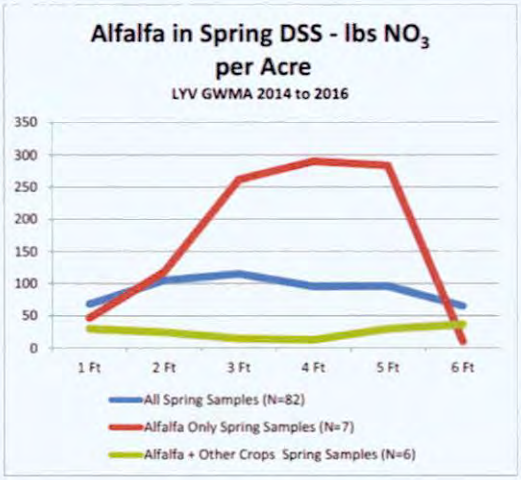
Graph 10.



But when the alfalfa data from spring sampling is analyzed there are surprises. The spring alfalfa fields have much higher nitrate levels than the combined fields for all spring sampling. Alfalfa only fields have higher nitrates than the fields with alfalfa plus multiple other crops in the spring sampling.

18

Graph 11.



A closer look at the spring "alfalfa only" data provides a clue. There are some extreme values in fields #2044, #2047 and #4152. The range of values for these fields is huge.

Table 5. Spring Sampling: Alfalfa = Only Crop

Field ID	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	Ammonia	Organic
2045	29	4	20	22	13	31	119	25	2.37
2047	113	466	913	951	626	242	3321	21	3.11
2073	36	35	31	38			140	27	2.42
2074	75	55	68	97	94	26	415	26	2.51
4152	25	106	319	279	256	219	1204	26	2.63
2044	29	152	457	623	706	409	2376	31	3.4
4153	17	9	21	21	5	10	83	17	2.62
Averages	46.29	118.14	261.29	290.14	283.33	10	1094	24.7	2.72

19

According to the DSS spreadsheets for the fields with high nitrate levels:

- No irrigation type is listed for #2044 but it is likely sprinkler. Soil testing is done annually. "No nutrients have been applied during last four years." Crop yield is slightly less than average at 7.5 tons per acre. Soil type is Outlook Silt Loam with a moderately high to high Ksat. Rooting depth averages 3.7 ft with a range of 1.5 ft to 5.4 ft
- Irrigation is pivot sprinkler for #2047. Soil testing is done annually. This field received 300#/acre of N from liquid manure in 2012, 2013, & 2014 and 150#/acre of N from liquid manure in 2015. Average crop yield was 8.75 tons per acre. Soil type is Warden Silt Loam 5-8% slopes with moderately high to high Ksat. Average rooting depth is 3.8 ft with a range of 2ft to 5.9 ft.
- Irrigation is pivot sprinkler for #4152 and moisture sensors had been in place for a year. Soil testing is done annually. "No nutrients applied from 2013 thru 2016". Average crop yield was 8 tons per acre. Soil type is Sinloc Silt Loam 2-5% slopes with a moderately high to high Ksat. Rooting depth averaged 4 ft with a range of 1.5 ft to 6 ft.

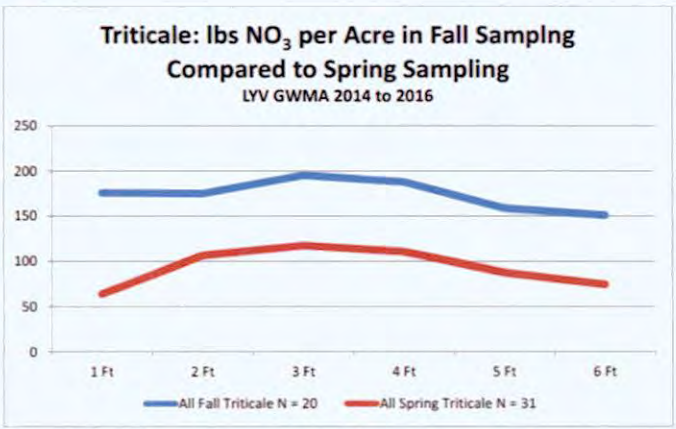
For the fields with low nitrate levels:

- Irrigation is by wheel lines on field #2045. Soil testing is done annually. "No nutrients applied since fall of 2011." Crop yield is slightly less than average at 7.5 tons per acre. Soil type is Sinloc Fine Sandy Loam 0-2% slopes with moderately high to high Ksat. Rooting depth averaged 3.55 ft with a range of 3 ft to 4.7 ft.
- Irrigation is by pivot sprinkler on field #2073. Soil testing is done twice a year. The field received 150# of N per acre from liquid manure in 2012, 2013, 2014 & 2015. Crop yield was 9.75 tons per acre. Soil type is Warden Silt Loam 8-15% slopes with moderately high to high Ksat. Rooting depth averaged 3 ft with a range of 2.4 ft to 3.3 ft. There was refusal of the auger at < 4 ft at all four bore holes.
- Irrigation is by wheel lines on field #2074. Soil testing is done annually and soil moisture sensors are used. The field received 106 #N per acre in 2012 and 177 #N per acre in 2013 & 2014 from liquid manure. Crop yield averages 8 tons per acre. Soil type is Finley Silt Loam 0-2% slopes with high Ksat. Rooting depth averages 3.9 ft with a range of 2.6 ft to 6 ft.
- Irrigation is by wheel lines on field #4153. Soil testing is done annually. "No nutrients applied 2013 thru 2016." Crop yield averages 16.7 tons of green chop per year. Soil type is Warden Silt Loam 5-8% slopes with moderately high to high Ksat. Rooting depths average 3.9 ft with a range of 3 ft to 4.8 ft.

This information is insufficient to explain the great differences in nitrate levels.

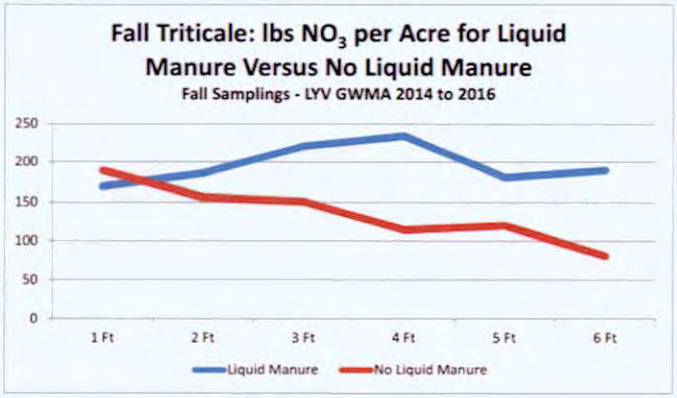
Triticale: Most of the fields planted in triticale are double cropped with corn silage. For purposes of analysis the fields in which triticale is listed as the most recently harvested crop in the *Crop #1* category are considered. Nitrate levels from triticale fields were higher during the fall sampling than during the spring sampling. Overall nitrate levels tended to peak at a depth of 3 ft.

Graph 10.

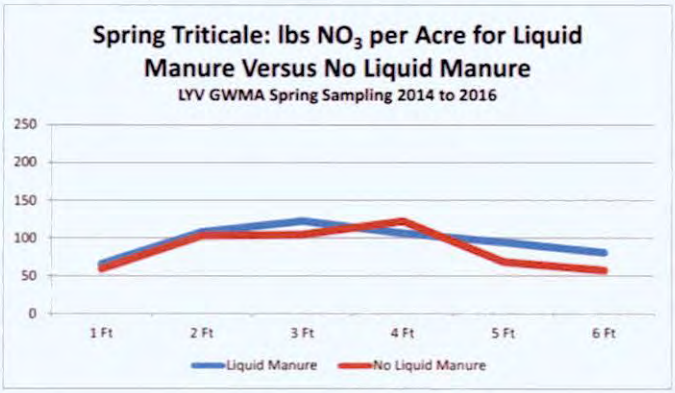


In the fall sampling triticale fields that received liquid manure tended to have higher nitrate levels than those that did not.

Graph 11.



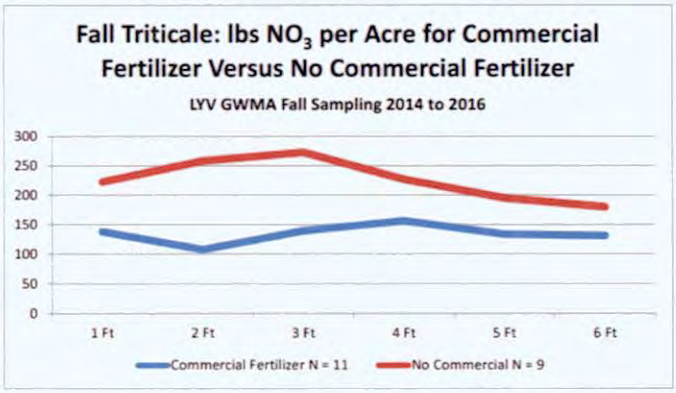
Graph 12.



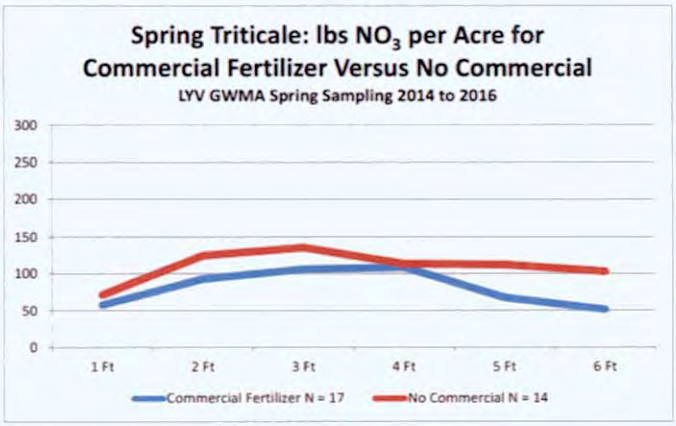
Triticale fields that received commercial fertilizer tended to have lower nitrate levels than those that did not.

22

Graph 13.



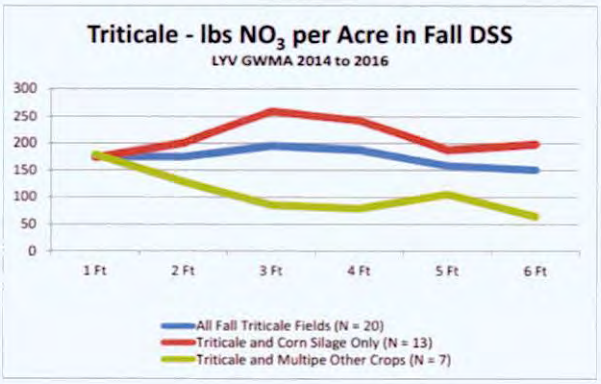
Graph 14.



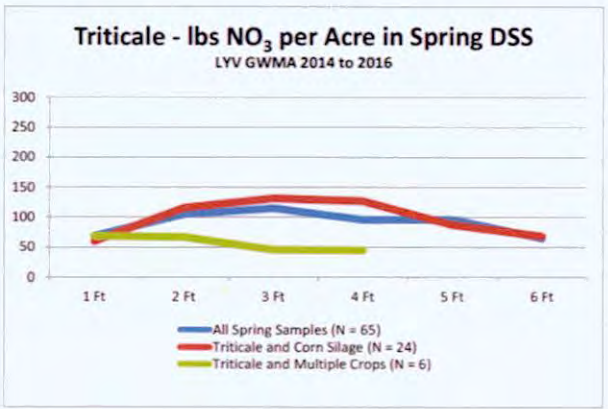
23

Fields planted only in triticale and corn silage tended to have higher nitrate levels than fields planted in triticale plus multiple other crops.

Graph 15.

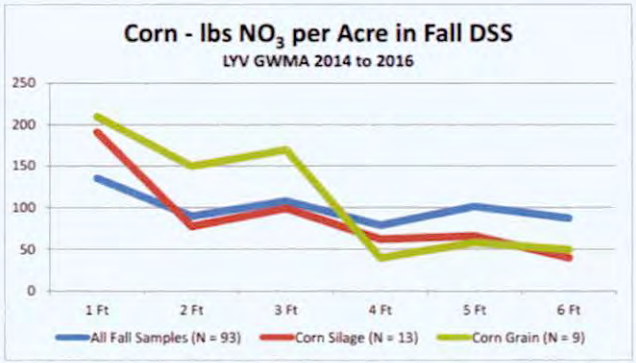


Graph 16.

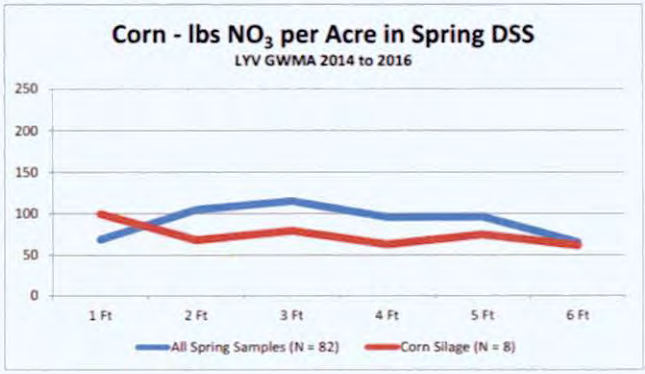


Corn: Both grain corn and silage corn fields were sampled in the fall. Only silage corn was sampled in the spring. Except for the first foot silage corn had lower nitrate levels than the average of all crops in both fall and spring. The fields described below had corn as the most recently harvested crop in the *Crop #1* category of the spreadsheets.

Graph 17.



Graph 18.

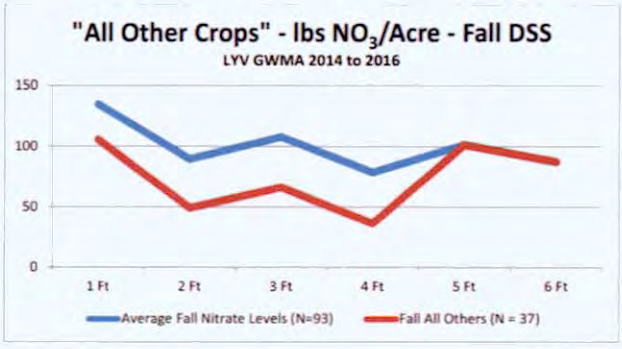


25

"All Other Crops": This includes first listed crops other than alfalfa, corn and triticale.

Fall Sampling: There were 37 fields out of 93 for this category in the fall samplings. Crops were: apples (3), barley (1), cherries (2), fallow (1), grapes (6), hay (3), hops (5), mint (5), pasture (5), pears (1), Sudan grass (1), wheat (3), and wine grapes (1)

Graph 19.



Here are the nitrate levels at depths for those fall DSS crops with more than 2 samples. There was refusal before six feet for 17 out of 37 fields so total nitrogen is not included. There were potential outliers.

Table 6. NO_3 Levels for "All Other" Crops for LYV GWMA Fall Sampling

	N	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Ammonia	Organic
"All Other"	37	105.68	49.11	66.03	36.13	101.43	87.43	21.76	1.86
Apples	3	35.33	19	7	3.5	3	3	13.33	1.87
Cherries	2	34	4.5	3	3			6.5	1.26
Grapes *	6	19.33	111.5	182	146	301	292	10.67	1.35
Hay	3	15	5.67	9	7.67	14	18	19.33	1.89
Hops *	5	519.8	27	161	28.2	377.5	304	17.2	1.64
Mint	5	33.8	6.8	21.4	17.8	14.6	13.2	28.8	1.944
Pasture	5	27.8	27	4	4.25	9.25	8	40.4	2.28
Wheat	3	59.33	185	112	45	31	19	27.33	2.02

Possible Outliers are included in the table. These extreme values strongly influence the averages.

The potential outliers are

Grapes:

- Field #3117 is a 37 acre grape field with solid set irrigation. Soil testing is done annually. "This is an organic grape vineyard. No fertilizer is applied. We use vetch legume with triticale as a cover crop and the vetch does nitrogen fixing." Crop yield averages 6.75 tons per year. Soil type is Warden Silt Loam 2-5% slopes with moderately high to high Ksat.
- Field #3119 is a 15 acre grape field with solid set irrigation. Soil testing is done every two years. No fertilizer is applied. "Previous farmer 40 years ago had a history of excessive nitrogen application according to current farmer." Crop yield averages 7.5 tons per acre. Soil type is Warden Silt Loam 8-5% slopes with moderately high to high Ksat.

Hops:

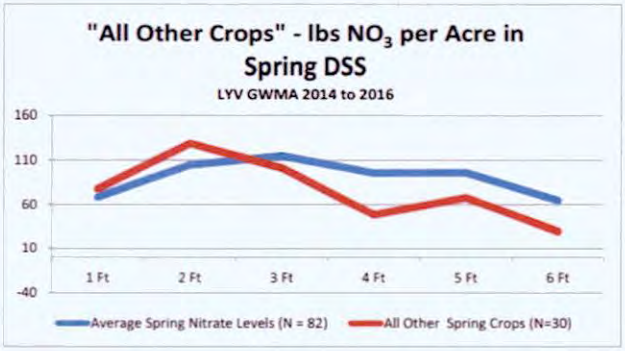
- Field #3141 is a 20 acre hop field with drip irrigation. Soil testing is done annually. 200# N per acre of commercial fertilizer was applied in 2013, 2014 & 2015. Crop yield averages 1.25 tons per acre. Soil type is Esquatzel Silt Loam 0-2% slopes with moderately high to high Ksat.

Table 7. NO_3 Levels: Potential Outliers for "All Other" Crops in LYV GWMA Fall Sampling

Field #	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	Ammonia	Organic
3117	51	301	573	400			1325	9	1.67
3119	20	213	260	213	559	580	1845	11	1.49
3141	950	59	596	57	1344	1204	4210	22	2.25

Spring Sampling: There were 30 out of 82 fields in this category for the spring samplings. Crops were: apples (1), asparagus (2), cherries (1), hops (5), mint (2), pasture (1), wheat (2), wine grapes (1) and unknown (15)

Graph 20.



Here are the nitrate levels at depths for those spring DSS crops with more than 2 samples. There was refusal before six feet for 14 out of 30 fields so total nitrogen is not included. There were potential outliers.

Table 8. NO_3 Levels for "All Other" Crops for LYV GWMA Spring Sampling

	N	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Ammonia	Organic
All Other Crops	30	77.5	129.04	101.04	48.17	67.85	29.47	16.87	1.75
Asparagus *	2	231.5	499.5	412	207	212	111.5	14	0.91
Hops	5	124	223	111.8	28.8	30.2	20	11.4	1.43
Mint	2	176.5	68.5	175.5	48.5	158	18.5	10	162.63
Wheat	2	104	40					42	3.38
Unknown	15	31.2	60.83	43.27	34.64	48.11	21.5	16.87	1.79

Potential outliers were Fields # 4175 & 4176. These are the only asparagus fields in the DSS and should not be considered typical of asparagus in the area.

28

- Field # 4175 is a 10 acre asparagus field. The irrigation type is not identified and soil testing is done annually. "No nutrients applied for at least the last three years. No manure applied for over 10 years. Field gets subby when SVID canal fills up in spring and dries out when canal shuts off." No crop yield is recorded. Soil type is Cleman Very Fine Sandy Loam 0-2% slopes with moderately high to high Ksat.
- Field #4176 is a 20 acre asparagus field with rill irrigation. Soil testing is done annually. "No nutrients applied for at least the last three years. No manure applied for over 10 years. Field gets subby when SVID canal fills up in spring and dries out when canal shuts off." No crop yield is recorded. Soil type is Cleman Very Fine Sandy Loam 0-2% slopes with moderately high to high Ksat.

Here are the nitrate levels for the asparagus fields:

Table 9. Asparagus fields in the LYV GWMA Spring DSS

Field #	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	Ammonia	Organic
4175	427	766	664	242	281	169	2549	12	0.69
4176	36	233	160	172	143	54	798	16	1.12
Average	231.5	499.5	412	207	212	111.5	1673.5	14	0.91

Here are the nitrate levels for the fields in which crops were unknown for the Spring DSS. There was early refusal on 9 out of 15 fields in this group.

Table 10. Fields with Unknown Crop in Spring DSS

Field #	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	Ammonia	Organic
2061	5	3	10	4			22	9	1.78
2062	5	6	11	14	10		46	7	0.84
4146	35						35	9	1.64
4147	54	51	96	197	323		721	13	1.82
4148	41	39					80	36	2.95
4151	37	10	6	4	5	3	65	16	1.19
4160	9						9	19	1.79
4162	14	4	3	3	3	63	30	30	1.66
4163	11	5	13	4	38	3	74	19	1
4164	6	3	3	5	16	14	47	12	1.54
4165	4	51	4	4	6		69	10	1.47
4168	52						52	21	3.2

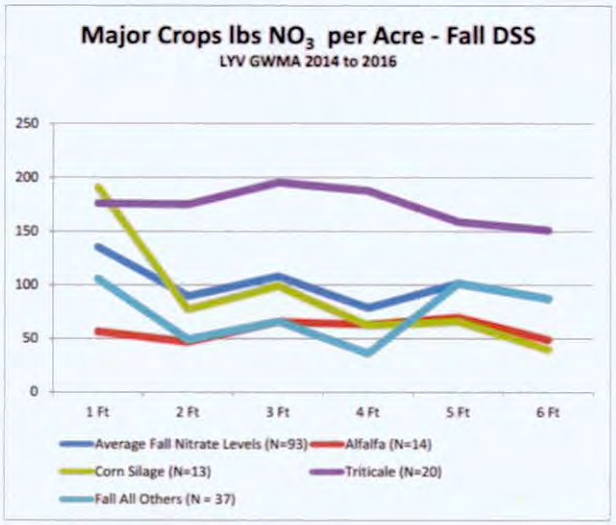
29

4171	29	6	16	22	29	27	129	13	1.3
4172	25	11	3	3	3	19	64	15	2.02
4173	141	541	311	121			1114	24	2.64
Average	31.2	60.83	43.27	34.64	48.11	21.5	170.47	16.87	1.79

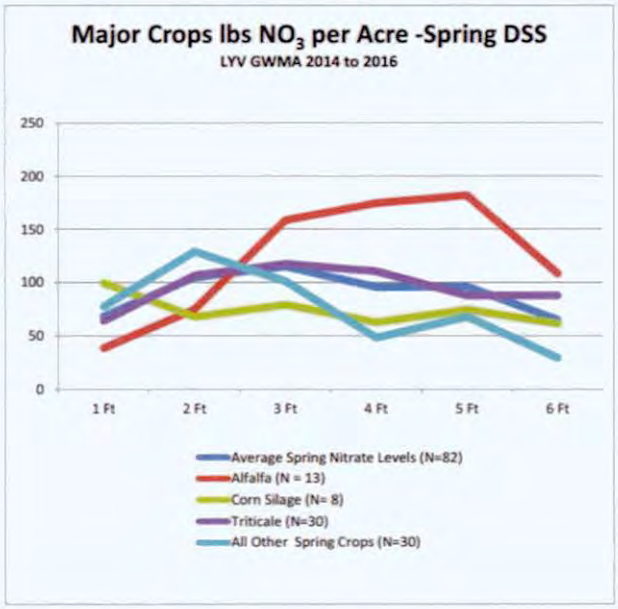
Comparison of Major Crops for Fall & Spring DSS:

Below are graphs that compare average nitrate levels for all crops to nitrate levels for: alfalfa, corn silage, triticale, and all other crops for the fall and spring DSS.

Graph 21.

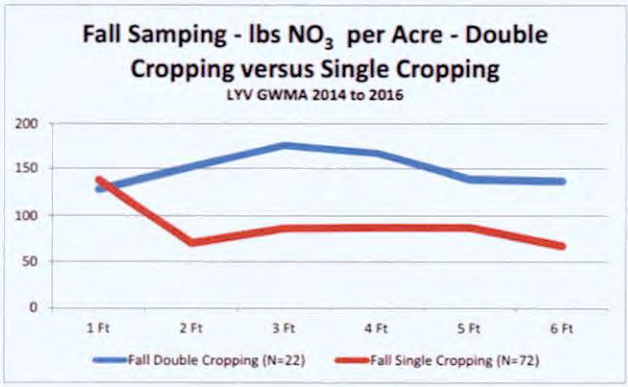


Graph 22.

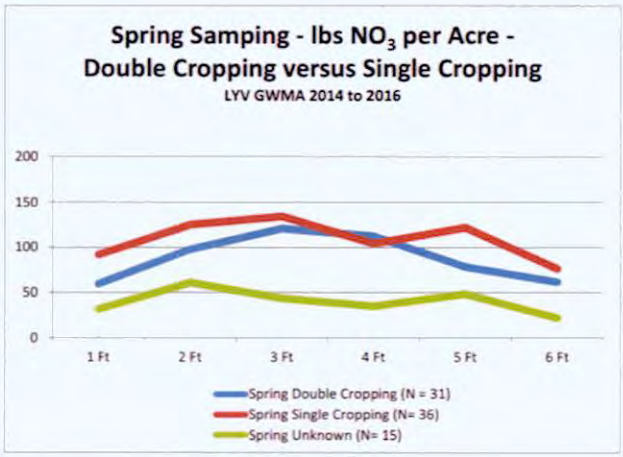


Double Cropping: This practice shows higher nitrate levels than single cropping in the fall sampling and general lower levels in the spring sampling. The 15 samples without cropping information for spring sampling complicate the analysis.

Graph 23.



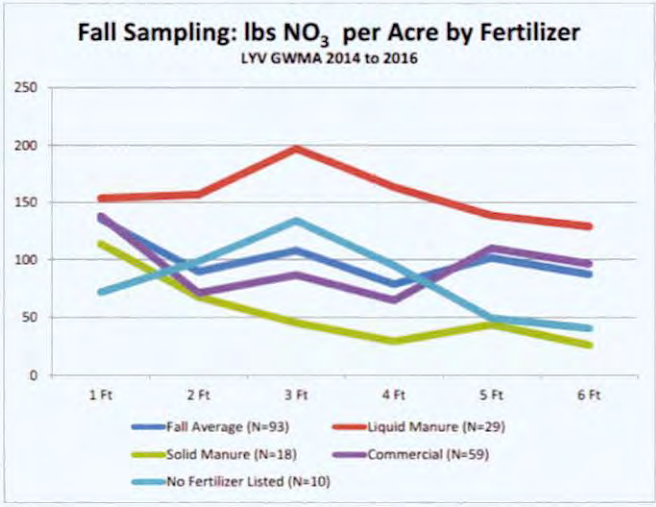
Graph 24.



32

Type of Fertilizer: For the fall sampling (N=93) there were fairly clear differences in nitrate levels for the various fertilizer types.

Graph 25. Fall Sampling by Fertilizer Type



There were 29 fields (31%) that received liquid manure. These fields had the highest percentage of organic matter. They were most likely to be double cropped and most likely to use sprinkler irrigation. Soil testing was highest for this group.

There were 18 fields (19%) that received solid manure. These fields had the highest ammonia levels and second highest levels of organic matter. They had the most rill irrigation and were least likely to receive sprinkler irrigation.

There were 59 fields (63%) that received commercial fertilizer. These fields had the lowest percentage of organic matter and were least likely to receive more than one type of fertilizer.

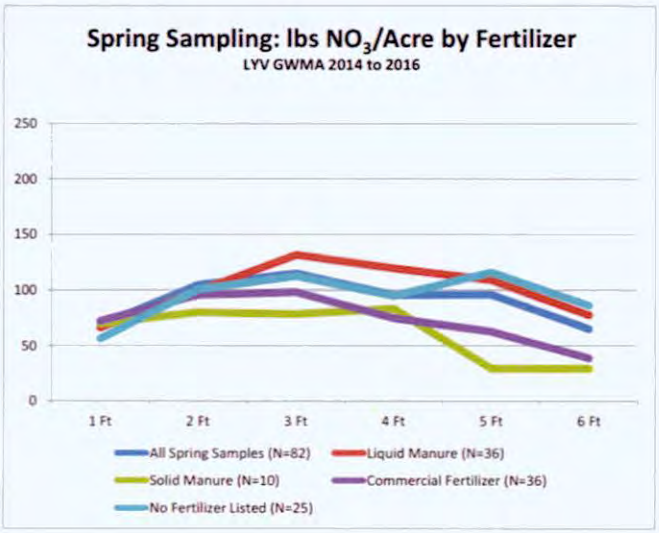
There were 10 fields (11%) with no fertilizer listed. These fields had the lowest ammonia levels and second lowest levels of organic matter. Soil testing was only done on half of these fields, the lowest percentage of all.

Table 11. Analysis of Fertilizer Types for Fall Sampling – LYV GWMA DSS

	NH_3 #/ac Average	Organic Matter	Double Cropped	Rill Irrigation	Sprinkler Irrigation	Soil Testing	> 1 Type Fertilizer
Fall Total N = 93	22.7	2.01%	24%	23%	71%	75%	
Liquid = 29	24.62	2.28%	38%	12%	88%	90%	55%
Solid N = 18	32.33	2.15%	28%	39%	61%	78%	50%
Commercial N = 59	20.27	1.9%	20%	26%	67%	80%	37%
None listed N = 10	15.5	1.94%	20%	10%	80%	50%	

For the spring sampling (N=82) nitrate levels were close together at shallow levels and spread out at deeper levels.

Graph 26. Spring Sampling by Fertilizer Type



34

There were 36 fields (44%) that received liquid manure. 18 of these fields also received commercial fertilizer. All had soil testing. These fields had the highest ammonia levels and the highest percentage of organic matter. They were most likely to be double cropped and had the highest percentage of sprinkler irrigation.

There were 10 fields (12%) that received solid manure. In contrast to the fall soil sampling these fields with solid manure had the lowest ammonia levels and the lowest levels of organic matter. They were least likely to be double cropped, least likely to receive sprinkler irrigation and most likely to receive drip irrigation. 60% received other additional fertilizers.

There were 36 fields (44%) that received commercial fertilizer. 18 of these fields also received liquid manure. These fields had the second highest ammonia levels and the second highest levels of organic matter.

There were 25 fields with no documented fertilizers. This includes fifteen fields with no survey data returned. These fields had the lowest levels of ammonia and organic matter.

Table 12. Analysis of Fertilizer Types for Spring Sampling – LYV GWMA DSS

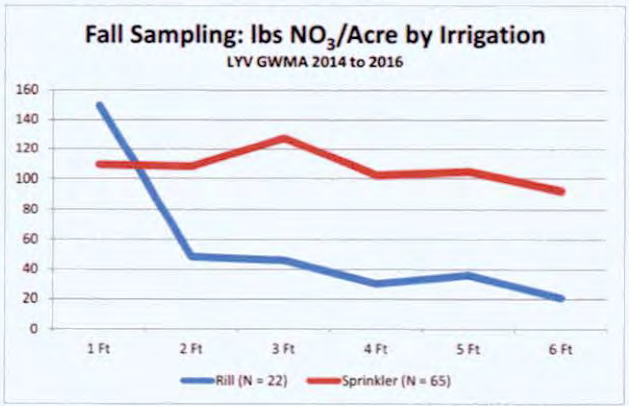
	NH_3 lbs/ac	Organic Matter	Double Cropped	Rill Irrigation	Sprinkler Irrigation	Drip Irrigation	Soil Testing	> 1 Type Fertilizer
Spring Total N = 82	23.8	2.13%	46%	10%	76%	10%	99%	35%
Liquid N = 36	30.86	2.36%	69%	8%	92%	0%	100%	56%
Solid N = 10	20.8	2.07%	50%	10%	70%	20%	100%	60%
Commercial N = 36	26.28	2.21%	56%	8%	78%	14%	97%	58%
None Listed N = 25	18.44	1.85%	4%					

Type of Irrigation: One field in the 93 fall samples received no irrigation. Five fields received drip irrigation and that analysis was complicated by early refusals and the fact that two fields had extremely high and unusual nitrate readings. For this reason drip irrigation is not included in the fall analysis.

Nitrate levels for the 65 fields that received sprinkler irrigation remained around 100 lbs per acre at all levels while the readings for the 22 fields that received rill irrigation rapidly declined after 1 foot.

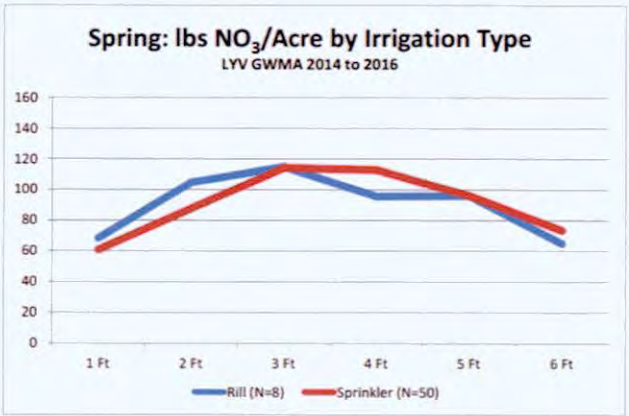
There were 2 fields that had both rill and sprinkler irrigation. They were placed in the rill category according to the DSS plan.

Graph 27.



For clarity only rill and sprinkler irrigation for spring sampling are presented here.

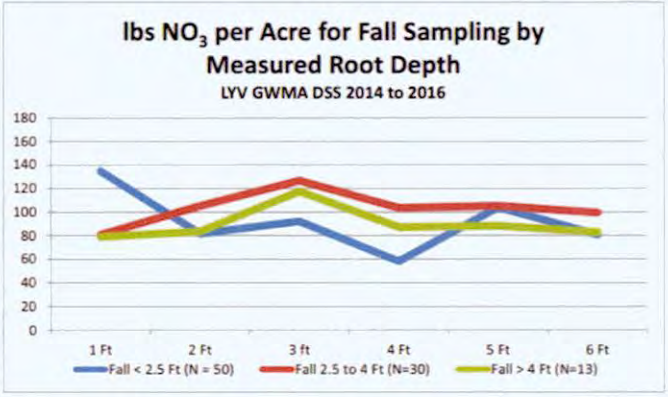
Graph 28.



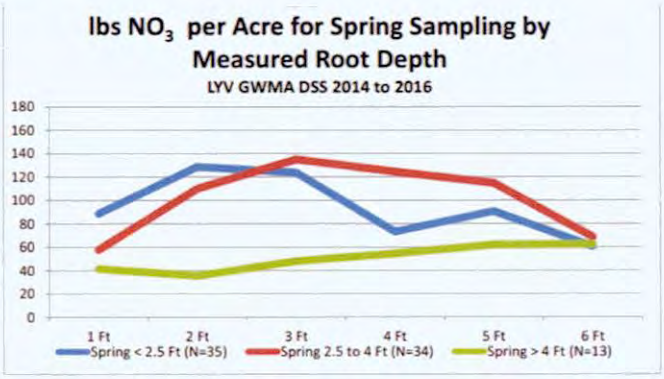
36

Measured Root Depth: The teams that gathered the soil samples measured root depths on each sampled field. This makes possible a comparison of nitrate levels based on how deep the root of crops penetrated the soil. This is not the same as grouping root depth by crops.

Graph 29.



Graph 30.



37

Table 13. NO_3 Levels by Measured Root Depths for Fall & Spring DSS

	Fall 2014 & 2015		Average N by Measured Root Depths						
Group	N	1 FT	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft	Ammonia	Organic
< 2.5 Ft	50	134.72	81.76	92.02	58.15	103.91	80.63	35.46	2.06%
2.5 to 4 Ft	30	160.8	105.2	126.63	103.57	105.23	99.32	17.67	1.87%
> 4 Ft	13	78.92	83.38	117.54	87.08	88.17	82.83	23.69	2.12%
	Spring 2015 & 2016		Average N by Measured Root Depths						
Group	N	1 FT	2 Ft	3 Ft	4 Ft	5 Ft	6 Ft	Ammonia	Organic
< 2.5 Ft	35	88.6	128.63	123.64	73.1	90.6	60.5	23.23	2.21%
2.5 to 4 Ft	34	57.85	110.06	134.88	124.47	114.68	68.54	21.79	2.1%
> 4 Ft	13	41.54	35.46	48.08	54.54	62	62.46	30.62	2.03%

The measured root depths are different from the classification of root depths according to crop type. There is a full range of crops in each category of measured root depths. For example the category < 2.5 feet in the fall sampling included fields planted in triticale, corn, pasture, alfalfa, grapes, barley, mint, apples, grass hay, hops, and pears.

Note the lower nitrate levels for samples where the roots extend to deeper levels.

Statistical Analysis

Another way to look at the data is to describe the sampling at different soil depths. For the sake of brevity this paper only looks at the 2 Ft and 4 Ft depths. Two feet is the approved level for deep soil testing in Ecology's newly released CAFO General Permit. Four feet is below the root depth for most crops in the DSS and consequently estimates nitrate available for leaching.

The analyses that follow look at the results of soil testing at these levels from a statistical perspective. Previous graphing shows apparent differences in nitrate levels with respect to crops, irrigation, fertilizers and leaching factors. The Student T-test is used here to determine whether those differences have statistical significance. The calculations are

based on whether a factor is present or not present. There is no attempt to measure complex associations.

Two Foot Analysis

Table14. Characteristics of Risk Levels at Two Foot Sampling Depths (Low Risk is < 55 lbs NO_3/Acre, Medium Risk/High Risk is 55 lbs NO_3/Acre to 165 lbs NO_3/Acre, Very High Risk is > 165 lbs NO_3/Acre)

		Low Risk	Medium/High Risk	Very High Risk
N		96	47	27
Irrigation				
	Rill	19 (20%)	6 (13%)	3 (11%)
	Sprinkler	62 (65%)	35 (74%)	18 (67%)
	Drip	4 (4%)	4 (9%)	4 (15%)
	Unknown/None	12 (12%)	2 (4%)	2 (7%)
Crops				
	Alfalfa	19 (20%)	6 (13%)	2 (7%)
	Apples	3 (3%)		1 (4%)
	Asparagus			2 (7%)
	Barley	1 (1%)		
	Cherries	3 (3%)		
	Corn Grain		2 (4%)	2 (7%)
	Fallow		1 (2%)	
	Corn Silage		9 (19%)	2 (7%)
	Grapes	3 (3%)	1 (2%)	2 (7%)
	Hay	3 (3%)		
	Hops	4 (4%)	3 (6%)	3 (11%)
	Mint	6 (6%)	1 (2%)	
	Pasture	5 (5%)	1 (2%)	
	Pears	1 (1%)		
	Sudan Grass		1 (2%)	
	Triticale	19 (20%)	21 (45%)	10 (37%)
	Wheat	2 (2%)		2 (7%)
	Wine Grapes	1 (1%)	1 (2%)	
	Unknown	11 (11%)		1 (4%)
	Double Crop	26 (27%)	15 (32%)	10 (37%)

Fertilizer				
	Liquid Manure	29 (30%)	22 (47%)	12 (44%)
	Solid Manure	17 (18%)	8 (17%)	3 (11%)
	Commercial	54 (56%)	26 (55%)	13 (52%)
	Biosolids			1 (4%)
	Compost	2 (2%)		
	Unknown/None		7 (15%)	5 (19%)
Leaching				
	Low	5 (5%)	4 (9%)	1 (4%)
	Moderate	78 (81%)	39 (83%)	25 (93%)
	High	13 (14%)	4 (9%)	1 (4%)

A. Irrigation Types: Analysis using the Student T-test at the 2 foot soil testing depth finds no statistically significant difference in nitrate levels for different types of irrigation except that rill irrigation is associated with lower nitrate levels at the $p < .10$ level of significance.

Rill Irrigation: The average nitrate level at two feet for fields that received rill irrigation is 61.67 lbs per acre. The average nitrate level at two feet for fields with documented irrigation type that did not receive rill irrigation is 102.66 lbs per acre. *The t-value is -1.41917. The p-value is .078941. The result is not significant at $p < .05$ but it is significant at $p < .10$.*

B. Crops by Category from DSS Plan: Analysis using the Student T-test was performed for crops at the < 2.5 ft root depth, 2.5 to 4 ft root depth, > 4 ft root depth, > 4 ft root depth minus alfalfa, for alfalfa, corn silage and triticale. Soil tests for fields with no documented crops were omitted from the calculations. Most results were not statistically significant. Here are the noteworthy results.

< 2.5 Ft Root Depth: The average nitrate level at two feet for this category was 24.43 lbs per acre (N=7). The average nitrate level for all other categories was 102.58 lbs per acre. *The t-value is -1.34184. The p-value is .090799. The result is not significant at $p < .05$ but it is significant at $p < .10$.*

Alfalfa: The average nitrate level at two feet for alfalfa was 60.30 lbs per acre. The average nitrate level for all other crops was 107.11 lbs per acre. *The t-value is -1.47226. The p-value is .071482. The result is not significant at $p < .05$ but it is significant at $p < .10$.*

Triticale: The average nitrate level at two feet for triticale was 133.90 lbs per acre. The average nitrate level for all other crops was 83.01 lbs per acre. *The t-value is 1.98851. The p-value is .024252. The result is significant at p < .05.*

C. Fertilizer: It appears that the type of fertilizer impacts nitrate levels at two feet.

a. Looking at all 170 samples with results at two feet the Student T-test tells us that the higher levels of nitrates seen with application of liquid manure are significant.

Liquid M: The average nitrate level at two feet for fields that received liquid manure is 125.57 lbs per acre. The average level for fields that did not receive liquid manure is 79.24 lbs per acre. *The t-value is 1.94819. The p-value is .026529. The result is significant at p < .05.*

Commercial: The average nitrate level for fields that received commercial fertilizer is 80.18 lbs per acre. The average nitrate level for fields that did not receive commercial fertilizer is 116.49 lbs per acre. *The t-value is -1.56554. The p-value is .059669. The result is not significant at p < .05 but it is significant at p < 0.10.*

Differences in nitrate levels for other fertilizer types are not significant for this data set.

b. If we leave out the fields with no documented fertilizer applications and look only at the 135 samples known to receive fertilizer the Student T-test tells us that, at two feet, the higher levels of nitrates seen with application of liquid manures and the lower levels seen with application of commercial fertilizer are significant.

Liquid M: The average nitrate level at two feet for fields that received liquid manure is 125.57 lbs per acre. The average nitrate level for fertilized fields that did not receive liquid manure is 67 lbs per acre. *The t-value is 2.39048. The p-value is .009114. The result is significant at p < .05.*

Commercial: The average nitrate level at two feet for fields that received commercial fertilizer is 80.18 lbs per acre. The average nitrate level for fertilized fields that did not receive commercial fertilizer is 126.78 lbs per acre. *The t-value is -1.73592. The p-value is .042447. The result is significant at p < .05.*

D. Leaching Categories: 142 out of the 170 fields (84%) with data at two feet had soils in the moderate to moderately high Ksat category. This makes analysis of leaching less certain. This data showed no significant differences in nitrate levels for the three leaching categories except for a possible mild effect at the p < .10 level of significance.

Moderate: The average nitrate value at the two foot level for fields with moderately high to high Ksat soils was 103.93 lbs per acre. The average nitrate level for fields not in that category was 58.29 lbs per acre. *The t-value is 1.46704. The p-value is .072118. The result is not significant at p < .05 but it is significant at p < .10.* Note that both low to moderately low and high to very high fields had lower nitrate levels than moderately high to high. The graph is dome shaped and not a straight line.

Four Foot Analysis

Table15. Characteristics of Risk Levels at Four Foot Sampling Depths (Low Risk is < 55 lbs NO_3/Acre, Medium Risk/High Risk is 55 lbs NO_3/Acre to 165 lbs NO_3/Acre, Very High Risk is > 165 lbs NO_3/Acre)

		Low Risk	Medium/High Risk	Very High Risk
N		89	34	24
Irrigation				
	Rill	21 (23%)	6 (18%)	2 (8%)
	Sprinkler	52 (59%)	23 (68%)	19 (79%)
	Drip	7 (8%)	4 (12%)	
	Unknown/None			3 (13%)
Crops				
	Alfalfa	16 (18%)	3 (9%)	4 (21%)
	Apples	2 (2%)	1 (3%)	
	Asparagus			2 (8%)
	Barley	1 (1%)		
	Cherries	1 (1%)		
	Corn Grain	4 (4%)	2 (6%)	
	Corn Silage	13 (15%)	5 (15%)	2 (8%)
	Grapes	2 (2%)	1 (3%)	2 (8%)
	Hay	3 (3%)		
	Hops	7 (8%)	3 (9%)	
	Mint	5 (6%)	2 (6%)	
	Pasture	5 (6%)		
	Pears	1 (1%)		
	Sudan Grass	1 (1%)		
	Triticale	16 (18%)	15 (44%)	12 (50%)

	Wheat	1 (1%)	1 (3%)	
	Wine Grapes	2 (2%)		
	Unknown	9 (10%)	1 (3%)	1 (4%)
	Double Crop	19 (21%)	13 (38%)	12 (50%)
Fertilizer				
	Liquid Manure	20 (23%)	17 (50%)	11 (46%)
	Solid Manure	20 (23%)	5 (15%)	1 (4%)
	Commercial	47 (53%)	16 (47%)	8 (33%)
	Biosolids	2 (2%)		1 (4%)
	Compost			
	Unknown/None	10 (11%)	1 (3%)	9 (38%)
Leaching				
	Low	2 (2%)		1 (4%)
	Moderate	76 (85%)	30 (88%)	22 (92%)
	High	11 (12%)	4 (12%)	1 (4%)

A. Irrigation Type: Analysis using the Student T-test at the 4 foot level finds a statistically significant association between sprinkler irrigation and higher nitrate levels and a statistically significant association between rill irrigation and lower nitrate levels.

Rill Irrigation: The average nitrate reading at 4 feet for fields that receive rill irrigation was 40.3 lbs per acre. The average reading for fields that did not receive rill irrigation was 98.54 lbs per acre. *The t-value is -1.92605. The p-value is .028124. The result is significant at $p < .05$.*

Sprinkler Irrigation: The average nitrate reading at 4 feet for fields that receive sprinkler irrigation was 106.59 lbs per acre. The average reading for fields that did not receive sprinkler irrigation was 37.66 lbs per acre. *The t-value is 2.54584. The p-value is .006025. The result is significant at $p < .05$.*

Drip Irrigation: The average nitrate reading at 4 feet for fields that receive drip irrigation was 30.45 lbs per acre. The average reading for fields that did not receive drip irrigation was 90.42 lbs per acre. *The t-value is -1.29622. The p-value is .098581. The result is not significant at $p < .05$ but it is significant at $p < .10$.*

B. Crops: Analysis using the Student T-test was performed for crops at the < 2.5 ft root depth, 2.5 to 4 ft root depth, > 4 ft root depth, > 4 ft root depth minus alfalfa, for alfalfa, corn

silage and triticale. Soil tests for fields with no documented crops were omitted from the calculations. The only statistically significant results were for triticale.

Triticale: The average nitrate level at four feet for triticale was 142.81 lbs per acre. The average nitrate level at four feet for all other crops was 66.46 lbs per acre. The *t*-value is 2.75448. The *p*-value is .003348. The result is significant at $p < .05$.

Unusually high nitrate levels at four feet for a few alfalfa fields complicate the analysis.

C. Fertilizer: The data suggests that the type of fertilizer impacts nitrate levels at four feet.

a. Looking at all 147 samples that had data at 4 feet the Student T-test tells us that the higher levels of nitrates seen with application of liquid manure are significant. There may be a more modest reduction of nitrate levels with solid manure and commercial fertilizer.

Liquid M: The average nitrate level at four feet for fields that received liquid manure is 139.65 lbs per acre. The average for fields that did not receive liquid manure is 60.61 lbs per acre. *The t-value is 3.08855. The p-value is .001206. The result is significant at $p < .05$.*

Solid M: The average nitrate level at four feet for fields that received solid manure is 47.85 lbs per acre. The average for fields that did not receive solid manure is 94.7 lbs per acre. *The t-value is -1.45353. The p-value is .074119. The result is not significant at $p < .05$ but it is significant at $p < .10$.*

Commercial: The average nitrate level at four feet for fields that received commercial fertilizer is 68.19 lbs per acre. The average for fields that did not receive commercial fertilizer is 108.79 lbs per acre. *The t-value is -1.64521. The p-value is .051047. The result is not significant at $p < .05$ but it is significant at $p < .10$.*

b. Looking only at the 117 samples that had data at 4 feet and received fertilizer, the Student T-test tells us that the increased nitrate levels associated with liquid manure and the decreased nitrate levels associated with commercial fertilizer are significant.

Liquid M: The average nitrate level at four feet for fields that received liquid manure is 139.65 lbs per acre. The average for fertilized fields that did not receive liquid manure is 45.71 lbs per acre. *The t-value is 3.4706. The p-value is .000366. The result is significant at $p < .05$.*

Solid M: The average nitrate level at four feet for fields that received solid manure is 47.85 lbs per acre. The average for fertilized fields that did not receive solid manure is 94.65 lbs per acre. *The t-value is -1.40234. The p-value is .081753. The result is not significant at $p < .05$ but it is significant at $p < .10$.*

Commercial: The average nitrate level at four feet for fields that received commercial fertilizer is 68.19 lbs per acre. The average for fertilized fields that did not receive commercial fertilizer is 120.39 lbs per acre. *The t-value is -1.74448; p-value is .041874. The result is significant at p < .05.*

D. Leaching: There were no statistically significant differences in the nitrate levels at four feet for the three leaching categories in this study.

Conclusion

This summary of the LYV GWMA DSS concludes that:

- There are differences between spring and fall deep soil testing results
- There was unequal coverage of the various combinations of irrigation practices, crop types and leaching factors.
    - Data was gathered for 15 out of 27 categories.
    - Only 7 categories had six or more samples
    - One category had 3 samples
    - Two categories had 2 samples
    - Five categories had only one sample.
- Sixty five of 175 samples or 37% fell into the category of sprinkler irrigation, 2.5 ft to 4 ft crops and moderately high to high Ksat
- There were fields with extreme values that would ideally be re-tested. Those fields are #'s 3141, 2044, 2047, 4152, 3117, and 3119.
- The two asparagus samples, #'s 4175 and 4176 may not be representative of that crop
- The range of values for alfalfa is huge and suggests a need for further study
- The range of values for hops is large and suggests a need for further study
- Over half of the fields planted in triticale are at medium to high risk for leaching nitrate to the groundwater
- Double cropping is associated with higher nitrate levels
- In this data set rill irrigation is more protective of the groundwater than sprinkler irrigation
- Application of liquid manure is significantly more likely to result in high nitrate levels
- There is more soil testing on fields with higher nitrate levels.
- There are wide ranges in values for many of the crops in this data set.
- Some of the project purposes were not achieved in this round of DSS. Baseline data for many of the crops and conditions is still lacking. However there is adequate information to proceed with recommendations regarding triticale and application of liquid manure.

References

Lower Yakima Valley Groundwater Management Area (2014) *Deep Soil Sampling Plan Lower Yakima Valley Groundwater Management Area.* (Attachment 1)

Lower Yakima Valley Groundwater Management Area (2013) *PP Summary of Proposed Allocation Processes.* (Attachment 2)

WA State Dept. of Agriculture (2017*) Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area.* Available in draft form only.

WA State Dept. of Ecology (2017) *Concentrated Animal Feeding Operation General National Pollutant Discharge Elimination System and State Waste Discharge General Permit.* Available at http://www.ecy.wa.gov/programs/wq/permits/cafo/docs/01182017CombinedPermit.pdf

WA State Dept. of Ecology (2017) *Concentrated Animal Feeding Operation State Waste Discharge General Permit.* Available at http://www.ecy.wa.gov/programs/wq/permits/cafo/docs/01182017StatePermit.pdf

Deep Soil Sampling Analysis of Fields Planted in Triticale

Lower Yakima Valley Groundwater Management Area Deep Soil Sampling Analysis of Fields Planted in Triticale/Corn Silage

By Jean Mendoza

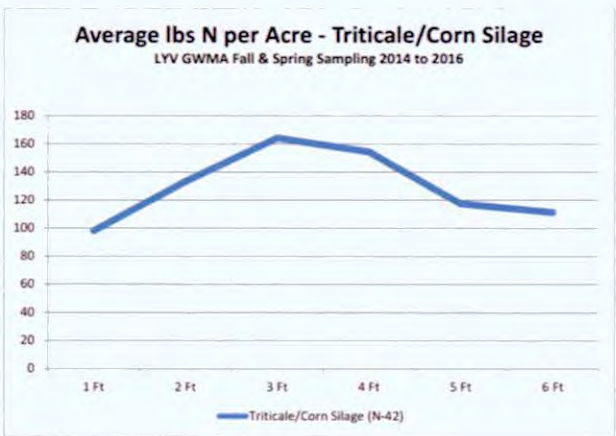
July 2017

Between the fall of 2014 and the spring of 2016 the Lower Yakima Valley (LYV) Groundwater Management Area (GWMA) contracted with the South Yakima Conservation District and Landau Associates to perform four rounds of deep soil sampling (DSS) on agricultural land in the GWMA target area. All fields were voluntarily submitted and anonymously recorded. 24% of the fields (42 out of 175) were double cropped in Triticale/Corn Silage (40) or Triticale/Sudan Grass (2). This is the largest number for any crop in the DSS and lends itself to a more detailed study.

Overview of the Data

Below is a graph that depicts the nitrate levels in lbs of nitrate (NO_3) per acre at depths by one foot increments.

Graph 1.



1

The average field was 55.5 acres. Soil testing was done on all fields. Testing was done twice a year for 27 of the fields (64%) and annually for 15 of the fields (36%). There was rill irrigation on one field, rill & sprinkler irrigation on two fields and sprinkler irrigation only on thirty nine fields.

Liquid manure was applied to 31 of the fields (74%), solid manure to 5 of the fields (12%), commercial fertilizer to 26 (of the fields 62%) and bio-solids to 1 of the fields (2%). More than one type of fertilizer was used on 22 of the fields (52%).

The capacity of the most limiting layer to transmit water (Ksat) classifications were "very low to moderately low" on 4 of fields (10%), "moderately high to high" on 34 of fields (81%), and "high to very high" on 4 of fields (9%).

There was early refusal of the soil drilling equipment on one field at 2 feet, four more at 3 feet, one more at 4 feet and six more at 5 feet. Early refusal was more likely in the soils classified as very low to moderately low leaching.

Average root depth was 2.87 feet and the median was 2.85. The range for root depths was 1 ft to 5.8 ft.

Data Analysis for Triticale/Corn Silage

Table 1. Nitrate in lbs per Acre for Triticale/Corn Silage

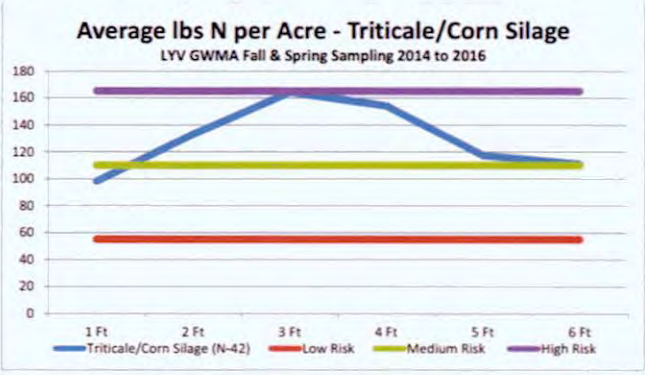
	1 FT	2Ft	3 Ft	4 Ft	5 Ft	6 Ft	Total	NH_3	Organic
Average (lbs/acre)	98.07	133.24	164.3	154.36	117.43	111.2	668.5	29	2.25
Median (lbs/acre)	57	60	87	89	60	66	356.5	24	2.18
Range (lbs/acre)	4 to 467	3 to 986	3 to 892	3 to 726	6 to 576	4 to 565	17 to 3754	9 to 108	0.95 to 3.94
Early Refusal (ft)	0	1	5	6	12	12			

The median is much less than the average at all depths. The data has a positive skew.

The sampling shows that there are high nitrate levels at depths where the crops no longer take up the nitrate for plant use. In other words, there is significant leaching to the aquifer from fields planted in triticale/corn silage.

One way to look at the data is to determine how many fields have nitrate levels above the risk levels that were defined by Ecology (2017) for the CAFO General Permits. According to that document there is low risk when nitrate levels at two feet are < 55 lbs per acre, medium risk when levels are 55lbs per acre to 110 lbs per acre, high risk when levels are 110 lbs per acre to 165 lbs per acre and very high risk when levels are > 165 lbs per acre. The average level of nitrate in this study was in the high risk range for all levels except one foot.

Graph 2.



Analysis at the Two Foot Level

Another way to analyze the material is to look at the two foot level where most nutrient management plan decision making is done for Eastern Washington. Numbers in the table below were sorted by size for the two foot level. There were 19 samples in the low risk category (< 55 lbs/acre), 14 samples in the medium risk category (55lbs/acre to 110 lbs/acre), none in the high risk category (110 lbs/acre to 165 lbs/acre) and 9 samples in the very high risk category (>165lbs/acre).

Table 2.

Field ID #	1 FT lbs/ac	2Ft lbs/ac	3 Ft lbs/ac	4 Ft lbs/ac	5 Ft lbs/ac	6 Ft lbs/ac	Total lbs/ac	Ammonia lbs/ac	Organic Matter
Very High Risk		N = 9 (21%)							
2058	119	986	892	694	407	287	3385	16	1.92%
3094	467	644	776	726	576	565	3754	50	2.85%
3108	311	465	612	684	247	264	2583	27	2.66%
3106	316	445	465	248	256	222	1952	15	0.95%
3097	336	363	335	263	113	64	1474	28	2.18%
2063	227	337	424	528			1516	24	3.94%
2065	213	304					517	15	2.59%
3121	275	193	162	137	202	272	1241	32	2.91%
2066	44	182	193				419	24	3.23%
Medium Risk		N = 14 (33%)							
2037	50	106	226	183	149	72	786	93	1.9%
3110	93	100	125	154	283	413	1168	34	2.19%
2067	19	97	197	115	40	27	495	18	1.56%
3115	82	90	149	111	192	195	819	14	1.67%
3095	60	90	140	178			468	17	1.92%
2078	49	89	86	156	172	111	663	27	2.62%
2046	36	88	95	70	65	72	426	33	2.67%
4167	97	81	88	13			279	68	1.39%
1004	177	79	63	69	42	50	480	16	2.06%
3112	39	73	87	95	47	38	379	22	1.87%
2079	9	66	127	173	98	108	581	17	2.62%
3109	82	60	223	238	56	100	759	12	1.48%
2053	84	58					142	11	1.59%
2035	55	56	56	103	110	93	473	108	3.04%
Low Risk		N = 19 (45%)							
2081	75	48	40	42	32	24	261	35	2.45%
2036	90	47	31	23	12	6	209	65	2.37%
3111	35	45					80	24	1.59%
2068	7	35	137	115			294	13	1.71%
3086	139	30	33	56	47	29	334	14	1.76%
2070	37	26	63	83	51	38	298	9	0.98%
2064	52	26	43	26			147	19	3.21%
2040	41	25	13	36	88	68	271	26	3.09%
2082	41	22	55	70	58	74	320	25	3.36%

4

2077	26	22	26	25	35	41	175	16	1.81%
3122	101	20	14	3	16	4	158	23	2.07%
4159	34	16	36	27	7	9	129	40	2.41%
2080	15	15	27	44			101	17	2.63%
2050	18	9	21	43	61	51	203	25	2.95%
4161	66	9	6	5	8	8	102	39	2.59%
3096	27	8	10	17	47	19	128	44	2.06%
4158	12	5					17	38	2.18%
2041	4	3	3	4	6	12	32	9	1.46%
2052	59						59	16	2.16%

These nitrate values do not conform to a normal curve but statistical analyses can be done by plotting log values for the nitrate levels. This normalizes the data and tells us that 95% of the nitrate levels at 2 feet for the fields in this study will lie between 4.2 lbs per acre and 815.2 lbs per acre. This is a very large range. There are 2 out of 41 values in the study that lie outside the 95 percentile range. They are 3 lbs per acre at the low end and 986 lbs per acre at the high end.

Analysis of Irrigation Practices found that most samples (89% to 100%) used sprinkler. There is a small trend for lower risk fields to use rill irrigation but the numbers are not large enough to prove statistical significance. :

Table 3. Irrigation Practices and Risk Levels for Triticale/Corn Silage

	Low Risk	Medium/High Risk	Very High Risk	All Samples
Rill	2 (11%)	1 (7%)	0 (0%)	3 (7%)
Sprinkler	17 (89%)	13 (93%)	9 (100%)	39 (93%)
Drip	0 (0%)	0 (0%)	0 (0%)	0 (0%)

There were no dose dependent relationships for ammonia or organic matter and risk

Table 4. Average Ammonia & Organic Matter Levels for Triticale/Corn Silage

	Low Risk	Medium/High Risk	Very High Risk	All Samples
Ammonia	26.16	35.00	25.67	28.27
Organic Matter	2.25	2.04	2.58	2.32

Note: Field #2035 in the Medium Risk category had an unusually high ammonia level of 108 #/acre

5

There were no clear trends regarding crop yields and risk categories:

Table 5. Crop Yield for Triticale & Corn Silage in Different Risk Levels

	Low Risk	Medium Risk	Very High	All Samples
Average of Most Recent Crop Yields for Triticale in Tons	8.14 T	8 T	8.22 T	8.11 T
Average of Most Recent Crop Yields for Corn Silage in Tons	29.39 T	31.25 T	30.22 T	30.15 T

There were no clear trends regarding impact of fertilizer type for these crops:

Table 6. Percentage of Fields that Received Major Types of Fertilizer for Triticale/Corn

	Low Risk	Medium Risk	Very High Risk	All Samples
Liquid Manure	15 (79%)	10 (71%)	6 (86%)	31 (74%)
Solid Manure	3 (16%)	1 (7%)	1 (14%)	5 (12%)
Commercial Fertilizer	12 (63%)	10 (71%)	4 (57%)	26(62%)
Biosolids	0 (0%)	0 (0%)	1 (14%)	1(2%)
Unknown	0 (0%)	1 (7%)	0 (0%)	1 (2%)
More Than One Type	10 (53%)	8 (57%)	4 (44%)	22 (52%)

There were no clear trends regarding soil type and leaching potential for these crops:

Table 7. Soil Categories and Risk Levels for Triticale/Corn Silage

	Low Risk	Medium Risk	Very High Risk	All Samples
Low to Moderately Low	2 (11%0	1 (7%)	1 (11%)	4 (10%)
Moderate to High Ksat	14 (74%)	13 (93%)	7 (78%)	34 (81%)
High to very High Ksat	3 (16%)	0 (0%)	1 (11%)	4 (10%)

The major conclusion from analysis of data at the two foot level is that over half of the fields in this study are at medium to very high risk for leaching to the groundwater.

Analysis Based on Median Levels at One Foot Intervals

Another way to analyze the data is to look at median levels of nitrate in lbs per acre at each level of testing. Half of all fields in a data set are above the median level and half are below the median level. The data in this study is skewed positively, meaning that median values are lower than average values. In this study half of nitrate levels were above:

a. 57 lbs per acre at one foot

b. 60 lbs per acre at two feet

c. 87 lbs per acre at three feet

d. 89lbs per acre at four feet

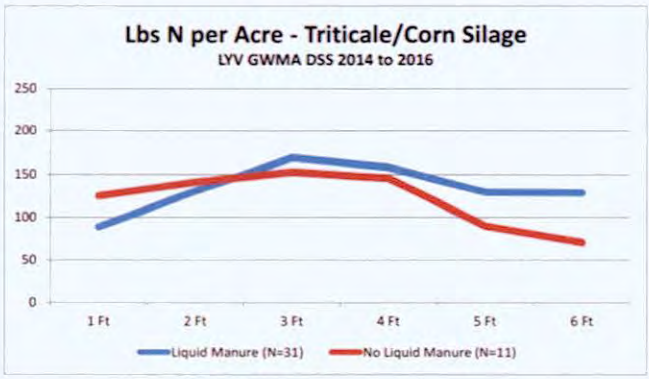
e. 60#lbs per at five feet

f. 66 lbs per acre at six feet.

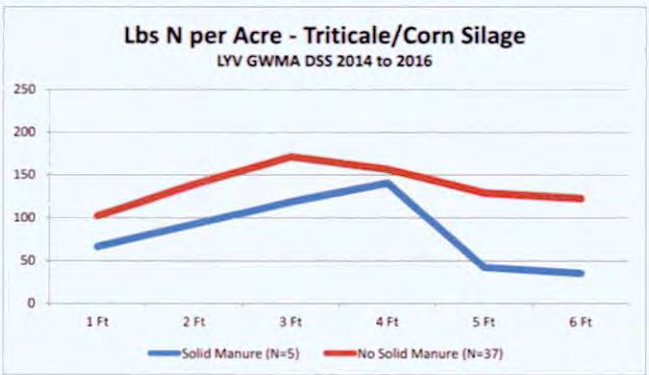
Types of Fertilizers

Analysis of the DSS as a whole indicates that nitrate levels are higher when liquid manure is applied to the fields. Application of solid manure, on the other hand, is associated with lower nitrate levels. The graphs below describe nitrate levels for triticale/corn silage fields based on yes or no for application of each major class of fertilizer. 52% of the fields received more than one type of fertilizer and this practice was associated with a reduction in nitrate levels.

Graph 3. Fields that Received Liquid Manure and Those That Did Not

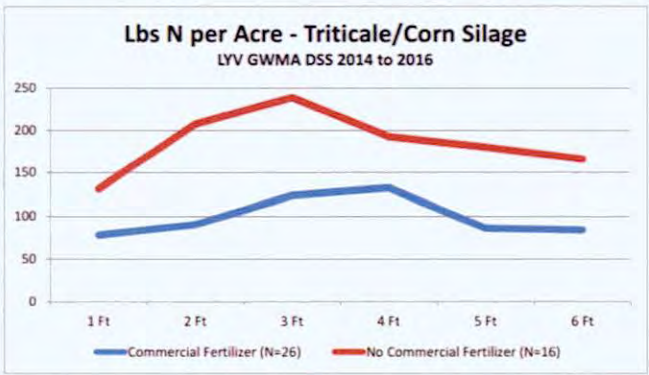


Graph 4. Fields that Received Solid Manure and Those That Did Not

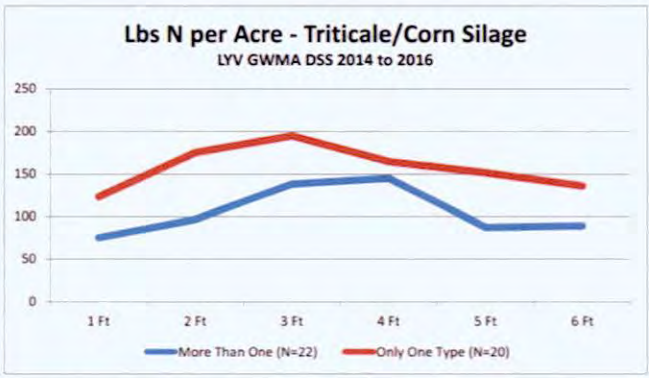


8

Graph 5. Fields That Received Commercial Fertilizer and Those That Did Not



Graph 6. Fields That Received More Than One Type of Fertilizer or Did Not



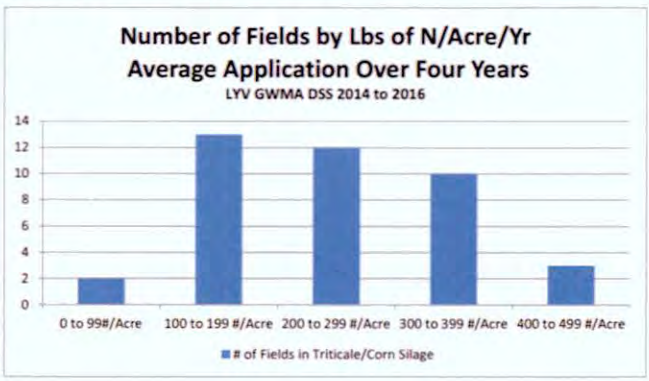
Could this indicate that farmers who apply more than one type are more thoughtful about fertilizer applications?

9

Amount of Fertilizer

DSS surveys asked farmers how much nitrogen they applied in lbs N per acre to the sampled fields. Average application over four years was calculated for each field and the number of fields with application of 0 to 99lbs, 100 to 199 lbs, 200 to 299 lbs, 300 to 399 lbs and 400 to 499 lbs was counted.

Graph 7. Range of Fertilizer Application Rates to Triticale/Corn Silage Fields in DSS



According to the WSDA Nitrogen Loading Assessment (2017) and the recommendations of members of the GWMA Irrigated Ag Work Group the average uptake of nitrogen for corn silage is 270 #/acre. The uptake by triticale ranges from a low of 190 lbs per acre to a high of 210 lbs per acre. This indicates that most farmers in the DSS apply less than the recommended amounts of nitrogen to triticale/corn silage fields.

Some fields received high amounts of nitrogen fertilizer in single years. For example, Field # 2065 received 575lbs of N per acre in 2013; Fields # 2066 received 500 lbs of N per acre in 2012; Field # 2046 received 500 lbs of N per acre in three out of four years.

There is a clear upward trend in nitrogen application related to level of risk: On average fields in the low risk level received 211 lbs N per acre; those in the medium to high level received 250 lbs N per acre and those in the very high level received 258 lbs per acre.

Table 8. Average Nitrogen Application at Different Risk Levels

	Low Risk	Medium/High Risk	Very High Risk	All Samples
Average N Application in lbs per Acre	211.45	249.92	258.25	237.06
Range of Average N Applications in lbs per Acre	31.25 - 379.75	105 to 436	170 to 391.25	31.25 - 436

Relationships can be examined by looking at the ratio of Total Nitrogen to Average Applied Nitrogen. Calculated Total Nitrogen is the sum of measurements at all six foot levels. Therefore those samples with early refusal were deleted from this analysis. The average ratios of Total Nitrogen to average Applied Nitrogen - were:

Very High Risk: 11.82 (Range = 7.44 to 20.42)

Medium to High Risk: 3.22 (Range = 1.10 to 7.23)

Low Risk: 1.52 (Range = 0.29 to 6.50)

References

WA State Dept. of Agriculture (2017) *Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area.* Available in draft form only.

WA State Dept. of Ecology (2017) *Concentrated Animal Feeding Operation General National Pollutant Discharge Elimination System and State Waste Discharge General Permit.* Available at http://www.ecy.wa.gov/programs/wq/permits/cafo/docs/01182017CombinedPermit.pdf

WA State Dept. of Ecology (2017) *Concentrated Animal Feeding Operation State Waste Discharge General Permit.* Available at http://www.ecy.wa.gov/programs/wq/permits/cafo/docs/01182017StatePermit.pdf

Errata

Towards the end of this analysis it was noted that two of the fields were planted in Sudan grass as well as the Triticale/Corn Silage combination. This could impact the data. The fields planted in Sudan grass were # 2046 and # 3096.

Appendix G – Best Management Practices Recommended by Irrigated Agriculture Work Group

Best Management Practices for Irrigated Cropland

OB = objective; MT = management target; BMP = best management practice

The IAWG has reviewed the list of BMPs compiled by HDR that could be implemented on irrigated cropland activities which may provide protections to nitrate (N) leaching to groundwater. These include irrigation practices, cropping practices, and N source management (type, quantity, and timing).

The IAWG believes that the core BMPs to reduce negative impacts to ground water are
1) managing nutrient inputs to ensure that the 4R's are utilized (right amount, the right source, the right timing, and the right location) (accounting for all sources including soil amendments, compost, biosolids, manure and commercial fertilizer) and
2) irrigation water management.
The IAWG felt that these two BMPs had the greatest potential to reduce the problem. They are also beneficial to all parties.
The IAWG believes the BMPs included in the table below will not replace the core BMPs above but may provide additional proctections to ground water. The BMPs listed in the table below have a range of applicability in the Lower Yakima Valley GWMA. Some are potentially very effective, some moderately effective, and some that have no applicability in this GWMA. The comments in the right hand column are a compilation of input from the IAWG and are intended to provide the GWAC with some sense of the effectiveness of the BMPs as they would apply to this specific GWMA. The IAWG emphasized that the BMPs are voluntary, not always suited to a particular farm, and still require the judgment of the farm operator to achieve the desired results.

Management Target	Best Management Practices	References	Work Group Comments
MT 1.1.1 Perform irrigation system evaluation and monitoring	BMP 1.1.1.1 Conduct irrigation system performance evaluation	EM 4885 – IP 2.01.03; PNW 293; EM4828	More practical to preform routine maintenance and observe uniformity of coverage.
	BMP 1.1.1.2 Install and use flow meters or other measuring devices to track water volume applied to each field at each irrigation	EM 4885 – IP 2.01.01	Meters not practical; soil moisture sensing devices are used effecively - even required in some cases, to monitor and schedule irrigation.
	BMP 1.1.1.3 Conduct pump performance tests	EM 4885 – IP 2.01.02	Relatively simple and easy to do. Requires an ultrasonic flow meter and pressure gage.
MT 1.1.2 Improve irrigation scheduling	BMP 1.1.2.1 Use weather based irrigation scheduling	EM 4885 – IP 2.01.05, 2.01.06	This is one of the most practical way to help solve the issues. It is now free and easy to do. (http://weather.wsu.edu/is)
	BMP 1.1.2.2 Use plant-based irrigation scheduling	EM 4885 – IP 2.01.05, 2.01.06; EM4821; EB1513	Time consuming to do, unless there are automated sensors. Research is still being done in this area. It is not easy or very accurate.
	BMP 1.1.2.3 Measure soil moisture content to guide irrigation timing and amount	EM 4885 – IP 2.01.05, 2.01.06; PNW0475	Soil moistures sensors are expensive and data-interpretation requires assistance.
	BMP 1.1.2.4 Avoid heavy pre-plant or fallow irrigations		Depends on definition of "heavy"
MT 1.1.3 Improve surface gravity system design and operation	BMP 1.1.3.1 Convert to surge irrigation	EM 4885 – IP 2.02.03; EM4826	A good idea, but requires a certain field setup. Most people who have tried surge, migrate back to conventional rill irrigation. Better to encourage to conversion to sprinkler or drip.
	BMP 1.1.3.2 Use high flow rates initially, then cut back to finish off the irrigation	EM 4885 – IP 2.02.10; EM4828	Good idea, but difficult to implement unless irrigation delivery can be variable.
	BMP 1.1.3.3 Reduce irrigation run distances and decrease set times	EM 4885 – IP 2.02.04; EM4828	Good, but increases labor and equipment costs
	BMP 1.1.3.4 Increase flow uniformity among furrows (e.g., compaction furrows)	EM 4885 – IP 2.02.02	Encourange use of PAM
	BMP 1.1.3.5 Grade fields as uniformly as possible	EM 4885 – IP 2.02.05, 2.02.05	Good but within constraints of topography.
	BMP 1.1.3.6 Where high uniformity and efficiency are not possible, convert to drip, center pivot, or linear move systems	EM 4885 – IP 2.01.08	Good

MT 1.1.4 Improve sprinkler system design and operation	BMP 1.1.4.1 Monitor flow and pressure variations throughout system	EM 4885 – IP 2.03.02	Good idea on district scale (they already do much of this), but logging pressure and flow variation is not cost-effective for individual growers.
	BMP 1.1.4.2 Repair leaks and malfunctioning sprinklers, follow manufacturer recommended replacement intervals	EM 4885 – IP 1.00.05, 2.03.03	Power companies often have monitary energy savings incentives for repair of irrigation systems.
	BMP 1.1.4.3 Operate sprinklers during the least windy periods	EM 4885 – IP 2.03.05	For the most part not possible when water delivered by a major irrigation entitiy.
	BMP 1.1.4.4 Reduce distance between lateral lines or alternate lateral line location over successive irrigations	EM 4885 – IP 2.03.04, 2.03.06	Requires additional moves (labor $) and sometimes additional hardware (e.g. an additional wheel line). Get a good design!
	BMP 1.1.4.5 When pressure variation is excessive, use flow control or pressure regulating nozzles	EM 4885 – IP 2.03.02	Good.
MT 1.1.5 Improve micro-irrigation system design and operation	BMP 1.1.5.1 Use appropriate lateral hose length to improve uniformity	EM 4885 – IP 2.04.02	Good. I.e. get a good and appropriate irrigation system design.
	BMP 1.1.5.2 Check for clogging potential and prevent or correct clogging	EM 4885 – IP 2.04.03	Good and necessary for good crop yields and uniformity.
MT 1.1.6 Make other irrigation infrastructure improvements	BMP 1.1.6.1 Installation of subsurface drains	EM 4885 – IP 5.01.01	Good. When necessary.
	BMP 1.1.6.2 Backflow prevention	EM 4885 – IP 6.00.03, EB1722	Required by law if chemigating.

MT 1.2.1 Modify crop rotation	BMP 1.2.1.1 Grow cover crops	EM 4885 – IP 5.01.01	Good in areas where they are not water limited. Probably not cost effective.
	BMP 1.2.1.2 Include deep-rooted or "nitrogen scavenger" crop species in annual crop rotations	PNW513	Good.
	BMP 1.2.1.3 Grow more crops per year (double cropping)	Bul 869	Utilize extra cropping to utilize excess nutrients on soil
	BMP 1.2.1.4 Include perennial crop rotation	PNW513	Encourage crop rotation
MT 1.2.2 Monitor crops	BMP 1.2.2.1 Monitor crop performance for each field including yield, nitrogen content, estimate of nitrogen removed from field versus remaining in field	NRCS Part 651. Ch. 13, Appendix 13B	Great
MT 1.3.1. Improve rate, timing, and placement of N fertilizers	BMP 1.3.1.1 Adjust nitrogen fertilization rates based on soil nitrate testing	EM 4885 – IP 3.02.01	Great
	BMP 1.3.1.2 Adjust timing of nitrogen fertilization based on plant tissue analysis	EM 4885 – IP 3.02.03	Good.
	BMP 1.3.1.3 Apply nitrogen fertilizer in small multiple doses rather than single large dose	EM 4885 – IP 3.02.05	Great - use fertigation
	BMP 1.3.1.4 Measure nitrate content of irrigation water and adjust fertilizer accordingly	EM 4885 – IP 3.02.02	Very little N in irrigation water. More in rainfall, but that is negligible in the Yakima River Basin.
	BMP 1.3.1.5 Use low rates of foliar nitrogen instead of higher rates applied		This is an OK method for micro-nutrients, but not for macro-nutrients.

MT 1.3.1. Improve rate, timing, and placement of N fertilizers	BMP 1.3.1.6 Vary nitrogen application rates within large fields according to expected needs (precision agriculture)	Peters and Davenport	Good.
	BMP 1.3.1.7 When fertilizing in surface gravity systems, use delayed injection procedures		Chemigating with surface gravity systems is not recommended
	BMP 1.3.1.8 Develop a nitrogen budget that includes crop nitrogen harvest removal, supply of nitrogen from soil, and other inputs	CSU-XCM-173	Good.
	BMP 1.3.1.9 Use controlled release fertilizers, nitrification inhibitors, and urease inhibitors	EM 4885 – IP 3.02.06	Good.
	BMP 1.3.1.10 Assess the risk of contamination of ground and surface water due to fertilizer leaching or runoff	EM 4885 – IP 3.01.01	Good.
	BMP 1.3.1.11 Maintain records of all soil, tissue, and water tests, cropping rotations, yields, and applications (dates, material, method, results)	CSU-XCM-173	Good.
	BMP 1.3.1.12 Develop realistic yield goals	EM 4885 – IP 3.02.07	Good.

MT 1.3.2. Improve rate, timing, and placement of animal manure applications	BMP 1.3.2.1 Apply moderate rates of manure and compost, and use materials with high nitrogen content (inorganic fertilizer) to meet the peak nitrogen demand		Good.
	BMP 1.3.2.2 Incorporate solid manure immediately to decrease ammonia volatilization loss	EM 4885 – IP 3.03.05	Good.
	BMP 1.3.2.3 When applying liquid manure in surface gravity irrigation systems, use the delayed injection procedure to improve application uniformity		Not recommended
	BMP 1.3.2.4 Use quick test methods to monitor dairy lagoon water nitrogen content immediately before and during application, and adjust application rate accordingly		By law, dairies are required to test manure once in the spring prior to the first application.
	BMP 1.3.2.5 Develop a nitrogen budget that includes crop nitrogen harvest removal, supply of nitrogen from manure, and other inputs	CSU-XCM-173; USU 2010	Good.
	BMP 1.3.2.6 Calibrate solid manure and compost spreaders	EM 4885 – IP 3.03.01; NRCS Part 651. Ch. 13, Appendix 13A	Good.
	BMP 1.3.2.7 Ensure uniformity of application with manure	EM 4885 – IP 3.03.07	Good.
	BMP 1.3.2.8 Do not apply manure to frozen ground, especially sloping fields	EM 4885 – IP 3.03.08	Good. Although this is a surface runoff issue, not a groundwater issue.
	BMP 1.3.2.9 Test manure or other organic by-product materials for nutrient content	EM 4885 – IP 3.02.04; NRCS Part 651. Ch. 13, Appendix 13B	Great
	BMP 1.3.2.10 Use synchronized rate nutrient application of lagoon water to reduce or eliminate the need for fertilizer	NDESC 2005 (II)	

MT 1.3.3. Use fertilizer guides to determine and apply appropriate fertilizer amounted.	BMP 1.3.3.1 Follow recommendations of Fertilizer Guide: Home Vegetable Gardens, Irrigated Central Washington	FG0052	Good.
	BMP 1.3.3.2 Follow recommendations of Fertilizer Guide: Irrigated Alfalfa Central Washington	FG0003	All FG need to be looked at to make sure they are not outdated.
	BMP 1.3.3.3 Follow recommendations of Fertilizer Guide: Irrigated Asparagus	FG0012	Good.
	BMP 1.3.3.4 Follow recommendations of Fertilizer Guide: Irrigated Field Beans for Central Washington	FG0005	Good.
	BMP 1.3.3.5 Follow recommendations of Fertilizer Guide: Irrigated Field Corn for Grain or Silage	FG0006	Good.
	BMP 1.3.3.6 Follow recommendations of Fertilizer Guide: Irrigated Hops for Central Washington	FG0011	Good.
	BMP 1.3.3.7 Follow recommendations of Fertilizer Guide: Irrigated Mint Central Washington	FG0008	Good.
	BMP 1.3.3.8 Follow recommendations of Fertilizer Guide: Irrigated Peas for Central Washington	FG0033	Good.

MT 1.3.3. Use fertilizer guides to determine and apply appropriate fertilizer amounted.	BMP 1.3.3.9 Follow recommendations of Fertilizer Guide: Irrigated Small Grains, Central Washington	FG0009	Good.
	BMP 1.3.3.10 Follow recommendations of Fertilizer Guide: Irrigated Sudangrass Pasture or Silage	FG0036	Good.
	BMP 1.3.3.11 Follow recommendations of Fertilizer Guide: Irrigated Vineyards for Entire State	FG0013	Good.
	BMP 1.3.3.12 Follow recommendations of Fertilizer Guide: Ornamentals, Entire State Except Central Irrigated Washington	FG0049	Does not pertain to Irrigated AG
	BMP 1.3.3.13 Follow recommendations of Fertilizer Guide: Vegetable and Flower Gardens, Except Irrigated Central Washington	FG0050	Does not pertain to Irrigated AG
	BMP 1.3.3.14 Follow recommendations of Fertilizer Guide: Improved Pasture, Hay, Eastern Washington	FG0037	Good.
	BMP 1.3.3.15 Follow recommendations of Fertilizer Guide: Grass Seed for Eastern Washington	FG0038	Good.

MT 1.3.3. Use fertilizer guides to determine and apply appropriate fertilizer amounted.	BMP 1.3.3.16 Follow recommendations of Fertilizer Guide: Barley for Eastern Washington	FG0029	Good.
	BMP 1.3.3.17 Follow recommendations of Fertilizer Guide: Soil Samples/Orchards	FG0028C	Good.
	BMP 1.3.3.18 Follow recommendations of Fertilizer Guide: Instructions for Tree Fruit Leaf Nutrient Analysis	FG0028E	Good.
	BMP 1.3.3.19 Follow recommendations of Fertilizer Guide: Peas and Lentils for Eastern Washington	FG0025	Good.
	BMP 1.3.3.20 Follow recommendations of Fertilizer Guide: Lawns, Playfields and Other Turf, East and Central Washington	FG0024	Good.

MT 1.4.1 Avoid fertilizer material and manure spills during transport, storage, and application	BMP 1.3.4.1 Do not overfill trailers or tanks. Cap or cover loads.	EM 4885 - IP 4.01.06	Good
	BMP 1.3.4.2 When transferring fertilizer, take care not to allow materials to accumulate on the soil		Good.
	BMP 1.3.4.3 Maintain all fertilizer storage facilities and protect them from the weather		Good.

MT 1.4.1 Avoid fertilizer material and manure spills during transport, storage, and application	BMP 1.3.4.4 Clean up fertilizer spills promptly		Good.
	BMP 1.3.4.5 Shut off fertilizer applicators during turns and use check valves		Good.
	BMP 1.3.4.6 Maintain proper calibration of fertilizer application equipment	EM 4885 - IP 3.03.01	Good.
	BMP 1.3.4.7 Create a buffer around wellheads from fertilizer and manure storage, handling, and application	EM 4885 - IP 6.00.02	Good.
	BMP 1.3.4.8 Distribute rinse water from fertilizer application equipment throughout field		Good.
	BMP 1.3.4.9 Avoid manure spills/discharges during transport, storage, and application		Good.
	BMP 1.3.4.10 Prevent back siphonage/flow of chemicals or nutrients down a well after injection	EM 4885 - IP 6.00.03, EB1722	Required by law.
	BMP 1.3.4.11 Identify and properly seal all abandoned and improperly constructed wells	EM 4885 - IP 6.00.04	Good.

Appendix H – Best Management Practices Recommended by Livestock/CAFO Work Group

NRCS Standards Recommended by Livestock/CAFO Work Group

Title	Revision Date
Amendments for Treatment of Agricultural Wastes (591) Standard	1/27/2014
Anaerobic Digester (366) Standard	1/11/2011
Animal Mortality Facility (316) Standard	1/11/2011
Composting Facility (317) Standard	1/11/2011
Dam (402) STANDARD	2/25/2013
Diversion (362) STANDARD	2/25/2013
Feed Management (592) Standard	1/15/2013
Filter Strip (393) Standard	2/11/2015
Heavy Use Area Protection (561) Standard	2/12/2015
Monitoring Well (353) Standard	2/11/2015
Nutrient Management (590) Standard	2/18/2014
Pond Sealing or Lining, Bentonite Sealant (521C) Standard	11/4/2015
Pond Sealing or Lining, Compacted Clay Treatment (521D) Standard	11/4/2015
Pond Sealing or Lining, Flexible Membrane (521A) STANDARD	2/25/2013
Pond Sealing or Lining, Soil Dispersant (521B) Standard	11/4/2015
Pumping Plant (533) Standard	2/12/2015
Roof Runoff Structure (558) STANDARD	2/12/2015
Short Term Storage of Animal Waste and By Products (318) – National NRCS Standard http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1263507.pdf	
Solid/Liquid Waste Separation Facility (632) Statement of Work	1/11/2008
Sprinkler System (442) Standard	11/4/2015
Stream Crossing (578) Standard	2/12/2015
Vegetative Treatment Area (635) Standard	1/29/2016
Waste Facility Closure (360) STANDARD	2/25/2013
Waste Recycling (633) STANDARD	2/25/2013
Waste Separation Facility (632) STANDARD	1/27/2014
Waste Storage Facility (313) Standard	2/11/2015
Waste Transfer (634) Standard	2/12/2015
Waste Treatment (629) Standard	2/12/2015
Waste Treatment Lagoon (359) STANDARD	2/25/2013
Water Well (642) Standard	2/12/2015
Well Decommissioning (351) Standard	2/11/2015
Groundwater Testing (355) Standard	2/11/2015

Appendix I – Comprehensive List of Alternative Management Strategies

The Groundwater Management Committee first made a list of approximately 300 potential alternatives, incorporating working group recommendations, ideas raised in working group conversations and reviews of scientific and environmental literature.

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	management programs
Remediation								
Pump, treat and reinject groundwater	WGD	not feasible, treatment area too large	not effective because of 3-dimensional size of treatment area	excessive				
Pump-and-fertilize. Use existing (or new) agricultural water wells to remove nitrate-contaminated groundwater and "treat" the water by using it to irrigate crops which will take up the nitrogen concentration in the irrigation water (presumes the existence of a proper nutrient management plan for the irrigated acreage).	JD							
Fill irrigation ditches with water and let it sit there to leak into groundwater. Use groundwater recharge as a means to dilute nitrate concentrations in the groundwater.	WGD						irrigation district canal maintenance in winter, increased personnel?, irrigation district compensation, relation to water rights? problem of freezing of flow meters in laterals, interaction with Bureau of Reclamation	
Drill new 1,500 foot wells to replace contaminated wells .	WGD			$12 million				
Regionalize and connect users to a larger system with reliable quality water.—pipe connection to an existing system	WGD							
Blend better quality water with contaminated water to reduce nitrate concentrations	JD	works for larger community systems with more than one water source.						
Construct a potable water line from nearby developed area into deadhead water stations at central rural location (permit potable water collection at deadhead water stations).	JD							
Discontinue use of shallow wells. Rebuild, repair or replace poorly constructed wells.	WGD							
Remediate local nitrate contamination hotspots only .	JD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	with local comprehensive plans and water management programs
Administration/Lead Agency--Yakima County?								
Identify or create of an organization (Lead Entity) responsible for implementation and oversight of the LYV GWMA Groundwater Management Plan and acquisition of stable funding to support their activities. Potential entities include, Yakima County, South Yakima Conservation District (SYCD), Yakima County Health District, Washington State Department of Agriculture (WSDA), Ecology, and/or a yet to be formed entity.	L/C WG							
Implement an Adaptive Management Plan utilizing data collected, progress made, or lack of progress to inform the community on adjustments that need to be implemented. Plan could incorporate availability of technology, education and outreach, tracking exports, land use regulations, treatment systems, and other changes to inform decision makers regarding management changes necessary for a successful program.	L/C WG							
Let the lead agency determine who will do monitoring. Possible assignment of long-term monitoring after 2017 to Yakima Health District.	WGD							
Inform livestock operators and facilitate a dialogue with representatives of the regulatory agencies, other agricultural producers, and the general public through a public information/education program to protect the quality of the area groundwater resource. Information and incentives provided to Lower Yakima Valley agricultural operators will expedite implementation of BMPs.	L/C WG							
Collect, analyze, and interpret data to track water quality improvement progress, nutrients generated, applied, or exported, which will inform the implementation of an Adaptive Management Plan within the LYV GWMA.	L/C WG							
Focus implementation of analyzed data based on information and data included in the Nitrogen Loading Assessment, Soil Sampling Program, Ambient Groundwater Monitoring Plan, USGS Reports, and other similar scientifically based publications.	L/C WG							
Increase education and outreach efforts by improving the availability of technical assistance to develop nutrient management plans for all livestock industries. Assist industry trade organizations to enhance their local efforts to bring information to their members. Help increase livestock operator awareness of the need for procedures for proper management of animal wastes and wastewater. Potential funding sources include industry, government, educational institutions, grants, industry associations, etc...	L/C WG							
Cooperate with the WCC and WSDA in their efforts to document regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP). Explore the possibility of disclosing non-proprietary data produced through the DNMP process.	L/C WG							
Further develop a local forum for disseminating information and facilitating technical exchange regarding BMPs for livestock management and groundwater protection. Endorse and distribute materials by all effective means that will educate the public about the facts of livestock waste management and the science of groundwater protection.	L/C WG							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	e plans and water management programs
Quantify the nutrient value and rate of release of nitrate from livestock waste under various Lower Yakima Valley conditions to become part of the nutrient management guidelines.	L/C WG							
Voluntary development and implementation of NMPs by operations not already required to hold permits or a DNMP as an effective means of environmental protection.	L/C WG							
Allocate cost share funding or other funding assistance to operators implementing environmental protection measures.	L/C WG							
Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of manure and other livestock wastes.	L/C WG							
Provide Yakima County fiscal support to maintain its GIS data base on the GWMA over time.	JD							
Overlay GIS density maps reflecting different sources of nitrogen in order to geographically indicate the total density from all sources.	JD							
Map those areas that can tolerate more nitrogen application and areas that are more vulnerable to its application.	JD							
Use USGS particle tracking model to indicate where groundwater moves faster (permeability).	WGD							
Assess groundwater contamination potential, making use of the available information on soils, geology, and groundwater in order to identify those areas that are the most vulnerable to contamination. These areas may be closer to surface water, areas where recharge is faster or more frequent, or areas where shallow soils overlie soluble bedrock. Identify strategies "upstream" of sensitive areas to reduce contributions of nitrate sources.	WGD							
Enact County ordinances that would affect the problem grower.	WGD						Difficult to enforce.	
Maintain the County's GWMA website.	WGD							
Create an aquifer protection area.	WGD	Requires vote of people within protection area		Generates tax revenue				
Consider the enactment of a county ordinance addressing the density of segments of nitrate producing agricultural activity within the areas currently zoned as agricultural within the GWMA.	WGD		Prospective application					
Consider creation of subcategories of agricultural zoning, limiting density in those areas where soils are more permeable or groundwater moves faster.	WGD		Prospective application					
Consider "overlay" zoning ordinance adding special groundwater conservancy restrictions to otherwise conventionally zoned properties. Uses consumptive of groundwater quality resources are precluded or more generally regulated. Uses that are not consumptive of groundwater quality resource are permitted. Specific limitations might include limitations of water use, drainage, development density, septic use.	JD		Prospective application					

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	water management programs
Define "conditional uses" that can be allowed after assurance that groundwater resources would not be damaged.	JD		Prospective application					
Consider a county ordinance concerning overapplication of manure.	WGD		Prospective application				Difficult to enforce	
Create county ordinance limiting total number or density of cows or dairies (lid).	WGD		Prospective application				Difficult to enforce	
Adopt a LYC GWMA or county-wide CAFO ordinance	L/C WG (no consensus in WG)	Lengthy public process to create a CAFO Ordinance. Uncertain outcomes and timing. Too much uncertainty to rely on this option for the plan at this time. The county might consider legislative action as an alternative if public outreach, voluntary compliance, implementation of identified BMP's, and other efforts are not						
Establish a quota system through zoning regulations establishing how much nitrogen could be applied (based on agronomic rates for individual crop types) within fixed zones.	WGD		Prospective application				Difficult to enforce	
Consider density limitations, building codes for farm structures, development standards for farm activities.	WGD		Prospective application					
Regulate crop mix to weight more toward nitrogen-light crops--	JD						Difficult to enforce	

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	e plans and water management programs
Consider limitation of septic systems (therefore building permit) where soil filtration rate is high, where housing density is already big, where nitrate concentration is already great downstream of the septic plume	JD	Applied admnistratively, requires GIS mapping of soil zones					Growers view as governmental interference with economic choice if nitrogen-heavy crops generate better returns	
Property tax for properties with onsite septic systems, waived in the case of proper inspection and pumping	JD							
Protect Critical Aquifer Recharge Areas	WGD							
Require bonding as prerequisite to permitting of livestock operations so as to assure financial capability for clean up in the instance of bankruptcy or other economic failure.	GWACD							
Measure the effects of GWAC program on Yakima County economics.	WGD							
Establish a more interactive and frequent relationship between Yakima County and NRCS.	WGD							
Education								
Develop post GWAC education and outreach campaign	EPO							
Broaden the pool of people GWMA is educating or communicating with.	EPO							
Maintain a public education program regarding nitrate pollution and health risk over a 5-10 year period. Provide all materials distributed to the public in English and Spanish.	EPO							
Billboard campaign – urging well testing	EPO							
Create 1 FTE Bilingual Outreach Coordinator Position to implement a post-adoption outreach campaign (EPO meeting summary 8/1/2014 & proposed to GWAC 8/21/14 - voted low priority)	EPO	Low	Unknown	$83,000 annually		1 FTE	Requires clear, measurable outcomes[1], a "home" agency to house, provide oversight, and to measure effectiveness; and ongoing funding.	
Develop a K-12 education program about groundwater and best management practices--mobile program visiting schools.	EPO							
Employ/enlist college students to conduct surveys, consider outreach methodologies as part of classwork to assist with GWMA education	EPO							
Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations	EPO							
Educate private well owners: Re: protect your family; know who's at risk; test your well regularly.	EPO							
Private well owners' responsibility to protect WQ	EPO							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	water management programs
Publish public information about proper septic system construction and operation	EPO							
Advise the public that GWMA is looking for abandoned wells. Wellhead protection education	EPO							
Offer incentives for property owners to identify and properly abandon wells.	EPO							
Offer incentives to drill deeper wells for homeowners served by shallow, poorly constructed, poorly located wells.	EPO							
Offer incentives to connect households on private wells near community water systems to connect to a community water system. (Nitrate Treatment Pilot Program-June 2011)	EPO							
Provide a resource hotline (as proposed by RCIM on 8/2014)	EPO							
Prepare a fact sheet/develop outreach campaign to growers that explains agronomic rates – applying nutrients at the right time/right place/right amount	EPO							
Study report outreach: Show/Identify how much nitrogen is left after nutrient uptake in crops.	EPO							
Encourage commodity groups to provide education on water management and fertilizer use through regular meetings.	EPO							
Outreach targeted to small farm/hobby farm/rachettes manure management	EPO							
Educate irrigation users on the consequences of too much irrigation.	EPO							
Inform farmers about technological improvements in irrigation that permit easier management of water, descriptions of specific improved technology, and economic viability of technological advancements .	EPO							
Enlist advocacy groups/Farm Bureau/federations/associations to host workshops/informational meetings regarding GWMA education goals and partnerships in success	EPO							
Make presentations at trade shows, communicate with agricultural consultants who have positive relationships with farmers suggesting that they change practices	EPO							
Partner with UW Pediatric Environmental Health Specialty Unit (PEHSU) to continue training local healthcare providers to recognize and address Nitrate risk in their patients (pregnant women and infants up to six months)	EPO	Feasible	Effective	Up to $30,000 annually (.25 FTE; + translation, printing, coordination)	Unknown	.25 FTE	Coordinate partnership through either DOH or YHD	
Advise the public that GWMA is looking for abandoned wells	WGD							
Encourage commodity groups to provide education on water management and fertilizer use through regular meetings	WGD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)					
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement
Research and Data Collection							
Use both method-based measurement and performance-based measurement.	WGD						
Establish performance objectives against which monitoring data can be compared--number of at risk wells, BMP implementation, funding success, reduction in number of underperforming farming practices	JD						
Implement Ambient Groundwater Monitoring Plan	GWAC	Feasable					
Implement Drinking Water Quality Monitoring Plan	GWAC	Feasable					
Establish a fund and plan to analyze data collected in ambient water quality monitoring and drinking water well monitoring programs. Study short-term seasonal variations in nitrate concentrations over next year or two--addresses how changes in nutrient application over the agricultural cycle affects things. Study long-term trends that develop over several years--to track whether the overall picture is getting better, whether changes recommended by GWMA are having impact.	WGD						
Use hydro-geologically directed monitoring well placement to detect cause/effect remediation opportunities.	JD						

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	e plans and water management programs
Building from the WSDA's Nitrogen Availability Assessment, develop a Nitrogen Loading Assessment for all agricultural, residential and commercial properties, using newly collected data. Hire a technical consultant to conduct a literature review to determine the most relevant information and accurate factors for use in the Nitrogen Loading Assessment. Periodically repeat the grower survey used in the Nitrogen Availability Assessment to compare against the currently established data. Collect data on how many acres in the GWMA are fertilized in various crops with manure and how many with commercial fertilizer. Update and monitor the percentage of acreage in various crops, particularly silage corn and field corn. Study effect of contribution of nitrogen from cover crops used to form mulch. Determine acreage for triticale. Discover commercial fertilizer tonnage for Yakima County and/or for GWMA. Explore how much nitrogen leaches into groundwater from drains and wasteways. Study atmospheric deposition more comprehensively. Understand the difference between plant uptake and plant removal of nitrogen.	WGD, JD							
Get fertilizer loading numbers per crop type. Get economic engine factors per crop type. Determine crop/fertilizer utility ratios. Consider economic benefit of various crop type categories. Consider agricultural usage categories (e.g., field crop, row crop, vineyard, orchard, dairy. Determine amount of land appropriate for each, and location best for each given soil, climate, effect upon groundwater, etc. Ensure adequate supply of each in order to permit opportunity of market choice.	JD							
Recommend that the Yakima Health District or Yakima County continue the High Risk Well Assessment (survey to identify outreach messaging related to health risks and well sampling) periodically over a 5-10 year period. Collect more information on wells known to have high nitrate concentrations, perhaps identifying whether the concentration is self-caused	WGD							
Conduct recurrent drinking water testing where drinking water standards have previously been exceeded.	JD							
Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results for future expansion of findings.	JD							
Explore whether nitrate leaching is greater with vetch amended soil or commercial fertilizer amended soil. The results of one study indicate that vetch nitrogen, in comparison to fertilizer nitrogen, leads to lower concentrations of soil inorganic nitrogen and greater immobilization of added nitrogen in soil organic matter. This would reduce the potential for nitrate leaching.	JD							
Recommend that WSU Extension Service update Appendices A and B of the Washington Irrigation Guide.	WGD							
Recommend that Western Fertilizer Handbook, Western Plant Health Association, Ninth Edition (2002) be updated.	WGD							
Fund professional adaptation of Utah Fertilizer Guide for Washington State http://extension.usu.edu/files/publications/publication/AG_431.pdf	JD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Consistency with comprehensive plans and water management programs
Washington State Department of Agriculture								
Develop Nitrogen Loading Assessment as provided in Research and Data Collection above.	WGD							
Summarize the DNMP reporting and provide information that would disclose the amount of manure the CAFO's in the GWMA created and where it was distributed.	WGD							
Review and evaluate the WSDA Dairy Nutrient Management Program inspection protocols to assist in determining if additional resources should be allocated and identify any areas for improvement of the inspections themselves.	L/C WG							
Add staff to WSDA to oversee Dairy Nutrient Management Plans and complaints regarding manure spills.	WGD							
Promote on-going research for managing animal nutrients.	WGD							
Southern Yakima Conservation District								
Ask SYCD for projected plan to expand fiscal and administrative capacity	JD							
Fund post GWMA education and outreach through Conservation District	WGD							
Put request for $$$ for SYCD in State Conservation Commission budget	WGD							
Enhance engineering expertise (personnel) within Conservation District--none there or at NRCS	WGD							
Charge dairies for Conservation District preparation of Dairy Nutrient Management Plans	WGD							
Recommend funding for Southern Yakima Conservation District review of Dairy Nutrient Management Plans	WGD							
Provide better funding and more staffing for Conservation District: hard money funding, increase property tax assessment, create exceptions to taxation for demonstrated testing and monitoring.	WGD							
Develop water sorption graph or chart. List volumes of water applied, soil types, absorption/compaction rates, depths to water, pre-season and post-season appropriate moisture levels.	JD							
US Geological Survey								
Use USGS Particle Tracking Model	WGD							
Use USGS particulate tracking model to identify targets of education	WGD							
USGS Particle Tracking Model Overview--potentially combined with MT3D MODFLOW application to the vadose Zone	WGD							
Yakima Health District								
Study potential nitrate contamination attributable to improperly operated septic systems. Consider restoration/retrofit of older septic systems through incentives or county property tax breaks.	WGD							
Drill deeper water wells further from septic drain systems	WGD							
Require builders to demonstrate that septic system design will not add to nitrogen loading problem as condition of construction	WGD							
Publish and distribute homeowner guide on how to use septic systems	WGD							
Department of Ecology								

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	programs
Publish the Department of Ecology's lists of certified laboratories that can test private wells for nitrates and pathogens and Ecology's providing funding to low income, private well users, in order to conduct this testing.	WGD							
Encourage an increase in the number and availability of soil testing laboratories.	JD							
Make grants that complement projects related to non-point source pollution.	WGD							
Provide grant funding for well decommissioning.	WGD							
Search for abandoned wells.	WGD							
Send a postcard to 10 % of known property owners on record having a well asking about knowledge of older wells.	WGD							
Compare Google Earth to Yakima County GIS images to determine building changes and thus possible well usage changes. Focus first on hotspot high density areas in GWMA. Ground truth suspected problem wells.	WGD							
Educate realtors and banking industry about disclosure of abandoned wells in property transfers.	WGD							
Educate public regarding liability of an ill-secured well.	WGD							
Provide some form of protection for self-reporting of abandoned or improperly decommissioned wells.	WGD							
Seek legislative change on requirements for well decommissioning, making them cheaper.	WGD							
Amend RCW 18.104.055 to dedicate a portion of "notice of intent" fees to a fund to be used by Ecology (or Health) for the proper decommissioning of wells in those cases where DOE (or Health) determines that such publicly-funded action is necessary in the public interest to protect or enhance the quality of public health ("infirmity" of the public health).	JD							
Amend authority of Department of Ecology to gain access to properties where manure is spread outside land subject to nutrient management plans	WGD							
Residential, Commercial, Industrial, Municipal								
Encourage municipalities within the GWMA to extend municipal sewer systems within urban growth areas and retire ROSS and LOSS.	RCIM WG							
Encourage connection of residences within urban growth zones to sewer systems extended by municipalities.	RCIM WG							
Encourage the development of group septage-management or treatment systems in areas outside urban growth zones where the density of residential development could exacerbate the effect of multiple OSS on groundwater quality.	RCIM WG							
Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development.	RCIM WG							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Consistency with local comprehensive plans and water management programs
Request Yakima County Public Services to perform an engineering study of locations outside urban growth areas where there is rural residential medium to high density OSS and the nitrate concentration is greater than the state water quality standard where community water systems could feasibly be constructed in lieu of individual water wells.	RCIM WG							
Request Yakima County Public Services to perform an engineering study of locations outside urban growth areas where there is rural residential medium to high density OSS and the nitrate concentration is greater than the state water quality standard where community waste water systems could feasibly be constructed in lieu of individual on-site septic systems.	RCIM WG							
Request that the Yakima Health District prepare a plan, as required and described by WAC 246-272A-0015, giving primary emphasis on educational programs for operation and maintenance of existing on-site septic systems (OSS), reserving a determination regarding the advisability of the establishment of regulatory or enforcement programs until data is available from the GWMA's monitoring well system.	RCIM WG							
Request the Yakima Health District to consider the nitrate density element when approving proposed septic systems, including those technologies verified by the U.S. EPA's Environmental Technology Verification Program, for reducing the nutrient nitrogen in domestic wastewater discharged from OSS, including fixed film trickling filter biological treatment, media filter biological treatment, and submerged attached-growth biological treatment.	RCIM WG							
Recommend that soil testing be performed below at least two ROSS drain fields (one with a shallow water table, one with a deeper water table) in high density areas to analyze nitrogen loads as the septage approaches the water table.	RCIM WG							
Request that the State Department of Health determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported, so that the LOSS will continue to operate as designed.	RCIM WG							
Recommend that the State Department of Health consider not approving additional LOSS or otherwise require an effective nitrate removal system.	RCIM WG							
Request that the Department of Ecology analyze the trends of nitrate data contained within reports required by NPDES and SDWA permits.	RCIM WG							
Educate the public regarding the importance of the integrity of wells, particularly those without a well log, and fund and encourage periodic well inspection by the Yakima Health District or professional well engineers.	RCIM WG							
Require that site inspections for possible abandoned wells be performed before building permits are issued for properties that are proposed to be redeveloped after prior development of domestic, agricultural or industrial uses.	RCIM WG							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)					
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement
Request that the Department of Ecology develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project.	RCIM WG						
Permit the repair or decommissioning of wells by general contractors, rather than exclusively by well-drillers, so as to diminish costs of decommissioning.	RCIM WG						
Assist hobby farmers to locate ROSS drain fields on their property so as to avoid animal farming over the drain field.	RCIM WG						
Request the county include the EPO flyer on OSS maintenance in correspondence with GWMA home owners for 5 years. i.e. tax bills, property transfers.	RCIM WG						
Make facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume.	JD						
Replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching.	JD						
Require new developments to address impacts on groundwater quality through permitting review of "site plan review criteria."	JD						
Technology							
Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater.	L/C WG						
AKART--industry can't keep up with technology, required if performance already meets performance standards?	WGD						
AKART problems--does standard mandate installation of new technologies even when existing ones accomplish the measured objective	WGD						

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	Consistency with local comprehensive plans and water management programs
Require nitrogen reducing technologies for onsite septic systems:	WGD			estimated installation costs $20,000, yearly operational costs about $1,500, recirculating sand filters, carbon systems, old system retrofits cost $5,000-7,000 per system				
Explore public investment in waste to energy technology	WGD							
Promote new products that are found through research	WGD							
Promote markets for those products	WGD							
Use commodity group "check off" money for research and development	WGD							
BMPs								
Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups from HDR list to reflect greatest effectiveness in nitrate reduction	WGD							
Determine who implements the BMP and who monitors it and the time frame in which to measure/monitor it--problem with available expertise, timing, installation cost	WGD							
Identify and publish a list of poor management practices. Recommend that they be terminated or avoided.	JD							
Establish a BMP monitoring well network. Monitor BMP performance and effectiveness with the monitoring well network first, then monitor water quality.	Bowen: Having a monitoring plan for the BMP's in place is part of the work the GWAC is required to do.							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	e plans and water management programs
Livestock								
Recommend that dairies and CAFOs use those Best Management Practices contained within Attachment B to the Livestock/CAFO Work Group's Report to GWAC	L/C WG	Feasable	GWAC has not reached consensus that pursuing this recommendation alone would accomplish Goals # 1, 2.					
Encourage the WSDA and Conservation Districts to continue education and outreach to livestock operators about impacts and practices related to compliance with relevant State and federal requirements for groundwater protection, particularly addressing those not currently acting in good faith toward that objective.	L/C WG	Feasability depends upon available resources		2 additional FTE's cost ?	Industry, government, private or public research and development, foundations, and industry associations.			
Implement an Education and Outreach Program (EOP) informing producers of Best Management Practices (BMP's) including increased funding for the DNMP assistance program.	L/C WG							
Create and maintain a central depository of public information online, as part of an Education and Outreach Program (EOP) informing producers of the nitrate issue, community impacts, and Best Management Practices (BMP's).	L/C WG				Industry, government, private or public research and development, foundations, and industry associations.			
Increase funding for the local Conservation District and Natural Resources Conservation Service (NRCS) so that assistance programs for nutrient management planning, engineering, cost share, and loan funds are more available.	L/C WG				Industry, government, private or public research and development, foundations, and industry associations.			
Streamline current enforcement activities so as to improve customer service and protocols, increase clarity of process, escalate enforcement for facilities not following management practices, identify methods to discourage repeatedly unfounded complaints, and improve overall transparency.	L/C WG							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	with local comprehensive plans and water management programs
Collect data to track water quality improvement progress and nutrients generated, applied, or exported within the LYV GWMA. Generate data through soil testing, Ambient Groundwater Monitoring Plan implementation - including purpose built and existing wells, sampling of liquid and solid waste to be field applied, composted, or exported, the CAFO General Permit, and tracking nutrients applied by non-dairy operations.	L/C WG							
Support and advocate private, public, and industry investment in technology, including at research institutions, specific to addressing nitrate contamination in groundwater, especially where it creates improvements for the public good.	L/C WG							
Require more complete disclosure of Dairy Nutrient Management Plans.	WGD							
Incentivize technology and management of fertilizers and manures.	WGD							
Install separation systems--separate liquids from solids.	WGD							
Use anaerobic digestion in waste storage lagoons	WGD			Very expensive				
Install liners in liquid waste storage lagoons.	WGD							
Install impervious surfaces beneath silage/feed storage.	WGD							
Revise WAC 246-203-130 so that it defines "health hazard" and "nuisance" and includes specific and enforceable requirements designed to protect human health.	WGD, JD							
Compost more manure	WGD							
Improve composting regulations	WGD							
Provide underlying soils information to each livestock opeeration so that individual evaluations can be made.	JD							
Remove wastes from barnyards and other areas of animal concentrations and frequently convey them to waste storage or treatment facilities.	JD							
Prevent contaminants from flowing into wells by ensuring that the external areas around well casings are properly sealed and that wastes are kept the recommended distance from wells.	JD							
Entrain water (as rain or snow-melt) collected from roofs away from animal pen or manure collection facilities.	JD							
Drain low areas where ponds accumulate to collect and manage waste waters.	JD							
Treat manure supply in excess of that which can reasonably be applied as nutrient to agricultural lands as a "waste" product. Apply waste management strategies including land disposal at designated site, incineration, centralized waste-to-energy facility.	JD							
Create a state CAFO Siting Team, composed of representatives of relevant state agencies with support from USGS, to which the county commission could refer proposed CAFO sitings or expansions. The CAFO Siting Team would provide a recommended site suitability determination, based upon a predetermined scoring system, including description of environmental risk factors and mitigation strategies.	WSDA, Gary Bahr							
Amend Dairy Nutrient Management Act to extend WSDA's authority t land application acreage with which dairy facilities contract pursuant to nutrient management plans.	JD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	e plans and water management programs
Collect data to track water quality improvement progress and nutrients generated, applied, or exported within the LYV GWMA. Generate data through soil testing, Ambient Groundwater Monitoring Plan implementation - including purpose built and existing wells, sampling of liquid and solid waste to be field applied, composted, or exported, the CAFO General Permit, and tracking nutrients applied by non-dairy operations.	L/C WG							
Support and advocate private, public, and industry investment in technology, including at research institutions, specific to addressing nitrate contamination in groundwater, especially where it creates improvements for the public good.	L/C WG							
Require more complete disclosure of Dairy Nutrient Management Plans.	WGD							
Incentivize technology and management of fertilizers and manures.	WGD							
Install separation systems--separate liquids from solids.	WGD							
Use anaerobic digestion in waste storage lagoons	WGD			Very expensive				
Install liners in liquid waste storage lagoons.	WGD							
Install impervious surfaces beneath silage/feed storage.	WGD							
Revise WAC 246-203-130 so that it defines "health hazard" and "nuisance" and includes specific and enforceable requirements designed to protect human health.	WGD, JD							
Compost more manure	WGD							
Improve composting regulations	WGD							
Provide underlying soils information to each livestock opeeration so that individual evaluations can be made.	JD							
Remove wastes from barnyards and other areas of animal concentrations and frequently convey them to waste storage or treatment facilities.	JD							
Prevent contaminants from flowing into wells by ensuring that the external areas around well casings are properly sealed and that wastes are kept the recommended distance from wells.	JD							
Entrain water (as rain or snow-melt) collected from roofs away from animal pen or manure collection facilities.	JD							
Drain low areas where ponds accumulate to collect and manage waste waters.	JD							
Treat manure supply in excess of that which can reasonably be applied as nutrient to agricultural lands as a "waste" product. Apply waste management strategies including land disposal at designated site, incineration, centralized waste-to-energy facility.	JD							
Create a state CAFO Siting Team, composed of representatives of relevant state agencies with support from USGS, to which the county commission could refer proposed CAFO sitings or expansions. The CAFO Siting Team would provide a recommended site suitability determination, based upon a predetermined scoring system, including description of environmental risk factors and mitigation strategies.	WSDA, Gary Bahr							
Amend Dairy Nutrient Management Act to extend WSDA's authority t land application acreage with which dairy facilities contract pursuant to nutrient management plans.	JD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	with local comprehensive plans and water management programs
Irrigated Agriculture								
Anecdotal results of deep soil sampling carried out by SYCD with farmers with pre-existing relationship with SYCD were informative. Word-of-mouth reporting within farmer community greatly increased acres sampled. Establish a multi-year deep soil sampling program where farmers subscribe for a duration with pre-determined fiscal remuneration for completed sampling. Cost share with farmer. Farmer to provide checklist indicating performance with BMPs. Test throughout growing year, in order to observe effects of fertilization throughout year. Share data with public.	WGD			Expensive	Federal or State			
Do deep soil sampling on fields within GWMA that apply biosolids.	WGD							
Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits.	WGD							
Hire soil scientists to do publicly funded "spot auditing" soil checks for feedback to farmers and fertilizer sellers.	JD							
Incentivize development and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies	JD							
Commission the creation of a data assembly software that could receive, translate, assemble and analyze the data produced by agricultural equipment technology manufactured by different agricultural equipment manufacturers, so as to permit integration of data per field, crop or enterprise.	WGD, Doug Simpson							
Monitor nitrate concentrations of irrigation water at headgates.	JD							
Stimulate news coverage of progress in irrigation technology.	WGD							
Land acquisition—purchase properties with greatest nitrate contribution and retire uses that generate nitrate.	JD							
Incentives—provide credit against county real property tax for investment in source abatement.	WGD							
Develop farmer-specific irrigation water use programs including collection of data, records of irrigation management, education of farmer regarding new processes and technology.	WGD							
Create irrigation management plans (similar to nutrient management plans) for farms over a minum size and provide financial assistance for implemented plans.	WGD							
Encourage advanced irrigation management. Recognizing that there is significant cost involved in changing an irrigation system, look for strategic opportunities in the area where the use of more advanced irrigation management systems could have the greatest benefit for reducing nitrogen impacts to groundwater. One example of advanced irrigation management is electronic sensor irrigation water management (IWM). Identify federal, state and local incentive programs, such as grants, and low interest loans, to facilitate a transition to more advanced irrigation management in those areas	EPA Region 10							
Provide funding for a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts.	WGD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	e plans and water management programs
Provide financial assistance for 1) conversions from rill irrigation to sprinkler or drip irrigation, 2) installation of flow meters and moisture meters to reflect over-irrigation, high water table, drought conditions, 3) the cost of hiring third party sampling , measuring equipment, personnel or self-test kits, 4) management of sprinkler systems so they do not drive nutrients past the root system.	WGD							
Establish a voluntary irrigation management cost-share program with SYCD. Data shared with public.	WGD							
Manage sprinkler systems so they do not drive nutrients past the root system.	WGD							
Advise farmers of the relative propensity of wheel lines, center pivots, and drip lines to cause leaching.	JD							
Use available techniques to determine how much and when irrigation is needed instead of irrigating according to a prearranged schedule.	JD							
Schedule water and nitrogen application according to the need for optimal crop yields.	JD							
Analyze irrigation practices to discover whether frequency or volume creates greater propensity for leaching.	JD							
Identify and decommission abandoned agricultural irrigation wells.	JD							
Upgrade irrigation districts' open, earthen or concrete delivery laterals and head ditches to PVC pipe.	JD							
Route irrigation-return flow through a constructed managed wetland to reduce concentrations of nutrients and suspended sediment.	JD							
Add polyacrylamide (PAM) to irrigation water.	JD							
Install effective backflow prevention devices on supply lines of water supplied from groundwater wells to avoid backflow from chemigation.	JD							
Structure irrigation water pricing by volume per acre used with preference for lower volume use.	JD							
Improve micro-irrigation system design and operation.	JD							
Recommend that irrigation districts be authorized to condition delivery of irrigation water on irrigation practices consistent with agronomic rate of application of water.	WGD							
Require irrigated agriculture nutrient management plans. Record the source and type of fertilizer and number of acres fertilized with each.	WGD							
Establish water use "domains" (zones) to apply water use constraints, or well construction design constraints, for agricultural uses.	JD							
Develop and implement Nutrient Management Plans (NMPs) for all producers (those that apply manure and those that apply synthetic fertilizer that include annual soil testing for phosphorus and nitrogen and which follow available guidance (i.e. Land Grant University) for developing appropriate land application rates for phosphorus and nitrogen. These NMPs can identify site specific conservation practices that are, or will be, implemented to minimize the transport of phosphorus or nitrogen to surface and ground waters. NMPs that are "adaptive" -- adjusted based on annual soil tests, the types of crops grown, and other site or field specific factors – allow producers to adjust their plans and practices as new information becomes available.	EPA Region 10							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	with local comprehensive plans and water management programs
Provide funding for nutrient management education or information distribution.	WGD							
Make Nutrient Management Plan records available upon Department of Agriculture determination of potential excessive application of nutrients.	JD							
Incentivize investment in crops that require less fertilization, or which take up greater amounts of nitrogen.	JD							
Distribute information to farmers on what can happen with applied manure, what should be applied and reasonable, agronomic rates of application.	WGD							
Integrate use of animal waste and synthetic fertilizer, balancing nutrient application amounts so as to maximize crop production and full nitrogen uptake.	JD							
Track nutrients and their application regardless of the end user, including commercial fertilizer.	L/C WG		Nutrients from animal waste are tracked now while in the control of dairy operations. Once those nutrients are transferred to a third party no further regulation exists.					
Keep track of synthetic fertilizer sales.	WGD							
Avoid fertilizer material and manure spills during transport, storage, and application.	WGD							
Use effective application schedules, placement, rate and time of application and speed of release for specific crop requirements.	JD							
Where possible, apply nitrogen through to plant-specific root zone means, rather than broadcast application.	JD							
Identify areas with highly permeable and susceptible soils where fertilization and pesticide application should be most carefully managed.	JD							
Amend Yakima County Code 16C.09.070 to include excess fertilizer application to list of prohibited uses within critical aquifer recharge areas.	WGD							
Amend the list of prohibited uses under the Critical Aquifer Recharge Area ordinance 16C.09.070 (6) to include "activities that would add nutrients to the soil column beyond those amounts that can be taken up within a reasonable time by plant materials." Or perhaps, activities inconsistent with NCRS Code 590	JD							
Inform farmers that fertilization and supplemental irrigation beyond the optimum rate will not necessarily produce better yields or higher profits without serious side effects.	WGD							
Develop an approach for data collection of volume and location of manure application off dairy sites.	WGD							
Place areawide limitation on number of acres where manure can be spread as fertilizer. Require permit to spread manure as fertilizer. Allow market in permits. Allow dairies to own permits which could be leased to other agricultural properties.	JD							

Alternative land and water use management strategies for reaching program goals and objectives per WAC 172-100-100(4)		Evaluation Criteria per WAC 173-100-100 (4)						
Action	Proposed by	Feasibility	Effectiveness	Cost	Proposed funding	Time	Difficulty to implement	
Intermittent fallowing (leaving lands dormant) to reduce both natural plant nitrogen and fertilizer nitrogen additions to the soil.	JD							
Refrain from tilling under herbaceous remnants of prior crops, reducing plant nitrogen contributions to soil column.	JD							
No Action								
Consider costs of health risks to families from nitrate exposures, costs incurred by growers and producers of various recommendations, costs of bottled water, costs to connect to public sewage systems, cost for WSDA to monitor DNMP, costs of soil sampling	WGD							

Appendix J – Consensus List of Potential Recommendations

The Groundwater Management Committee first made a list of approximately 300 potential alternatives, incorporating working group recommendations, ideas raised in working group conversations and reviews of scientific and environmental literature. The GWAC first applied a consensus screen in order to reduce the large list of alternatives to those potential recommendations with which no one would disagree. This produced a shorter list of 83 potential recommendations to be evaluated by the criteria established by WAC 173-100-100 (4).

GWAC members responded to a request to evaluate the draft recommendations, placing a value of -3 to +3 on each draft recommendation. The results were totaled. A unanimous consensus could not be obtained that the outcome of this method represented the consensus of the GWAC regarding its recommendations. The GWAC membership took a recorded vote at its May 17, 2018 meeting whether to recommend all draft recommendations which had received a total score greater than zero. The GWAC voted 17 to 1, 1 not voting, to recommend those draft recommendations. They appear as "Recommended Actions in Volume I." Those draft recommendations obtaining a total value of zero or less are also presented in Volume I.

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?
			Education						
1	DOH, Yakima Health District, Lead Agency	Develop a health-risk education and outreach campaign	Establish a public education program regarding nitrate pollution and health risk over a 5-10 year period. Broaden the pool of people GWMA is educating or communicating with. Provide all materials distributed to the public in English and Spanish. Provide education about concepts that people can understand.Billboard campaign – urging well testing. Partner with UW Pediatric Environmental Health Specialty Unit (PEHSU) to continue training local healthcare providers to recognize and address Nitrate risk in their patients (pregnant women and infants up to six months)	Feasible	Effective	$50K; $100K (5 Year plan)	Ecology, Legislature	2019 Session	Not difficult
2	Yakima Health District	Publish and distribute homeowner guide on how to maintain septic systems		Feasible	Effective	Part of previous item cost.	Ecology, Legislature	2019 Session	Easy
3	OSPI, ESD 105	Develop educational materials that could be elected by instructors at 8-12 levels about aquifer protection, groundwater and best management practices.		Feasible	Effective depending on use	$10K. Contract with educational consultant; see what materials/models out there already	County General Fund	One year	Difficult to fit ir curriculum
4	Lead Agency	Develop an urban and hobby agriculturalist education and outreach campaign.	Provide information targeted to small farm/hobby farm/ranchettes about manure management. Publish public information about proper septic system construction and operation. Educate the public, particularly in towns, about lawn and garden nitrogen applications' contribution to nitrate concentrations. Recommend against farming around a water well	Feasible	Not Effective, based on prior efforts	$30 K	Legislature	2019 Session	Easy
5	WCC, WSU Extention, DOE, SYCD, WSDA, Lead Entity, Ag Industry Associations	Develop a post-GWAC agricultural producer education and outreach campaign. Create a broad-based advocacy group (e.g., regulatory agencies, AG industry associations such as the Farm Bureau, Dairy Federation, hop growers, wine grape growers and producers) to carry out the educational components. . Create a central repository (e.g., website) of agricultural information that provides technical assistance to growers and producers, provides education on nitrate, and identifies BMPs specific to each local agricultural industry. Address consequences of too much irrigation. Technological improvements in irrigation that permit easier management of water. Descriptions of specific improved technology. Economic viability of technological advancements BMP implementation, irrigation water management, soil nutrient management and manure management and application.	Elements could include: encourage commodity groups to provide education on water management and fertilizer use through regular meetings; distribute information to producers on what can happen with applied nitrogen, what should be applied and reasonable, agronomic rates of application; encourage agencies and subject matter experts to make presentations at trade shows; ask agricultural consultants to share the latest BMP developments with their clients; increase livestock operators' awareness of the need for procedures for proper management of animal wastes and wastewater; provide producers with information on funding sources (e.g., industry, government, educational institutions, industry associations etc.) that will improve their ability to apply BMPs; enlist partners (Farm Bureau/federations/associations) to host workshops/informational meetings regarding GWMA goals and recommendations.	Feasible	Effective	DOE: $100 K /yr; SYCD; $100 K / yr, WSDA $50-100 K / yr	Operating budgets	2019 Session	Ask WCC, WSU
6	SYCD, WCC	Establish a local forum for disseminating information and facilitating technical exchange regarding BMPs for irrigated agriculture and livestock management and groundwater protection.	Prepare a fact sheet/develop outreach campaign to growers that explains agronomic rates, applying nutrients at the right time/right place/right amount. Endorse and distribute materials that will educate producers about the facts related to all fertilizer types, including livestock waste and the science of groundwater protection.	Feasible	Effective depending on attendance	Included in above item	Operating budgets	2019 Session	Easy
7	WSDA, SYCD	Inform farmers of those BMPs prioritized by Livestock/CAFO and Irrigated Agriculture Work Groups to reflect greatest effectiveness in nitrate reduction.	Focus implementation of BMPS based on information and data included in the Nitrogen Availability Assessment, Soil Sampling Program, Ambient Groundwater Monitoring Plan, USGS Reports, and other similar scientifically based publications. GWMA: Publish lists as appendices to GWMA Program. WSDA: Adopt a llist Lower Yakima Valley GWMA-specific BMPs; Determine who implements each BMP and who monitors it. Determine the time frame in which to measure/monitor each BMP. SYCD: provide farmer-specific consultation.	Feasible	Effective	Included in above item	Operating budgets	2019 Session	Easy
8	WSDA, SYCD	Encourage appropriate use of surface banding ("dribblling," "stripping" of liquid fertilizer, "broadcasting" or prompt incorporation of manures and fertilizers after application to cropland..	broadcast is effective for corn, alfalfa, triticale. Incorporation should occur within 24 hours.	Ask WSDA	Effective	Included in above item	Operating budgets	2019 Session	Ask WSDA
9	WSDA, SYCD	Continue to provide underlying soils information to individual livestock operations, provide same for all irrigated agriculture	So that individual property owners can evaluate contamination potential., already in DNMP process	Feasible, info available from NRCS	Effective	Current service of NRCS, SYCD	None	N/A	Easy

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?	Co loc co pla ma pr
		Administrative								
1	DOE, Lead Agency, Yakima Health District	Establish or maintain ongoing, extended funding necessary for the Yakima County Department of Public Services and Yakima Health District to actively participate in water quality improvement, testing, monitoring, scientific data analysis, and infrastructure development.	Collect data to track water quality improvement progress and nutrients generated, applied, or exported within the LYV GWMA. Generate data through soil testing, Ambient Groundwater Monitoring Plan implementation - including purpose built and existing wells, sampling of liquid and solid waste to be field applied, composted, or exported, the CAFO General Permit, and tracking nutrients applied by non-dairy operations. Collect, analyze, and interpret data to track water quality improvement progress, nutrients imported, generated, applied, or exported, which will inform the implementation of an Adaptive Management Plan within the LYV GWMA.	Feasible	Effective	DOE $250 K yr. Other cost included in other itemized recommendations	DOE: State operating budget; YHD paid by applicant	2019 Session	Easy	
2	Washington Conservation Commission	Fund SYCD, through State Conservation Commission budget, for projected educational, administrative, nutrient management planning, engineering, cost share, and lending activities.		Feasible,	Effective	Cost included in other itemized recommendations	State operating budget	2019 Session	Easy	
3	SYCD, WSDA	Monitor changes occurring in agricultural operations. Evaluate whether those changes positively affect improvement in groundwater quality.	Requires cooperation of producers & landowners, multi-year effort to account for crop rotation, dry vs. wet years, changing technology, decades to monitor groundwater quality change. WSDA: prepare report to Legislature and Department of Ecology.	Feasible	Effective	$100 K at SYCD; $50 K at WSDA	WCC Operating Budget; WSDA Operating Budget	2019 Session	Requires cooperation of producers	Co 9.1
4	Lead Agency	Establish a Lead Agency reponsible for implementation and oversight of the LYV GWMA Groundwater Management Plan and acquisition of stable funding to support their activities.	Administration of Groundwater Quality Program. Administer funds and distribute to other entities by subcontract. Maintain Yakima County's GWMA website. Maintain a GIS data base on the GWMA.	Feasible	Effective	$100 K / yr	Legislature	2019 Session	Not difficult	Co 9.1
5	Lead Agency	Perform an engineering study of water supply alternatives.	Possible alternatives: 1) Discontinue use of contaminated shallow wells. Build new 1,500 foot community wells. 2) Rebuild, repair or replace poorly constructed wells. 3) Construct a potable water line from nearby developed area into deadhead water stations at central rural location (permit potable water collection at deadhead water stations). 4) Offer incentives to drill deeper wells or connect households on private wells near community water systems to connect to a community water system. (Nitrate Treatment Pilot Program-June 2011).	Feasible	Effective	$100 K	Legislature	2019 Session	Not difficult	Co 9.1 3.1
6	Lead Agency	Adopt and Implement an Adaptive Management Plan	Utilizing data collected, progress made, or lack of progress, to inform the community on adjustments that need to be implemented. Plan would incorporate necessary adjustments to availabley of technology, education and outreach, tracking exports, land use regulations, treatment systems, and other changes to inform decision makers regarding management changes necessary for a successful program.	Feasible	Effective	$100 K / yr	Legislature	Continuous, 2018-2030	Not difficult, depends on funding	Co 9.1
7	EPA, DOE, WSDA	Streamline current regulatory enforcement activities	Improve customer service and protocols, increase clarity of process, escalate enforcement for facilities not following management practices, identify methods to discourage repeatedly unfounded complaints, and improve overall transparency.	Feasible	Effective	$ 0 - $ 300 K / yr, WSDA $100 K	Legislature	2019 Session	Not difficult	Co 9.1
8	DOE, WSDA	Improve composting regulations (statutory)	Unclear as to particular reguations proposed	Yes	Potentially effective. .	$50 K	Legislature	2019	Unceertain	Co 9.1
9	DOE	Inspect, monitor and regulate stockpiled manures.	Coordinate with WSDA. Currently being done; currently required as part of dairy nutrient management plans	Feasible	DOE:	$0 (part of current work)	NA	2018	Not difficult	Co 9.1
10	DOE	Review applications for and issue exemptions for agricultural composting operations in a manner that protects public health and the environment, as required by state rules and regs		Feasible	Currently being done	$0 (part of current work)	NA	2018	Not difficult	Co 9.1
11	DOE	Provide assistance to local departments of health regarding the regulation of agricultural composting operations		Feasible	Currently being done	$0 (part of current work), 1/4 FTE/yr	NA	2018	Not difficult	Co 9.1
12	DOE	Analyze the trends of nitrate data contained within reports required by NPDES and SWD permits.		Feasible	Currently being done	$0 (part of current work), 1/4 FTE/yr	NA	2018	Not difficult	

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?
13	DOE,	Develop a plan for finding and decommissioning abandoned wells in the next 12 months, using the LYVGWMA as a pilot project.	Educate the public regarding liability of an ill-secured well, and the importance of the integrity of wells, particularly those without a well log. Educate realtors and banking industry officials about disclosure of abandoned wells in property transfers. Compare Google Earth to GIS images to determine where building or usage changes indicate possible well usage changes. Focus first on hotspot high density areas in GWMA. Ground truth suspected problem wells. Offer incentives, for property owners to identify and properly abandon wells. Offer grant funding to Yakima Health District or professional engineers for well inspections and to assist in abandoned well decomissioning. Provide some form of protection for self-reporting of abandoned or improperly decommissioned wells.	Feasible	Unknown	$30-50 K / yr	Legislature	Two years	Difficult
14	DOE	Require facility process improvements in waste treatment and food processing plants to reduce nitrogen and total discharge volume.	Addressed by Department of Ecology General Permit for Food Processing, specific problems can be addressed through "special protection areas, " WAC 173-200-090.	Difficult, in general, feasible in specific	Uncertain	$20 K administrative cost. Costly to fruit processing facilities	DOEOperating Budget, Private	2019	Requires amendment to state Water Pollution Cont Act (RCW 90.4
15	DOE, EPA	Study the relationship between nitrogen emissions and atmospheric deposition of reactive nitrogen. Develop a model that predicts what percentage of emissions return to the GWMA area as atmospheric deposition.		Feasible, but inconsequential	Not effective, has demininmus impact on problem	Cost disproprotionate to benefit		2019-2122	Possible
16	WDOH	Determine, prior to issuing or reissuing LOSS permits, that all employee counts are regularly reported.	So that the LOSS will continue to operate as designed.	Feasible, already being done	Effective	$0 part of current work	DOH operating budget	2018	Easy
17	WDOH	Revise WAC 246-203-130 (keeping of animals)	So that it includes specific and enforceable requirements designed to protect human health.	Feasible	Effective	$200K	Legislature	2019 Session	Not difficult
18	WSDA	Design and implement pilot studies focusing on innovative farm techniques which reduce nitrogen loading to crops and monitor results..		Feasible	Effective	$ 25 K	WSDA operating budget		
19	WSDA	Document and publish regulatory compliance for dairies within the GWMA that are completing and implementing Dairy Nutrient Management Plans (DNMP).	Explore the possibility of disclosing non-proprietary data produced through the DNMP process. Summarize the DNMP reporting and provide information that would disclose the amount of manure the CAFO's in the GWMA create and where it is distributed.	Feasible	Effective	$ 50 K	WSDA / DNMP operating budget	2018	Easy
20	DOE, Yakima Regional Clean Air Agency, WSDA	Estimate emissions of reactive nitrogen - gaseous nitrogen oxides (NO_x), ammonia (NH_3), nitrous oxide (N_2O), the anion nitrate, NO_3^- -from animal agriculture, manure and fertilizer applications in the Lower Yakima Valley. Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	Use this to inform the nitrogen balance data base for the GWMA area and refine estimates of atmospheric deposition.	Not Feasible CAA Not Willing		"big and expensive"			
21	WSDA	Establish a monitoring system for compliance with NRCS Standard 317 on new composting facilities at Washington dairies (phased in for existing facilities).		Feasible but inconsequential	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA	Ask WSDA
22	Yakima Health District	Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, as required by state rules and regs.		Feasible, requires authorization from County Board of Health	Effective	$10K, depends upon number of composting facilities	Legislature, balance funded by permit applicant.	2019	Not difficult
23	Yakima Health District	Require new developments outside towns to address potential impacts on groundwater quality	Through permitting review of site plan criteria.	Feasible	Effective	Approx. $25-50 K Costly for developer & purchaser	Developer/ purchaser	Decades	Requires BOCC approval
24	Yakima Health District	Study potential nitrate contamination attributable to improperly operated septic systems.	Consider restoration/retrofit of older septic systems through incentives or county property tax breaks. Require nitrogen reducing technologies for onsite septic systems where appropriate. Assist hobby farmers to locate ROSS drain fields on their property so as to avoid animal farming over the drain field.	Feasible	Effective	$700 per applicant for system repair permit application fee. 100 applicants subsidezed = $70K; subsidize cost of reconstruction = $500K	permit applicant	2020	Not difficult
25	Yakima Health District	Issue permits for agricultural composting operations, to appropriately inspect composting operations and to enforce regulations that protect public health and the environment, as required by state rules and regulations.		Uncertain	Uncertain	Cost would be charged to permittee	Perrmit applicant	?	?
26	Yakima County Building Department	Require new developments to address potential impacts on groundwater quality. Limit new development utilizing septic system where soil filtration rate is high, where housing density is already big, where nitrate concentration is already great downstream of the septic plume. Consider the nitrate density element (# of systems per-area) when approving proposed septic systems in order to reduce the nutrient nitrogen in domestic wastewater discharged from OSS.	Recommendations for conditions on issuance of building permits. Determine "density" evaluation criteria. Including those technologies verified by the U.S. EPA's Environmental Technology Verification Program: fixed film trickling filter biological treatment, media filter biological treatment, and submerged attached-growth biological treatment. Recommend use of anaerobic digestion in waste storage lagoons as a best management practice.	Feasible; Not Feasible for YHD, Would need authorization from County Board of Health. Feasible for YC Planning	Effective	Approx. $10-50 K; Costly for developer & purchaser. $410 per applicant for septic permit from YHD; Building permit application fee	Developer / purchaser / permit applicant	Decades	Requires BOCC approval. Requ knowledge of specific area s and current se densities.

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Difficult to implement?
		Data Collection and Monitoring							
1	DOE, DOH	Establish time-based performance objectives against which well-monitoring data can be compared. Establish criteria by which to measure whether performance of nitrate reduction strategies is successful.	E.g., number of at risk wells, BMP implementation, funding success, reduction in number of underperforming farming practices. Use both method-based measurement and performance-based measurement.	Feasible, depends upon immediacy of expectations	Effective in measuring attainment of objectives	DB: $200-250K / Yr; GS 25 K, 1/4 FTE	DOE, DOH Operating Budget	2019 Session	Difficult; need to define timeframe for water quality improvement
2	Yakima County Public Works	Install Ambient Groundwater Monitoring Wells	Monitoring well construction: Monitoring well data collection:	Feasible	Effective	$700,000 in hand, balance uncertain;	Balance from DOE Capital Budget	2019 Session	Already designed, to be installed before 12/31/18
3	YHD	Collect data from Ambient Groundwater Monitoring Wells	Study short-term seasonal variations in nitrate concentrations over next year or two.--addresses effects of changes in nutrient application over the agricultural cycle. Study long-term trends that develop over several years--to track whether time-based performance objectives are being met.	Feasible	Effective	$20K / year	DOE Operating Budget		
4	Irrigation Districts	Monitor nitrate concentrations of irrigation water at headgates.	Report nitrate concentrations annually to Department of Ecology	Feasible	Effective	$30 K	Ratepayers or DOE grant	2019	Ditch-rider expense
5	USGS	Contract with USGS to collect data from water well system per 2017		Feasible	Effective	$300K			
6	USGS	Contract with USGS to do particle tracking model study to indicate where groundwater moves faster (permeability).	USGS Particle Tracking Model Overview--potentially combined with MT3D MODFLOW application to the vadose Zone	Feasible, already exists	Unknown	$50K Agency Memo only, $500 + K for 5-year study	Legislature	2019 Session	Easy
7	WSDA, DOE, Lead Agency	Assess Nitogen Loading. Building from the WSDA's Nitrogen Availability Assessment, develop a Nitrogen Loading Assessment for all agricultural, residential and commercial properties, using newly collected data.	Hire a technical consultant to conduct a literature review to determine the most relevant information and accurate factors for use in the Nitrogen Loading Assessment. Periodically repeat the grower survey used in the NAA to compare against currently established data. Collect data on how many acres in the GWMA are fertilized in various crops with manure and/or commercial fertilizer. Update and monitor the percentage of acreage in various crops, particularly silage corn and field corn. Study effect nitrogen contribution from cover crops. Determine acreage for triticale. Discover commercial fertilizer tonnage for Yakima County and/or for GWMA. Explore how much nitrogen leaches into groundwater from drains and wasteways. Study atmospheric deposition more comprehensively. Understand the difference between plant uptake and plant removal of nitrogen. Ask EPA to use its CMAQ model, or other tools, to estimate emissions of reactive nitrogen - gaseous nitrogen oxides (NOx), ammonia (NH_3), nitrous oxide (N_2O), the anion nitrate, NO_3,- from animal agriculture, manure and fertilizer applications.. Use this to inform the nitrogen balance data base and refine estimates of atmospheric deposition.	Feasible	Dependent upon completion of NAA & GWAC resolution of course of action	WSDA $1 million. DOE $250 K	WSDA, DOE Operating Budget	Dependent upon completion of NAA & GWAC resolution of course of action	Dependent upon completion of NAA & GWAC resolution of course of action
		Water							
1	WSU	Provide funding to WSU for a mobile irrigation lab to assess the efficiency of current or advised irrigation practices, either through a singular lab or component parts.	Inform farmers of the relative propensity of wheel lines, center pivots, and drip lines to cause leaching and that fertilization and supplemental irrigation beyond the optimum rate will not necessarily produce better yields or higher profits without serious side effects.. Advise re corn and triticale water practices.	Feasible	Effective	Approx. $100 K / yr (IAWG)	WSU Operating Budget	2019 Session	Not difficult
2	SYCD, WSDA, WSU	Create Irrigation Management Plans (similar to Nutrient Management Plans) for farms over a minimum size and provide financial assistance for implemented plans.	Use available techniques to determine how much and when irrigation is needed instead of irrigating according to a prearranged schedule. Analyze irrigation practices to discover whether frequency or volume creates greater propensity for leaching. Manage sprinkler systems so they do not drive nutrients past the root system. Improve micro-irrigation system design and operation. Schedule water and nitrogen application according to the need for optimal crop yields. Monitor the timing of application of fertilizers to fields and how much water was then applied.	Difficult	Effective	WCC $200 K / yr; SYCD $200 K / yr	WCC , WSU Operating Budgets	2019 Session	Difficult, plans are property-specific,
3	WSU, SYCD, WSDA, WCC	Encourage advanced irrigation management. Integrate management of synthetic/organic fertilizers and application of water	Recognizing that there is significant cost involved in changing an irrigation system, look for strategic opportunities where the use of more advanced irrigation management systems could have the greatest benefit for reducing nitrogen impacts to groundwater. One example of advanced irrigation management is electronic sensor irrigation water management (IWM). Identify federal, state and local incentive programs (like EQIP), such as grants, and low interest loans, to facilitate a transition to more advanced irrigation management in those areas. Provide financial assistance for 1) conversions from rill irrigation to sprinkler or drip irrigation, 2) installation of flow meters and moisture meters to reflect over-irrigation, high water table, drought conditions, 3) the cost of hiring third party sampling , measuring equipment, personnel or self-test kits, 4) management of sprinkler systems so they do not drive nutrients past the root system. Establish a voluntary irrigation management cost-share program from which data may be shared with the public.	Feasible	Effective	$25 million (18 K acres of rill irrigation in GWMA @ $3 K / acre, split 50/50 with landowner) $36 million @ $4 K / acre.	Identify federal, state and local incentive programs (like EQIP), such as grants, and low interest loans, financial assistance	Short & Long-Term	

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?	Dif imp
		Public Works							
1	Municipalities	Provide funding for municipalities to replace aging sewer system infrastructure and ensure proper system maintenance to reduce nitrate leaching.	Municipalities need to estimate costs and system integration.	Feasible	Effective	$10 million	Congress, Infrastructure Bill	Decades	Rec to r sta
2	Lead Agency	Encourage municipalities within the GWMA to extend municipal sewer systems within urban growth areas and retire ROSS and LOSS., alternatively extend public water systems. Encourage connection of residences within urban growth zones to sewer systems extended by municipalities		Feasible	Effective	$5 million	Congress, Infrastructure Bill	Decades	Has acc dat
		Research and Development							
1	EPA, DOE	Identify and support opportunities, including educational research institutions, for private, public, and industry investment in technology specific to addressing nitrate contamination in groundwater.	EPA & DOE construct a LYVGWMA Program for coordinated implementation.	Feasible	Effective	$100-250 K / yr	Agency budgets	2018	Eas
2	WSDA	Identify and support opportunities, including education research institutions for private, public and industry investment in technology and management of fertilizers and manures, including separation of solid and liquid wastes.	WSDA construct LYVGWMA administrative program.	Feasible	Effective	$1.75-$4 million, WSDA $10 million	WSDA Capital Budget	2018	Eas
3	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	Feasible	Effective	Included in item above	Congress, Energy Bill	2020	Eas
4	WSU Extension Service	Continue research of water management with application of agricultural nutrients.	Develop water sorption graph or chart. List volumes of water applied, soil types, infiltration rates, water holding capacity, absorption/compaction rates, depths to water, pre-season and post-season appropriate moisture levels, evapotranspiration rates.	Feasible	Effective	$250 K	WSU Operating Budget	Five years	Cor
5	WSU, Producers	Integrate use of animal waste and synthetic fertilizer.	Research chemical integration of animal waste and synthetic ferlizers with objective of balancing nutrient application amounts in order to maximize crop production and full nitrogen uptake.	Feasible	Effective	$250 K	Private, WSU Operating Budget	Ongoing, 2019 Session	No req of s
6	WSDA, WSU	Quantify the nutrient value and rate of release of nitrate from livestock waste under various Lower Yakima Valley conditions to become part of nutrient management guidelines.		Feasible	Effective	$500 K. $100 K	WSDA, WSU Operating Budgets	2019 Session	Dif kno are and inf
7	WSDA	Develop strategies for marketing the economic, fertilizer value, and soil enhancing properties of appropriate application of manure and other livestock wastes.		Feasible	Effective	$25 K	WSDA Operating Budghet	2019 Session	Ask
8	WCC	Identify and support opportunities, including education research institutions for private, public and industry investment in technology and management of fertilizers and manures, including separation of solid and liquid wastes.		Feasible	Effective	$1 million	WCC Capital Budget	2019 Session	No
9	Legislature	Require Commodity Commissions to dedicate "check off" money for research and development in water quality technology and practices.	include in funding alternatives for technology R & D	Feasible	Effective	Portion of other estimates above.	CC Members	2019	Res sta
10	USDOE, USDOA	Explore investment in animal and agricultural waste to energy technology	Explore state of technology, economic viability, return on investment (national corporate research & development/ governmental incentives)	Feasible	Effective	$1 million	Congress	2020	Eas
11	SYCD, WSDA, WSU, Private Industry, Producers	Educate producers regarding aplication of nutrients at Agronomic Rate	Develop technologies and provide information about improvements made in nutrient management and agronomic rate application of fertilizer by specific developing technologies.	Feasible	Effective	Dependent on technologies included in combined education recommendation GB $500,000	Private, Legislature	Ongoing, 2019 Session	Dej tec

Formatted: Line spacing: Multiple 1.15 li

	Recommend To:	Recommendation	Details	Feasible?	Effective?	Cost?	Proposed funding?	Time?
		Agriculture						
1	NRCS, DOE	Provide financial assistance for implementation of Irrigation Management Plans.	1) conversions from rill irrigation to sprinkler or drip irrigation, 2) installation of flow meters and moisture meters to reflect over-irrigation, high water table, drought conditions, 3) the cost of hiring third party sampling , measuring equipment, personnel or self-test kits, 4) management of sprinkler systems so they do not drive nutrients past the root system.	Feasible	Effective	$ 1 million one time ($250 K x 4; NRCS EQIP program limited to $450 K per farmer unless new Farm Bill authorization)	Congress (Farm Bill), DOE Capital Budget	2019 Session
2	DOE, WSDA	Make grants and allocate cost share funding or other funding assistance to people implementing environmental protection measures affecting groundwater quality.	Assign personnel to investigate which environmental protection measures utilized by irrigated agriculturalists and livestock/dairy producers have positive influence on groundwater quality and explore means to share costs of implementing such measures. (Coordinated DOE, WSDA, Conservation District program). See NRCS Environmental Stewardship Program (2012).Also WCC, Voluntary Stewardship Program (Bill Isler), USDA Rural Community Assistance Group environmental program	Feasible	Effective, depending upon definition of "environmental measures"	DOE: $1 million, WSDA: $500 K	DOE, WSDA Capital Budget	2019 Session
3	SYCD, Producers	Develop and implement Nutrient Management Plans for all farmers.	Mandatory or Voluntary. Farming operations currently are not required to hold permits or a prepare a Nutrient Management Plan.	Feasible	Effective	SYCD $200 K, on farm costs born by producer	WCC Operating Budget	Recurrent/ Annual
4	WSDA	Amend the Dairy Nutrient Management Act to extend WSDA's authority to manure application on properties other than those owned by dairies, provide more complete disclosure of Nutrient Management Plans.		Feasible	Effective	$200 K / yr	WSDA Operating Budget	2019 Session
5	SYCD	Establish a multi-year deep soil sampling program where farmers subscribe for a duration with pre-determined fiscal remuneration for completed sampling. Cost share with farmer. Farmer to provide checklist indicating performance with BMPs. Test throughout growing year, in order to observe effects of fertilization throughout year. Share data with public.	Farmers would subscribe for a duration with pre-determined fiscal remuneration for completed sampling. Cost share with farmer. Farmer would provide checklist indicating performance with BMPs. Testing would occur throughout growing year, in order to observe effects of fertilization throughout year. Data grossly accumulated would be shared with public without attribution to individual farmers. Anecdotal results of deep soil sampling carried out by SYCD with farmers with pre-existing relationship with SYCD were informative. Word-of-mouth reporting within farmer community greatly increased acres sampled.	Feasible	Effective	$250 K / year for 5 years to finance extensive deep soil sampling program;	WCC Operating Budget	2019 Session
6	WSDA	Complete NRCS Technical Note 23 inspections on all waste storage ponds (lagoons) within the GWMA boundaries.		Feasible	Ask WSDA	WSDA $20 K	WSDA Operating Budget	2019 Session
7	Producers	Make capital improvements	Install liners in liquid waste storage lagoons. Install impervious surfaces beneath silage storage.	Feasible	Effective	$10 million	Cost-share/ producers & WSDA (Legislature)	2019
8	Legislature	Make shallow (1, 2, 3 foot) soil testing reports prerequisites for funding, lending or building permits.	In the nature of Phase I Environmental Audits. Makes nitrate-related information/data available for water quality management.	Feasible	Effective	$2 k / per mit application	Private	2019

Appendix K – Recommendations Received From Public Comment

These recommendations consolidated in this appendix came out of the public comments. In many instances the exact wording from the comment letter was used, however some were edited for length.

During the Program creation process, the GWAC met for 6 years, spending many hours drafting, analyzing, and voting on potential recommended actions for the program. Some of the items in this appendix have previously been discussed by the GWAC, however all items have been included as documentation for future use.

Recommendations Related to Dairies or Large Farming:

All agriculture (including hops, mint, row crops, tree fruit, grapes) should be required to take annual soil samples and have a written nutrient management plan plus inspections.

Encourage adoption of irrigation and nutrient management practices.

Create means for all agriculture to work together.

Create a cost share program for earthen lagoons.

Recommendations Related to Ongoing Data:

The Departments of Ecology, Agriculture and Conservation Commission, as well as Yakima County, the Yakima County Health District and the Southern Yakima Conservation District should not regard the investigation of groundwater contamination in the Lower Yakima Valley as a fait accompli, but rather as a fait ab initio.

Results from the next steps in the U.S. Geological Survey work could be useful to implementing the GWMA program. The next phase would be to conduct a reverse-loading analysis based on the 2015 particle tracking study, to estimate how much reduced nitrogen loading would need to occur to decrease nitrate concentrations in downgradient residential wells to meet the drinking water maximum contaminant level. These findings could be used to refine and focus efforts to implement the final GWMA program in the coming years.

The Washington State Conservation Commission awarded competitive grants for demonstration projects statewide to test various technological approaches to recapture or recycle nutrients, including one in the Yakima Valley. The results of these projects could be useful in the implementation phase.

Use new information from research, data gathering, and technology demonstration projects nationwide pertaining to both understanding the nature of groundwater contamination and strategies to reduce it.

Collect nitrate data from domestic wells as a substitute for monitoring wells. Collection of additional data, including hydrogeological and water quality data should focus on areas with identified deeper nitrate contamination, with a goal of identifying potential conduits to deeper aquifer zones.

Seek to broadly and proportionately represents the affected community.

Duly authorized governmental agencies and duly elected public officers are charged with a public duty to execute those rules and regulations currently in effect, and exercise those powers with which they are currently authorized, notwithstanding that they are not recommended by public interest groups.

Neither the final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program, nor the recommendations contained therein, are limiting upon the choices available to the public at large or governmental agencies with relevant jurisdiction.

The Washington hop commission funded a WSU, three year, deep sampling to 6 ft. in 23 hop yards from 1990-1992. This study showed the variability between spring and fall sampling and explained some of the reasons why this happens. It also demonstrated how variable management practice can effect soil test nitrate over time. Take this into account.

Ensure that QAPPs are developed for any new work that includes data collection.

Overlay historical nitrate levels against farming practices over the same time and the population growth of the area of both livestock and people. If this long term (more than a decade) historic data is not available, perhaps a trend or timeline should be established prior to making broad decisions.

Recommendations Related to Public Outreach and Education:

Send a mass mailing to all residents located outside of public water supply service areas within the Lower Yakima Valley. The mailing would explain the problem of nitrates in shallow groundwater, and that it is of particular danger to expecting mothers and infants. The mailing would provide a telephone number for free testing of their well water for nitrates.

Use Spanish-language radio educational information as an outreach tool.

Provide education on double cropping and agronomic application of nitrogen

Recommendations Related to Gathering Additional Data:

Assign staff dedicated to collection of water samples from domestic wells for nitrate analysis. The staff should be able to respond to requests to sample within one week of a telephone request. Households with infants or expecting mothers (or women of childbearing age) would be bumped to the top of the list. Shallower wells should be given a higher priority than deeper wells. The sampling staff would maintain a database, including available well construction information.

A higher percentage of the committee be comprised of members who reside in the affected GWMA area so as to more accurately represent their community and neighbors' best interests.

Because of potential negative effects on fish and fish habitat, ammonia (NH_3) should be investigated in irrigation return flows to surface waters. Arid area waters tend to be more alkaline than those in wetter areas, and NH_3 toxicity to aquatic organisms increases as

Formatted: Heading 1,GW Heading 1

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Font: Bold

pH increases. (EPA Quality Criteria for Water, 1986 as updated). If initial investigations do not indicate a problem, no further monitoring should be required.

Consideration should be given to supplemental funding to include nitrogen analysis of groundwater samples from Superfund/MTCA site monitoring wells within the study area. This would potentially increase the number of available data points within the study area at a very modest increase in cost.

Information not provided to the GWAC but obtainable from the Washington State

Department of Agriculture should be analyzed:
a. Growth in agricultural use intensity (density/acre, acreage fanned, production volume)
b. Amount of chemical fertilizer sold or used within GWMA
c. Report of dairy nutrient management plan information on distribution of manure (see RCW 90.64.026(3), RCW 42.56.270(7), WAC 16-06-210(29))
d. Nitrogen Loading Assessment (as distinguished from Nitrogen Availability Assessment, see: June 19, 2014, August 21, 2014, October 16, 2014, and December 18, 2014 GWAC meeting summaries; Yakima County/Department of Agriculture Interagency Agreement

Information not provided to the GWAC but obtainable from the Department of Ecology should be analyzed:
a. Report on enforcement of RCW groundwater standards
b. Report on effect of large scale water usage on groundwater quality

Identify or analyze information about the amount of chemical fertilizers sold or distributed to managers of orchards and crops, or applied to orchards and crops within the study area.

Reflect the often-expressed view/opinion within the Advisory Committee that the effect of groundwater contamination in the Lower Yakima Valley influences the lives and health of human demographic groups disproportionately. Study or describe the socioeconomic effect of groundwater contamination within the study area upon on future generations. Both effects should be studied.

Correlate the economic benefit derived from the private small industrial, agricultural, urban/suburban residential sector sources' activity within the study area with the economic costs likely to be incurred by the public remedial, corrective, educational, or regulatory activities responding to the problem. Quantify the economic value of the natural resource (groundwater) consumed through contamination (an unmeasured and undocumented expense incurred as part of the private small industrial, agricultural, and urban/suburban residential sectors' entrepreneurial enterprise). Study this relationship in order to determine correlate costs of remediation, if any, with the economic benefits of groundwater consumption.

Evaluate the causal relationship, if any, between the method and volumes of water applied to the ground surface (either generally or at specifically identifiable locations, or the volume of groundwater stored within the ground, within the studied area, and the extent, location or degree of groundwater contamination within the studied area or at specific contaminated wells.

Evaluate the correlation, if any, of the location, volume or movement of surface water within lined or unlined artificial conveyance systems (irrigation canals) with the extent, location or degree of groundwater contamination within the studied area.

Correlate changes in concentration, density, intensity, or use of source-related activities within the studied area with changes, if any, in the extent, location or degree of groundwater contamination within the studied area.

Analyze specific deep soil sampling data collected from known locations. Collect more deep soil sampling data, with data collection sites located, and that data analyzed.

Analyze trends in well data from Valley Institute for Research and Education Report (2002), Nitrate Pilot Project Well Samples, LVYGWMA High Risk Well Assessment Well Samples, and USGS 2017 Well Testing Data. Analyze trends in this data.

Identify plausible hypotheses of causation, transmission, or accumulation of contaminant between categorical sources and contamination events or locations. These hypotheses should be stated and explored.

Describe the processes of hydrogeologic or chemical transmission or accumulation of contaminant in the area of contamination. These processes should be more completely explored and described.

Investigate or analyze the geologic and hydrogeologic properties of denser locations of contaminated wells ("hotspots). These should be investigated and analyzed.

Investigate or analyze the plausible causal relationship between specifically identifiable sources and specific contamination events. These should be investigated and analyzed.

Explore the correlation, if any, between specific land use types and proximate water supply contamination events.

Explore the correlation, if any, between specific land use types and proximate water supply contamination events.

Address the specific land use regulations, or other regulation types, that might use, rectify, ameliorate or otherwise alter the general or specific contamination condition within the study area.

Address the effect of generic or specific sources on the protection of areas with "critical recharging effect on aquifers used for potable water or areas where a drinking aquifer is vulnerable to contamination that would affect the potability of the water" as designated by Yakima County pursuant to the Growth Management Act or otherwise (RCW 36.70A; WAC 365-190-030 (3); and YCC 16A, 16C), as "environmentally sensitive or special areas" as contemplated by WAC 197-11-330(2)(e)(i), WAC 197-11-305 (l)(a), WAC 197-11-908(l)(b) and the Growth Management Act. These effects should be described and analyzed.

Explore the strategy of taxation on the use or sale of materials containing chemical constituents common to known constituents of groundwater contamination as a means of source reduction.

Explore the strategy of usage limitations, imposed through land use regulation, on the nature, density, or intensity of use (analogous to limitations on industrial development).

Recommend any remedial action. Remedial actions should be studied.

Evaluate the costs or implications of inaction. These should be evaluated.

Locate and evaluate any past nitrate studies done for this area, specifically an unspecified study done approximately 40-50 years previous.

Formatted: Space After: 0 pt

Formatted: Space After: 0 pt

Formatted: Space After: 0 pt

Formatted: Space After: 0 pt

Use scientific data from additional sources, including: Collaborative work carried out by local, state and federal agencies in 2010, "Lower Yakima Valley Groundwater Quality." Data from other scientific studies are also available. Quality-assured/quality controlled available data. A few examples to draw upon include:

- United States Geological Survey (USGS): "Particle tracking for selected groundwater wells in the lower Yakima River Basin, Washington," 2015. The USGS assessed nitrate sources in specific geographic areas within the GWMA with groundwater contamination and identified associated likely nitrogen source areas, https://pubs.er.usizs.izov/publication/sir20155149
- The EPA: "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington," 2013 contains soil information such as permeability data from lagoons, and nitrogen concentrations in manured dairy crop fields, https://www.epa.izov/wa/lower-yakima-valleygroundwater
- Since a Consent Order was signed with three Lower Yakima Valley dairies in 2013, these dairies have made great strides in reducing the amount of nitrogen accumulating in their fields. In reports submitted under the EPA Consent Order and approved Quality Assurance Project Plan (QAPP), there are several years of biannual data from fields prior to the AOC-required limitations of field applications of manure and the subsequent transition to the present conditions. These dairies are also providing post-harvest data that can inform soil concentration estimates in the draft GWMA Plan. https://www.epa.gov/wa/lower-yakima-valley-groundwater

Study proportional impact of all sources of nitrate so as not to overly burden one group over another without knowing their respect impacts to groundwater nitrates.

Study scientific evidence of impacts related to regulations on farmers and dairymen.

Recommendations Related to Monitoring Wells:

Maintain a longitudinal record of measurements taken from groundwater monitoring wells so as to document trends in improvement or worsening of the present condition.

Map the "horizon" of analysis of monitoring well measurements from the groundwater monitoring well system (an undulating plane established by points (elevations) at each monitoring well, with the intervening spaces being calculated with reference to influence from proximate point data) should be mapped. This might indicate how the measured horizon intersects with the geologic regimes already known (theoretically) to exist within the study area.

Introduce some sort of non-pollutive tracer in selected monitoring wells in order to ascertain whether that tracer expresses itself in other monitoring wells. This may be possible due to the density and location of monitoring wells within the study area. This may provide information helpful in establishing direction of groundwater flow (albeit at a rather surficial elevation).

Test monitoring wells whether the nitrates are coming from human waste or from animals and commercial fertilizer.

Place some wells around the town of Outlook to determine whether the nitrates are coming from people or agriculture.

In addition to randomly placed monitoring wells, consideration should be given to more intensive targeted monitoring at and around "hot spots" as changes in N concentrations (improvements and further degradation) will be particularly important in those areas.

Include wells in the urban growth areas.

Wells deemed anomalies to be discontinued.

Recommendations Related to Providing Resources:

Identify locations for household collection of free drinking water at each community in the Lower Yakima Valley. Once a household water supply well has been tested, the owner or resident would be provided with a document allowing them to pick up free drinking water (a reasonable weekly allotment could be calculated).

Begin a grant program for replacement of impacted shallow domestic wells. Such grants could be applied for by homeowners that have a shallow wells with nitrates above cleanup levels. Prioritization of grant recipients should be based on needs of the applicant. A fund for this grant can be contributed to by taxpayers and groundwater polluters. This recommendation would require legislative action.

Formation of rural PUD Water Districts for replacement water supplies, particularly in "hot spots" within the GWMA.

Use recirculating sand filters in areas where high density of ROSS.

Coordinate with DOH on WAC 246-272A-015 (5) which states "shall develop a written plan that will provide guidance to the local jurisdiction regarding development and management activities for all OSS within the jurisdiction".

Recommendations Related to Additional Regulations:

Drinking water wells required depth of greater than one hundred feet deep.

Onsite Sewage Systems (OSS) should be controlled by the county and a plan that is required by WAC 246-272A-015(5) should be developed by the Health Department for OSS. I would recommend that any parcel that requests an OSS permit that is less than 20 acres (just under High Density standards) should have an OSS that is designed to reduce the nitrogen flow in its effluent.

Recommendations Related to Additional Approaches:

Provide greater focus on eliminate exposure pathways.

Make providing drinking water to affected the top priority.

Formatted: Space After: 0 pt
Formatted: Space After: 0 pt
Formatted: Space After: 0 pt
Formatted: Font: Bold
Formatted: Space After: 0 pt
Formatted: Font: Bold
Formatted: Space After: 0 pt
Formatted: Space After: 0 pt
Formatted: Font: Bold
Formatted: Space After: 0 pt
Formatted: Font: Bold

Lower Yakima Valley Groundwater Management Program

Volume III

Accomplishments

June 2019 ~~August 20, 2018~~

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Volume III

ACCOMPLISHMENTS ____ 34

Preliminary Assessment ____ 34
Request for Identification ____ 34
Workplan ____ 34
Analysis of existing water quality ____ 34
Groundwater Monitoring Plan ____ 54
Groundwater Monitoring QAPP ____ 5
Ambient Groundwater Monitoring Network ____ 5
Drinking Water Sampling QAPP ____ 5
Drinking Water Sampling Results ____ 75
Deep Soil Sampling QAPP ____ 75
Nitrogen Availability Assessment ____ 76

DOCUMENTS PRODUCED BY LYVGWMA FOR EDUCATION AND PUBLIC OUTREACH ____ 97

Section 1: Education and Outreach Documents 108

What you can do to protect well water ____ 119
Septic Safety: What you can do ____ 1210
Small Farms: What you can do ____ 1311
Well Safety: What you can do ____ 1412
Granjas Pequenas: Lo que puede hacer ____ 1513
Que puede hacer para proteger el agua de pozo ____ 1614
Seguridad de sistemas septicos: Lo que usted puede hacer ____ 1715
Seguridad en pozos: Lo que usted puede hacer ____ 1816

Section 2: Letter to Physicians 1917

Survey Letter ____ 2018
Survey Health Care Provider Questionnaire (Attachment) ____ 2220
Letter to Physicians Methemoglobinemia (Attachment) ____ 2422
GWMA Map (Attachment) ____ 2624

Section 3: GWAC Public Opinion Survey Summary Report 2013 2725

GWAC Public Opinion Survey ____ 2826
GWAC Public Opinion Survey (Spanish) ____ 2927
Survey Answers ____ 3129
Survey Answers to Questions 9 and 11 ____ 3331

Section 4: Handouts 3432

Handout: Updated Certified Laboratories ____ 3533
Department of Health Private Wells ____ 3634
Department of Health Private Wells (Spanish) ____ 4038

____ 4142

Department of Health Coliform ____ 4142
Department of Health Coliform (Spanish) ____ 4543
Department of Health Nitrates in Drinking Water ____ 4745
Department of Health Nitrates in Drinking Water (Spanish) ____ 4947
Nitrates, Blue Baby Syndrome, and Drinking Water: A fact sheet for families ____ 5149
Nitrates, Methemoglobinemia, and Drinking Water: A fact sheet for clinicians ____ 5351
How to Keep Your Baby Safe from Nitrates in Drinking Water 5654
How to Keep Your Baby Safe from Nitrates in Drinking Water (Spanish) ____ 5755
PEHSU Nitrates Clinician Fact Sheet ____ 5856
Section 5: Phase I Well Testing 6159
High-Risk Well Testing: Media Talking Points ____ 6260
Phase I High-Risk Survey Instrument ____ 6462
Well Assessment Survey (July 13, 2015) ____ 7371
Free Well Water Testing: Phase II (English) ____ 7573
Free Well Water Testing: Phase II (Spanish) ____ 7674
Public Service Announcement: Free Well Water Testing (English) ____ 7775
Letter: Invite to Participate in Well Testing (English) ____ 7876
Letter: Invite to Participate in Well Testing (Spanish) ____ 7977
Section 6: Results Letters 8078
Letter 1: [Satisfactory] Nitrate Results and What They Mean ____ 8179
Letter 1: [Satisfactory] Nitrate Results and What They Mean (Spanish) ____ 8280
Letter 2: [5-9] Nitrate Results and What They Mean ____ 8381
Letter 2: [5-9] Nitrate Results and What They Mean (Spanish) ____ 8482
Letter 3: [Ten Plus] Nitrate Results and What They Mean ____ 8583
Letter 3: [Ten Plus] Nitrate Results and What They Mean (Spanish) ____ 8684
Letter 4: Unsatisfactory Coliform Results and What They Mean ____ 8785
Letter 4: Unsatisfactory Coliform Results and What They Mean (Spanish) ____ 8886
Letter 5: Unsatisfactory Coliform & E. Coli Results and What They Mean ____ 8987
Letter 5: Unsatisfactory Coliform & E. Coli Results and What They Mean (Spanish) ____ 9088
Section 7: GWAC Presentations 9189
GWMA Mission Presentation ____ 9290
Nitrate Education Presentation ____ 9593
Section 8: Promotional Billboards 9896
Private Well Users Test Your Water ____ 9896
Private Well Users Test Your Water (Spanish) ____ 9997

Accomplishments

Preliminary Assessment

Ecology (Washington State Department of Ecology). (2010). Lower Yakima Valley Groundwater Quality: Preliminary Assessment and Recommendations Document. Ecology Publication 10-10-009. Prepared by Washington State Department of Ecology, Washington State Department of Agriculture, Washington State Department of Health, Yakima County Public Works Department, and U.S. Environmental Protection Agency. https://fortress.wa.gov/ecy/publications/documents/1010009.pdf.

Request for Identification

PGG (Pacific Groundwater Group). (2011). Request for Identification: Lower Yakima Valley Groundwater Management Area. Prepared for Yakima County, Yakima, Washington, by Pacific Groundwater Group, Seattle. http://www.yakimacounty.us/DocumentCenter/View/2359.

Groundwater Management Area Advisory Committee Operating Guidelines

http://yakimacounty.us/DocumentCenter/View/10038/2012_0920_GWAC_OperatingGuidelines_Final?bidId=

Formatted: Heading 3,GW Heading 3

Formatted

Workplan

http://www.yakimacounty.us/DocumentCenter/View/2006/Groundwater-Advisory-Committee-Plan-PDF?bidId=

Analysis of existing water quality

PGG (Pacific Groundwater Group). (2013g). Potential Groundwater Monitoring Stations, Yakima Groundwater Management Area. Prepared for HDR Inc., Yakima County, and Lower Yakima Valley Groundwater Advisory Committee, by Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17689/20131203-PGG-Potential-Monitoring-Well-Locations.

Groundwater Monitoring Plan

PGG (Pacific Groundwater Group). (2014e). Interim Final Groundwater Monitoring Plan, Lower Yakima Valley GWMA, Initial Characterization. JE 1308. Prepared for Lower Yakima Valley Groundwater Advisory Committee and Yakima County, by Pacific Groundwater Group, Seattle, August 15, 2014. http://www.yakimacounty.us/DocumentCenter/View/13277.

Groundwater Monitoring QAPP

PGG (Pacific Groundwater Group). (2013d). Groundwater Monitoring, Quality Assurance/Quality Control Plan: Lower Yakima Valley GWMA, Initial Characterization. JE 1308. Prepared for Yakima County, Washington, by Pacific Groundwater Group, Seattle, September 16, 2013. http://www.yakimacounty.us/DocumentCenter/View/15880.

Ambient Groundwater Monitoring Network

PGG (Pacific Groundwater Group). (2016c). Lower Yakima Valley GWMA Proposed Ambient Groundwater Monitoring Network. Prepared for Lower Yakima Valley Groundwater Advisory Committee and Yakima County, by Pacific Groundwater Group, Seattle. https://www.yakimacounty.us/DocumentCenter/View/17700/20160608-PGG-Ambient-Monitoring-Network-Report-Final-for-Approval-approved-11-2016.

Drinking Water Sampling QAPP

USGS, 2017. Quality Assurance Project Plan, Nitrate in Groundwater of the Yakima River Basin. Tacoma, WA, 44 pgs.



QAPP_YakimaGWMA_nitrates.pdf

Formatted: Space After: 0 pt, Line spacing: single

Field Code Changed

Drinking Water Sampling Results

USGS (U.S. Geological Survey). (2018). Concentrations of Nitrate in Drinking Water in the Lower Yakima River Basin, Groundwater Management Area, Yakima County, Washington, 2017. [By Huffman, R.L.] U.S. Geological Survey Data Series 1084, p. 18. https://pubs.usgs.gov/ds/1084/ds1084.pdf.

Deep Soil Sampling QAPP

PGG (Pacific Groundwater Group). (2014c). Deep Soil Sampling Plan, Lower Yakima Valley Groundwater Management Area. Prepared for Yakima County, by Irrigated Agriculture Working Group.

https://www.yakimacounty.us/DocumentCenter/View/17692/20140328-PGG-DSS-Plan-Version-6.

Nitrogen Availability Assessment

WSDA (Washington State Department of Agriculture). (2018). Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area: A Study by the Washington State Department of Agriculture and Yakima County. [By Bahr, G., Beale, P., Drennan, M., Hancock, J., McLain, K., Redifer, V., Martian, M., and Kozma, C.] AGR PUB 103-691. https://agr.wa.gov/FP/Pubs/docs/103-691YakimaGWMANitrogenTransportReport.pdf.

Documents Produced by LYVGWMA for Education and Public Outreach

Section 1: Education and Outreach Documents

In early 2017, the GWAC created a test series of four "What You Can Do" one-page (front/back) English/Spanish flyers. The series had two purposes: the first was to promote the key messages identified by the GWAC (i.e., how to protect private well water, how to maintain a septic system, how to manage small farm waste, and how to promote well safety). The second purpose was to introduce a simple, one-page template that the GWAC could use for other educational outreach topics. The series was posted to the website and almost immediately 22,700 flyers were distributed during a widespread flooding event.

"What You Can Do to Protect Well Water" flyers were deployed in response to local flooding in the GWMA's unincorporated community of Outlook. Yakima Health District staff went door to door distributing over 100 flyers and nitrate test trips for private well testing in flooded areas. Approximately 22,700 flyers were inserted in the *Sunnyside Daily Sun News* and in the Spanish-language *El Sol* weekly newspaper. GWAC volunteers distributed flyers at the Sunnyside Walmart during the flooding event.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

What you can do to protect well water

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Steps to assure you have safe drinking water

Things to consider if you are a private household well owner:

Have your water tested – at least once a year for nitrates and coliform bacteria. High nitrates can harm pregnant women, newborn babies and the elderly, and high bacteria counts can cause illnesses. More information on Lower Yakima Valley Groundwater Management Area at http://www.yakimacounty.us/1617/Ground-Water-Management-Area. A list of certified labs and information on water testing are available online at http://www.yakimacounty.us/344/Drinking-Water-Testing.

Locate all wells on your property, both active and inactive. Make sure to cap your wells securely with manufactured or welded caps to prevent pollution and objects from entering your well.

Have your septic pumped - Neglecting septic system maintenance can result in backed-up sewage, expensive repairs and surface seepage that can pollute your well. A system for a four-person household should be pumped every three years.

Use less water – Not only does your septic system function better with less water, pumping more water from your well can pull nearby pollution toward your home.

Manage fertilizers and chemicals – Excess fertilizer moves easily through the soil and contributes to high nitrate levels. Spilled chemicals can reach your well water. Recycle household and hazardous wastes at the County collection facility. Never dump these items on your property or pour them down the drain.

Shield animal waste – Animal yards and piles of composting manure are sources for nitrates and bacteria. Take steps to prevent runoff and soil seepage.

Install backflow preventers – on all your outdoor faucets. Sometimes water can siphon backwards through a hose and down your well. Be very careful when you attach a chemical sprayer to your hose.

Do your part to keep groundwater safe and clean.

GROUNDWATER MANAGEMENT AREA



The purpose of the Lower Yakima Valley Groundwater Management Area is to reduce nitrate contamination where concentrations do not meet drinking water standards.

GWAC Working Groups

- Data Collection, Characterization, Monitoring
- Education and Public Outreach
- Funding
- Irrigated Agriculture
- Livestock/CAFO
- Regulatory Framework
- Residential, Commercial, Industrial and Municipal

To get involved, call (509) 574-2300

More information at: www.yakimacounty.us

Septic Safety: What you can do

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Septic Safety: What you can do

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Failing septic systems can pollute drinking water wells

Check it, fix it, maintain it:

Bacteria, viruses and other pollutants from the sewage of a failing septic system, may contaminate drinking water wells, groundwater aquifers, lakes, rivers and streams.

A septic system doesn't have to be a problem.

- Get regular inspections and maintenance. Choose a date or time of the year that's easy to remember for the inspection. Mark it on the calendar.
- Regularly pump your system. Typically, once every three years for a four-person household.
- Learn how to keep your system working properly. Be careful what you flush or pour down the drain. No pet waste, medications, grease, or toxic chemicals.
- Watch for clues that your tank is nearing capacity or your system is failing. Got odors? Get someone to check it out right away. Then fix it, if needed.
- Keep trees at least 30 feet from edge of drain field to keep their roots from invading. Never drive over the system.
- Conserve water. Too much can cause solids to escape your tank and plug your drain field.
- Repair or replace your system when it fails or is otherwise inadequate.

Locate your septic tank and drain field:

- Use your property map or follow discharge pipe from your house. Probe the ground with a rod to determine the location of your septic tank.
- Underground pipes distribute wastewater in a drain field. Wet spots can indicate a failing drain field that needs professional attention.

Do your part to keep groundwater safe and clean.

For more information:
http://www.ecy.wa.gov/programs/wq/wqguide/septic.html
http://www.yakimacounty.us/335/Septic-Systems

GROUNDWATER MANAGEMENT AREA



The purpose of the Lower Yakima Valley Groundwater Management Area is to reduce nitrate contamination where concentrations do not meet drinking water standards.

GWAC Working Groups
- Data Collection, Characterization, Monitoring
- Education and Public Outreach
- Funding
- Irrigated Agriculture
- Livestock/CAFO
- Regulatory Framework
- Residential, Commercial, Industrial and Municipal

To get involved, call (509) 574-2300

More information at: www.yakimacounty.us

Small Farms: What you can do

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Small Farms: What you can do

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Poor manure management can threaten drinking water wells

Collect, cover and compost:

Livestock manure can be great fertilizer. It may also be a source of water pollution when exposed to the weather. If you keep livestock, even just one or two, you have a special role to play in protecting drinking water, groundwater aquifers, rivers and streams.

What can you do to help?

- Use downspouts to direct runoff away from manure.
- Pick up manure from farm yards and paddocks at least every three days.
- Store manure under cover in a convenient site that's sheltered from heavy winds.
- When you use a tarp for a cover, secure it well. The tarp should be durable, heavy-weight and large enough to fully cover the pile.
- Work with the local conservation district office to make a plan and learn how to best handle your manure.
- Build a compost system or have an off-site compost facility collect the manure.

Washington's Dairy Nutrient Management Act requires all licensed dairies to develop and implement nutrient management plans. Large livestock operations must follow confined animal feeding operation (CAFO) regulations to protect water quality.

Good manure management also helps you:

- Prevent parasite re-infestation.
- Keep groundwater clean.
- Build goodwill with your neighbors.
- Support a healthy watershed.

Do your part to keep groundwater safe and clean.

For more information:
http://www.ecy.wa.gov/washington_waters/farms.html

GROUNDWATER MANAGEMENT AREA



The purpose of the Lower Yakima Valley Groundwater Management Area is to reduce nitrate contamination where concentrations do not meet drinking water standards.

GWAC Working Groups
- Data Collection, Characterization, Monitoring
- Education and Public Outreach
- Funding
- Irrigated Agriculture
- Livestock/CAFO
- Regulatory Framework
- Residential, Commercial, Industrial and Municipal

To get involved, call (509) 574-2300

More information at: www.yakimacounty.us

Well Safety: What you can do

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Well Safety: What you can do

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

The dangers of uncapped, abandoned or hand dug wells

Capping prevents pollution, serious injuries:

All wells must be securely capped, including those that are not in use, temporarily out of service, or not yet decommissioned, to protect the drinking water and the aquifer from contamination. Proper capping also prevents objects, animals and people from falling into the well.

Common methods of capping wells, include using:

- Manufactured well caps.
- Metal plates welded to the top of the well casing.
- A well-seal/artesian style cap for wells in vaults or located in areas where surface water ponds.

These can be found at pump and water supply stores. Securely attach the cap so that it prevents contamination and unpermitted access to the wells. *Don't use an overturned bucket or loose plate to cover the well casing.*

What to look for when searching for an abandoned well:

Landowners who don't know the history of wells on their property should look for the following when searching for abandoned wells:

- Pipes sticking out of the ground.
- Old well houses.
- Depressions.
- Concrete vaults, pits or tile.
- Metal plates, or old plywood lying on the ground or over concrete tile or vaults.

Do your part to keep groundwater safe and clean.

For more information:
http://www.ecy.wa.gov/programs/wr/wells/abandon-wells.html
https://fortress.wa.gov/ecy/publications/publications/96br097.pdf

GROUNDWATER MANAGEMENT AREA



The purpose of the Lower Yakima Valley Groundwater Management Area is to reduce nitrate contamination where concentrations do not meet drinking water standards.

GWAC Working Groups
- Data Collection, Characterization, Monitoring
- Education and Public Outreach
- Funding
- Irrigated Agriculture
- Livestock/CAFO
- Regulatory Framework
- Residential, Commercial, Industrial, and Municipal

To get involved, call (509) 574-2300

More information at: www.yakimacounty.us

Granjas Pequenas: Lo que puede hacer

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Granjas pequeñas: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):
El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado.

Un mal manejo del estiércol puede amenazar los pozos de agua potable

Recoja, cubra y haga composta:

El estiércol de ganado puede ser un gran fertilizante. También puede ser una fuente de contaminación del agua cuando se expone al clima. Si tiene ganado, incluso solo uno o dos, usted tiene un papel especial que desempeñar en la protección del agua potable, los acuíferos subterráneos, los ríos y arroyos.

Qué puede hacer para ayudar?

- Use canalones para dirigir el escurrimiento de agua lejos del estiércol.
- Recoja el estiércol de los corrales y potreros por lo menos cada tres días.
- Almacene el estiércol bajo cubierta en un sitio conveniente que esté al abrigo de vientos fuertes.
- Cuando utilice una lona como cubierta, asegúrela bien. La lona debe ser durable, pesada y lo suficientemente grande para cubrir totalmente el montón.
- Trabaje con la oficina local de conservación del distrito para hacer un plan y aprender a manejar mejor su estiércol.
- Construya un sistema de composta o busque una planta de compostaje para que recoja su estiércol.

La Ley de Manejo de Nutrientes de Leche de Washington Dairy Nutrient Management Act requiere que todas las lecherías con licencia desarrollen e implementen planes de manejo de nutrientes nutrient management plans. Las operaciones mayores de ganado deben seguir las regulaciones de operación de animales confinados (CAFO) para proteger la calidad del agua.

El buen manejo del estiércol también lo ayuda a:

- La prevención de reinfestación de parásitos.
- Mantener el agua subterránea limpia.
- Desarrollar buena voluntad con sus vecinos.
- Apoyar una cuenca acuífera saludable.

Haga su parte para mantener las aguas subterráneas limpias y seguras.

Para más información viste:
http://www.ecy.wa.gov/washington_waters/farms.html

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS



El propósito del Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima es reducir la contaminación de nitratos donde la concentración no cumplen con standares de Agua potable.

Grupos de trabajo GWAC

- Recolección de datos, caracterización, monitoreo
- Educación y divulgación al público
- Financiación
- Agricultura de riego
- Ganado/CAFO
- Marco Regulatorio
- Residencial, comercial, industrial y municipal

Para participar, llame al: (509) 574-2300

Para más información visite: www.yakimacounty.us

Que puede hacer para proteger el agua de pozo

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Qué puede hacer para proteger el agua de pozo

Área de Manejo de Aguas Subterráneas (GWMA):
El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado.

Pasos para asegurar que tenga agua potable

Cosas a considerar si tiene una vivienda con pozo privado:

Haga pruebas a su agua – Al menos una vez al año para nitratos y bacterias coliformes. Los altos niveles de nitratos pueden afectar a mujeres embarazadas, a los recién nacidos y a los ancianos, y las altas concentraciones de bacterias pueden causar enfermedades. Más información sobre el Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima en: http://www.yakimacounty.us/1617/Ground-Water-Management-Area. Una lista de laboratorios certificados e información sobre pruebas de agua está disponible en línea en: http://www.yakimacounty.us/344/Drinking-Water-Testing.

Localice todos los pozos en su propiedad, activos e inactivos. Asegúrese de tapar sus pozos de forma segura con tapas prefabricadas o soldadas para evitar que contaminación y objetos caigan a su pozo.

Haga un bombeo a su fosa séptica – Descuidar el mantenimiento de su sistema séptico puede resultar en que se regresen las aguas residuales, reparaciones costosas y filtración superficial que puede contaminar su pozo. Un sistema para un hogar de cuatro personas debe bombearse cada tres años.

Utilice menos agua – No solo su sistema séptico funciona mejor con menos agua, sino también el bombear más agua de su pozo puede atraer contaminación cercana hacia su hogar.

Maneje los fertilizantes y productos químicos – El exceso de fertilizante se mueve fácilmente a través del suelo y contribuye a altos niveles de nitrato. Productos químicos derramados pueden alcanzar el agua de su pozo. Recicle los residuos domésticos y peligrosos en los centros de recolección del Condado. Nunca tire estos productos en su propiedad ni los vierta en el drenaje.

Aísle los residuos animales– Los corrales de animales y los montones de estiércol son fuentes de nitratos y bacterias. Tome medidas para evitar el escurrimiento y la filtración del suelo.

Instale válvulas preventivas de reflujo – en todas sus llaves de agua fuera de la casa. A veces, el agua puede sifonar de regreso a través de una manguera y hacia su pozo. Tenga cuidado cuando conecte rociadores de químicos a su manguera.

Haga su parte para mantener las aguas subterráneas limpias y seguras.

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS



El propósito del Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima es reducir la contaminación de nitratos donde la concentración no cumplen con standares de Agua potable.

Grupos de trabajo GWAC

- Recolección de datos, caracterización, monitoreo
- Educación y divulgacion al publico
- Financiacion
- Agricultura de riego
- Ganado/CAFO
- Marco Regulatorio
- Residencial, comercial, industrial y municipal

Para participar, llame al: (509) 574-2300

Para más información visite: www.yakimacounty.us

Seguridad de sistemas septicos: Lo que usted puede hacer

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Seguridad de sistemas sépticos: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):
es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado

Los sistemas sépticos que fallan pueden contaminar los pozos de agua potable

Revíselo, arréglelo y dele mantenimiento:

La bacteria, los virus y otros contaminantes de las aguas residuales de un sistema séptico que falla pueden contaminar pozos de agua potable, acuíferos subterráneos, lagos, ríos y arroyos.

Un sistema séptico no tiene que ser un problema.

- Obtenga inspección y mantenimiento regular. Elija una fecha o una época del año que sea fácil de recordar para tener la inspección. Anótelo en su calendario.
- Bombee regularmente su sistema. Normalmente, una vez cada tres años para un hogar de cuatro personas.
- Aprenda a mantener su sistema funcionando correctamente. Tenga cuidado con lo que vierte por el desagüe. No desechos de mascotas, medicamentos, grasas ni químicos tóxicos.
- Esté atento a las señales de que su tanque está cerca de la capacidad o de que su sistema está fallando. ¿Tiene olores? Pídale a alguien que lo revise inmediatamente. Luego, arréglelo si es necesario.
- Mantenga los árboles por lo menos a 30 pies del borde del campo de drenaje para evitar que las raíces lo invadan. Nunca conduzca sobre el sistema.
- Conserve agua. Demasiada agua puede causar que los sólidos escapen del tanque y que tapen las líneas del campo de drenaje.
- Repare o reemplace el sistema cuando falle o cuando sea inadecuado.

Localice el tanque séptico y el campo de drenaje:

- Utilice el plano de su propiedad o siga la línea de descarga de su casa. Pruebe el suelo con una barra para determinar la ubicación del su tanque séptico.
- Las tuberías subterráneas distribuyen las aguas residuales en el campo de drenaje. Las áreas húmedas pueden indicar un campo de drenaje defectuoso que necesita atención profesional.

Haga su parte para mantener las aguas subterráneas limpias y seguras.
Para más información visite:
http://www.ecy.wa.gov/programs/wq/wqguide/septic.html
http://www.yakimacounty.us/335/Septic-Systems

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS



El propósito del Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima es reducir la contaminación de nitratos donde la concentración no cumplen con standares de Agua potable.

Grupos de trabajo GWAC

- Recolección de datos, caracterización, monitoreo
- Educación y divulgación al público
- Financiación
- Agricultura de riego
- Garantía/CAFO
- Marco Regulatorio
- Residencial, comercial, industrial y municipal

Para participar, llame al:
(509) 574-2300

Para más información visite:
www.yakimacounty.us

Seguridad en pozos: Lo que usted puede hacer

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Seguridad en pozos: Lo que usted puede hacer

Área de Manejo de Aguas Subterráneas (GWMA):
El propósito de GWMA es reducir concentraciones de contaminación de nitratos en aguas subterráneas por debajo de los estándares de agua potable del estado.

Los peligros de pozos destapados, abandonados o excavados a mano.

Las tapas evitan la contaminación y lesiones graves:

Todos los pozos deben estar tapados, incluyendo los que no están en uso, temporalmente fuera de servicio o que todavía no están retirados de servicio para proteger el agua potable y el acuífero de la contaminación. Una cubierta adecuada también impide que objetos, animales y personas caigan en el pozo.

Los métodos comunes de tapado de pozos, incluyen el uso de:

- Tapas para pozo prefabricadas.
- Placa de metal soldada a la parte superior del revestimiento del pozo.
- Una tapa de sello para pozo estilo artesiano en bóvedas o localizados en áreas donde el agua superficial se acumula.

Estos pueden encontrarse en tiendas de materiales para irrigación y bombas de agua. Fije la tapa para evitar la contaminación y el acceso no permitido al pozo. *No utilice solo un balde volteado o una placa suelta para cubrir el pozo.*

En qué debe fijarse durante la búsqueda de un pozo abandonado:

Los propietarios que no saben la historia de los pozos en su propiedad deben fijarse en lo siguiente durante la búsqueda de pozos abandonados:

- Tuberías que salen de la tierra.
- Estructuras y cobertizos para pozos.
- Depresiones en el suelo.
- Bóvedas de hormigor, hoyos, o Azulejo.
- Placas de metal o madera en el suelo o sobre revestimientos o bóvedas de concreto.

Haga su parte para mantener las aguas subterráneas limpias y seguras.

Para más información viste:
http://www.ecy.wa.gov/programs/wr/wells/abandon-wells.html
https://fortress.wa.gov/ecy/publications/publications/96br097.pdf

ÁREA DE MANEJO DE AGUAS SUBTERRÁNEAS



El propósito del Área de Manejo de Aguas Subterráneas del Valle Bajo de Yakima es reducir la contaminación de nitratos donde la concentración no cumplen con standares de Agua potable.

Grupos de trabajo GWAC

- Recolección de datos, caracterización, monitoreo
- Educación y divulgación al público
- Financiación
- Agricultura de riego
- Ganado/CAFO
- Marco Regulatorio
- Residencial, comercial, industrial y municipal

Para participar, llame al: (509) 574-2300

Para más información visite: www.yakimacounty.us

Section 2: Letter to Physicians

The joint Benton County/Yakima Health District letter to physicians launched the GWAC's three-part health risk and public awareness campaign in 2013. Over 200 local healthcare providers received nitrate-related health information as well as a survey asking them if they had observed symptoms of methemoglobinemia in their maternal or infant patients.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

YAKIMA HEALTH DISTRICT 1911 PREVENTION IS OUR BUSINESS

PUBLIC HEALTH Prevent • Promote • Protect BENTON-FRANKLIN HEALTH DISTRICT

Survey Letter

Dear Medical Provider:

The Lower Yakima Valley Ground Water Management Area Advisory Committee (GWAC) is working to address nitrate contamination and its sources in a wide area where elevated levels of nitrate have been identified in private drinking water wells (see attached map).

This letter is being written in cooperation with the Benton-Franklin and Yakima County Health Districts, which are active members of the advisory committee, and is designed to alert you to the health risks associated with nitrate contamination.

Attached is a handout to provide you with a brief refresher about methemoglobinemia in infants. Symptoms are common and have the potential of being under diagnosed.

At greatest risk are infants younger than six months of age because of the immaturity of their enzyme systems which convert methemoglobin back to hemoglobin.

Maternal exposure to environmental nitrates and nitrites may increase the risk of pregnancy complications such as anemia, abortion, premature labor, or preeclampsia. Study of other potential reproductive, developmental, or carcinogenic effects has not produced conclusive results.

If you are concerned about a patient the appropriate testing should be done to verify your diagnosis. Upon confirmation you should report the condition to the communicable disease section at the Yakima or Benton-Franklin Health Districts depending on your patient's county of residence. Environmental Health personnel at each district should be able to assist you with water quality information, if available, as well as assist the family with sampling of their water as needed.

Yakima County Health District Communicable Disease Report Line: 509-249-6521; for information about water quality, treatment, options, call be Environmental Health help desk at 509-249-6508. Benton-Franklin Health District: 509-460-4200.

We hope you will consider discussing the drinking-water conditions of your patients as you treat them, especially if they reside in the Lower Yakima Valley and exhibit symptoms of methemoglobinemia.

Suspected sources of nitrate contamination are from a variety of land uses, including commercial fertilizers for crop production, animal manures, septic systems and land application of waste water.

More information about the Lower Yakima Valley Ground Water Management Area is available online at: http://www.yakimacounty.us/gwma/

Sincerely,

Andre Fresco, Administrator
District Officer

Yakima County Health District
Health District

Amy D. Person, M.D.,

Benton-Franklin

attachments: Methemoglobinemia in infants

YVGWMA Vicinity Map

Survey Health Care Provider Questionnaire (Attachment)

Questionnaire for Health Care Providers

Nitrate contamination of drinking water is a growing concern in the United States and around the world. The Lower Yakima Valley has a history of elevated nitrates in groundwater wells that sometimes exceed drinking water standards. In 2011, the Lower Yakima Valley Groundwater Management Area (GWMA) was formed to address nitrate contamination.. The most pressing health issue related to elevated nitrate levels in drinking water is methemoglobinemia in very young children. You can help us gather critical information by completing and returning this questionnaire. We understand that confidentiality prevents sharing of patient information and ask that you provide general information only. Thank you very much for sharing your time and expertise.

1. During the past five years have you cared for infants with signs and symptoms of methemoglobinemia, such as cyanosis in the absence of heart and lung pathology? YES NO

Comments:

_____

_____

2. Are you aware of the relationships between methemoglobinemia and

   a. infants (<6 mo.) and well water contaminated with nitrates? YES NO

   b. diarrhea in infants? YES NO

   c. sepsis in infants? YES NO

3. Do you question about the use of well water when dealing with infants <6 mo. YES NO

4. Do you question about the use of well water when dealing with pregnant women? YES NO

5. Do you encourage families with a newborn to have their well tested for bacteria and nitrates to find out if it's safe before using it to mix formula for their new infant? YES NO

6. How would you like to learn more about nitrate related problems?

ON-LINE _____ WORKSHOPS _____ WRITTEN SELF STUDY _____HEALTH DEPARTMENT

MAILING _____ OTHER (Please describe) _____

7. Please share your thoughts on this subject

_____

_____

(END OF SURVEY)

If you wish to receive additional information on the Lower Yakima Valley Groundwater Management Area, you may either visit www.yakimacounty.us/GWMA/ or provide the following:

Name: _____

Mailing Address: _____

Phone: _____

E-mail: _____

Thank you for participating in this survey.

Please return this survey to: Lower Yakima Valley Groundwater Management Area, c/o Yakima County Public Services, 128 N 2nd St, Fourth Floor, Yakima WA 98901

Letter to Physicians Methemoglobinemia (Attachment)

METHEMOGLOBINEMIA

IN INFANTS < 6 MONTHS OF AGE

SYMPTOMS/SIGNS:

Bluish discoloration of skin (cyanosis): fails to respond to inhaled O2

Fatigue/lethargy

Shortness of breath/tachypnea

Nausea

Diaphoresis

Mental status changes

In severe intoxication (50-70% methemoglobin): shock, seizures, acidosis, death

DIAGNOSIS:

Methemoglobin level: normal <1%

bluish/chocolate brown blood

Arterial blood gas: usually normal PO2 in the face of cyanosis

Pulse oximetry: usually inaccurate in the face of methemoglobinemia

O2 saturation: usually low but inaccurate in the face of methemoglobinemia

ETIOLOGY:

Nitrates/nitrites in water supply (Sources: fertilizer, manure, damaged well heads, leaking septic systems): EPA recommends <10 ppm

Infants who have diarrhea, sepsis, or other infections may have increased endogenous production of nitrites. Infants already exposed to nitrates in their water source would be at greater risk for methemoglobinemia with these infections.

TREATMENT:

1% Methylene blue: 1-2mg/kg IV (beware of risks with G6PD deficiency)

ascorbic acid

oxygen

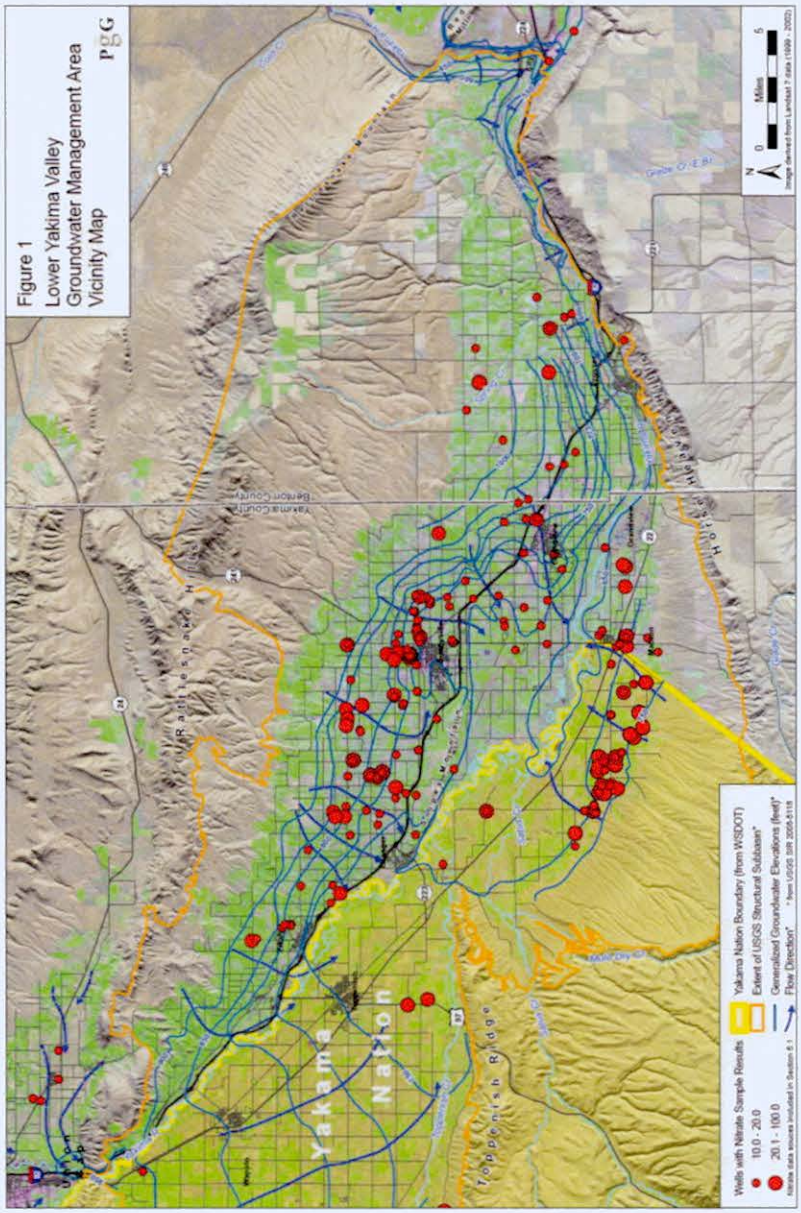
exchange transfusion

WEBSITES:

http://www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001588/

http://www.nap.edu/catalog.php?record_id=4795

GWMA Map (Attachment)



Section 3: GWAC Public Opinion Survey Summary Report 2013

The Public Opinion survey immediately followed the healthcare provider survey in 2013. The GWAC designed the survey to gauge the public's awareness of the nitrate issue, its potential health impacts, and to gauge awareness of the GWMA program development. Bilingual Heritage University students conducted 136 door-to-door surveys and distributed Department of Health information on a variety of topics. The survey instrument was posted to the GWMA website and was offered at public events and health fairs during the next four years.

GWAC Public Opinion Survey

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Form # GWMA0001 A
Revised 7/25/13

Groundwater Management Area (GWMA):
The profile of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Lower Yakima Valley Groundwater Management Area
Informational Public Questionnaire

☐ Survey Completed ☐ Survey Attempted/Not Completed:
No One Home____ Declined____ Other____
Number of Attempts____

***Address:**_____

***Parcel Number**_____ ***Survey Date**_____ ***Surveyor**_____

***Mandatory Information**

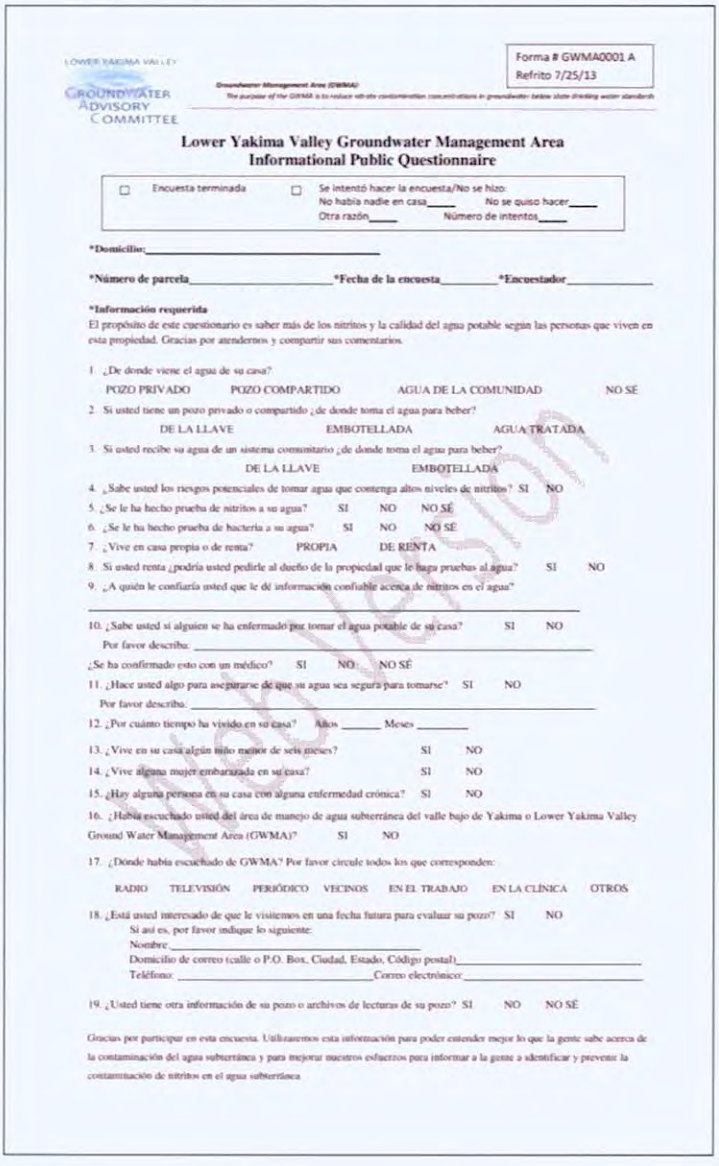
The purpose of this questionnaire is to learn more about water quality and nitrates in drinking water from people who live here. Thank you for sharing your ideas.

1. Where does the water in your home come from?
   PRIVATE WELL SHARED WELL COMMUNITY WATER DON'T KNOW
2. If you have a private or shared well, where do you get your drinking water?
   TAP WATER BOTTLED TREATED WATER
3. If you are on a community water system, where do you get your drinking water?
   TAP WATER BOTTLED
4. Are you aware of the potential health hazards in drinking water with high levels of nitrates? YES NO
5. Has your well water been tested for nitrates? YES NO DON'T KNOW
6. Has your well water been tested for bacteria? YES NO DON'T KNOW
7. Do you own your home or rent? OWN RENT
8. If you rent, do you feel comfortable asking your landlord to have the water tested? YES NO
9. Who would you trust to give you reliable information about nitrates in drinking water?
   _____
10. Are you aware of anyone in your home that has become ill from drinking your water? YES NO
    Please describe: _____
    Has this been confirmed by a physician? YES NO DON'T KNOW
11. Are there things that you do to make sure your drinking water is safe? YES NO
    Please describe _____
12. How long have you lived in your home? Years_____ Months _____
13. Is there a child under the age of six months in your household ? YES NO
14. Are there pregnant women in your household? YES NO
15. Are there chronically ill people in your household? YES NO
16. Have you heard of the Lower Yakima Valley Ground Water Management Area (GWMA)? YES NO
17. Where have you heard of the GWMA? Please circle all that apply:
    RADIO TELEVISION NEWSPAPER NEIGHBORS AT WORK HEALTH CARE OTHER
18. Are you interested in being contacted for a survey of your well at a later date? YES NO
    If yes, please provide the following:
    Name:_____
    Mailing Address (Street or P.O. Box, City, State, Zip)_____
    Phone: _____ E-mail: _____
19. Do you have any information about your well or your well log? YES NO DON'T KNOW

Thank you for participating in this survey. We will use the information to increase our understanding of what people know about groundwater contamination and to improve our efforts to educate people on how to identify and prevent nitrate contamination of the groundwater.

Please return this survey to: Lower Yakima Valley Groundwater Management Area, c/o Yakima County Public Services, 128 N 2nd St, Fourth Floor, Yakima WA 98901.

GWAC Public Opinion Survey (Spanish)



LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Forma # GWMA0001 A
Refrito 7/25/13

Lower Yakima Valley Groundwater Management Area
Informational Public Questionnaire

☐ Encuesta terminada ☐ Se intentó hacer la encuesta/No se hizo:
No había nadie en casa____ No se quiso hacer____
Otra razón____ Número de intentos____

***Domicilio:**_____

Número de parcela**_____Fecha de la encuesta**_____***Encuestador**_____

***Información requerida**
El propósito de este cuestionario es saber más de los nitritos y la calidad del agua potable según las personas que viven en esta propiedad. Gracias por atendernos y compartir sus comentarios.

1. ¿De donde viene el agua de su casa?
POZO PRIVADO POZO COMPARTIDO AGUA DE LA COMUNIDAD NO SÉ
2. Si usted tiene un pozo privado o compartido ¿de donde toma el agua para beber?
DE LA LLAVE EMBOTELLADA AGUA TRATADA
3. Si usted recibe su agua de un sistema comunitario ¿de donde toma el agua para beber?
DE LA LLAVE EMBOTELLADA
4. ¿Sabe usted los riesgos potenciales de tomar agua que contenga altos niveles de nitritos? SI NO
5. ¿Se le ha hecho prueba de nitritos a su agua? SI NO NO SÉ
6. ¿Se le ha hecho prueba de bacteria a su agua? SI NO NO SÉ
7. ¿Vive en casa propia o de renta? PROPIA DE RENTA
8. Si usted renta ¿podría usted pedirle al dueño de la propiedad que le haga pruebas al agua? SI NO
9. ¿A quién le confiaría usted que le dé información confiable acerca de nitritos en el agua?
_____
10. ¿Sabe usted si alguien se ha enfermado por tomar el agua potable de su casa? SI NO
Por favor describa: _____
¿Se ha confirmado esto con un médico? SI NO NO SÉ
11. ¿Hace usted algo para asegurarse de que su agua sea segura para tomarse? SI NO
Por favor describa: _____
12. ¿Por cuánto tiempo ha vivido en su casa? Años _____ Meses _____
13. ¿Vive en su casa algún niño menor de seis meses? SI NO
14. ¿Vive alguna mujer embarazada en su casa? SI NO
15. ¿Hay alguna persona en su casa con alguna enfermedad crónica? SI NO
16. ¿Había escuchado usted del área de manejo de agua subterránea del valle bajo de Yakima o Lower Yakima Valley Ground Water Management Area (GWMA)? SI NO
17. ¿Dónde había escuchado de GWMA? Por favor circule todos los que corresponden:
RADIO TELEVISIÓN PERIÓDICO VECINOS EN EL TRABAJO EN LA CLÍNICA OTROS
18. ¿Está usted interesado de que le visitemos en una fecha futura para evaluar su pozo? SI NO
Si así es, por favor indique lo siguiente:
Nombre:_____
Domicilio de correo (calle o P.O. Box, Ciudad, Estado, Código postal)_____
Teléfono: _____Correo electrónico:_____
19. ¿Usted tiene otra información de su pozo o archivos de lecturas de su pozo? SI NO NO SÉ

Gracias por participar en esta encuesta. Utilizaremos esta información para poder entender mejor lo que la gente sabe acerca de la contaminación del agua subterránea y para mejorar nuestros esfuerzos para informar a la gente a identificar y prevenir la contaminación de nitritos en el agua subterránea

Lower Yakima Valley Groundwater Management Area

Informational Public Questionnaire

Por favor devuelva esta encuesta a: Lower Yakima Valley Groundwater Management Area, c/o Yakima County Public Services, 128 N 2nd St, Fourth Floor, Yakima WA 98901.

Web Version

Survey Answers

	LOWER YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA INFORMATIONAL PUBLIC QUESTIONNAIRE							
		Number	Percentage	TOTAL				
	Number of Households in Survey			**300**				
	Number of Surveys Completed	136	45%					
	Number of households Not Possible (dogs, gates, etc)	88	29%					
	Number of Households Declining	60	20%					
	Number of Households Not Attempted	16	5%					
	TOTAL	**300**	**100%**					
	QUESTION	YES	DON'T KNOW	NO	NOT ANSWERED	TOTAL		
#1	Where does the water in your home come from?	PRIVATE WELL	SHARED WELL	COMM. WELL	DON'T KNOW			
		122	5	2	7	136		
		90%	4%	1%	5%			
#2	If you have a private or shared well, where do you get your drinking water?	TAP WATER	BOTTLED WATER	TREATED WATER	NOT ANSWERED			
		69	24	41	2	136		
		51%	18%	30%	1%			
#3	If you are on a community water system, where do you get your drinking water	TAP WATER	BOTTLED WATER	TREATED WATER	NOT ANSWERED			
		1	0	0	1	2		
		50%		50%				
		YES	DON'T KNOW	NO	NOT ANSWERED	TOTAL		
#4	Are you aware of the potential health hazards in drinking water with high levels of nitrates?	94	35		7	136		
		69%	26%		5%			
#5	Has your well water been tested for nitrates?	73	23	40		136		
		54%	17%	29%				
#6	Has your well water been tested for bacteria?	45	28	63		136		
		33%	21%	46%				
		OWN	RENT					
#7	Do you own your home or rent?	115	17					
		85%	12%					
#8	If you rent, do you feel comfortable asking your landlord to have the water tested.	12		5		17		
		71%		29%				
#9	Who would you trust to give you reliable information about nitrates in drinking water? (answers on p.2)							

#10	Are you aware of anyone in your homes that has become ill from drinking your water?	6		125	5	136		
		4%		92%				
#11	Are there things you do to make sure your drinking water is safe? (answers on p. 2)	81	39	16	0	136		
		59%	29%	12%	0%			
#12	How long have you lived in your home							
	Less than a year	8						
	1-10years	50						
	10-15years	24						
	15-20year	13						
	20-43years	21						
	Not Answered	20						
#13	Is there a child under the age of six months in your household?	1		134	1	136		
		<1.0%		99.0%	<1.0%			
#14	Are there pregnant women in your household?	1		134	1	136		
		<1.0%		99%	<1.0%			
#15	Are there chronically ill people in your household?	7		128	1	136		
		5%		94%	<1.0%			
#16	Have you heard of the Lower Valley GWMA?	57		73	6	136		
		42%		54%	4%			
					Percentages rounded to the nearest			
#17	Where have you heard of the Lower Yakima Valley Ground Water Management Area (GWMA)	**RADIO**	**TV**	**NEWSPAPER**	**AT WORK**	**HEALTH CARE**	**OTHER**	**NOT ANSWERED**
		8	4	24	1	2	18	79
		5%	2%	17%	0%	0%	13.0%	58.0%
#18	Are you interested in being contacted for a survey of your well at a later date?	45		76	15	136		
		33%		56%	11%			
#19	Do you have any information about your well or your well log?	17	24	81	14	136		
		13%	18%	59%	10%			

Survey Answers to Questions 9 and 11

#9	#11
Who would you trust to give you reliable information about nitrates in drinking water?	**Are there things that you do to make sure your drinking water is safe?**
18 Responses: County	42 Responses: Filter
14 Responses: Health Department	6 Responses: Test
10: Doctor	4: Purchase drinking water
9: Don't know	4-Reverse Osmosis
6: Government Agency	Have it checked
6: Independent Company	Inspection
3: Department of Health	Lab
2: Lab	A person was coming in that specializes in water treatment.
2: Testing Service	Refrigerator treats water
2: himself	Soft water tester
City	Buy Culligan
Culligan	Water Softener
Cascade Testing/Independent	Water system
Ask Owner	Whole house filter, considering upgrading (well drilled in 2009)
Down town	Zero test often number low
Drinking water Kinetico Personnel	
EPA	
Fed water	
Central Washington University	
Heritage University Students	
Local School	
Clean water in Tri Cities, from the fair	
4 years tested	
Labon Yakima	
My own research (not counting on 2nd hand info.)	
myself	
Nobody	
Anyone knows	
People who know about it	
Professionals who test the water	
Rain Water in Sunnyside	
Reputable servicer	
Service who tests water	
Somebody who test for nitrates	
Son	
Water officials @ clinic	
Water system facility	
Whoever his landlord tells him	
Yes but she/he lives in Texas	
Don't care	

Section 4: Handouts

The GWAC created a library of English/Spanish public health and self-help handouts that were distributed with every survey, inserted in mailings, made available at public events and health fairs, and posted to the website. The purpose was to reinforce the health messages created by the GWAC, and remind private well owners of their responsibility to test and maintain their drinking water wells. Most handouts were published by the Washington State Department of Health (DOH). The exceptions were the list of certified laboratories in the GWMA area, and the "How to Keep Your Baby Safe from Nitrates in Drinking Water" handout.

The "How to Keep Your Baby Safe from Nitrates in Drinking Water" flyer was created in collaboration with the University of Washington's Pediatric Environmental Health Specialty Unit (PEHSU). The GWAC kept local hospitals stocked with the English/Spanish flyer for distribution to their new mom patients during the GWMA program development. A handout for nurses – Nitrates, Blue Baby Syndrome, and Drinking Water: A Fact Sheet for Families – was also created and distributed.

For clinicians, a companion handout, Nitrates, Methemoglobinemia, and Drinking Water: A Fact Sheet for Clinicians and video were created to raise their awareness of possible nitrate exposure in their patients. PEHSU obtained authorization to offer Continuing Education Units (CEU) to participating healthcare providers.

Handout: Updated Certified Laboratories

Lower Yakima Valley GWMA Program
Certified Testing Laboratories
(Updated July 23, 2013)

Laboratory Name	Address	Phone	Web Site	Approximate Cost
Ag Health Laboratories, Inc.	445 Barnard Boulevard Sunnyside, WA	(509) 836-2020	www.aghealthlabs.com	Nitrate - $30 Coliform - $21
Benton-Franklin Health District Lab	7102 West Okanogan Place Kennewick, WA	(509) 460-4206	www.bfhd.wa.gov	Nitrate - $24 Coliform - $24
Cascade Analytical Inc. - Yakima	1008 West Ahtanum Road, #2 Yakima, WA	(509) 452-7707	www.cascadeanalytical.com	Nitrate - $27.50 Coliform - $25
Mukang Labs, Inc.	2526 E. Saint Helens Street Pasco, WA	(509) 544-2159	www.mukanglabs.com	Nitrate - $18.50 Coliform - $20
Northwest Agricultural Consultants, Inc.	2545 West Falls Ave. Kennewick, WA	(509) 783-7450	www.nwag.com	Nitrate - $17.50 Coliform - NA
Valley Environmental Laboratory	201 East D Street Yakima, WA	(509) 575-3999	http://www.valleylab.net/	Nitrate - $35 Coliform - $25

All of the above laboratories are certified by the Washington State Department of Ecology to test for nitrate in drinking water. Ag Health Laboratories, Benton-Franklin Health District, Cascade Analytical, Mukang Labs and Valley Environmental Laboratory are also certified to test for coliform in drinking water.

Costs shown for nitrate and coliform tests are approximate and subject to change.

Lower Yakima Valley GWMA Program
Laboratorios Certificados

Nombre del laboratorio	Dirección	Teléfono	Web Site	Costo aprox.
Ag Health Laboratories, Inc.	445 Barnard Boulevard Sunnyside, WA	(509) 836-2020	www.aghealthlabs.com	Nitratos - $30 Coliforme - $21
Benton-Franklin Health District Lab	7102 West Okanogan Place Kennewick, WA	(509) 460-4206	www.bfhd.wa.gov	Nitratos - $24 Coliforme - $24
Cascade Analytical Inc. - Yakima	1008 West Ahtanum Road, #2 Yakima, WA	(509) 452-7707	www.cascadeanalytical.com	Nitratos - $27.50 Coliforme - $25
Mukang Labs, Inc.	2526 E. Saint Helens Street Pasco, WA	(509) 544-2159	www.mukanglabs.com	Nitratos - $18.50 Coliforme - $20
Northwest Agricultural Consultants, Inc.	2545 West Falls Ave. Kennewick, WA	(509) 783-7450	www.nwag.com	Nitratos - $17.50 Coliforme - NA
Valley Environmental Laboratory	201 East D Street Yakima, WA	(509) 575-3999	http://www.valleylab.net/	Nitratos - $35 Coliforme - $25

Todos los laboratorios en éste documento están certificados por el Departamento de Ecología del Estado de Washington para probar nitratos en el agua potable Los laboratorios Ag Health Laboratories, Benton-Franklin Health District, Cascade Analytical, Mukang Labs, y Valley Environmental Laboratory también están certificados para probar la presencia de coliformes en el agua potable.

El costo por la prueba de nitratos y coliforme es aproximado y sujeto a cambio.

Department of Health Private Wells



Private Well Water

Coliform Bacteria and Nitrate Information for Private Well Users

Why should my well water be tested?
Drinking contaminated water is a health risk. Some contaminants cannot be seen, smelled, or tasted. Two of the most common contaminants in drinking water are coliform bacteria and nitrate and they can be harmful.

Who should be testing my well water?
You or your landlord. Private well users are responsible for testing their own water. If you don't own your home but you use a private well, talk with your landlord about getting your water tested or seeing the most recent results. You can always take a water sample yourself and have it tested.

What should I test for and how often?
The Department of Health recommends that you test your private well water every year for coliform bacteria and nitrate.

You should also test your water when:

- You notice a change in your water, such as taste, color, or smell.*
- Your well has been flooded.
- You replace any part of your well system.
- Someone in your household is pregnant, nursing, or has an unexplained illness and you suspect your water may be at risk.
- You hear that a neighbor's water is contaminated.
- You live near industrial or agricultural activities.*

*These may require testing for something other than coliform or nitrate.

If you have had previous contamination problems or are concerned about specific contaminants, you may want to test your well water more often.

Where do I go to get my water tested?
Certified drinking water labs are located across the state. The lab you select or your local health department can help you decide what to test for, how to collect samples, and how to understand results. There is a cost for these tests. Costs this year (2010) range from $20 to $25 per test for coliform bacteria, and $30 to $42 per test for nitrate. Most labs like to provide their own sample bottles.

My nitrate level is *less than* 10 ppm, what should I do?

Nitrate levels can vary throughout the year, so if your level is 5 ppm or higher, you may want to re-sample in six months.

My nitrate level is *more than* 10 ppm, what should I do?

If your nitrate test shows levels higher than 10 parts per million, find a different and safe drinking water supply. The quickest thing to do is to begin using bottled water for drinking and food preparation. Do NOT boil water with high nitrate. Boiling water may actually increase the nitrate level, making the problem worse!

Another option is to install a device or filter designed to remove nitrate from your water. These devices are often installed on kitchen faucets, where people get their water for drinking and cooking. Nitrate is not absorbed through the skin, so it is safe to clean and bathe with it.

Other, longer term solutions include:

- Drilling a deeper well into a different groundwater source;
- Connecting to a public water system; or
- Working with others in your community to develop a new public water system to serve your home and nearby neighbors.

My test results came back with coliform in the water, what should I do?

Coliform tests usually come back as SATISFACTORY or UNSATISFACTORY. If you receive a SATISFACTORY report, it means your water was free of these bacteria at the time of the sample. Be sure to test every year for coliform bacteria.

If you receive an UNSATISFACTORY report, it may be contaminated. Do not drink the water until it tests SATISFACTORY. Find a different and safe drinking water supply. The quickest thing to do is either begin using bottled water or boil all water for drinking and food preparation. This also includes water used for making ice or coffee, brushing teeth, and washing fruits and vegetables you eat raw. Boiling water rapidly for one minute usually kills bacteria.

Your lab and local health department can help you determine if you should resample, disinfect your well, or take other action based on your results.

What are coliform bacteria and why should I care?

Coliform bacteria are organisms that are present in the environment and in the feces of humans and animals. Coliform bacteria will not likely cause illness, but their presence in drinking water indicates disease-causing organisms may also be present.

What is nitrate?

Nitrogen is a chemical found in most fertilizers, animal manure, and in septic tanks. Natural bacteria in the soil can change nitrogen into nitrate. Rain water and irrigation water can carry nitrate down through the soil into the groundwater.

What can nitrate do to me?

Too much nitrate in your body makes it harder for red blood cells to carry oxygen. While many people do not notice a difference, this can be very dangerous for infants and pregnant women. Infants exposed to high amounts of nitrate may develop "blue –baby syndrome," a condition that is rare but can be fatal.

What are the symptoms of blue-baby syndrome?

Symptoms can be confused with other illnesses. An infant with mild to moderate blue-baby syndrome may have diarrhea, vomiting, and be lethargic.

In more serious cases, the infant may have:

- skin that becomes gray, darker brown, or blue, or
- lips, finger or toe nails with a blue-like color, or
- trouble breathing.

My test results came back with *both* coliform and nitrate, what should I do?

Find a different and safe drinking water supply. The quickest thing to do is to begin using bottled water for drinking and food preparation. Boiling water kills coliform bacteria, but does not remove nitrate. Do NOT boil water with both coliform and nitrate. It may increase the nitrate level, making the problem worse! See other options under nitrate and coliform above.

My test results came back OK, but I don't like the taste/smell/ appearance of my water. What is wrong with it?

Some contaminants make water smell, taste, or look bad but are not harmful to your health. Your lab and local health department can help you determine if you need to test or treat your water.

What about Home Water Treatment Units? I've heard that these can help.

Point of use (POU) filter systems treat water at a single tap. Point of entry (POE) filter systems treat water used throughout the house.

Three types of systems that can remove nitrate from your water are:

- Reverse Osmosis Unit
- Distillation Unit
- Anion Exchange Unit

Important: All POU and POE filter systems or treatment units need maintenance to operate effectively. If they are not maintained properly, contaminants may accumulate in the units and make your water worse. In addition, some vendors may make claims about their effectiveness that are not based on science. The EPA does not test or certify treatment units, but two organizations that do are NSF International and Underwriters Laboratory.

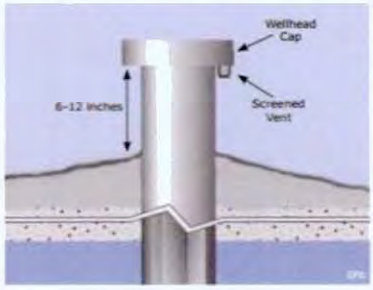
How can I protect my well water from contamination?

Make sure your wellhead extends 6 to 12 inches above the surface of the ground and is capped to keep contaminants out. Seal the ground around the wellhead and slope it away so water does not collect and seep into the well.

It is important to keep your well safe from potential contaminants that may be around your home. The further away from contamination sources, the better.

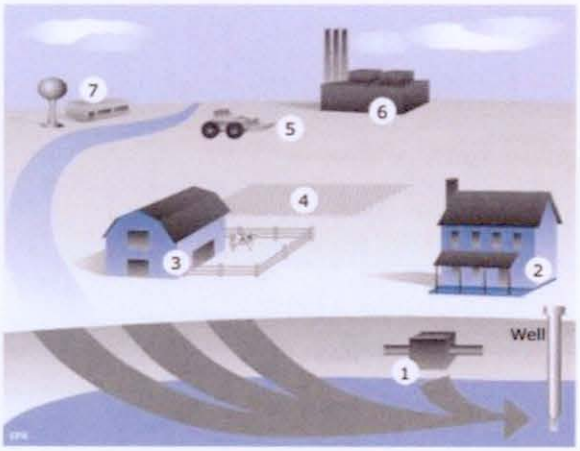
Experts suggest your well should be at least:

- 50 feet from a septic tank,
- 100 feet from the edge of a drainfield, fuel tank, barn, and any storage shed for fertilizers and pesticides, and
- 250 feet from a manure stack.



Potential Well Contaminants

1. Septic Tank
2. Household Wastes
3. Livestock Wastes
4. Pesticides and Fertilizers
5. Landfills
6. Local Industries
7. Underground Storage Tanks



Additional Resources

Local Health Departments
www.doh.wa.gov/LHJMap/LHJMap.htm

Certified Labs in Your Area
www.ecy.wa.gov/apps/eap/acclabs/labquery.asp

Certifying Organizations for Home Water Treatment Units
NSF International (Formerly National Sanitation Foundation), www.nsf.org
Underwriters Laboratory, www.ul.com

Center for Disease Control and Prevention Publications
Private Wells, www.cdc.gov/healthywater/drinking/private/wells/location.html
Emergency disinfection of wells, http://emergency.cdc.gov/disasters/wellsdisinfect.asp

Environmental Protection Agency Publications
Household wells, www.epa.gov/safewater/privatewells/pdfs/household_wells.pdf
Secondary Standards, www.epa.gov/safewater/consumer/2ndstandards.html
Filtration Facts booklet, www.epa.gov/safewater/faq/pdfs/fs_healthseries_filtration.pdf
Source Water Protection, http://cfpub.epa.gov/safewater/sourcewater

Washington State Department of Health
DOH 333-171 May 2010

For persons with disabilities, this document is available in other formats.
To make a request, call 1-800-525-0127 or 1-800-833-6388 (TTY/TDD).

Department of Health Private Wells (Spanish)



Agua de Pozos Privados

Información sobre las bacterias coliformes y el nitrato para usuarios de pozos privados

¿Por qué debería hacer un análisis del agua de mi pozo?
Beber agua contaminada es un riesgo para la salud. Algunos contaminantes no se pueden ver, oler ni notar por el sabor. Dos de los contaminantes más comunes del agua potable son las bacterias coliformes y el nitrato, los cuales pueden ser nocivos.

¿Quién debería analizar el agua de mi pozo?
Usted o su arrendador. Los usuarios de pozos privados son responsables de analizar su propia agua. Si usted no es propietario de su vivienda pero utiliza un pozo privado, hable con su arrendador para analizar el agua o ver los resultados más recientes. Siempre podrá tomar una muestra de agua usted mismo y hacerla analizar.

¿Qué debería buscar en el análisis y con qué frecuencia?
El Departamento de Salud recomienda que analice el agua de pozo privado todos los años para verificar que no existan bacterias coliformes y nitrato.

También deberá analizar el agua cuando:

- Note un cambio en el agua, tal como el sabor, color y olor.*
- El pozo se haya inundado.
- Reemplace cualquier parte de su sistema de pozo.
- Alguna mujer de su hogar esté embarazada, amamantando o tenga una enfermedad inexplicable y usted sospeche de que el agua puede estar en riesgo.
- Escuche que el agua de su vecino está contaminada.
- Viva cerca de zonas industriales o agrícolas.*

*Estos casos pueden requerir un análisis para evitar la existencia de otros elementos distintos de las coliformes o el nitrato.

Si ha tenido problemas de contaminación previos o está preocupado por contaminantes específicos, usted debería analizar el agua del pozo con mayor frecuencia.

¿Dónde me dirijo para analizar el agua?
Los laboratorios de análisis de agua potable certificados se encuentran en todo el estado. El laboratorio que seleccione o el departamento de salud local podrán ayudarlo a decidir qué buscar en el análisis, cómo tomar las muestras y cómo interpretar los resultados. Estos análisis tienen un costo. Los costos de este año (2010) van desde los $20 a los $25 por análisis de bacterias coliformes, y desde los $30 a los $42 para el análisis de nitrato. La mayoría de los laboratorios prefieren proporcionar sus propios recipientes para muestra.

El nivel del nitrato es *menor de* 10 ppm, ¿qué debo hacer?

Los niveles de nitrato pueden variar a lo largo del año, por lo tanto si el nivel es de 5 ppm o mayor, deberá volver a tomar una prueba dentro de seis meses.

El nivel de nitrato es *mayor de* 10 ppm, ¿qué debo hacer?

Si su análisis de nitrato muestra niveles mayores a 10 partes por millón, busque un suministro de agua potable diferente y más seguro. Lo primero que debe hacer es comenzar a utilizar agua embotellada para beber y cocinar. No hierva agua con altos niveles de nitrato. Hervir el agua puede incrementar el nivel de nitrato, ¡empeorando el problema!

Otra opción es instalar un dispositivo o filtro diseñado para eliminar el nitrato del agua. Estos dispositivos se instalan con frecuencia en los grifos de la cocina, donde las personas toman agua para beber y cocinar. El nitrato no se absorbe a través de la piel, por lo tanto es seguro utilizar esta agua para limpiar y bañarse.

Otras soluciones a largo plazo incluyen:

- Cavar un pozo más profundo en una fuente diferente de aguas subterráneas;
- Conectarse a un sistema de agua público; o
- Trabajar con otras personas de su comunidad para desarrollar un nuevo sistema público de agua para su hogar y los vecinos de la zona.

Los resultados de mi análisis indican coliformes en el agua, ¿qué debo hacer?

Los análisis de coliformes por lo general indican SATISFACTORIO o NO SATISFACTORIO. Si recibe un informe SATISFACTORIO, significa que su agua no contiene estas bacterias al momento de tomar la muestra. Asegúrese de realizar este análisis de coliformes todos los años.

Si recibe un informe NO SATISFACTORIO, el agua podría estar contaminada. No beba el agua hasta que el análisis sea SATISFACTORIO. Busque un suministro de agua potable distinto y seguro. Lo primero que debe hacer es comenzar a utilizar agua embotellada o hervida para beber y cocinar. Además, debe utilizarla para preparar hielo o café, lavarse los dientes y lavar frutas y verduras que come crudas. Hervir el agua durante un minuto por lo general mata las bacterias.

El laboratorio y el departamento de salud local pueden ayudarlo a determinar si debe volver a tomar una muestra, desinfectar el pozo o tomar otras medidas basadas en el resultado.

¿Qué son las bacterias coliformes y por qué debería tener cuidado?

Las bacterias coliformes son organismos que están en el medio ambiente y en las heces de humanos y animales. Las bacterias coliformes probablemente no causan enfermedades, pero su presencia en el agua potable indica que también puede haber organismos causantes de enfermedades.

¿Qué es el nitrato?

El Nitrógeno es un químico que se encuentra en la mayoría de los fertilizantes, en estiércol de animales y en los tanques sépticos. Las bacterias naturales de la tierra pueden cambiar el nitrógeno a nitrato. El agua de lluvia y el agua de riego pueden arrastrar el nitrato por debajo de la tierra hacia las aguas subterráneas.

¿Qué me puede hacer el nitrato?

El exceso de nitrato en el cuerpo dificulta el transporte de oxígeno que deben realizar los glóbulos rojos. Aunque muchas personas no noten la diferencia, esto puede ser muy peligroso para los bebés y las mujeres embarazadas. Los bebés expuestos a grandes cantidades de nitrato pueden desarrollar el "síndrome del bebé azul," una enfermedad extraña pero que puede ser fatal.

¿Cuáles son los síntomas del síndrome del bebé azul?

Los síntomas se pueden confundir con los de otras enfermedades. Un bebé con el síndrome del bebé azul leve a moderado puede tener diarrea, vómitos y estar apático.

En casos más graves el bebé puede tener:

- piel que cambia a color gris, café oscura o azul, o
- labios, dedos o las uñas de los pies de color azulado; o
- problemas para respirar.

Los resultados de mi análisis indican *tanto* coliformes *como* nitrato, ¿qué debo hacer?
Busque un suministro de agua potable distinto y seguro. Lo primero que debe hacer es comenzar a utilizar agua embotellada para beber y cocinar. Hervir el agua mata las bacterias coliformes, pero no elimina el nitrato. NO hierva agua con coliformes y nitrato. Puede incrementar el nivel de nitrato, ¡empeorando el problema! Consulte otras opciones bajo nitrato y coliformes más arriba.

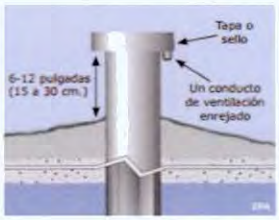
Los resultados del análisis indican que está bien, pero no me gusta el sabor/olor/la apariencia del agua. ¿Qué está pasando?
Algunos contaminantes hacen que el agua no tenga buen olor, sabor o apariencia pero no son nocivos para su salud. Su laboratorio y el departamento de salud local pueden ayudarlo a determinar si necesita analizar o tratar su agua.

¿Qué son las unidades domésticas de tratamiento de agua? He escuchado que son útiles.
Los sistemas de filtro en el punto de uso (POU) tratan el agua en un sólo grifo. Los sistemas de filtro en el punto de entrada (POE) tratan el agua utilizada por toda la vivienda.

Los tres tipos de sistemas que peuden eliminar el nitrato del agua son:
- Unidad de ósmosis inversa
- Unidad de destilación
- Unidad de intercambio iónico

Importante: Todos los sistemas de filtro POU y POE o las unidades de tratamiento requieren mantenimiento para funcionar bien. Si no reciben el mantenimiento adecuado, los contaminantes se podrían acumular en las unidades y empeorar el agua. Además, algunos vendedores podrían declarar su efectividad aunque no esté basado en la ciencia. EPA no analiza ni certifica las unidades de tratamiento, pero sí lo hacen dos organizaciones: la NSF International y el Underwriters Laboratory.

¿Cómo puedo proteger el agua de mi pozo de la contaminación?
Asegúrese que la boca del pozo se extienda entre 6 a 12 pulgadas (15 a 30 cm.) por encima de la superficie del suelo y que esté tapado para que no entren los contaminantes. Selle el suelo alrededor de la boca del pozo y hágalo en declive para que el agua no se acumule y filtre dentro del pozo.

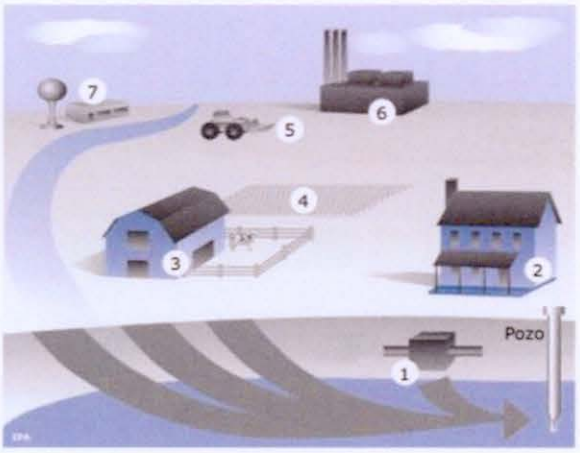


Es importante mantener el pozo protegido de contaminantes potenciales que pueden estar alrededor de su vivienda. Cuánto más lejos de las fuentes de contaminación, mucho mejor.

Los expertos sugieren que el pozo debe estar al menos:
- a 50 pies (15 metros) del tanque séptico,
- a 100 pies (30 metros) del borde de un campo de drenaje, tanque de combustible, graneros y cualquier depósito de fertilizantes y pesticidas, y
- a 250 pies (75 metros) de un montículo de estiércol.

Fuentes potenciales de contaminación del agua de pozos

1. Tanque séptico
2. Residuos domésticos
3. Residuos de animales
4. Pesticidas y fertilizantes
5. Vertedero
6. Industria local
7. Tanques de almacenamiento subterráneo



Recursos adicionales (información en inglés)

Departamentos de salud locales
www.doh.wa.gov/LHJMap/LHJMap.htm

Laboratorios certificados en su zona
www.ecy.wa.gov/apps/eap/acclabs/labquery.asp

Organizaciones certificadoras de unidades domésticas de tratamiento de agua
NSF International (Anteriormente, Fundación de Sanidad Nacional), www.nsf.org
Underwriters Laboratory, www.ul.com

Publicaciones del Centro para el Control y la Prevención de Enfermedades
Pozos privados, www.cdc.gov/healthywater/drinking/private/wells/location.html
Desinfección de emergencia de pozos, http://emergency.cdc.gov/disasters/wellsdisinfect.asp

Publicaciones de la Agencia de Protección Ambiental
Pozos domésticos, www.epa.gov/safewater/privatewells/pdfs/household_wells.pdf
Estándares secundarios, www.epa.gov/safewater/consumer/2ndstandards.html
Folleto sobre datos de filtración, www.epa.gov/safewater/faq/pdfs/fs_healthseries_filtration.pdf
Protección de fuente de agua, http://cfpub.epa.gov/safewater/sourcewater

Washington State Department of Health
DOH 333-171 mayo 2010

Para personas con discapacidades, este documento está disponible en otros formatos. Por favor llame al 1-800-525-0127 (TTY/TDD 1-800-833-6388).

Department of Health Coliform

Can I use bottled water?

You can use purchased bottled water. If you choose to use bottled water, Department of Health recommends water that is:

- Reverse-osmosis treated.
- Distilled.
- Filtered through an "absolute" one micron or smaller filter.

Carbonated water in cans or bottles is usually filtered or heated to remove illness-causing organisms.

During a health advisory, can I use tap water for...?

Drinking	No	Coffee or tea	No
Ice cubes	No	Showers/Baths	Yes
Brushing teeth	No	Washing clothes	Yes
Baby's formula	No	Baby's bath	See below
Washing vegetables/fruits	No	Washing dishes	See below
Preparing food	No	Pet's water bowl	Contact veterinarian

Can I bathe my baby or child using tap water?

Yes, as long as they do not drink any of the water. Don't let babies suck on a washcloth, as they will be ingesting some of the water.

Can I wash dishes?

You can use your dishwasher if you use the sanitizing/heat cycle and commercial dishwashing detergent. You can hand wash dishes, rinse them in a diluted bleach solution—one teaspoon household bleach to one gallon of water—and then let dishes air dry.

What must be done to fix the problem?

Fixing the problem could be different in each situation depending on whether the problem is at the water source or in the water lines. Usually, in every case the water lines will need to be flushed and the whole system will need to be disinfected using chlorine. The water will then be tested to make sure it is free of coliform bacteria.

How long will this health advisory be in effect?

This health advisory will remain in effect until the water is tested and results show that it meets public health drinking water standards. Your water system will notify you when that occurs.

For more information:

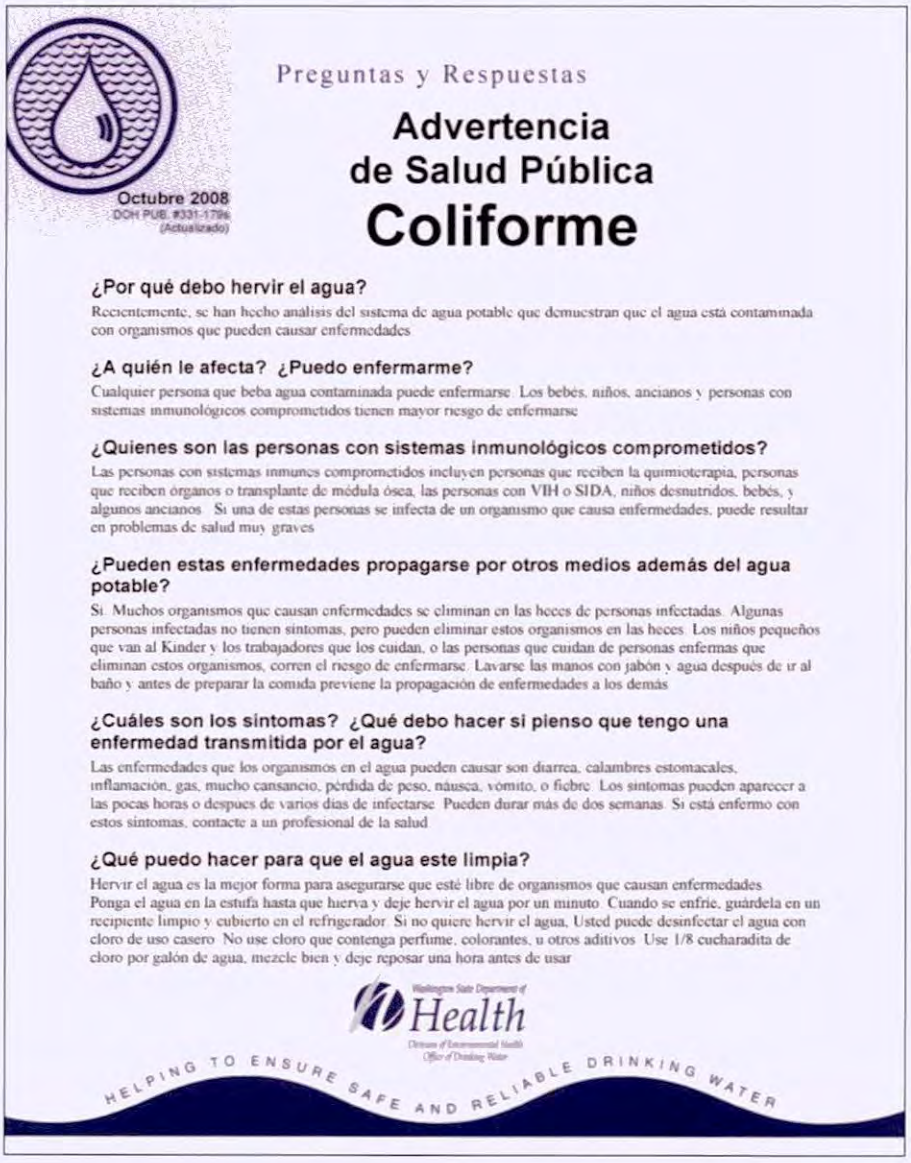
Personal medical questions: Contact your health care provider (physician, nurse consultant, etc.)

Call your local health jurisdiction with general questions about infectious disease, communicable disease transmission, symptoms, causes and prevention of waterborne disease.

PUBLIC HEALTH
ALWAYS WORKING FOR A SAFER AND HEALTHIER WASHINGTON

The Department of Health is an equal opportunity agency. For persons with disabilities, this document is available on request in other formats. To submit a request, please call 1-800-525-0127 (TTY 1-800-833-6388). For additional copies of this publication, call 1-800-521-0323. This and other publications are available at http://www.doh.wa.gov/ehp/dw

Department of Health Coliform (Spanish)



Preguntas y Respuestas

Advertencia de Salud Pública

Coliforme

Octubre 2008
DOH PUB. #331-179s
(Actualizado)

¿Por qué debo hervir el agua?

Recientemente, se han hecho análisis del sistema de agua potable que demuestran que el agua está contaminada con organismos que pueden causar enfermedades.

¿A quién le afecta? ¿Puedo enfermarme?

Cualquier persona que beba agua contaminada puede enfermarse. Los bebés, niños, ancianos y personas con sistemas inmunológicos comprometidos tienen mayor riesgo de enfermarse.

¿Quienes son las personas con sistemas inmunológicos comprometidos?

Las personas con sistemas inmunes comprometidos incluyen personas que reciben la quimioterapia, personas que reciben órganos o transplante de médula ósea, las personas con VIH o SIDA, niños desnutridos, bebés, y algunos ancianos. Si una de estas personas se infecta de un organismo que causa enfermedades, puede resultar en problemas de salud muy graves.

¿Pueden estas enfermedades propagarse por otros medios además del agua potable?

Si. Muchos organismos que causan enfermedades se eliminan en las heces de personas infectadas. Algunas personas infectadas no tienen síntomas, pero pueden eliminar estos organismos en las heces. Los niños pequeños que van al Kinder y los trabajadores que los cuidan, o las personas que cuidan de personas enfermas que eliminan estos organismos, corren el riesgo de enfermarse. Lavarse las manos con jabón y agua después de ir al baño y antes de preparar la comida previene la propagación de enfermedades a los demás.

¿Cuáles son los síntomas? ¿Qué debo hacer si pienso que tengo una enfermedad transmitida por el agua?

Las enfermedades que los organismos en el agua pueden causar son diarrea, calambres estomacales, inflamación, gas, mucho cansancio, pérdida de peso, náusea, vómito, o fiebre. Los síntomas pueden aparecer a las pocas horas o despues de varios días de infectarse. Pueden durar más de dos semanas. Si está enfermo con estos síntomas, contacte a un profesional de la salud.

¿Qué puedo hacer para que el agua este limpia?

Hervir el agua es la mejor forma para asegurarse que esté libre de organismos que causan enfermedades. Ponga el agua en la estufa hasta que hierva y deje hervir el agua por un minuto. Cuando se enfríe, guárdela en un recipiente limpio y cubierto en el refrigerador. Si no quiere hervir el agua, Usted puede desinfectar el agua con cloro de uso casero. No use cloro que contenga perfume, colorantes, u otros aditivos. Use 1/8 cucharadita de cloro por galón de agua, mezcle bien y deje reposar una hora antes de usar.

Washington State Department of Health
Division of Environmental Health
Office of Drinking Water

HELPING TO ENSURE SAFE AND RELIABLE DRINKING WATER

¿Puedo usar agua embotellada?

Usted puede comprar agua embotellada. Si Usted escoge agua embotellada, el Departamento de Salud recomienda que el agua sea:

- Tratada por osmosis inversa
- Destilada
- Filtrada con un filtro de un micrón "absoluto" o menor

El agua carbonatada de lata o botella ha sido filtrada o calentada para quitar organismos que causan enfermedades.

Bajo una advertencia de salud pública, ¿puedo usar el agua de la llave para...?

Beber	No
Cubos de hielo	No
Cepillar los dientes	No
Preparar el biberón	No
Lavar verduras/frutas	No
Preparar comida	No
Café o té	No
Duchas/baños	Sí
Lavar la ropa	Sí
El baño del bebé	Vea abajo
Lavar los platos	Vea abajo
El tazón de agua de las mascotas	Contacte al veterinario

¿Puedo bañar a mi bebé o niño con el agua de grifo?

Sí, mientras no beban nada del agua. No deje que los bebés chupen la toallita porque beberían algo del agua.

¿Puedo lavar los platos?

Usted puede usar el lavaplatos si utiliza el ciclo de esterilizador/calentador y detergente para lavaplatos comercial. Usted puede lavar los platos a mano, y enjuagar con una solución de agua y lejía- una cucharadita de lejía de uso casero por cada galón de agua. Después deje que se sequen al aire.

¿Qué hace falta para solucionar el problema?

La solución del problema es diferente en cada situación, dependiendo si el problema está en las tuberías o en la fuente principal del agua. Normalmente, en cada situación, hay que limpiar las tuberías y desinfectar el sistema entero con cloro. Entonces se analiza el agua para asegurar que esté libre de bacteria coliform.

¿Hasta cuando durará esta advertencia de salud?

Esta advertencia de salud estará en efecto hasta que el aqua sea analizada y los resultados cumplan con las normas de salud para el agua potable. Cuando esto ocurra, se notificará al público.

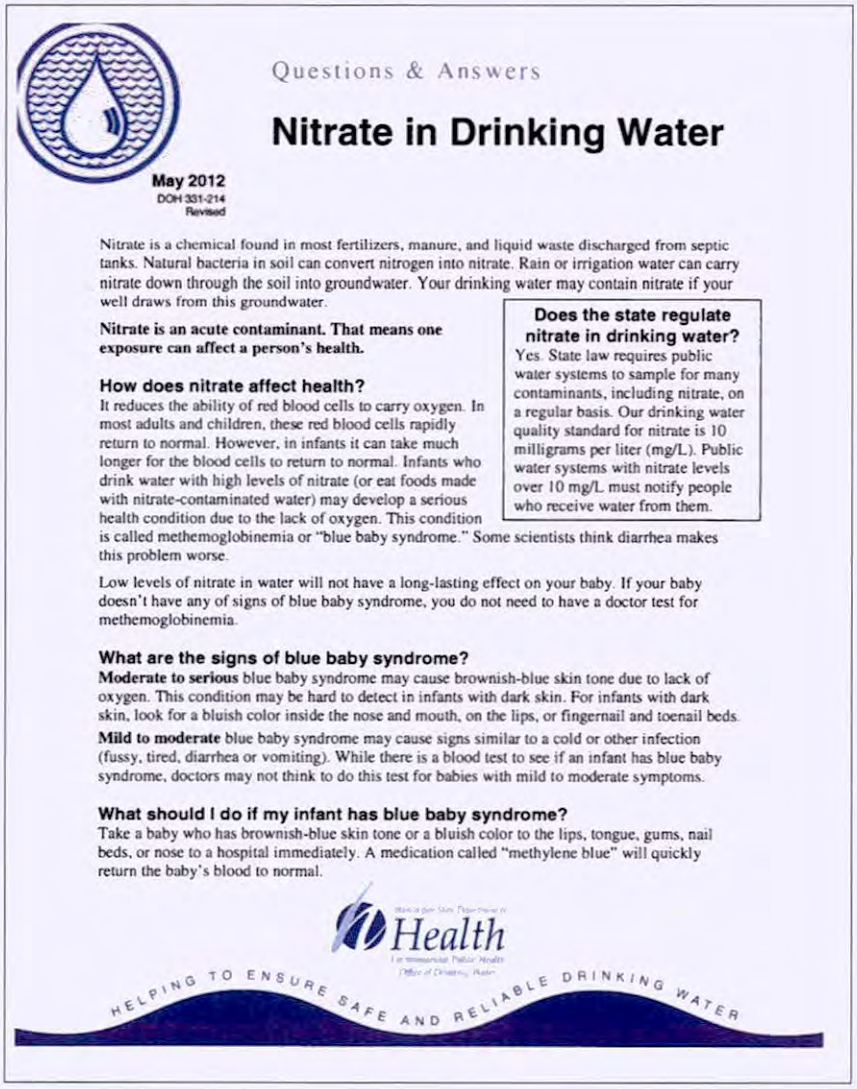
Para mayor información:

Preguntas médicas personales: Contacte a un profesional de salud (médico, enfermero, etc.)

Llame a la oficina de salud local en su área con preguntas generales acerca de las enfermedades infecciosas, transmisión de enfermedades, los síntomas, las causas y la prevención de enfermedades transmitidas por el agua.

El Departamento de Salud es una agencia que practica la igualdad de oportunidades en la selección de personal. Para personas con discapacidades, este documento está disponible en otros formatos. Por favor llame al 1-800-525-0127 (TTY/TDD 1-800-833-6388). Para recibir copias adicionales de esta publicación, llame al 1-800-521-0323. Esta publicación y otras están disponibles en el sitio de Internet: http://www.doh.wa.gov/ehp/dw

Department of Health Nitrates in Drinking Water



Questions & Answers

Nitrate in Drinking Water

May 2012
DOH 331-214
Revised

Nitrate is a chemical found in most fertilizers, manure, and liquid waste discharged from septic tanks. Natural bacteria in soil can convert nitrogen into nitrate. Rain or irrigation water can carry nitrate down through the soil into groundwater. Your drinking water may contain nitrate if your well draws from this groundwater.

Nitrate is an acute contaminant. That means one exposure can affect a person's health.

How does nitrate affect health?

It reduces the ability of red blood cells to carry oxygen. In most adults and children, these red blood cells rapidly return to normal. However, in infants it can take much longer for the blood cells to return to normal. Infants who drink water with high levels of nitrate (or eat foods made with nitrate-contaminated water) may develop a serious health condition due to the lack of oxygen. This condition is called methemoglobinemia or "blue baby syndrome." Some scientists think diarrhea makes this problem worse.

Does the state regulate nitrate in drinking water?

Yes. State law requires public water systems to sample for many contaminants, including nitrate, on a regular basis. Our drinking water quality standard for nitrate is 10 milligrams per liter (mg/L). Public water systems with nitrate levels over 10 mg/L must notify people who receive water from them.

Low levels of nitrate in water will not have a long-lasting effect on your baby. If your baby doesn't have any of signs of blue baby syndrome, you do not need to have a doctor test for methemoglobinemia.

What are the signs of blue baby syndrome?

Moderate to serious blue baby syndrome may cause brownish-blue skin tone due to lack of oxygen. This condition may be hard to detect in infants with dark skin. For infants with dark skin, look for a bluish color inside the nose and mouth, on the lips, or fingernail and toenail beds.

Mild to moderate blue baby syndrome may cause signs similar to a cold or other infection (fussy, tired, diarrhea or vomiting). While there is a blood test to see if an infant has blue baby syndrome, doctors may not think to do this test for babies with mild to moderate symptoms.

What should I do if my infant has blue baby syndrome?

Take a baby who has brownish-blue skin tone or a bluish color to the lips, tongue, gums, nail beds, or nose to a hospital immediately. A medication called "methylene blue" will quickly return the baby's blood to normal.

Health

HELPING TO ENSURE SAFE AND RELIABLE DRINKING WATER

Can I prevent blue baby syndrome?

Yes. Do not give infants younger than 12 months drinking water with nitrate levels above 10 mg/L. Do not offer high-nitrate vegetables such as beets, broccoli, carrots, cauliflower, green beans, spinach, and turnips until the baby is at least seven months old.

Nitrate levels in well water can vary throughout the year. If you have a private well and you're not sure about your water quality, you may want to use bottled water to prepare your baby's food and drinks. Although boiling water kills bacteria, it will not remove chemicals such as nitrate. In fact, boiling may actually increase the nitrate level.

Will breast-feeding give my infant blue baby syndrome?

Low levels of nitrate have been found in breast milk, but the levels are not high enough to cause blue baby syndrome.

Can nitrate affect adults?

Although red blood cells quickly return to normal, some health conditions can make people more susceptible to health problems from nitrate. Individuals with the following health conditions should not drink water with more than 10 mg/L of nitrate:

- Individuals who don't have enough stomach acids.
- Individuals with an inherited lack of the enzyme that converts affected red blood cells back to normal (methemoglobin reductase).
- Women who are pregnant or trying to become pregnant. Some studies have found an increased risk of spontaneous abortion or certain birth defects.

How can I tell if my well water has nitrate?

Shallow wells, poorly sealed or poorly constructed wells, and wells that draw from shallow aquifers are at greatest risk of nitrate contamination. Manure and septic tank waste may also contain disease-causing bacteria and viruses.

If you own a private well, we recommend that you test for coliform bacteria and nitrate every year. Your county health department can tell you where you can get your water tested and may have specific recommendations for testing. Many certified labs in Washington charge $20 to $40 per test. If your nitrate test results are 5 mg/L or higher, you may want to re-sample in six months.

Where can I get more information?

If you get your water from a public water system, call your water utility or the state Department of Health at 800-521-0323. You can also visit online at http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater.aspx

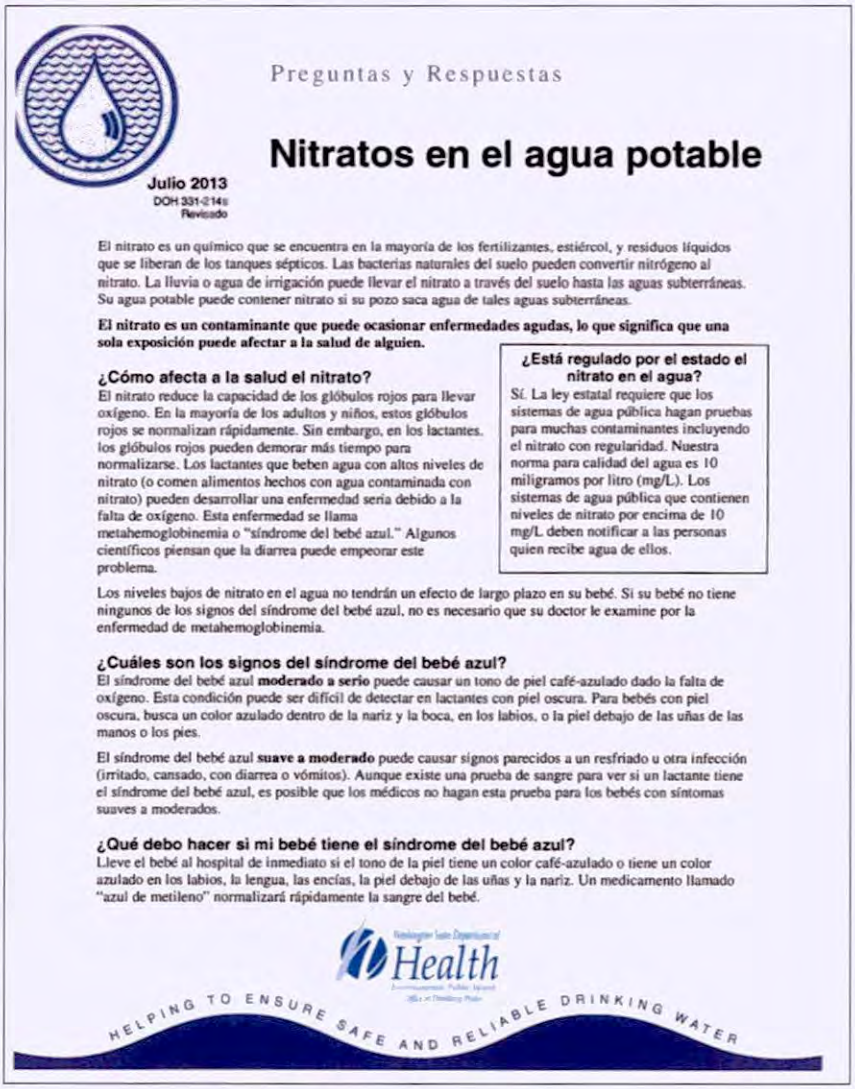
If you have a private well, call your local health department. You can also find information in *Private Wells: Information for owners* (331-349) a publication available in English and Spanish at https://fortress.wa.gov/doh/eh/dw/publications/publications.cfm

For a list of certified labs, visit the state Department of Ecology online at http://www.ecy.wa.gov/apps/eap/acclabs/labquery.aspUnder "Location," select your state, city, and county. Scroll down and click on "Show results." Click on the name of a lab to see the tests it performs. Call the lab to make sure it's accredited to analyze for nitrate in drinking water.

PUBLIC HEALTH
HEALTHIER WASHINGTON

If you need this publication in an alternate format, call 800-525-0127. For TTY/TDD, call 800-833-6388.

Department of Health Nitrates in Drinking Water (Spanish)



Preguntas y Respuestas

Nitratos en el agua potable

Julio 2013
DOH 331-214S
Revisado

El nitrato es un químico que se encuentra en la mayoría de los fertilizantes, estiércol, y residuos líquidos que se liberan de los tanques sépticos. Las bacterias naturales del suelo pueden convertir nitrógeno al nitrato. La lluvia o agua de irrigación puede llevar el nitrato a través del suelo hasta las aguas subterráneas. Su agua potable puede contener nitrato si su pozo saca agua de tales aguas subterráneas.

El nitrato es un contaminante que puede ocasionar enfermedades agudas, lo que significa que una sola exposición puede afectar a la salud de alguien.

¿Cómo afecta a la salud el nitrato?

El nitrato reduce la capacidad de los glóbulos rojos para llevar oxígeno. En la mayoría de los adultos y niños, estos glóbulos rojos se normalizan rápidamente. Sin embargo, en los lactantes. los glóbulos rojos pueden demorar más tiempo para normalizarse. Los lactantes que beben agua con altos niveles de nitrato (o comen alimentos hechos con agua contaminada con nitrato) pueden desarrollar una enfermedad seria debido a la falta de oxígeno. Esta enfermedad se llama metahemoglobinemia o "síndrome del bebé azul." Algunos científicos piensan que la diarrea puede empeorar este problema.

¿Está regulado por el estado el nitrato en el agua?

Sí. La ley estatal requiere que los sistemas de agua pública hagan pruebas para muchas contaminantes incluyendo el nitrato con regularidad. Nuestra norma para calidad del agua es 10 miligramos por litro (mg/L). Los sistemas de agua pública que contienen niveles de nitrato por encima de 10 mg/L deben notificar a las personas quien recibe agua de ellos.

Los niveles bajos de nitrato en el agua no tendrán un efecto de largo plazo en su bebé. Si su bebé no tiene ningunos de los signos del síndrome del bebé azul, no es necesario que su doctor le examine por la enfermedad de metahemoglobinemia.

¿Cuáles son los signos del síndrome del bebé azul?

El síndrome del bebé azul **moderado a serio** puede causar un tono de piel café-azulado dado la falta de oxígeno. Esta condición puede ser difícil de detectar en lactantes con piel oscura. Para bebés con piel oscura, busca un color azulado dentro de la nariz y la boca, en los labios, o la piel debajo de las uñas de las manos o los pies.

El síndrome del bebé azul **suave a moderado** puede causar signos parecidos a un resfriado u otra infección (irritado, cansado, con diarrea o vómitos). Aunque existe una prueba de sangre para ver si un lactante tiene el síndrome del bebé azul, es posible que los médicos no hagan esta prueba para los bebés con síntomas suaves a moderados.

¿Qué debo hacer si mi bebé tiene el síndrome del bebé azul?

Lleve el bebé al hospital de inmediato si el tono de la piel tiene un color café-azulado o tiene un color azulado en los labios, la lengua, las encías, la piel debajo de las uñas y la nariz. Un medicamento llamado "azul de metileno" normalizará rápidamente la sangre del bebé.

Health

HELPING TO ENSURE SAFE AND RELIABLE DRINKING WATER

¿Puedo prevenir el síndrome del bebé azul?

Si. No dé a los bebés menores de 12 meses de edad agua potable con niveles de nitrato más alto de 10 mg/L. No les dé verduras con alto contenido en nitrato como la remolacha, brócoli, zanahorias, coliflor, ejotes o judías, espinaca, y nabos hasta que el bebé tenga más de siete meses de edad.

Los niveles de nitrato en el agua de pozo pueden variar a través del año. Si usted tiene un pozo privado y no está seguro de la calidad del agua, es posible que desee usar agua en botella para preparar la comida y bebidas de su bebé. Aunque hervir el agua elimina las bacterias, no remueve químicos como el nitrato. De hecho, hirviendo causa la evaporación del agua que puede resultar en el incremento del nivel de nitrato.

¿Puede la lactancia materna ocasionar el síndrome del bebé azul?

Se ha encontrado bajos niveles de nitrato en la leche materna, pero los niveles no son bastantes altos para causar el "síndrome del bebé azul."

¿Puede el nitrato afectar a los adultos?

Aunque las células rojas vuelven rápidamente a la normalidad, las condiciones de salud de algunas personas las hacen más susceptible a los problemas de salud por nitrato. Las personas con las siguientes condiciones de salud no deberían beber agua con más de 10 mg/L de nitrato:

- Las personas que no tienen suficientes ácidos estomacales.
- Las personas con pérdida hereditaria de la enzima que convierte los glóbulos rojos afectados en células normales (metahemoglobina reductasa).
- Las mujeres embarazadas o que están tratando de quedar embarazadas. Alto contenido de nitratos puede incrementar el riesgo de aborto espontáneo o ciertos defectos de nacimiento.

¿Cómo puedo saber si mi agua de pozo tiene nitrato?

Los pozos poco profundos, mal sellados o construidos o los pozos que extraen agua de acuíferos poco profundos tienen riesgo más alto de tener agua contaminada con nitrato. El abono (estiércol) y los desechos de un tanque séptico pueden también contener bacterias y virus que causan enfermedades.

Si usted es el dueño de un pozo privado nosotros recomendamos que analice el agua por bacterias y nitrato cada año. El departamento de salud de su condado puede decirle donde puede obtener el análisis de su agua y pudiera tener recomendaciones específicas para el análisis. Muchos laboratorios certificados cobran entre $20 a $40 por análisis. Si el resultado del análisis de nitrato es de 5 mg/L o más alto, recomendamos que vuelva a hacer otro análisis en 6 meses.

¿Dónde puedo obtener más información?

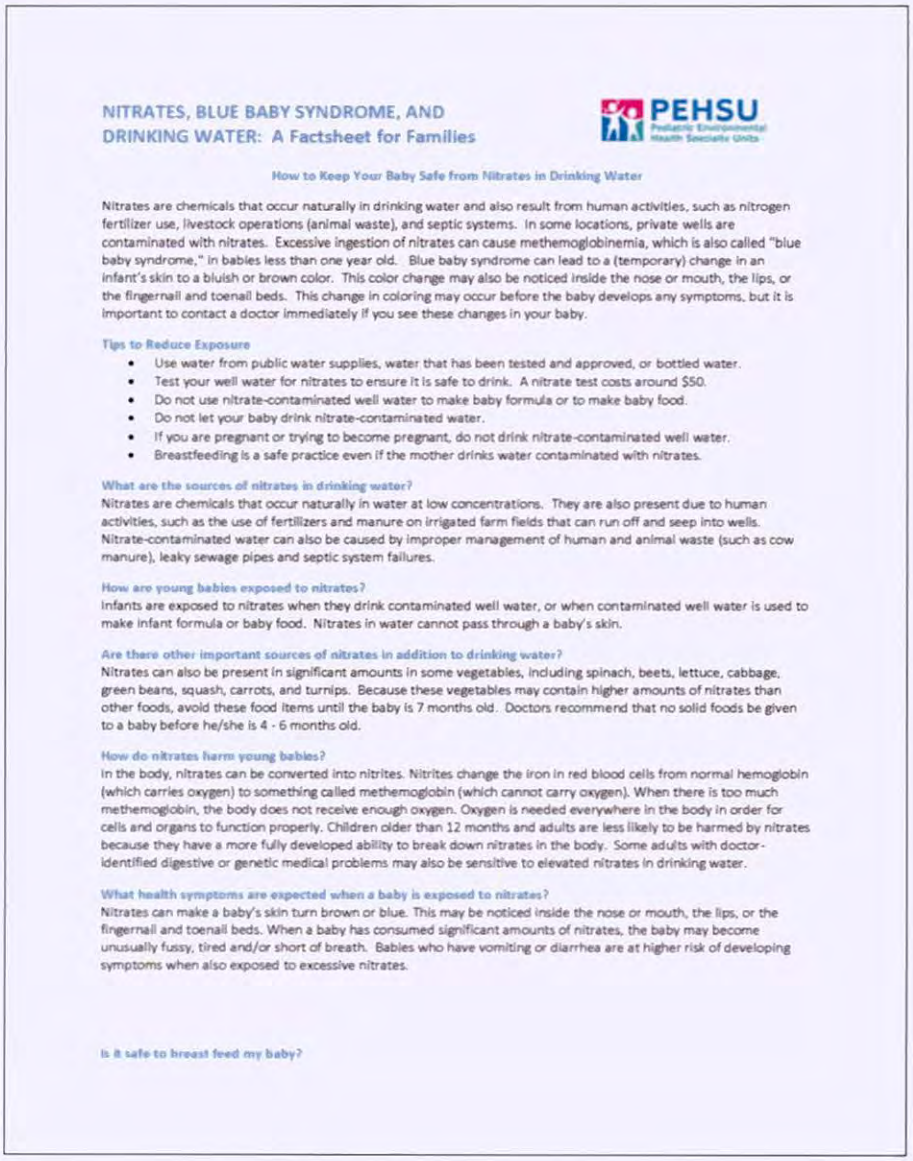
Si usted obtiene agua de un sistema público, llame a su servicio de agua o al Departamento de Salud del Estado de Washington, Oficina de Agua Potable, al número de teléfono (800) 521-0323 o visítenos en línea en: http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater.aspx

Si tiene un pozo privado, llame al departamento de salud local. También puede encontrar información en **Pozos Privados: Información para los propietarios (331-349s)** una publicación disponible en Inglés y Español https://fortress.wa.gov/doh/eh/dw/publications/publications.cfm

Para una lista de laboratorios certificados, visite en línea al Departamento de Ecología de Washington en: http://www.ecy.wa.gov/apps/eap/acclabs/labquery.asp. Bajo "Location" seleccione su estado, ciudad y condado. En la parte baja de la página haga click en "Show results." Haga click en el nombre de un laboratorio para ver qué tipo de análisis hace. Llame al laboratorio para asegurarse que esté acreditado para hacer análisis de nitrato.

Si usted necesita esta publicación en un formato diferente, llame al 800-525-0127. Para TTY/TDD, llame al 800-833-6388.

Nitrates, Blue Baby Syndrome, and Drinking Water: A fact sheet for families



NITRATES, BLUE BABY SYNDROME, AND DRINKING WATER: A Factsheet for Families

PEHSU Pediatric Environmental Health Specialty Units

How to Keep Your Baby Safe from Nitrates in Drinking Water

Nitrates are chemicals that occur naturally in drinking water and also result from human activities, such as nitrogen fertilizer use, livestock operations (animal waste), and septic systems. In some locations, private wells are contaminated with nitrates. Excessive ingestion of nitrates can cause methemoglobinemia, which is also called "blue baby syndrome," in babies less than one year old. Blue baby syndrome can lead to a (temporary) change in an infant's skin to a bluish or brown color. This color change may also be noticed inside the nose or mouth, the lips, or the fingernail and toenail beds. This change in coloring may occur before the baby develops any symptoms, but it is important to contact a doctor immediately if you see these changes in your baby.

Tips to Reduce Exposure

- Use water from public water supplies, water that has been tested and approved, or bottled water.
- Test your well water for nitrates to ensure it is safe to drink. A nitrate test costs around $50.
- Do not use nitrate-contaminated well water to make baby formula or to make baby food.
- Do not let your baby drink nitrate-contaminated water.
- If you are pregnant or trying to become pregnant, do not drink nitrate-contaminated well water.
- Breastfeeding is a safe practice even if the mother drinks water contaminated with nitrates.

What are the sources of nitrates in drinking water?

Nitrates are chemicals that occur naturally in water at low concentrations. They are also present due to human activities, such as the use of fertilizers and manure on irrigated farm fields that can run off and seep into wells. Nitrate-contaminated water can also be caused by improper management of human and animal waste (such as cow manure), leaky sewage pipes and septic system failures.

How are young babies exposed to nitrates?

Infants are exposed to nitrates when they drink contaminated well water, or when contaminated well water is used to make infant formula or baby food. Nitrates in water cannot pass through a baby's skin.

Are there other important sources of nitrates in addition to drinking water?

Nitrates can also be present in significant amounts in some vegetables, including spinach, beets, lettuce, cabbage, green beans, squash, carrots, and turnips. Because these vegetables may contain higher amounts of nitrates than other foods, avoid these food items until the baby is 7 months old. Doctors recommend that no solid foods be given to a baby before he/she is 4 - 6 months old.

How do nitrates harm young babies?

In the body, nitrates can be converted into nitrites. Nitrites change the iron in red blood cells from normal hemoglobin (which carries oxygen) to something called methemoglobin (which cannot carry oxygen). When there is too much methemoglobin, the body does not receive enough oxygen. Oxygen is needed everywhere in the body in order for cells and organs to function properly. Children older than 12 months and adults are less likely to be harmed by nitrates because they have a more fully developed ability to break down nitrates in the body. Some adults with doctor-identified digestive or genetic medical problems may also be sensitive to elevated nitrates in drinking water.

What health symptoms are expected when a baby is exposed to nitrates?

Nitrates can make a baby's skin turn brown or blue. This may be noticed inside the nose or mouth, the lips, or the fingernail and toenail beds. When a baby has consumed significant amounts of nitrates, the baby may become unusually fussy, tired and/or short of breath. Babies who have vomiting or diarrhea are at higher risk of developing symptoms when also exposed to excessive nitrates.

Is it safe to breast feed my baby?

Yes. Adults have more functional mechanisms to break down nitrates, so even if a mother drinks contaminated water, her breast milk is safe for her baby. Breast milk makes babies strong and healthy. Doctors recommend breast feeding.

Can nitrates harm the developing fetus?
Although the evidence is weak, nitrates may increase the risk of birth defects or spontaneous abortion. For this reason, women who are thinking about pregnancy or who are pregnant should avoid water contaminated with nitrates. Women considering pregnancy or who are pregnant should drink water from public water supplies, water that has been tested and has safe nitrate levels, or bottled water.

Why is it important to test my drinking water?
The only way to know if the nitrates in well water are at a safe level is to have the well water tested by a certified laboratory.

How do I test my drinking water for nitrates and how much will it cost?
All private wells should be tested before use and once per year for nitrates. Contact your state health department for assistance with selecting a certified laboratory. Generally the cost is around $50, although prices will vary by region.

What does my nitrate drinking water test result mean?
The United States Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) for nitrates is 10 mg/L (10 milligrams of nitrate in one liter of water) or 10 ppm (10 parts per million). The 10 mg/L standard was set to protect infants from nitrates. When a nitrate water test result is 10 mg/L or less, then the drinking water is considered safe with respect to nitrates.

Nitrates may change seasonally or randomly throughout the year. If the nitrate water test result is between 5 – 10 mg/L, test the well water every 3 months to confirm the water is still safe. When nitrates are present, pesticides or bacteria may also be present and additional water tests may be need. Contact your local health department for guidance.

Resources

- For acute poisoning assistance, contact your state poison center at 1-800-222-1222.
- For clinical and public health assistance, contact your regional PEHSU office. To find your regional office, call 1-888-347-2632 or go to http://www.aoec.org/PEHSU.htm

References

1. Nitrates, Methemoglobinemia and Drinking Water: A Fact Sheet for Clinicians. http://depts.washington.edu/pehsu/sites/default/files/PEHSU%20Nitrates%20Factsheet-%20Provider%20July%202014.pdf
2. Brender JD, et al. Prenatal nitrate intake from drinking water and selected birth defects in offspring of participants in the National Birth Defects Prevention Study. Environ Health Perspect. 2013;121:1083–1089.
3. Greer FR, Shannon M. Infant methemoglobinemia: the role of dietary nitrate in food and water. Pediatrics. 2005 Sep;116(3):784-6.
4. Hord NG, Tang Y, Bryan NS. Food sources of nitrates and nitrites: the physiologic context for potential health benefits. Am J Clin Nutr. 2009 Jul;90(1):1-10.
5. Rogan WJ et al. Drinking water from private wells and risks to children. Pediatrics. 2009 Jun;123(6):1599-605.
6. Pediatric Environmental Health, 3rd edition. American Academy of Pediatrics, 2012. pgs 471-478
7. EPA's website on Nitrates and Drinking Water at http://water.epa.gov/drink/contaminants/basicinformation/nitrate.cfm

Disclaimer: PEHSU funding was made possible (in part) by the cooperative agreement award number UTI Grant Number U61 TS000118 from the Agency for Toxic Substances and Disease Registry (ATSDR). The views in this guidance do not necessarily reflect the official policies of the Department of Health and Human Services; nor does mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government.

Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing funds to ATSDR under Inter-Agency Agreement number DW-75-92301301-0. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

Authors: N. Beaudet, MS, CIH; A. Otter, DNP, ARNP; C. Karr, MD, PhD; A. Perkins, BA; S. Sathyanarayana, MD, MPH. Last updated July 2014

Northwest Pediatric Environmental Health Specialty Unit (PEHSU)
University of Washington 1 - 877 - KID - CHEM
http://depts.washington.edu/pehsu

Nitrates, Methemoglobinemia, and Drinking Water: A fact sheet for clinicians

NITRATES, METHEMOGLOBINEMIA, AND DRINKING WATER: A Factsheet for Clinicians

PEHSU Pediatric Environmental Health Specialty Units

Nitrates are chemicals that occur naturally in drinking water and also result from human activities. In some areas private wells are contaminated with nitrates. Excessive nitrates can cause acquired methemoglobinemia in young infants. This severe syndrome of inadequate tissue oxygenation is potentially fatal; prompt clinical recognition and treatment is vital. Families should be counseled on nitrate safety.

Nitrate Background

- Nitrates and nitrites are naturally occurring inorganic nitrogen ions found in soil, water, and some foods. They are a natural part of the human diet. However, excessive consumption (e.g. drinking water or eating food from areas where ground water has become contaminated by excessive nitrate from fertilizers or improper manure management) can cause serious adverse health effects.

Nitrate Sources

- Drinking water
  - Nitrates occur naturally in water at low concentrations. Nitrates are also present as a result of human activities, such as the use of fertilizers and manure on irrigated farm fields that can run off and seep into wells. Nitrate-contaminated water can also be due to improper management of farm animal (i.e. cow) waste, leaky sewage pipes, and septic system failures.
  - Large suppliers of public water sources are required to monitor nitrate concentrations regularly, but private wells are not. In some areas private wells are contaminated with nitrates.
  - The American Academy of Pediatrics (AAP) consensus panel recommends that all prenatal and well-infant visits need to include questions about the home water supply.
  - The only way to know if the nitrate level in well water is at a safe level is to have the well water tested by a certified laboratory. All private wells should be tested before use and once per year for nitrates. Families should contact their state health department for assistance with selecting a certified laboratory.
  - Regulations and water testing frequency:
    - The United States Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) for nitrates is 10 mg/L (or 10 parts per million, 10 ppm). The 10 mg/L standard was set to protect infants from nitrates. When a nitrate water test result is 10 mg/L or less, the water is considered safe for infant use.
    - Nitrates may change seasonally or randomly throughout the year. If the nitrate concentration is between 5 – 10 mg/L, monitor more closely and test the well drinking water every 3 months to confirm the water is still safe. When nitrates are present, pesticides or bacteria may also be present and additional water tests may be needed. Families should contact their local health department for guidance.
- Food
  - Nitrates can also be a problem in some vegetables, including spinach, beets, lettuce, cabbage, green beans, squash, carrots, and turnips. Because these vegetables may contain higher amounts of nitrates, recommend other foods until infants are over 6 months old.

Infant Nitrate Exposure

- Infants are exposed to nitrates when they drink contaminated well water or when contaminated well water is used to make infant formula or baby food.
- Nitrates in water are not significantly absorbed through the skin.
- Breastfeeding is safe even if a mother drinks water polluted with nitrates.

Methemoglobinemia and Other Health Effects

- Hemoglobin in blood contains iron normally found in the Fe^{2+} (ferrous) state. Excessive nitrates or nitrites can alter the iron in hemoglobin to the Fe^{3+} (ferric) state, forming methemoglobin (an abnormal form of hemoglobin

which cannot bind oxygen). Methemoglobinemia (an excess of methemoglobin) results in poor tissue oxygenation and anoxia.

- Methemoglobinemia, also known as "blue baby syndrome", can be inherited or acquired. The acquired form, such as from excessive nitrate exposure, is a serious medical emergency. Among the reported cases of acquired methemoglobinemia in US infants, most have been attributed to the use of nitrate contaminated well water for preparation of infant formula.
- Infants less than 1 year old are physiologically vulnerable to the development of methemoglobinemia due to several factors:
  - Their higher gastric pH favors nitrate-reducing bacteria that convert ingested nitrate into methemoglobin-producing nitrite.
  - Fetal hemoglobin, the predominant form in infants up to 3 months of age, is oxidized more readily to methemoglobin by nitrite than is adult hemoglobin.
  - The activity of the red blood cell enzyme systems that reduce methemoglobin back to normal hemoglobin is reduced by about half in infants compared with adults.
  - Gastroenteritis can increase the risk of developing methemoglobinemia.
- **Women who are thinking about pregnancy or who are pregnant should avoid water contaminated with nitrates. Women considering pregnancy or who are pregnant should drink water from public water supplies, water that has been tested and has safe nitrate levels, or bottled water.** While not conclusive due to study limitations, epidemiological data suggest an association between maternal ingestion of nitrate from drinking water and preeclampsia, spontaneous abortion, intrauterine growth restriction, and various birth defects. A few studies have hinted at a role for childhood nitrate intake in the risk for later developing diabetes mellitus.

METHEMOGLOBINEMIA CLINICAL MANAGEMENT

Clinical presentation

- In children and adults with acute acquired methemoglobinemia, methemoglobin levels >20% are associated with clinical symptoms.
- Early methemoglobinemia symptoms include nonspecific headache, fatigue, dyspnea, and lethargy. In infants, this may present as unusual fussiness, decreased alertness, diarrhea, vomiting, shortness of breath, and increased work of breathing.
- At higher methemoglobin levels, cyanosis becomes visible. A brownish-blue skin tone may be present due to anoxia. This condition may be harder to detect in infants with dark skin- look for a bluish color of the nasal or oral mucosa, lips, or nail beds.
- Respiratory depression, altered consciousness, shock, seizures, and death may occur. Acquired methemoglobinemia is life threatening when methemoglobin comprises more than 30% of total hemoglobin and mortality rates are high when methemoglobin levels exceed 40%.

Diagnosis

- Initial diagnosis is based on history and exam findings. In addition, the presence of methemoglobin should be suspected with 1) clinical cyanosis despite normal arterial pO2, or 2) a significant difference between the oxygen saturations measured by pulse oximetry and by arterial blood gas analysis ("saturation gap").
- A diagnosis of methemoglobinemia should be confirmed by laboratory analysis, to be done in the emergency setting (i.e. not in primary care). Hemoximetry, also called co-oximetry, is recommended way for measuring methemoglobin. Most current blood gas analyzers have incorporated the ability to do hemoximetry
- A fresh blood specimen (venous is fine) should always be obtained as methemoglobin levels tend to increase with storage.
- Note that routine pulse oximetry is inaccurate for monitoring oxygen saturation when methemoglobin is present, and should not be used for diagnosis.

Treatment

- Acute onset of acquired methemoglobinemia should be considered a medical emergency and requires immediate treatment in the ER setting.
- When the patient is symptomatic or the methemoglobin level is >20%, intravenous methylene blue (MB, dosed at 1 to 2 mg/kg over five minutes) can be life-saving and is considered the treatment of choice. Blood transfusion or

exchange transfusion may be helpful in patients who are in shock. See appropriate clinical guidelines for more detailed treatment and monitoring guidance.

Prevention and Advice for Families

- **Only use water from public water supplies, water that has been tested and confirmed as safe, or bottled water.**
- **Test well water for nitrates to ensure it is safe to drink. A nitrate test is around $50.**
- **Don't use nitrate-contaminated well water to make baby formula or to make baby food.**
- **Don't let infants drink nitrate-contaminated water.**
- **Women who are pregnant or trying to get pregnant should not drink nitrate-contaminated well water.**
- **Breastfeeding is safe even if the mother drinks water contaminated with nitrates.**
- **Because some vegetables may contain higher amounts of nitrates, choose other solid foods until infants are over 6 months old.**

Reporting

- Methemoglobinemia is not currently a mandatory notifiable condition in Washington State. However new passive surveillance has been initiated by the Yakima Health District under the supervision of Health Officer Dr. Chris Spitters. Yakima Health District requests notification of laboratory-confirmed methemoglobinemia by calling (509) 249-6541 within three days of diagnosis. Please include an exposure history and your clinical impression regarding etiology, if known.

Resources and References

For acute poisoning assistance contact your state poison center at 1-800-222-1222.
For additional non-urgent clinical and public health assistance, contact the NW PEHSU. The University of Washington based Pediatric Environmental Health Specialty Unit (PEHSU) serves medical and public health professionals in Alaska, Washington, Idaho, and Oregon. For more information contact us at 1–877–543-2436 (1-877-KID-CHEM) or pehsu@uw.edu. Visit our website http://www.depts.washington.edu/pehsu.

- ATSDR ToxFAQsTM for Nitrates and Nitrites: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=1186&tid=258
- ATSDR Case Studies in Environmental Medicine (CSEM): Nitrate/Nitrite Toxicity (course: WB2342): http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=0
- Brender JD, et al. Prenatal nitrate intake from drinking water and selected birth defects in offspring of participants in the National Birth Defects Prevention Study. Environ Health Perspect. 2013 121:1083 – 1089.
- Karr C. Children's Environmental Health in Agricultural Settings. Journal of Agromedicine. 2012 April; 17(2), 127-139.
- Greer FR, Shannon M. American Academy of Pediatrics Committee on Nutrition; American Academy of Pediatrics Council on Environmental Health. Infant methemoglobinemia: the role of dietary nitrate in food and water. Pediatrics. 2005 Sep;116(3):784-6.
- Hord NG, Tang Y, Bryan NS. Food sources of nitrates and nitrites: the physiologic context for potential health benefits. Am J Clin Nutr. 2009 Jul;90(1):1-10.
- Rogan WJ et al. Drinking Water from Private Wells and Risks to Children. Pediatrics. 2009 Jun;123(6):1599-605.
- Washington State Department of Health: Nitrate in Drinking Water WEB site. Last accessed March 31, 2014. http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/Contaminants/Nitrate.aspx
- Yakima Health District Drinking Water WEB site last accessed March 31, 2014. http://yakimacounty.us/yakimahealthdistrict/drinking_water.php

Authors: N. Beaudet, MS, CIH; A. Otter, DNP, ARNP; C. Karr, MD, PhD; S. Sathyanarayana, MD, MPH; A. Perkins, BA. Last updated July 2014

Disclaimer: PEHSU funding was made possible (in part) by the cooperative agreement award number UTI Grant Number U61 TS000118 from the Agency for Toxic Substances and Disease Registry (ATSDR). The views in this guidance do not necessarily reflect the official policies of the Department of Health and Human Services; nor does mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government.

Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing funds to ATSDR under Inter Agency Agreement number DW-75-92301301-0. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

How to Keep Your Baby Safe from Nitrates in Drinking Water

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Nitrates are chemicals that occur naturally in drinking water and also result from human activities. Some private wells in the Yakima Valley are contaminated with nitrates. Nitrates can cause babies less than one year old to become sick. A symptom of nitrate exposure is your baby's skin turning brown or blue. You might see this inside the nose or mouth, the lips, or the fingernail and toenail beds. Contact a doctor immediately if you see these changes in a baby.

Tips to Reduce Exposure

- Test your well water for nitrates and bacteria to ensure it is safe to drink for your baby. Information on testing well water is offered below.
- Do not use nitrate-contaminated well water to make baby formula.
- Do not let baby drink nitrate-contaminated water.
- If you have city water it should be safe to use for baby, or use well water that has been tested and is safe, or bottled water for baby.
- Nitrates can be a problem in some vegetables. Try to choose commercially prepared vegetable baby foods until the baby is 7 months old. Doctors recommend no solid foods before 4-6 months old.
- If you are pregnant, or plan to get pregnant, do not drink nitrate-contaminated well water
- Breast milk is safe for baby even if the mother drinks water contaminated with nitrates.

Children over one year old have the ability to break down nitrates so they're not at risk. To keep babies safe, women who are pregnant or thinking of getting pregnant should not drink water with elevated nitrates.

Test your drinking water. All private wells should be tested before use and once per year for nitrates and bacteria. Nitrate concentrations change randomly throughout the year in the Yakima Valley. If nitrates are present in well water, other contaminants may also be present such as pesticides or bacteria.

Certified laboratories in the Yakima area that will test well drinking water for nitrates and bacteria:

- Cascade Analytical, Inc., 1008 W. Ahtanum, Yakima, WA 98903, (509) 452-7707
- Valley Environmental Laboratory, 201 E. "D" St., Yakima, WA 98901, (509) 575-3999
- Ag Health Laboratories, 445 Barnard Blvd, Sunnyside, WA 98944, (509) 836-2020

The total cost for nitrates and bacteria tests is between $52 and $70. Follow the directions provided by the laboratory – this is important to get good test results.

If a nitrate water test result is 10 mg/L or less the drinking water is safe. This means the water is safe for infants to drink and the water can be used to make formula for infants. The water is also safe for women who are pregnant or thinking about getting pregnant.

For more information about nitrates contact: Yakima Health District Help Line at (509)249-6508.

For clinician diagnosis and treatment guidance or other health effects: University of Washington (UW) PEHSU (Pediatric Environmental Health Specialty Unit) at 1-800-543-2436.

For more children's health information: www.epa.gov/children and ATSDR at http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=0

Benton County: Benton Franklin Health District (509) 460-4200

Yakama Nation: Indian Health Services - Environmental Health (509) 865-1776

Map: http://www.yakimacounty.us/gwma/documents/GWMA_Boundary.pdf

How to Keep Your Baby Safe from Nitrates in Drinking Water (Spanish)

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Cómo Mantener Seguro a su Bebé de los Nitratos en el Agua Potable

Área de Manejo de Agua Subterránea (GWMA):

El propósito de GWMA es reducir la concentración de contaminación por nitrato en el agua subterránea a niveles por debajo de los estándares del estado para el agua potable.

Los nitratos son químicos que se dan de manera natural en el agua potable pero también pueden ser el resultado de las actividades humanas. Algunos pozos privados en el Valle de Yakima están contaminados con nitratos. Los nitratos pueden causar que se enfermen los bebés menores de un año de edad. Un síntoma de exposición a nitrato es la piel de su bebé cambia de color café o azul. Es posible que vea esto dentro de la boca y la nariz, los labios o en las uñas de las manos y de los pies. Si ve estos cambios de coloración en su bebé, comuníquese inmediatamente con su doctor.

Recomendaciones para reducir la exposición

- Haga la prueba por nitratos y bacteria al agua de su pozo para asegurar que es segura que su bebé la beba. En este folleto encontrará información para la prueba al agua de su pozo.
- No utilice agua de pozo contaminada con nitratos para preparar la fórmula del bebé.
- No permita que su bebé beba agua contaminada con nitratos.
- Si Ud. recibe agua de la ciudad debe ser seguro de usar para el bebé. Para el bebé sólo use agua de pozo que ha sido probado y es segura o use agua embotellada.
- Los nitratos pueden ser un problema para algunas verduras. Escoja alimentos para bebés con verduras preparadas comercialmente hasta que su bebé tenga 7 meses de edad. Los doctores no recomiendan que los bebés coman alimentos sólidos antes de tener de 4 a 6 meses de edad.
- Si usted está embarazada o planea quedarse embarazada, no beba agua de pozo contaminada con nitratos.
- La leche materna es segura para el bebé aun cuando la madre beba agua contaminada con nitratos.

Los niños mayores de un año de edad tienen la capacidad de descomponer los nitratos y por lo tanto no están en riesgo. Para mantener seguros a los bebés, las mujeres embarazadas o las que planean quedarse embarazadas no deben beber agua con niveles altos de nitratos.

Haga la prueba a su agua para beber. A todos los pozos privados se les debería hacer la prueba por nitratos y bacteria antes de usarslos y una vez al año después. En el Valle de Yakima, la concentración de nitrato varía durante el año. Si en el agua de su pozo hay nitratos presentes, también pudiera haber presentes otros contaminantes como pesticidas o bacteria.

Los laboratorios certificados en el área de Yakima que realizan la prueba para nitratos y bacteria al agua de pozo son:

- Cascade Analytical, Inc., 1008 W. Ahtanum, Yakima, WA 98903, (509) 452-7707
- Valley Environmental Laboratory, 201 E. "D" St., Yakima, WA 98901, (509) 575-3999
- Ag Health Laboratories, 445 Barnard Blvd, Sunnyside, WA 98944, (509) 836-2020

El costo total de las pruebas por nitrato y bacteria es entre $52 a $70 dólares. Siga las instrucciones proveídas por el laboratorio seleccionado. Esto es especialmente importante para obtener buenos resultados en la prueba.

Si el resultado de la prueba por nitrato es de 10 mg/L o menos, el agua es segura para beber. Esto significa que el agua es segura para que la beban los bebés y para utilizar en preparar la fórmula del bebé. Este nivel también indica que el agua es segura para mujeres embarazadas o aquellas que piensan quedarse embarazadas.

Para más información acerca de los nitratos comuníquese a: línea de asistencia de Yakima Health District (509)249-6508.

Para diagnosis clínico y guía de tratamiento u otro efecto en la salud: University of Washington (UW) PEHSU (Pediatric Environmental Health Specialty Unit) al 1-800-543-2436.

Más información sobre la salud de los bebés: www.epa.gov/children y ATSDR http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=0

Benton County: Benton Franklin Health District (509) 460-4200

Yakama Nation: Indian Health Services - Environmental Health (509) 865-1776 Mapa: http://www.yakimacounty.us/gwma/documents/GWMA_Boundary.pdf

PEHSU Nitrates Clinician Fact Sheet

NITRATES, METHEMOGLOBINEMIA, AND DRINKING WATER: A Factsheet for Clinicians

PEHSU Pediatric Environmental Health Specialty Units

Nitrates are chemicals that occur naturally in drinking water and also result from human activities. In some areas private wells are contaminated with nitrates. Excessive nitrates can cause acquired methemoglobinemia in young infants. This severe syndrome of inadequate tissue oxygenation is potentially fatal; prompt clinical recognition and treatment is vital. Families should be counseled on nitrate safety.

Nitrate Background

- Nitrates and nitrites are naturally occurring inorganic nitrogen ions found in soil, water, and some foods. They are a natural part of the human diet. However, excessive consumption (e.g. drinking water or eating food from areas where ground water has become contaminated by excessive nitrate from fertilizers or improper manure management) can cause serious adverse health effects.

Nitrate Sources

- Drinking water
  - Nitrates occur naturally in water at low concentrations. Nitrates are also present as a result of human activities, such as the use of fertilizers and manure on irrigated farm fields that can run off and seep into wells. Nitrate-contaminated water can also be due to improper management of farm animal (i.e. cow) waste, leaky sewage pipes, and septic system failures.
  - Large suppliers of public water sources are required to monitor nitrate concentrations regularly, but private wells are not. In some areas private wells are contaminated with nitrates.
  - The American Academy of Pediatrics (AAP) consensus panel recommends that all prenatal and well-infant visits need to include questions about the home water supply.
  - The only way to know if the nitrate level in well water is at a safe level is to have the well water tested by a certified laboratory. All private wells should be tested before use and once per year for nitrates. Families should contact their state health department for assistance with selecting a certified laboratory.
  - Regulations and water testing frequency:
    - The United States Environmental Protection Agency's (EPA) Maximum Contaminant Level (MCL) for nitrates is 10 mg/L (or 10 parts per million, 10 ppm). The 10 mg/L standard was set to protect infants from nitrates. When a nitrate water test result is 10 mg/L or less, the water is considered safe for infant use.
    - Nitrates may change seasonally or randomly throughout the year. If the nitrate concentration is between 5 – 10 mg/L, monitor more closely and test the well drinking water every 3 months to confirm the water is still safe. When nitrates are present, pesticides or bacteria may also be present and additional water tests may be needed. Families should contact their local health department for guidance.
- Food
  - Nitrates can also be a problem in some vegetables, including spinach, beets, lettuce, cabbage, green beans, squash, carrots, and turnips. Because these vegetables may contain higher amounts of nitrates, recommend other foods until infants are over 6 months old.

Infant Nitrate Exposure

- Infants are exposed to nitrates when they drink contaminated well water or when contaminated well water is used to make infant formula or baby food.
- Nitrates in water are not significantly absorbed through the skin.
- Breastfeeding is safe even if a mother drinks water polluted with nitrates.

Methemoglobinemia and Other Health Effects

- Hemoglobin in blood contains iron normally found in the Fe^{2+} (ferrous) state. Excessive nitrates or nitrites can alter the iron in hemoglobin to the Fe^{3+} (ferric) state, forming methemoglobin (an abnormal form of hemoglobin

which cannot bind oxygen). Methemoglobinemia (an excess of methemoglobin) results in poor tissue oxygenation and anoxia.

- Methemoglobinemia, also known as "blue baby syndrome", can be inherited or acquired. The acquired form, such as from excessive nitrate exposure, is a serious medical emergency. Among the reported cases of acquired methemoglobinemia in US infants, most have been attributed to the use of nitrate contaminated well water for preparation of infant formula.
- Infants less than 1 year old are physiologically vulnerable to the development of methemoglobinemia due to several factors:
    - Their higher gastric pH favors nitrate-reducing bacteria that convert ingested nitrate into methemoglobin-producing nitrite.
    - Fetal hemoglobin, the predominant form in infants up to 3 months of age, is oxidized more readily to methemoglobin by nitrite than is adult hemoglobin.
    - The activity of the red blood cell enzyme systems that reduce methemoglobin back to normal hemoglobin is reduced by about half in infants compared with adults.
    - Gastroenteritis can increase the risk of developing methemoglobinemia.
- **Women who are thinking about pregnancy or who are pregnant should avoid water contaminated with nitrates. Women considering pregnancy or who are pregnant should drink water from public water supplies, water that has been tested and has safe nitrate levels, or bottled water.** While not conclusive due to study limitations, epidemiological data suggest an association between maternal ingestion of nitrate from drinking water and preeclampsia, spontaneous abortion, intrauterine growth restriction, and various birth defects. A few studies have hinted at a role for childhood nitrate intake in the risk for later developing diabetes mellitus.

METHEMOGLOBINEMIA CLINICAL MANAGEMENT

Clinical presentation

- In children and adults with acute acquired methemoglobinemia, methemoglobin levels >20% are associated with clinical symptoms.
- Early methemoglobinemia symptoms include nonspecific headache, fatigue, dyspnea, and lethargy. In infants, this may present as unusual fussiness, decreased alertness, diarrhea, vomiting, shortness of breath, and increased work of breathing.
- At higher methemoglobin levels, cyanosis becomes visible. A brownish-blue skin tone may be present due to anoxia. This condition may be harder to detect in infants with dark skin- look for a bluish color of the nasal or oral mucosa, lips, or nail beds.
- Respiratory depression, altered consciousness, shock, seizures, and death may occur. Acquired methemoglobinemia is life threatening when methemoglobin comprises more than 30% of total hemoglobin and mortality rates are high when methemoglobin levels exceed 40%.

Diagnosis

- Initial diagnosis is based on history and exam findings. In addition, the presence of methemoglobin should be suspected with 1) clinical cyanosis despite normal arterial pO2, or 2) a significant difference between the oxygen saturations measured by pulse oximetry and by arterial blood gas analysis ("saturation gap").
- A diagnosis of methemoglobinemia should be confirmed by laboratory analysis, to be done in the emergency setting (i.e. not in primary care). Hemoximetry, also called co-oximetry, is recommended way for measuring methemoglobin. Most current blood gas analyzers have incorporated the ability to do hemoximetry
- A fresh blood specimen (venous is fine) should always be obtained as methemoglobin levels tend to increase with storage.
- Note that routine pulse oximetry is inaccurate for monitoring oxygen saturation when methemoglobin is present, and should not be used for diagnosis.

Treatment

- Acute onset of acquired methemoglobinemia should be considered a medical emergency and requires immediate treatment in the ER setting.
- When the patient is symptomatic or the methemoglobin level is >20%, intravenous methylene blue (MB, dosed at 1 to 2 mg/kg over five minutes) can be life-saving and is considered the treatment of choice. Blood transfusion or

exchange transfusion may be helpful in patients who are in shock. See appropriate clinical guidelines for more detailed treatment and monitoring guidance.

Prevention and Advice for Families

- **Only use water from public water supplies, water that has been tested and confirmed as safe, or bottled water.**
- **Test well water for nitrates to ensure it is safe to drink. A nitrate test is around $50.**
- **Don't use nitrate-contaminated well water to make baby formula or to make baby food.**
- **Don't let infants drink nitrate-contaminated water.**
- **Women who are pregnant or trying to get pregnant should not drink nitrate-contaminated well water.**
- **Breastfeeding is safe even if the mother drinks water contaminated with nitrates.**
- **Because some vegetables may contain higher amounts of nitrates, choose other solid foods until infants are over 6 months old.**

Reporting

- Methemoglobinemia is not currently a mandatory notifiable condition in Washington State. However new passive surveillance has been initiated by the Yakima Health District under the supervision of Health Officer Dr. Chris Spitters. Yakima Health District requests notification of laboratory-confirmed methemoglobinemia by calling (509) 249-6541 within three days of diagnosis. Please include an exposure history and your clinical impression regarding etiology, if known.

Resources and References

For acute poisoning assistance contact your state poison center at 1-800-222-1222.
For additional non-urgent clinical and public health assistance, contact the NW PEHSU. The University of Washington based Pediatric Environmental Health Specialty Unit (PEHSU) serves medical and public health professionals in Alaska, Washington, Idaho, and Oregon. For more information contact us at 1–877–543-2436 (1-877-KID-CHEM) or pehsu@uw.edu. Visit our website http://www.depts.washington.edu/pehsu.

- ATSDR ToxFAQsTM for Nitrates and Nitrites: http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=1186&tid=258
- ATSDR Case Studies in Environmental Medicine (CSEM): Nitrate/Nitrite Toxicity (course: WB2342): http://www.atsdr.cdc.gov/csem/csem.asp?csem=28&po=0
- Brender JD, et al. Prenatal nitrate intake from drinking water and selected birth defects in offspring of participants in the National Birth Defects Prevention Study. Environ Health Perspect. 2013 121:1083 – 1089.
- Karr C. Children's Environmental Health in Agricultural Settings. Journal of Agromedicine. 2012 April; 17(2), 127-139.
- Greer FR, Shannon M. American Academy of Pediatrics Committee on Nutrition; American Academy of Pediatrics Council on Environmental Health. Infant methemoglobinemia: the role of dietary nitrate in food and water. Pediatrics. 2005 Sep;116(3):784-6.
- Hord NG, Tang Y, Bryan NS. Food sources of nitrates and nitrites: the physiologic context for potential health benefits. Am J Clin Nutr. 2009 Jul;90(1):1-10.
- Rogan WJ et al. Drinking Water from Private Wells and Risks to Children. Pediatrics. 2009 Jun;123(6):1599-605.
- Washington State Department of Health: Nitrate in Drinking Water WEB site. Last accessed March 31, 2014. http://www.doh.wa.gov/CommunityandEnvironment/DrinkingWater/Contaminants/Nitrate.aspx
- Yakima Health District Drinking Water WEB site last accessed March 31, 2014. http://yakimacounty.us/yakimahealthdistrict/drinking_water.php

Authors: N. Beaudet, MS, CIH; A. Otter, DNP, ARNP; C. Karr, MD, PhD; S. Sathyanarayana, MD, MPH, A. Perkins, BA. Last updated July 2014.

Disclaimer: PEHSU funding was made possible (in part) by the cooperative agreement award number UTI Grant Number U61 TS000118 from the Agency for Toxic Substances and Disease Registry (ATSDR). The views in this guidance do not necessarily reflect the official policies of the Department of Health and Human Services; nor does mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government.
Acknowledgement: The U.S. Environmental Protection Agency (EPA) supports the PEHSU by providing funds to ATSDR under Inter-Agency Agreement number DW-75-92301301-0. Neither EPA nor ATSDR endorse the purchase of any commercial products or services mentioned in PEHSU publications.

Section 5: Phase I Well Testing

The GWAC partnered with the Yakima Health District to offer free nitrate and coliform sampling to private (and shared) well owners in two phases between 2014 and 2017. The purpose was to help residents learn more about water quality and about how the area's drinking water could impact local public health. More than 460 households participated. The EPO employed bilingual direct mail, letters to the editors of local newspapers, English and Spanish radio talk shows, PSAs, and news releases to solicit participation.

High-Risk Well Testing: Media Talking Points

Results of the 2014 Free Well Testing
Offered by the Lower Yakima Valley Groundwater Advisory Committee (GWAC)
Lower Yakima Valley Groundwater Management Area (GWMA)

Background

- The Lower Yakima Valley Groundwater Management Area (GWMA) was formed in 2011 to address nitrate contamination in groundwater.
- The GWMA is a response to elevated nitrate levels found in the lower Yakima Valley.
- The GWMA boundaries extend west from Union Gap east to County Line Road, minus the Yakama Nation. (273.7 mi.^{2})
- Its goal is to reduce nitrate in groundwater to below state drinking water standards (below 10 mg/L).
- The GWAC is a multi-agency and citizen-based group with 21 primary members and alternates. It is responsible for developing the GWMA Program.
- The GWMA Program will be a comprehensive program designed to protect groundwater quality in the Lower Yakima Valley.

Why was the well testing conducted?

- To help private well owners learn about the health of their drinking water and how to protect themselves against possible contamination.
- To remind well owners to test their well at least once a year.
- To spread the word about the GWAC's work and the LYV Groundwater Management Area.

What did you test for?
Nitrate and coliform.

Who participated?

- Households on private or shared wells in the Lower Yakima Valley GWMA were invited to participate.

How many wells were tested?
172 private and shared wells

What did you learn?

Of the 172 wells tested:

- 59% (101) had little or no nitrates (0-4.99 mg/L)
- 25% (43) had moderate (still acceptable) amounts of nitrate (5.0-9.99 mg/L)
- 16% (28) had nitrates at or above 10 mg/L

What will you do with this information?
While the sample size is too small to draw meaningful conclusions, we did learn we have a lot of work ahead of us:

- Many people don't know that they should test their wells regularly.
- They don't know who is at risk from elevated nitrates for how to protect themselves.

We will use these results to help educate well owners and to prepare for the next round of the free well testing, which we expect to conduct later this year.

Is there anything else you'd like to add?
Yes. If you missed out on our free well testing, we will be offering it again soon. Please call 509-574-2300 to sign up for this year's free testing.

Phase I High-Risk Survey Instrument

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

☐ Survey Completed ☐ Survey Attempted/Not Completed:

☐ No One Home ☐ Declined ☐ Other _____Number of Attempts

Date Survey Completed_____

Parcel #_____Surveyor_____

Name Of Person Surveyed_____

Address_____City_____State_____ Zip_____

Email_____

Home Phone_____Cell Phone_____

Answers to the following questions will help assess the potential health risk for private well owners. Specifically, those risks associated with high levels of nitrate in their well. A potential High Public Health Risk (HPHR) is identified with a yellow highlight and a heavy border around the checkbox. A potential Public Health Risk (PHR) is only identified with a yellow highlight in the checkbox. . Water supply wells found with a potential HPHR will be given recommendations for testing, repairs, or maintenance of their well.

As a general rule the Washington Departments of Health and Ecology recommend private groundwater wells be tested for nitrate every three years and bacteria every year.

Classify the surrounding area as	☐ Farm	☐ Rural	☐ Rural Community Sub-Division	☐ Suburb
Does the home have a treatment system installed?			☐ Yes	☐ No
If yes what kind?	☐ POU	☐ POE	☐ Ion Exchange (Water Softener)	☐ Other
Does the home have bottled water?			☐ Yes	☐ No
Sample Scheduled or Taken?	☐ Nitrate	☐ Nitrate Test Strip	☐ Coliform	☐ Other
GPS Coordinates	X:		Y:	

High Risk: (80% of PHR and HPHR boxes checked) Possible contamination of the water supply and for the long term may need testing, improvements, repairs, or replacement. You should test your water immediately. If tests are positive for Fecal or E.Coli bacteria or have a nitrate level higher than 10 mg/L, you should consider using an alternative source of drinking water for daily uses, until the observed risk(s) can be corrected. If you believe you or your family is experiencing health effects associated with your drinking water, you should discuss the test results with your health care provider.

Moderate Risk: (60% of PHR and HPHR boxes checked) Your well may be a potential health threat to anyone consuming the water and may be susceptible to contamination. Recommend regular maintenance of the well and frequent water tests for nitrate and coliform bacteria.

Low Risk: Recommend regular maintenance of the well and water tests for nitrate and coliform bacteria.

Section Summary		Boxes Checked HPHR	Boxes Checked PHR
1	☐ Yes ☐ No		
2	☐ Yes ☐ No		
3	☐ Yes ☐ No		
4	☐ Yes ☐ No		
Total	Yes:_____ No:_____		
☐ High	☐ Moderate	☐ Low	

Section 1: General Population Questions	Yes	No	Unk	Comments
1. How many residents live in your household?				

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

2. Are there very young children less than 1-yr old in your household?	☐	☐	☐	
3. Are there pregnant women in your household?	☐	☐	☐	
4. Women who can possibly become pregnant in your household?	☐	☐	☐	
5. Are there chronically ill people in your household?	☐	☐	☐	
6. Would you be willing to provide your household income?				
7. What is the primary language spoken in your home?				
Total High Risk Boxes Checked:	**At Risk Population:**	**Yes:** ☐		**No:** ☐

Section 2: General Water Quality Questions	Yes	No	Unk	Comments
8. Has the well been tested for Total Coliform (Bacteria)?	☐	☐	☐	
a. Answered yes to previous question, was the sample positive for Total Coliform?	☐	☐	☐	
b. Answered yes to previous question, was the sample positive for Fecal or E. Coli?	☐	☐	☐	
9. Has the well been tested for nitrate?	☐	☐	☐	
a. Answered yes to previous question (9), was the sample lower than 5.0 mg/L?	☐	☐	☐	
b. Answered no to previous question (9a), was the sample higher than 10.0 mg/L?	☐	☐	☐	
10. Does the well water have an unusual taste, odor, or color?	☐	☐	☐	
Total High Risk Boxes Checked:	**Potential Public Health Risk(s):**	**Yes:** ☐		**No:** ☐

Section 3: Sanitary Control Area Risk Factors	Yes	No	Unk	Comments
11. Does the owner live on a small lot with an onsite septic system (less than 1-acre)?	☐	☐	☐	
a. Is the well within 50 ft of a septic tank or 100 ft of a drainfield?	☐	☐	☐	
b. Have you had your septic tank pumped recently?	☐	☐	☐	
c. Do neighbors live on small lots with onsite septic systems?	☐	☐	☐	
12. Is there surface water within 100 feet of the well? (like ponds, lagoons, rivers, unlined irrigation ditches)	☐	☐		Surface Water Type
a. Is there surface water within 200 feet of the well?	☐	☐		Surface Water Type
13. Do you use the area surrounding the well as a pasture or have structures to house personal animals?	☐	☐		Type:_____ How Many:_____
a. Does your neighbor use the area surrounding the well as a pasture or have structures for housing personal animals?	☐	☐		Type:_____ How Many:_____
14. Do you see large mounds of manure near your well, within 100-ft?	☐	☐		Owner:_____ Neighbors:_____
a. Do you see large mounds of manure near your well, within 200-ft?	☐	☐		Owner:_____ Neighbors:_____
15. Have you seen manure spreading near your well, within 100-ft?	☐	☐		How Often:
a. Have you seen manure spreading near your well, within 200-ft?	☐	☐		How Often:
16. Is your well located within 100-ft of any type of agricultural field or orchard?	☐	☐		Crop:_____ Distance:_____
a. Is your well located within 200-ft of any type of agricultural field or orchard?	☐	☐		Crop:_____ Distance:_____

LOWER YAKIMA VALLEY
GROUND WATER ADVISORY COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

17. Have you sprayed or seen sprayed any chemicals within 100-ft of your well?	☐	☐	How Often:_____ How Close:_____
a. Have you sprayed or seen sprayed any chemicals within 200-ft of your well?	☐	☐	How Often:_____ How Close:_____

Total High Risk Boxes Checked:		Well Susceptible to Surface Contamination:	Yes: ☐ No: ☐

Section 4: Well Construction	Yes	No	Unk	Comments
18. Do you have a copy of the well log?	☐	☐	☐	_____-yr
19. Do you know how old your well is?	☐	☐	☐	
20. Do you know the depth of your well?	☐	☐	☐	_____-ft
21. Is it a hand dug well?	☐	☐	☐	
22. Is it a driven well (sand point)?	☐	☐	☐	
23. Does the well appear poorly maintained (condition of wellhead or pump house)?	☐	☐	☐	
24. Does the well appear to have a broken wellhead seal or holes in the casing?	☐	☐	☐	
25. Is the wellhead subject to flooding?	☐	☐	☐	
Total High Risk Boxes Checked:		Well Vulnerable to Surface Contamination:	Yes: ☐	No: ☐

Section 5: Long Term Monitoring Consideration				
26. Type of Well:	☐ Domestic	☐ Public Supply	☐ Industrial	☐ Irrigation
27. Describe Wellhead Completion (pitless adapter, wellhouse, etc.): _____				
28. Record the Ecology UWID if tagged on the wellhead or noted on the well log:	_ _ _ - _ _ _			
29. GPS Latitude of the Wellhead (valid coordinates must be positive and from 45-47, must be a minimum of 4 decimal places):				
30. GPS Longitude of the Wellhead (valid coordinates must be negative and from -119 to -121, must be a minimum of 4 decimal places):				
31. Depth to Water (ft below Measuring Point, MP):				
a. MP Description:				
b. DTW Method Description (e.g. well log, measured, etc.):				
32. Is Type of Pump Known?	☐ Yes	☐ No	☐ Unknown	
a. Pump Is (e.g. Submersible, Suction-lift, Jet pump, Line Shaft Turbine):				
33. Is Sampling Port available downstream (before water enters) treatment system, holding tanks, or pressure tanks?	☐ Yes	☐ No	☐ Unknown	
a. Description of sampling port (location, type):				

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

34. Is Participant interested in having their well considered for Long-Term Monitoring?	☐ Yes	☐ No	☐ Unknown
a. Directions for gaining access to the site (notification request, allowed if owner/resident not present, etc.):			
b. Special tools or materials to access/open sampling port or to manage purge water:			
c. Safety considerations for samplers (e.g. domestic animals, rodents):			

Section 5: Graphics (Required)

Site Sketches and Photos: Must include sufficient detail and scale to enable field personnel unfamiliar with the site to readily locate the well from the driveway or street. Include land cover/use features from Section 3 (septic, agriculture, etc.). Compass directions and horizontal scale required.

a. Site Sketch is on additional page(s) attached to this Survey form:	☐ Yes	☐ No
b. Digital Photos of the site taken (if camera does not have GPS capabilities, first photo in series at individual site must clearly document Site ID):	☐ Yes	☐ No

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

Wellhead Sketches and Photos: Must include sufficient detail and scale to enable field personnel unfamiliar with the well to readily locate the sampling port and water level measuring point if applicable.		
a. Wellhead Sketch is on additional page(s) attached to this Survey form:	☐ Yes	☐ No
b. Digital Photos of the wellhead taken (if camera does not have GPS capabilities, first photo in series at individual site must clearly document Site ID):	☐ Yes	☐ No

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Form #GWMA0002 A
Revised 10/16/2013

Assessment Of Health Risk - Water Supply Well - Lower Yakima Valley (GWMA 2013)

Well Assessment Survey Test Results

Well Assessment Survey Test Results

Through February 15, 2016

Nitrate Test Results

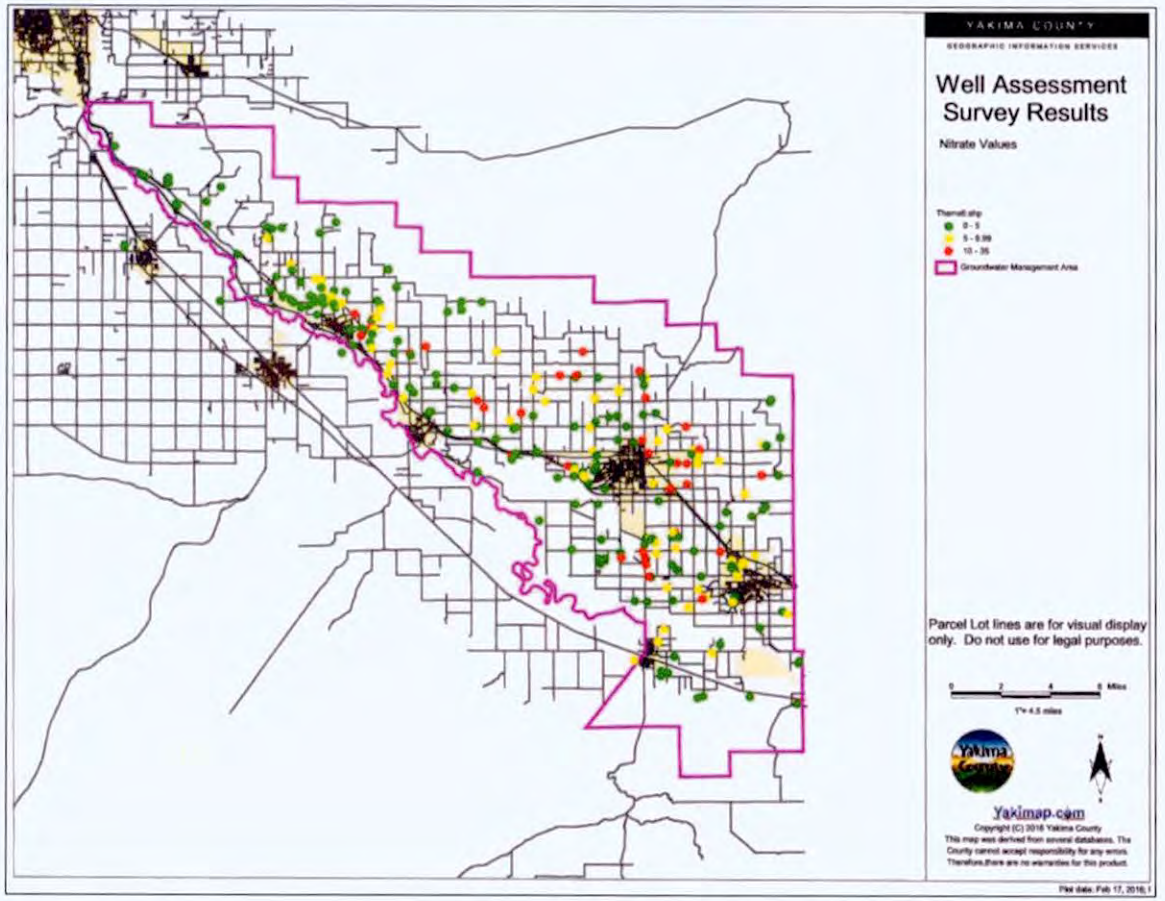
Nitrate Range	Number of Wells	Percent
0 to 5.0	172	60%
5.01 to 9.99	76	26%
10.0 to 35	40	14%
Grand Total	288	100%

Bacteria Test Results

Result	Number of Wells		
	Bacteria Present	Ecoli Present	Fecal Present
Satisfactory	228	286	288
Unsatisfactory	60	2	0
Grand Total	288	288	288

Nitrate and Bacteria Test Results

Nitrate Range	Number of Wells	Bacteria Present	Ecoli Present	Fecal Present
0 to 5.0	172	40	2	0
5.01 to 9.99	76	14	0	0
10.0 to 35	40	6	0	0
Grand Total	288	60	2	0


YAKIMA COUNTY
GEOGRAPHIC INFORMATION SERVICES
Well Assessment Survey Results
Nitrate Values
Thematic.shp
0 - 5
5 - 9.99
10 - 35
Groundwater Management Area
Parcel Lot lines are for visual display only. Do not use for legal purposes.
0 2 4 8 Miles
1"= 4.5 miles
Yakimap.com
Copyright (C) 2016 Yakima County
This map was derived from several databases. The County cannot accept responsibility for any errors. Therefore,there are no warranties for this product.
Plot date: Feb 17, 2016

High Risk Well Assessment Letters-Variables

Where:

Nitrate Results Are	And Coliform Results Are	And	Letter is
N is 0-4.9 mg/L	Satisfactory	N/A	Letter #1
N is 0-4.9 mg/L	Unsatisfactory	N/A	Letter #1 with coliform variation
N is 5-9.9 mg/L	Satisfactory	N/A	Letter #2
N is 5-9.9 mg/L	Unsatisfactory	N/A	Letter #2 with coliform variation
N is 10 mg/L or greater	Satisfactory	N/A	Letter #3
N is 10 mg/L or greater	Unsatisfactory	E-Coli Not present	Letter #3 with coliform variation
N is 10 mg/L or greater???	Unsatisfactory	E-Coli Present	Letter #?? With disinfect message

# of pages	Letter #1 Enclosures	Letter #2 enclosures	Letter #3 enclosures
1 (single)	Lab results	Lab results	Lab results
1 (single)	2A_Certified Lab List (English/Spanish)	2A_Certified Lab List (English/Spanish)	2A_Certified Lab List (English/Spanish)
1 (double)	2B_DOH Coliform 331-79 Q&A	2B_DOH Coliform 331-79 Q&A	2B_DOH Coliform 331-79 Q&A
1 (double)	2B_(Sp) DOH Coliform 331-79 Q&A	2B_(Sp) DOH Coliform 331-79 Q&A	2B_(Sp) DOH Coliform 331-79 Q&A
1 (double)	2C_DOH Nitrate in Drinking Water 331-214	2C_DOH Nitrate in Drinking Water 331-214	2C_DOH Nitrate in Drinking Water 331-214
1 (double)	2C_(Sp) DOH Nitrate in Drinking Water 331-214	2C_(Sp) DOH Nitrate in Drinking Water 331-214	2C_(Sp) DOH Nitrate in Drinking Water 331-214
			Emergency disinfect

Formatted Table

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

High Risk Well Assessment

Section 1 - General Information

Parcel #: _____ Date: _____

Address: _____
Street *Apt. #*

_____
City *State* *Zip*

GPS: _____ N _____ W
° ' " ° ' "

Surveyor Name: _____

Resident Name: _____

Resident Type: ☐ Resident ☐ Owner ☐ Both

Primary Phone: _____ ☐ Home ☐ Work

Section 2 - Site Information

1. **Is there an onsite septic system?** ☐ No ☐ Yes - Specify Below
   ☐ Septic tank within 50 ft. of well ☐ Drain field within 100 ft. of well

2. **Is there surface water within 100 ft. of the well?** ☐ No ☐ Yes - Specify Below
   ☐ Ponds ☐ Lagoons ☐ Lined irrigation canal
   ☐ Unlined irrigation canal ☐ River ☐ Other

3. **Are there animals/agriculture within 100 ft. of the well?** ☐ No ☐ Yes - Specify Below
   ☐ Orchard/Field ☐ Structure/Animals Type/# _____

4. **Are there large mounds of manure within 100 ft of the well?** ☐ No ☐ Yes - Specify Below
   ☐ Owner ☐ Neighbor

5. **Can you see the condition of the well and wellhead?** ☐ No ☐ Yes - Specify Below
   ☐ Driven Well (sand point) ☐ Hand Dug ☐ Poorly Maintained
   ☐ Broken wellhead seal ☐ Holes in casing ☐ Other _____

Materials Requested _____

High Risk Well Assessment

Section 3 - Survey Questions

6. Do you drink your tap water ☐ No ☐ Yes

7. What is the main source of your drinking water? ☐ Specify Below

☐ Tap water ☐ Bottled Water ☐ Other _____

8. Do you have a system to remove nitrates from your water? ☐ No ☐ Yes - Specify below

Where is it located? ☐ Before the house ☐ At the sink

What type is it? ☐ R/O ☐ Ion

☐ Ultra-filtration ☐ Other _____

9. Just a few questions about your household:

☐ # of people ☐ Children < Year ☐ Vulnerable Health Condition *[Script]*

☐ W Child bearing age ☐ Pregnant ☐ Household Income < $48,000

10. Has your well been tested within the past 3 years? ☐ No ☐ Yes - Specify below

☐ Coliform ☐ Fecal/E. coli ☐ Nitrate _____ mg/L

11. Are you familiar with your well? ☐ No ☐ Yes - Specify below

☐ Well log _____ Age of well _____ Depth of well

12. Is your well subject to flooding? ☐ No ☐ Yes

13. Has your on-site septic system been pumped in the last 5 years? ☐ No ☐ Yes ☐ N/A

14. Has there been manure or any chemicals applied within 50 ft. of the well? ☐ No ☐ Yes - Specify below

☐ Manure _____ Frequency _____ By who

☐ Chemicals _____ Frequency _____ Type

15. Have you ever participated in a Yakima County well survey? ☐ No ☐ Yes ☐ Return

Free Well Water Testing: Phase II (English)

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Yakima Health District

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Attention LOWER VALLEY Residents!



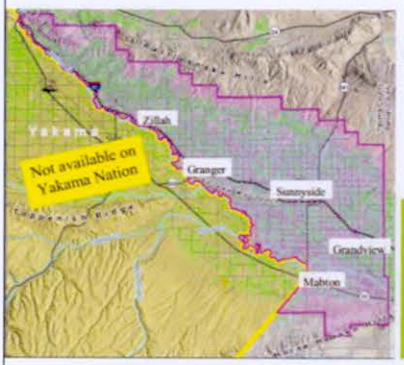
Does your drinking water come from a private well?

For a LIMITED TIME ONLY you may be eligible for
FREE WELL WATER TESTING
through the
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

What's involved?

- Your drinking water well sampled for nitrates and bacteria for free
- A short survey by a Yakima Health District employee where you can share your concerns and learn about nitrates
- You receive sampling results to help you protect your drinking water and family





How can I be considered for free testing?

- You must live in the Lower Yakima Valley *and*
- Obtain your drinking water from a private or shared well

For more information or to participate, please call
The Yakima Health District Help Desk

509.249.6508

This sampling is made possible by the GWAC. Your participation will help the committee to better understand and help find some solutions to possible contamination in drinking water wells.
For more information, please visit: **http://www.yakimacounty.us/gwma/**

Free Well Water Testing: Phase II (Spanish)

LOWER YAKIMA VALLEY GROUNDWATER ADVISORY COMMITTEE

Yakima Health District
Prevention is our Business

Comité Asesor del Área de Manejo de Agua Subterránea (GWMA):
El propósito de GWMA es reducir la concentración de contaminación por nitrato en el agua subterránea por debajo del estándar estatal para el agua potable.

¡Atención Residentes del VALLE BAJO!



¿El agua que usted bebe viene de un pozo privado?

SÓLO POR TIEMPO LIMITADO usted puede ser elegible para una
PRUEBA GRATIS DEL AGUA DE SU POZO
a través del
Comité Asesor de Agua Subterránea del Valle Bajo de Yakima (GWAC)

¿De qué se trata? Se evaluará por nitrato y bacteria a pozos de agua potable. Un empleado del Departamento de Salud de Yakima tomará la muestra de su pozo y se le invitará a participar en una encuesta corta. Usted puede consultar sobre cualquier preocupación que tenga del agua de su pozo y los resultados de las prueba estarán disponibles.





¿Qué puedo hacer para ser considerado para la prueba gratis?

Para ser considerado, usted debe vivir en el Valle Bajo de Yakima y obtener el agua que bebe de un pozo privado o de un pozo compartido.

Para más información o para participar, llame a la
Línea de información del Departamento de Salud de Yakima

509.249.6508

Estas pruebas son posibles gracias a GWAC. Su participación ayudará al comité a entender mejor y a ayudar a encontrar soluciones a la posible contaminación en los pozos de agua potable. Para más información, visite:
http://www.yakimacounty.us/gwma/

Public Service Announcement: Free Well Water Testing (English)

Public Service Announcement
GWAC Lower Yakima Valley Well Sampling

The Lower Yakima Valley Groundwater Advisory Committee (GWAC) is offering free well water sampling to Lower Yakima valley residents beginning in September.

Drinking water wells will be sampled for nitrate and bacteria. A Yakima Health District employee will be available to discuss any concerns or questions with the survey or sample results with survey participants or the general public. This sampling will help the Committee to better understand and help find solutions to possible contamination in drinking water wells.

For more information and to participate, contact the Yakima Health District Help Desk at: 509-249-6508

Letter: Invite to Participate in Well Testing (English)

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

September 2015

Dear Resident:

The Lower Yakima Valley Groundwater Advisory Committee (GWAC) in partnership with the Yakima Health District is offering *free* nitrate and coliform samples for private and shared wells. This is part of an ongoing effort to help residents in the Lower Yakima Valley learn more about the water quality and impact to public health of the area's drinking water.

We are writing to encourage you to participate in our sampling program that should take about 30 minutes. This will be a quick look at conditions surrounding your well that may impact water quality and the health of your family. The samples will show if the water quality may also be a concern to your family's health. The short survey and samples will be completed by an environmental health specialist from the Yakima Health District.

The sampling will be paid for by state funds made available to Yakima County to address areas where there may be high levels of nitrate in drinking water. The survey will help us understand the conditions that exist around the wells and how to best help the residents. It is not our intention to collect personal data for any other use or purpose.

All information collected will be made available to you and will help you make informed decisions about your drinking water and your family's health.

To set up an appointment to participate, please call the Yakima Health District Help Desk at 509-249-6508.The sampling program will begin in September.

The Lower Yakima Valley GWAC is a multiagency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC and this program, please visit: http://www.yakimacounty.us/gwma/.

We look forward to working with you.

Sincerely,

J. Rand Elliott, Yakima County Commissioner
Chairman
The Lower Yakima Valley Groundwater Management Area Advisory Committee

Letter: Invite to Participate in Well Testing (Spanish)

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Septiembre 2015

Estimado residente:

El Comité Asesor del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima (GWAC) en asociación con el Distrito de Salud de Yakima está ofreciendo muestras *gratis* de nitrato y bacterias coliformes para los pozos privados y compartidos. Como parte de un esfuerzo continuo para ayudar a los residentes en el Valle Bajo de Yakima a informarse más sobre la calidad y el impacto que tiene el agua para beber del área en la salud pública.

Le escribimos para animarle a que participe en nuestro programa de muestreo que sólo debe durar aproximadamente 30 minutos. La encuesta es un vistazo rápido a las condiciones que rodean su pozo y que pueden afectar la calidad del agua y la salud de su familia. Las muestras mostrarán si la calidad del agua pudiera ser también una preocupación para la salud de su familia. La encuesta corta y las muestras serán tomadas por un especialista en salud ambiental del Distrito de Salud de Yakima.

Las muestras serán pagadas con fondos estatales disponibles para atender áreas del Condado de Yakima donde pudiera haber niveles altos de nitratos en agua para beber. La encuesta nos ayudará a entender las condiciones que existen alrededor de los pozos y la manera de apoyar mejor a los residentes. No es nuestra intención recolectar datos personales para ningún otro uso o propósito.

Toda la información recolectada estará disponible para usted y le ayudará a tomar decisiones informadas acerca de su agua para beber y la salud de su familia.

Para hacer una cita para participar, por favor llame a la línea de ayuda del Distrito de Salud de Yakima al 509-249-6508. El programa de muestreo iniciará este mes. El comité GWAC del Valle Bajo de Yakima es un grupo formado por varias agencias y ciudadanos que coordinan los esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle bajo de Yakima. Para más información acerca de GWAC y de este programa, visite: http://www.yakimacounty.us/gwma/.

Esperamos poder trabajar con usted.

Atentamente,

J. Rand Elliott, Presidente de Comisionados del Condado de Yakima
Comité Asesor del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima

Section 6: Results Letters

Every participating household in the assessment received a personalized letter with their assessment results and individualized instructions tailored to their certified lab results. Educational handouts were included with each results letter (see Section 4).

Letter 1: [Satisfactory] Nitrate Results and What They Mean

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

May 2015

Parcel number
Name
Address
City State Zip

Dear Resident:

Thank you for participating in the 2014 Lower Yakima Valley Groundwater Management Area (LYV GWMA) High Risk Well Assessment Survey. A certified lab analyzed the water quality samples taken from your home or well during the survey. These samples included an inorganic sample for Nitrate and a bacteriological sample for Coliform.

We enclosed a copy of the lab results for your drinking water.

* The Nitrate level detected was fill in here mg/L. These results are normal and well within the acceptable range for nitrate.
* The coliform results were satisfactory.

We recommend you continue sampling for nitrate each year, even though your nitrate levels are within an acceptable range (less than 10 mg/L).

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

* You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or
* Go to Well Owner.org http://www.wellowner.org/water-quality/water-testing/, for information on private wells, recommended testing, treatment, maintenance, and so on.

Why was my well water tested for Nitrate and Coliform?
The Lower Yakima Valley Groundwater Advisory Committee (GWAC) is a multi-agency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC, please visit: http://www.yakimacounty.us/gwma/. Our interest in the study was to inform residents and homeowners served by private or shared wells in the Lower Yakima Valley of the potential health risks associated with their drinking water. We were also interested in gathering more information about the Nitrate level in your drinking water.

Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call
(509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

Enclosures

Letter 1: [Satisfactory] Nitrate Results and What They Mean (Spanish)

LOWER YAKIMA VALLEY

GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Mayo, 2016

«PARCEL»
«RESIDENT»
«ADDRESS»
«CITY», «STATE» «ZIP»

Estimado residente:

Gracias por su participación en la Encuesta de Evaluación de Pozos de Alto Riesgo del Área de Manejo de Agua Subterráneas del Valle Bajo de Yakima (LYV GWMA). Un laboratorio certificado analizó la calidad de las muestras de agua que se tomaron de su casa o pozo durante la encuesta. Las muestras se sometieron a una muestra inorgánica para Nitrato y una muestra bacteriológica para Coliforme.

Adjuntamos en esta carta una copia de los resultados de laboratorio de su agua para beber.

* El nivel de Nitrato detectado fue de «NITRATE» mg/L. Este resultado es normal y el pozo está dentro de los niveles aceptables de nitrato.

* Los resultados para bacteria coliforme fueron satisfactorios.

Aunque los niveles de Nitrato estén dentro de un rango aceptable (menos de 10.0 mg/L), le recomendamos que continúe haciendo pruebas por Nitrato a su pozo cada año.

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

* Para obtener una explicación detallada de sus resultados para cualquier contaminante al que se le haya echo la prueba a su agua para beber y recomendaciones para un tratamiento posible, usted puede ingresar sus resultados en la Ohio Watershed Interpretation Tool en: http://ohiowatershed.osu.edu/know-your-well-water/well-water-interpretation-tool , o

* Para información sobre pozos privados, pruebas que se recomiendan, tratamientos y mantenimiento vaya a Well Owner.org http://www.wellowner.org/water-quality/water-testing/

¿Por qué se hicieron pruebas por Nitrato y Coliforme al agua de mi pozo?
El grupo GWAC del Valle Bajo de Yakima es un grupo formado de varias agencias y ciudadanos que está coordinando esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle Bajo de Yakima. Para más información acerca de GWAC, por favor visite: http://www.yakimacounty.us/gwma/. Nuestro interés en el estudio fue informar a los residentes y propietarios de casas que usan el agua de pozos privados o compartidos en el Valle Bajo de Yakima de los riesgos potenciales de salud asociados con su agua para beber. También estamos interesados en reunir más información sobre el nivel de Nitrato en su agua para beber.

¿Puedo ayudar en algo?
Si, y una vez más, estamos muy agradecidos por la asistencia que ya nos ha brindado. Existen más fondos disponibles para hacer más pruebas y encuestas en casas que usan pozos privados. Nuestro interés es pasar la palabra a más residentes del Valle Bajo de Yakima. Por favor, si conoce a un vecino o amigo en el área que esté interesado en que se le hagan pruebas a su pozo y en hacer la encuesta, llámenos al (509) 574-2300 ó envíe un email a: PSWebContacts@co.yakima.wa.us. Como parte de nuestro esfuerzo para evaluar los niveles de nitrato en el Valle Bajo de Yakima, quizás busquemos lugares permanentes para monitoreo continuo. Por favor, si deses que consideremos su pozo para parte de este esfuerzo llámenos al (509) 574-2300.

Atentamente,

J. Rand Elliott, Presidente
Comité Asesor de Aguas Subterráneas del Valle Bajo de Yakima (GWAC)

Adjuntos

Letter 2: [5-9] Nitrate Results and What They Mean

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

May 2015

parcel #
name
address
city state zip

Dear Resident:

Thank you for participating in the 2014 Lower Yakima Valley Groundwater Management Area (LYV GWMA) High Risk Well Assessment Survey. A certified lab analyzed the water quality samples taken from your home or well during the survey. These samples included an inorganic sample for Nitrate and a bacteriological sample for Coliform.

We enclosed a copy of the lab results for your drinking water.

- The Nitrate level detected was fill in here mg/L. A score between 5 - 9 mg/L shows the nitrate levels are high but still acceptable. However, they may be rising to an unacceptable range.
- The bacteria (Total Coliform) results were satisfactory.

Because your Nitrate level is approaching the State Standard of 10.0 mg/L, we recommend you consider sampling your well for Nitrate once every 3 to 6 months.

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

- You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or
- Go to Well Owner.org http://www.wellowner.org/water-quality/water-testing/, for information on private wells, recommended testing, treatment, and maintenance.

Why was my well water tested for Nitrate and Coliform?
The Lower Yakima Valley Groundwater Advisory Committee (GWAC) is a multi agency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC, please visit: http://www.yakimacounty.us/gwma/. Our interest in the study was to inform residents and homeowners served by private or shared wells in the Lower Yakima Valley of the potential health risks associated with their drinking water. We were also interested in gathering more information about the Nitrate level in your drinking water.

Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call (509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

Enclosures

Letter 2: [5-9] Nitrate Results and What They Mean (Spanish)

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Mayo, 2015

parcel #
name
address
city state zip

Estimado residente:

Gracias por su participación en la Encuesta de Evaluación de Pozos de Alto Riesgo del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima (LYV GWMA), 2014. Un laboratorio certificado analizó la calidad de las muestras de agua que se tomaron de su casa o pozo durante la encuesta. Las muestras se sometieron a una muestra inorgánica para Nitrato y una muestra bacteriológica para Coliforme.

Adjuntamos en esta carta una copia de los resultados de laboratorio de su agua para beber.

* El nivel de Nitrato detectado fue de fill in here mg/L. Un resultado entre 5 y 9 mg/L indica que los niveles de nitrato son altos, pero continúan siendo aceptables. Sin embargo, pudiera ser que los niveles estén en aumento y pudieran llegar a un rango inaceptable.
* Los resultados para bacteria (Coliforme Total) fueron Satisfactorios.

Debido a que su nivel de Nitrato se está acercando al Estándar Estatal de 10.0 mg/L, le recomendamos que considere hacer pruebas por Nitrato a su pozo de cada 3 a 6 meses.

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles Máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

* Para obtener una explicación detallada de sus resultados para cualquier contaminante al que se le haya echo la prueba a su agua para beber y recomendaciones para un tratamiento posible, usted puede ingresar sus resultados en la Ohio Watershed Interpretation Tool en: (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool), o
* Para información sobre pozos privados, pruebas que se recomiendan, tratamientos y mantenimiento vaya a Well Owner.org http://www.wellowner.org/water-quality/water-testing/.

¿Por qué se hicieron pruebas por Nitrato y Coliforme al agua de mi pozo?
El grupo GWAC del Valle Bajo de Yakima es un grupo formado de varias agencias y ciudadanos que está coordinando esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle Bajo de Yakima. Para más información acerca de GWAC, por favor visite: http://www.yakimacounty.us/gwma/. Nuestro interés en el estudio fue informar a los residentes y propietarios de casas que usan el agua de pozos privados o compartidos en el Valle Bajo de Yakima de los riesgos potenciales de salud asociados con su agua para beber. También estamos interesados en reunir más información sobre el nivel de Nitrato en su agua para beber.

¿Puedo ayudar en algo?
Si, y una vez más, estamos muy agradecidos por la asistencia que ya nos ha brindado. Existen más fondos disponibles para hacer más pruebas y encuestas en casas que usan pozos privados. Nuestro interés es pasar la palabra a más residentes del Valle Bajo de Yakima. Por favor, si conoce a un vecino o amigo en el área que esté interesado en que se le hagan pruebas a su pozo y en hacer la encuesta, llámenos al (509) 574-2300 ó envíe un email a: PSWebContacts@co.yakima.wa.us. Como parte de nuestro esfuerzo para evaluar los niveles de nitrato en el Valle Bajo de Yakima, quizás busquemos lugares permanentes para monitoreo continuo. Por favor, si desea que consideremos su pozo para parte de este esfuerzo llámenos al (509) 574-2300.

Atentamente,

J. Rand Elliott, Presidente
Comité Asesor de Aguas Subterráneas del Valle Bajo de Yakima (GWAC)

Adjuntos

Letter 3: [Ten Plus] Nitrate Results and What They Mean

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

May 2015

parcel #
name
address
city state zip

Dear Resident:

Thank you for participating in the 2014 Lower Yakima Valley Groundwater Management Area (LYV GWMA) High Risk Well Assessment Survey. A certified lab analyzed the water quality samples taken from your home or well during the survey. These samples included an inorganic sample for Nitrate and a bacteriological sample for Coliform.

We enclosed a copy of the lab results for your drinking water.

* The Nitrate level detected was fill in here mg/L. A score of 10 mg/L or greater indicates a high unacceptable nitrate level that exceeds the State Standard of 10.0 mg/L.
* The bacteria (Total Coliform) results were fill in here [satisfactory or unsatisfactory].

Because your Nitrate level is at 10.0 mg/L or above, we recommend you have your well tested every three months for nitrate. You should also consider installing a treatment system to remove excess nitrate or use bottled water for drinking and cooking if a member of your household is:

* An infant less than one year of age
* Pregnant
* May become pregnant or
* Has certain blood disorders

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

* You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or
* Go to Well Owner.org http://www.wellowner.org/water-quality/water-testing/, for information on private wells, recommended testing, treatment, maintenance, and so on.

Why was my well water tested for Nitrate and Coliform?
The Lower Yakima Valley Groundwater Advisory Committee (GWAC) is a multi agency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC, please visit: http://www.yakimacounty.us/gwma/. Our interest in the study was to inform residents and homeowners served by private or shared wells in the Lower Yakima Valley of the potential health risks associated with their drinking water. We were also interested in gathering more information about the Nitrate level in your drinking water.

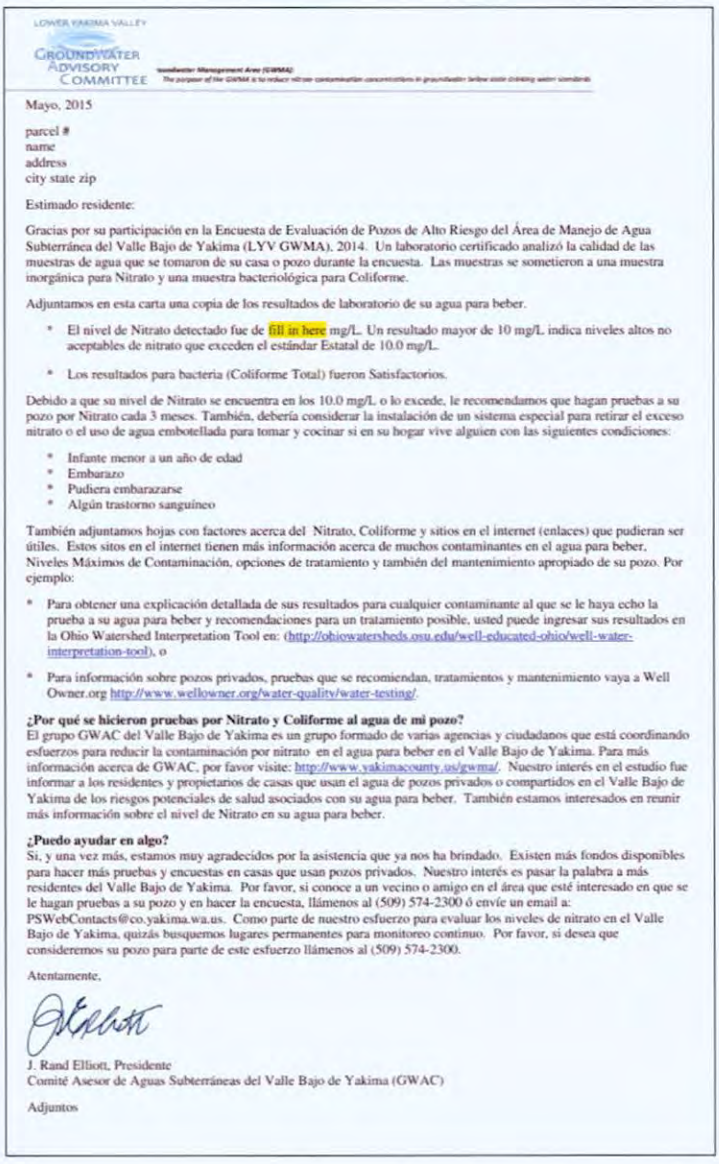
Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call at (509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

Enclosures

Letter 3: [Ten Plus] Nitrate Results and What They Mean (Spanish)



LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Mayo, 2015

parcel #
name
address
city state zip

Estimado residente:

Gracias por su participación en la Encuesta de Evaluación de Pozos de Alto Riesgo del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima (LYV GWMA), 2014. Un laboratorio certificado analizó la calidad de las muestras de agua que se tomaron de su casa o pozo durante la encuesta. Las muestras se sometieron a una muestra inorgánica para Nitrato y una muestra bacteriológica para Coliforme.

Adjuntamos en esta carta una copia de los resultados de laboratorio de su agua para beber.

* El nivel de Nitrato detectado fue de fill in here mg/L. Un resultado mayor de 10 mg/L indica niveles altos no aceptables de nitrato que exceden el estándar Estatal de 10.0 mg/L.

* Los resultados para bacteria (Coliforme Total) fueron Satisfactorios.

Debido a que su nivel de Nitrato se encuentra en los 10.0 mg/L o lo excede, le recomendamos que hagan pruebas a su pozo por Nitrato cada 3 meses. También, debería considerar la instalación de un sistema especial para retirar el exceso nitrato o el uso de agua embotellada para tomar y cocinar si en su hogar vive alguien con las siguientes condiciones:

* Infante menor a un año de edad
* Embarazo
* Pudiera embarazarse
* Algún trastorno sanguíneo

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles Máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

* Para obtener una explicación detallada de sus resultados para cualquier contaminante al que se le haya echo la prueba a su agua para beber y recomendaciones para un tratamiento posible, usted puede ingresar sus resultados en la Ohio Watershed Interpretation Tool en: (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool), o

* Para información sobre pozos privados, pruebas que se recomiendan, tratamientos y mantenimiento vaya a Well Owner.org http://www.wellowner.org/water-quality/water-testing/.

¿Por qué se hicieron pruebas por Nitrato y Coliforme al agua de mi pozo?
El grupo GWAC del Valle Bajo de Yakima es un grupo formado de varias agencias y ciudadanos que está coordinando esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle Bajo de Yakima. Para más información acerca de GWAC, por favor visite: http://www.yakimacounty.us/gwma/. Nuestro interés en el estudio fue informar a los residentes y propietarios de casas que usan el agua de pozos privados o compartidos en el Valle Bajo de Yakima de los riesgos potenciales de salud asociados con su agua para beber. También estamos interesados en reunir más información sobre el nivel de Nitrato en su agua para beber.

¿Puedo ayudar en algo?
Si, y una vez más, estamos muy agradecidos por la asistencia que ya nos ha brindado. Existen más fondos disponibles para hacer más pruebas y encuestas en casas que usan pozos privados. Nuestro interés es pasar la palabra a más residentes del Valle Bajo de Yakima. Por favor, si conoce a un vecino o amigo en el área que esté interesado en que se le hagan pruebas a su pozo y en hacer la encuesta, llámenos al (509) 574-2300 ó envíe un email a: PSWebContacts@co.yakima.wa.us. Como parte de nuestro esfuerzo para evaluar los niveles de nitrato en el Valle Bajo de Yakima, quizás busquemos lugares permanentes para monitoreo continuo. Por favor, si desea que consideremos su pozo para parte de este esfuerzo llámenos al (509) 574-2300.

Atentamente,

J. Rand Elliott, Presidente
Comité Asesor de Aguas Subterráneas del Valle Bajo de Yakima (GWAC)

Adjuntos

Letter 4: Unsatisfactory Coliform Results and What They Mean

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

May 2015

Parcel #
Name
Address
City, State Zip

Dear Resident:

Thank you for participating in the 2014 Lower Yakima Valley Groundwater Management Area (LYV GWMA) High Risk Well Assessment Survey. A certified lab analyzed the water quality samples taken from your home or well during the survey. These samples included an inorganic sample for Nitrate and a bacteriological sample for Coliform.

We enclosed a copy of the lab results for your drinking water.

* The Nitrate level detected was fill in here mg/L. These results are normal and well within the acceptable range for nitrate.

  We recommend you continue sampling for nitrate each year, even though your nitrate levels are within an acceptable range (less than 10 mg/L).

* The coliform results were UNSATISFACTORY.

Your coliform sample was Unsatisfactory. An Unsatisfactory result means Total Coliform was found in your sample. The presence of this bacteria indicate there is a breach in your well or pipes where dirt is getting into your pipes. We recommend having another coliform sample taken to the lab for analysis.

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

* You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or

* Go to Well Owner.org http://www.wellowner.org/water-quality/water-testing/, for information on private wells, recommended testing, treatment, maintenance, and so on.

Why was my well water tested for Nitrate and Coliform?
The Lower Valley GWAC is a multi agency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC, please visit: http://www.yakimacounty.us/gwma/. Our interest in the study was to inform residents and homeowners served by private or shared wells in the Lower Yakima Valley of the potential health risks associated with their drinking water. We were also interested in gathering more information about the Nitrate level in your drinking water.

Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call
(509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

enclosure: copy of lab results
Fact Sheets

Letter 4: Unsatisfactory Coliform Results and What They Mean (Spanish)

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Mayo, 2015

parcel #
name
address
city state zip

Estimado residente:

Gracias por su participación en la Encuesta de Evaluación de Pozos de Alto Riesgo del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima (LYV GWMA), 2014. Un laboratorio certificado analizó la calidad de las muestras de agua que se tomaron de su casa o pozo durante la encuesta. Las muestras se sometieron a una muestra inorgánica para Nitrato y una muestra bacteriológica para Coliforme.

Adjuntamos en esta carta una copia de los resultados de laboratorio de su agua para beber.

- El nivel de Nitrato detectado fue de fill in here mg/L. Este resultado es normal y el pozo está dentro de los niveles aceptables por nitrato.

  Aunque los niveles de Nitrato estén dentro de un rango aceptable (menos de 10.0 mg/L), le recomendamos que continúe haciendo pruebas por Nitrato a su pozo cada año.

- Los resultados para bacteria Coliforme fueron INSATISFACTORIOS.

Los resultados para la bacteria coliforme fueron INSATISFACTORIOS. Un resultado Insatisfactorio significa que en su muestra se encontró bacteria Coliforme Total. La presencia de esta bacteria indica que en su pozo o tuberías existe alguna ruptura que permite que entre tierra al sistema. Le recomendamos tome otra muestra para que la analicen en el laboratorio.

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

- Para obtener una explicación detallada de sus resultados para cualquier contaminante al que se le haya echo la prueba a su agua para beber y recomendaciones para un tratamiento posible, usted puede ingresar sus resultados en la Ohio Watershed Interpretation Tool en: (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool), o
- Para información sobre pozos privados, pruebas que se recomiendan, tratamientos y mantenimiento vaya a Well Owner.org http://www.wellowner.org/water-quality/water-testing/.

¿Por qué se hicieron pruebas por Nitrato y Coliforme al agua de mi pozo?
El grupo GWAC del Valle Bajo de Yakima es un grupo formado de varias agencias y ciudadanos que está coordinando esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle Bajo de Yakima. Para más información acerca de GWAC, por favor visite: http://www.yakimacounty.us/gwma/. Nuestro interés en el estudio fue informar a los residentes y propietarios de casas que usan el agua de pozos privados o compartidos en el Valle Bajo de Yakima de los riesgos potenciales de salud asociados con su agua para beber. También estamos interesados en reunir más información sobre el nivel de Nitrato en su agua para beber.

¿Puedo ayudar en algo?
Si, y una vez más, estamos muy agradecidos por la asistencia que ya nos ha brindado. Existen más fondos disponibles para hacer más pruebas y encuestas en casas que usan pozos privados. Nuestro interés es pasar la palabra a más residentes del Valle Bajo de Yakima. Por favor, si conoce a un vecino o amigo en el área que esté interesado en que se le hagan pruebas a su pozo y en hacer la encuesta, llámenos al (509) 574-2300 ó envíe un email a: PSWebContacts@co.yakima.wa.us. Como parte de nuestro esfuerzo para evaluar los niveles de nitrato en el Valle Bajo de Yakima, quizás busquemos lugares permanentes para monitoreo continuo. Por favor, si desea que consideremos su pozo para parte de este esfuerzo llámenos al (509) 574-2300.

Atentamente,

J. Rand Elliott, Presidente
Comité Asesor de Aguas Subterráneas del Valle Bajo de Yakima (GWAC)

Adjuntos

Letter 5: Unsatisfactory Coliform & E. Coli Results and What They Mean

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA)
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

May 2015

Parcel #
Name
Address
City, State Zip

Dear Resident:

Thank you for participating in the 2014 Lower Yakima Valley Groundwater Management Area (LYV GWMA) High Risk Well Assessment Survey. A certified lab analyzed the water quality samples taken from your home or well during the survey. These samples included an inorganic sample for Nitrate and a bacteriological sample for Coliform.

We enclosed a copy of the lab results for your drinking water.

* The Nitrate level detected was fill in here mg/L. These results are normal and well within the acceptable range for nitrate.

  We recommend you continue sampling for nitrate each year, even though your nitrate levels are within an acceptable range (less than 10 mg/L).

* The coliform results were UNSATISFACTORY.

Your coliform sample was Unsatisfactory. An Unsatisfactory result means Total Coliform was found in your sample. In addition, further testing found E. coli (Fecal) present. The presence of this bacteria indicate there is a breach in your well or pipes where dirt is getting into your pipes. We recommend reviewing the enclosed fact sheet for emergency disinfection procedures and having another coliform sample taken to the lab for analysis.

We also enclosed fact sheets on Nitrate, Coliform, and websites (links) that you may find helpful. These websites have more information about many drinking water contaminants, Maximum Contaminant Levels, treatment options, as well as proper maintenance for your well. For example:

* You may enter your results into the Ohio Watershed Interpretation Tool at (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool) for a detailed explanation of your results for any drinking water contaminant sampled and possible treatment recommendations, or

* Go to Well Owner.org http://www.wellowner.org/water-quality/water-testing/, for information on private wells, recommended testing, treatment, maintenance, and so on.

Why was my well water tested for Nitrate and Coliform?
The Lower Valley Groundwater Advisory Committee (GWAC) is a multi agency and citizen-based group coordinating efforts to reduce nitrate contamination in drinking water in the Lower Yakima Valley. To learn more about the GWAC, please visit: http://www.yakimacounty.us/gwma/. Our interest in the study was to inform residents and homeowners served by private or shared wells in the Lower Yakima Valley of the potential health risks associated with their drinking water. We were also interested in gathering more information about the Nitrate level in your drinking water.

Can I be of more help?
Yes, and again we are very grateful for the assistance you have already given us. There is more funding available for doing more tests and surveys on homes served by private wells. Our interest is to get the word out to more residents of the Lower Yakima Valley. Please give us a call at (509) 574-2300 or email us at PSWebContacts@co.yakima.wa.us if you know a neighbor or friend in the area who is interested in having their well tested and the survey completed. As part of our effort to evaluate the levels of nitrate in the LYV, we may be looking for permanent ongoing monitoring sites. Please call
(509) 574-2300 if you want us to consider your well for part of this effort.

Sincerely,

J. Rand Elliott, Chairman
Lower Yakima Valley Groundwater Advisory Committee (GWAC)

enclosure: copy of lab results
Fact Sheets

Letter 5: Unsatisfactory Coliform & E. Coli Results and What They Mean (Spanish)

LOWER YAKIMA VALLEY
GROUNDWATER ADVISORY COMMITTEE

Groundwater Management Area (GWMA):
The purpose of the GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards

Mayo, 2015

Parcel #
Name
Address
City, State Zip

Estimado residente:

Gracias por su participación en la Encuesta de Evaluación de Pozos de Alto Riesgo del Área de Manejo de Agua Subterránea del Valle Bajo de Yakima (LYV GWMA), 2014. Un laboratorio certificado analizó la calidad de las muestras de agua que se tomaron de su casa o pozo durante la encuesta. Las muestras se sometieron a una muestra inorgánica para Nitrato y una muestra bacteriológica para Coliforme.

Adjuntamos en esta carta una copia de los resultados de laboratorio de su agua para beber.

* El nivel de Nitrato detectado fue de fill in here mg/L. Este resultado es normal y el pozo está dentro de los niveles aceptables por nitrato.

  Aunque los niveles de Nitrato estén dentro de un rango aceptable (menos de 10.0 mg/L), le recomendamos que continúe haciendo pruebas por Nitrato a su pozo cada año.

* Los resultados para bacteria coliforme fueron INSATISFACTORIOS.

Los resultados para bacteria coliforme fueron INSATISFACTORIOS. Un resultado Insatisfactorio significa que en su muestra se encontró bacteria Coliforme Total. Además al evaluarse la muestra más a fondo se encontró E. Coli (Fecal) (Presente / No Presente). La presencia de esta bacteria indica que en su pozo o tuberías existe alguna ruptura que permite que entre tierra al sistema. Le recomendamos que revise la hoja de factores adjunta para que realice los procedimientos de desinfección de emergencia y que tome otra muestra para que la analicen en el laboratorio.

También adjuntamos hojas con factores acerca del Nitrato, Coliforme y sitios en el internet (enlaces) que pudieran ser útiles. Estos sitos en el internet tienen más información acerca de muchos contaminantes en el agua para beber, Niveles máximos de Contaminación, opciones de tratamiento y también del mantenimiento apropiado de su pozo. Por ejemplo:

* Para obtener una explicación detallada de sus resultados para cualquier contaminante al que se le haya echo la prueba a su agua para beber y recomendaciones para un tratamiento posible, usted puede ingresar sus resultados en la Ohio Watershed Interpretation Tool en: (http://ohiowatersheds.osu.edu/well-educated-ohio/well-water-interpretation-tool),

* Para información sobre pozos privados, pruebas que se recomiendan, tratamientos y mantenimiento vaya a Well Owner.org http://www.wellowner.org/water-quality/water-testing/.

¿Por qué se hicieron pruebas por Nitrato y Coliforme al agua de mi pozo?
El grupo GWAC del Valle Bajo de Yakima es un grupo formado de varias agencias y ciudadanos que está coordinando esfuerzos para reducir la contaminación por nitrato en el agua para beber en el Valle Bajo de Yakima. Para más información acerca de GWAC, por favor visite: http://www.yakimacounty.us/gwma/. Nuestro interés en el estudio fue informar a los residentes y propietarios de casas que usan el agua de pozos privados o compartidos en el Valle Bajo de Yakima de los riesgos potenciales de salud asociados con su agua para beber. También estamos interesados en reunir más información sobre el nivel de Nitrato en su agua para beber.

Puedo ayudar en algo?
Si, y una vez más, estamos muy agradecidos por la asistencia que ya nos ha brindado. Existen más fondos disponibles para hacer más pruebas y encuestas en casas que usan pozos privados. Nuestro interés es pasar la palabra a más residentes del Valle Bajo de Yakima. Por favor, si conoce a un vecino o amigo en el área que esté interesado en que se le hagan pruebas a su pozo y en hacer la encuesta, llámenos al (509) 574-2300 ó envíe un email a: PSWebContacts@co.yakima.wa.us. Como parte de nuestro esfuerzo para evaluar los niveles de nitrato en el Valle Bajo de Yakima, quizás busquemos lugares permanentes para monitoreo continuo. Por favor, si desea que consideremos su pozo para parte de este esfuerzo llámenos al (509) 574-2300.

Atentamente,

J. Rand Elliott, Presidente
Comité Asesor de Aguas Subterráneas del Valle Bajo de Yakima (GWAC)

Adjuntos

Section 7: GWAC Presentations

Powerpoint presentations were created for GWAC representatives to share with their constituents. The presentations were also posted to the web.

GWMA Mission Presentation

GWMA Mission

Groundwater Management Area (GWMA):

The goal of the Lower Yakima Valley GWMA is to reduce nitrate contamination concentrations in groundwater below state drinking water standards.

Groundwater Management Area (GWMA)

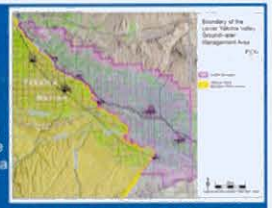
Background

- In 2011, the Lower Yakima Valley Groundwater Management Area (GWMA) was formed to address nitrate contamination in groundwater.
- The GWMA is a response to the elevated nitrate levels found in the Lower Yakima Valley which exceed the state standard of 10.0 mg/L.
- Private drinking water wells with nitrate levels higher than the state standard, pose a greater health risk to those individuals susceptible to elevated nitrate in their drinking water.

Groundwater Management Area (GWMA)

GWMA Boundaries

The GWMA boundaries extend west from Union Gap east to County Line Road, minus the Yakama Nation.



The GWMA encompasses 175172.66 acres or 273.7 square miles.

http://www.yakimacounty.us/541/Ground-Water-Management-Area

Groundwater Management Area (GWMA)

What the GWMA Intends to Do:

Yakima County requested Dept of Ecology to recognize the GWMA and provide assistance for helping reduce the nitrate level in the groundwater. Objectives include:

- Data Collection, Monitoring and Analysis.
- Public Education and Outreach.
- Problem Identification.
- Potential Measures or Practices for Reducing Groundwater Contamination.

Groundwater Management Area (GWMA)

GWMA GroundWater Advisory Committee

- The Lower Yakima Valley Groundwater Management Area Committee (GWAC) is responsible for developing the (GWMA) plan.
- The GWAC is a multi-agency and citizen-based group with 22 primary members and alternates.
- To learn about their progress or to attend a meeting, please visit: http://www.yakimacounty.us/agendacenter

Groundwater Management Area (GWMA)

GWMA GroundWater Advisory Committee Membership

Commissioner Rand Elliott,
Yakima County Board of Commissioners

Vern Redifer, P.E. (alternate),
Yakima County Public Services

Lower Yakima Valley GWAC Members and Alternates

http://www.yakimacounty.us/541/Ground-Water-Management-Area

Groundwater Management Area (GWMA)

GWMA Working Groups:

http://yakimacounty.us/583/Working-Groups

Livestock / CAFO
Chair: David Bowen

Irrigated Agriculture
Chair: Dr. Troy Peters

Residential, Commercial, Industrial, Municipal
Chair: Dan DeGroot

Data Collection, Characterization, Monitoring
Chair: Melanie Redding

Regulatory Framework
Chair: Jean Mendoza

Education & Public Outreach
Chair: Lisa Freund

Funding
Chair: Pending

Groundwater Management Area (GWMA)

GWAC Working Groups

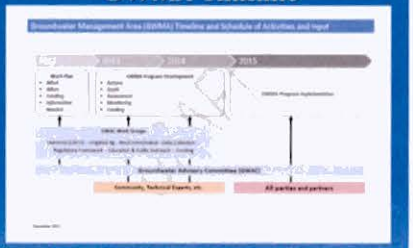
Working groups were convened to provide focused information and plans for the objectives identified in the request.

The GWMA website offers reference material and guides users to agency partners who have additional information.

The working group meetings are posted on the website and are open to the public just like the committee meetings.

Groundwater Management Area (GWMA)

GWMA Timeline



Groundwater Management Area (GWMA)

Citizen-Based Pollution Prevention

Pollution prevention will be a guiding principle for all work.

A coordinated effort to address groundwater contamination in the Yakima Basin.

Seeks credibility with the general public, the farming community, stakeholders, and special interest groups.

Multiple approaches including education, technical assistance and accountability strategies.

Groundwater Management Area (GWMA)

How To Get It Done?

Identify the primary sources of nitrate contamination using scientific data.

Identify or develop practices that will minimize nitrate contamination of groundwater

Develop a plan that recommends strategies for implementing improved practices

Provide appropriate education and outreach on health risks and how to prevent exposure.

Groundwater Management Area (GWMA)

How To Get It Done?

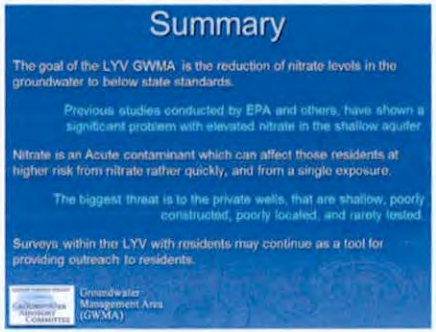
Citizen surveys.

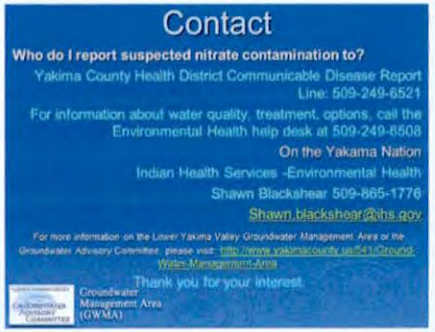
Multi-language media outreach.

Health community education, awareness and participation.

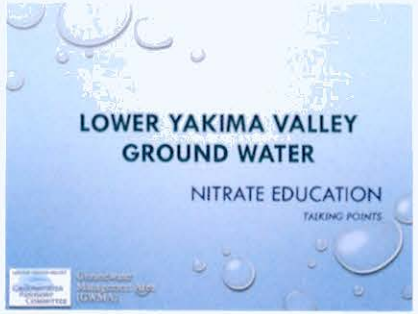
Partnerships with Agricultural businesses and employers, farming community, special interest groups, medical organizations, and other interested stakeholders.

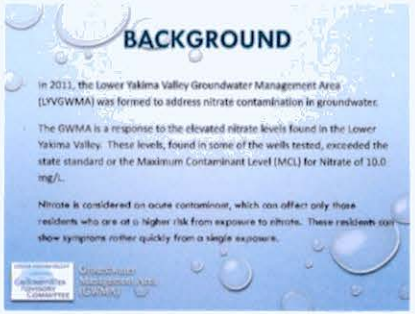
Groundwater Management Area (GWMA)


Summary
The goal of the LYV GWMA is the reduction of nitrate levels in the groundwater to below state standards.
Previous studies conducted by EPA and others, have shown a significant problem with elevated nitrate in the shallow aquifer
Nitrate is an Acute contaminant which can affect those residents at higher risk from nitrate rather quickly, and from a single exposure.
The biggest threat is to the private wells, that are shallow, poorly constructed, poorly located, and rarely tested.
Surveys within the LYV with residents may continue as a tool for providing outreach to residents.
Groundwater Management Area (GWMA)

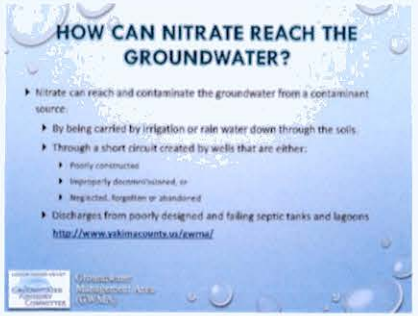

Contact
Who do I report suspected nitrate contamination to?
Yakima County Health District Communicable Disease Report Line: 509-249-6521
For information about water quality, treatment, options, call the Environmental Health help desk at 509-249-6508
On the Yakama Nation
Indian Health Services -Environmental Health
Shawn Blackshear 509-865-1776
Shawn.blackshear@ihs.gov
For more information on the Lower Yakima Valley Groundwater Management Area or the Groundwater Advisory Committee, please visit: http://www.yakimacounty.us/541/Ground-Water-Management-Area
Thank you for your interest.
Groundwater Management Area (GWMA)

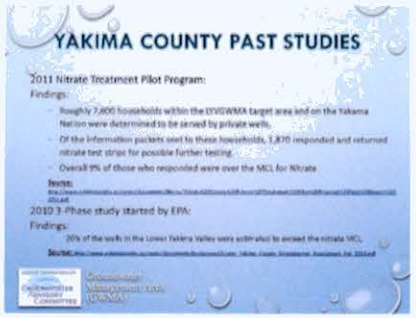
Nitrate Education Presentation

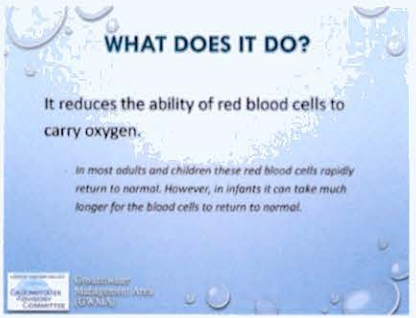


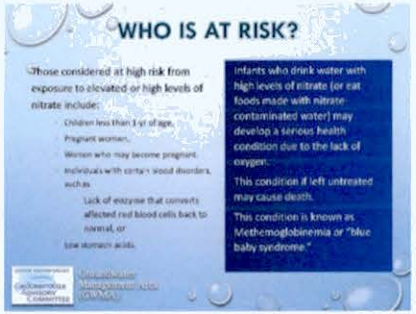




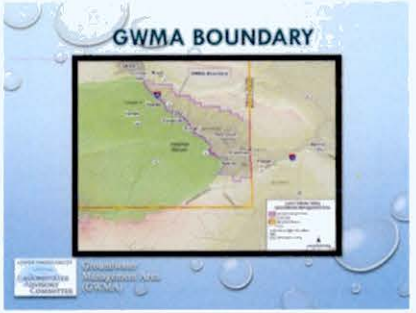


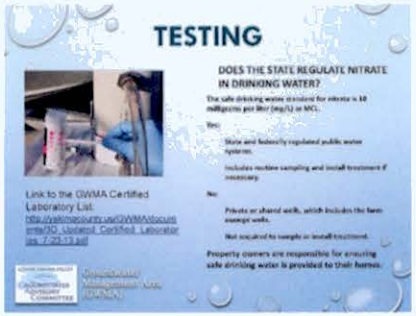





WHO IS AT RISK?
Those considered at high risk from exposure to elevated or high levels of nitrate include:
Children less than 1 yr of age,
Pregnant women,
Women who may become pregnant,
Individuals with certain blood disorders, such as
Lack of enzyme that converts affected red blood cells back to normal, or
Low stomach acids.
Infants who drink water with high levels of nitrate (or eat foods made with nitrate-contaminated water) may develop a serious health condition due to the lack of oxygen.
This condition if left untreated may cause death.
This condition is known as Methemoglobinemia or "blue baby syndrome."


"BLUE BABY SYNDROME"
Methemoglobinemia
MODERATE TO SERIOUS
Lethargic
Mental Status Changes
Respiratory Distress
Blue color, especially around mouth, lips & nail beds
Rapid Heart Rate
Chocolate Colored Blood
Shock-Seizures-Coma-Death


GWMA BOUNDARY


TESTING
DOES THE STATE REGULATE NITRATE IN DRINKING WATER?
Yes:
State and federally regulated public water systems.
Includes routine sampling and install treatment if necessary.
No:
Private or shared wells, which includes the farm manager wells.
Not required to sample or install treatment.
Property owners are responsible for ensuring safe drinking water is provided to their homes.
Link to the GWMA Certified Laboratory List.


AVAILABLE RESOURCES
LOWER YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA (LYVGWMA)
Observe the committee's progress.
Find out about upcoming meetings, activities and public events and how to get involved.


AVAILABLE RESOURCES
Education and outreach materials developed during the Nitrate Treatment Program:
http://www.yakimacounty.us/nitrateprogram/english/default.htm
Materials identify:
Vulnerable population – Those most at risk from health effects associated with elevated nitrate.
State certified water quality sampling labs – Coliform (Bacteria) and nitrate.
Technical assistance for private well owners.


THANK YOU

Section 8: Promotional Billboards

Private Well Users Test Your Water



Private Well Users Test Your Water (Spanish)



Lower Yakima Valley Groundwater Management Program

Volume IV

Member Contributions

June: 20198~~August 20, 2018~~

LOWER YAKIMA VALLEY
GROUNDWATER
ADVISORY
COMMITTEE

Member Contributions

Groundwater advisory committee members were given an opportunity to express differing opinions with aspects of this plan. Some members also chose to submit additional recommendations or information to be considered as the implementation phase begins. These are individual contributions and do not necessarily reflect the consensus or the opinion of the GWAC.

Specific questions related to the content or science of a minority report should be directed to the author of the minority report.

Formatted: Intense Emphasis

Formatted: Intense Emphasis

Formatted: Intense Emphasis

Research (Long List) of Health Problems Related to Nitrates

Compiled by Jean Mendoza

Formatted: Default Paragraph Font

Formatted: Normal

Abu Naser AA, Ghbn N, Khoudary R. (2007) Relation of nitrate contamination of groundwater with methaemoglobin level among infants in Gasa East Mediterr Health J. 12(5) pp. 994-1004. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/18290391

Agency for Toxic Substances and Disease Registry. (2001). Case Studies in Environmental Medicine Nitrate/Nitrite Toxicity. *Department of Health & Human Services*. Atlanta, GA. Retrieved from http://www.atsdr.cdc.gov/csem/nitrate/docs/nitrate_nitrite.pdf

Arbuckle, T.E., Sherman, G.J., Corey, P.N., Walters, D. & Lo, B. (1988) Water nitrates and CNS birth defects: a population-based case-control study. *Arch.Environ.Health 43*(2) pp. 162-167. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3377550

Avery A.A. (1999) Infantile methemoglobinemia: reexamining the role of drinking water nitrates. *Environmental Health Perspectives 107*(7) pp. 583–6. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1566680/pdf/envhper00512-0111.pdf

Balazs, C., Morello-Frosch, R., Hubbard, A., & Ray, I. (2011). Social disparities in nitrate-contaminated drinking water in California's San Joaquin Valley. *Environmental Health Perspectives*, *119*(9), 1272. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3230390/

Barrett, J. H., Parslow, R. C., McKinney, P. A., Law, G. R., & Forman, D. (1998). Nitrate in drinking water and the incidence of gastric, esophageal, and brain cancer in Yorkshire, England. *Cancer Causes and Control*, *9*(2), 153-159. Retrieved from

https://www.researchgate.net/profile/Graham_Law/publication/226280359_Nitrate_in_drinking_water_and_the_incidence_of_gastric_esophageal_and_brain_cancer_in_Yorkshire_England/links/54368e0d0cf2dc341db35c4f.pdf

Benini, D., Vino, L., & Fanos, V. (1998) Acquired methemoglobinemia: a case report. Pediatr Med Chir 20(6) pp. 411-413. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10335542

Berlin G., Brodin B., Hilden J. (1985) Acute dapsone intoxication: a case treated with continuous infusion of methylene blue, forced diuresis, and plasma exchange. *J Toxicol Clin Toxicol* 22 pp. 537–48. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/6535846

Brender, J.D., Olive, J.M., Felkner, M., Suarez, L., Marckwardt, W., & Hendricks, K.A. (2004) Dietary nitrites and nitrates, nitrosatable drugs, and neural tube defects. *Epidemiology 15*(3) pp. 330-336. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/15097014

Brender, J., Olive, J., Felkner, M., Suarez, L., Hendricks, K., & Marckwardt, W. (2004). Intake of nitrates and nitrites and birth defects in offspring. *Epidemiology*, *15*(4), S184. Retrieved from

http://journals.lww.com/epidem/Citation/2004/07000/Intake_of_Nitrates_and_Nitrites_and_Birth_Defects.487.aspx

Bukowski, J., Somers, G., & Bryanton, J. (2001) Agricultural contamination of groundwater as a possible risk factor for growth restriction or prematurity. J.Occup.Environ.Med. 43(4) pp. 377-383. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11322099

Bunin, G.R., Kuijten, R.R., Boesel, C.P., Buckley, J.D. & Meadows, A.T. (1993) Relation between maternal diet and subsequent primitive neuroectodermal brain tumors in young children. New England Journal of Medicine 19;329(8) pp. 536-541. http://www.ncbi.nlm.nih.gov/pubmed/8167265

Burkholder, J., Libra, B., Weyer, P., Heathcote, S., Kolpin, D., Thorne, P. S., & Wichman, M. (2007). Impacts of waste from concentrated animal feeding operations on water quality. *Environmental health perspectives*, *115*(2), 308. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1817674/

Cantor, K. P. (1997). Drinking water and cancer. *Cancer Causes & Control*, *8*(3), 292-308.Retrieved from https://www.researchgate.net/profile/Kenneth_Cantor/publication/51297605_Drinking_water_and_cancer/links/548719ca0cf268d28f070c4f/Drinking-water-and-cancer.pdf

Cedergren, M.I., Selbing, A.J., Lofman, O., & Kallen, B.A. (2002) Chlorination byproducts and nitrate in drinking water and risk for congenital cardiac defects. *Environmental Research 89*(2) pp. 124-130. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/12123645

Center for Disease Control (1993) Methemoglobinemia in an infant - - Wisconsin, 1992 Morbidity & Mortality Weekly http://www.ncbi.nlm.nih.gov/pubmed/8450825

Centers for Disease Control and Prevention. (1995) A survey of the quality of water drawn from domestic wells in nine Midwest states. *US Department of Health and Human Services*. Retrieved from http://www.cdc.gov/nceh/hsb/disaster/pdfs/A%20Survey%20of%20the%20Quality%20ofWater%20Drawn%20from%20Domestic%20Wells%20in%20Nine%20Midwest%20States.pdf

Center for Disease Control (1996) Spontaneous abortions possibly related to ingestion of nitrate-contaminated well water-LaGrange County, Indiana, 1991–1994. *MMWR 45* pp. 569–72. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/00042839.htm

Center for Disease Control (1997) Methemoglobinemia Attributable to Nitrite Contamination of Potable Water Through Boiler Fluid Additives - New Jersey, 1992-1996. Morbidity and Mortality Weekly Report March 7, 1997. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/00046656.htm

Chan, T.Y. (1996) Food-borne nitrates and nitrites as a cause of methemoglobinemia. *Southeast Asian J Trop Med Public Health 27*(1) Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9031426

Chiu, H. F., Tsai, S. S., & Yang, C. Y. (2007). Nitrate in drinking water and risk of death from bladder cancer: an ecological case-control study in Taiwan. *Journal of toxicology and environmental Health, Part A*, *70*(12), 1000-1004. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/15287390601171801

Comly HH. Landmark article Sept 8, 1945: cyanosis in infants caused by nitrates in well-water. JAMA. 1987;257:2788–2792. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/3553637 or http://jama.jamanetwork.com/article.aspx?articleid=366259

Coss, A., Cantor, K. P., Reif, J. S., Lynch, C. F., & Ward, M. H. (2004). Pancreatic cancer and drinking water and dietary sources of nitrate and nitrite. *American Journal of Epidemiology*, *159*(7), 693-701. Retrieved from https://academic.oup.com/aje/article/159/7/693/71809

Formatted: Default Paragraph Font

Craun, G.F., Greathouse, D.G. & Gunderson, D.H. (1981) Methaemoglobin levels in young children consuming high nitrate well water in the United States. Int.J.Epidemiol. 10(4) pp. 309-317. Retrieved from http://ije.oxfordjournals.org/content/10/4/309.abstract

Croen, L.A., Todoroff K., Shaw G.M. (2001) Maternal exposure to nitrate from drinking water and diet and risk of neural tube defects. *Am J Epidemiol 153* pp.325–31. Retrieved from http://aje.oxfordjournals.org/content/153/4/325.full.pdf

Crutchfield, S., Cooper, J., & Hellerstein, D. (2016). The Benefits of Safer Drinking Water: The Value of Nitrate Reduction. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2736657

Dean B.S., Lopez G., Krenzelok E.P. (1992) Environmentally-induced methemoglobinemia in an infant. *Toxicol Clin Tociclo 30*(1) pp. 127-133 Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/1542142

De Roos, A. J., Ward, M. H., Lynch, C. F., & Cantor, K. P. (2003). Nitrate in public water supplies and the risk of colon and rectum cancers. *Epidemiology*, *14*(6), 640-649. Retrieved from http://journals.lww.com/epidem/Abstract/2003/11000/Nitrate_in_Public_Water_Supplies_and_the_Risk_of.4.aspx

Donahoe, W. E. (1949). Cyanosis in infants with nitrates in drinking water as cause. *Pediatrics*, *3*(3), 308-311. Retrieved from http://pediatrics.aappublications.org/content/pediatrics/3/3/308.full.pdf

Dorsch, M.M., Scragg, R.K., McMichael, A.J., Baghurst, P.A. & Dyer, K.F. (1984) Congenital malformations and maternal drinking water supply in rural South Australia: a case-control study. *Am.J.Epidemiol. 119*(4) pp. 473-486. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/6711537

Durosev, D. (1979) Toxic methemoglobinemia in newborns and infants. *Bilt Hematol Transfuz* http://www.ncbi.nlm.nih.gov/pubmed/552247

Dusdieker L.B., Getchell J.P., Liarakos T.M., Hausler W.J., Dungy C.I. (1994) Nitrate in baby foods: adding to the nitrate mosaic. *Arch Pediatric Adolesc Med 148* pp. 490–94. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8180640

Dusdieker L.B., Dungy C.I. (1996) Nitrates and babies: A dangerous combination. *Contemp Pediatr 13*(11) pp. 91–102.

Eichholzer M., Gutzwiller F. (1998) Dietary nitrates, nitrites, and *N*-nitroso compounds and cancer risk: a review of the epidemiologic evidence. *Nutr Rev 56* pp.95–105. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1753-4887.1998.tb01721.x/abstract

Environmental Protection Agency (2010) Yakima Valley Groundwater Contamination: Summary of EPA Sampling Activities. Retrieved from http://yosemite.epa.gov/r10/water.nsf/bb9c63e62d1ae1f8882564f4007da918/1ea7e8c810acb757882576470077b0e3/$FILE/Yakima%20Valley%20EPA%20Sampling%20Summary%20June%2022%202010.pdf

Environmental Working Group. (n.d.) *Pouring it on: the health effects of Nitrate Exposure*. Retrieved from http://www.ewg.org/node/7712

Eubank, W., Carpenter, J. D., Maltsberger, B. A., & Mancl, K. (1998). Nitrate in drinking water. Retrieved from https://mospace.umsystem.edu/xmlui/bitstream/handle/10355/52688/wq0103-1998.pdf?sequence=1

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font, Font: Univers

Fan A.M, Steinberg V.E. (1996) Health implications of nitrate and nitrite in drinking water: An update on methemoglobinemia occurrence and reproductive and development toxicity. *Regul Toxicol Pharmacol 23*(11) pp. 35–43. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8628918

Felsot A.S. (1998) Re-examining the link between nitrates and "blue baby" syndrome: a necessary first step for managing ground water quality to protect public health. Agric Environ News. 150 pp. 1–14. Retrieved from http://aenews.wsu.edu/Oct98AENews/aenewsoctober98.htm#anchor545063

Fewtrell, L (2004) Drinking-Water Nitrate, Methemoglobinemia, and Global Burden of Disease Environmental Health Perspectives 112:1371-1374. Doi:10.1289/ehp.7216 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1247562/pdf/ehp0112-001371.pdf

Freedman, D. M., Cantor, K. P., Ward, M. H., & Helzlsouer, K. J. (2000). A case-control study of nitrate in drinking water and non-Hodgkin's lymphoma in Minnesota. *Archives of Environmental Health: An International Journal*, *55*(5), 326-329. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/00039890009604024

Gatseva, P. D., & Argirova, M. D. (2008). High-nitrate levels in drinking water may be a risk factor for thyroid dysfunction in children and pregnant women living in rural Bulgarian areas. *International journal of hygiene and environmental health*, *211*(5-6), 555-559. Retrieved from https://www.sciencedirect.com/science/article/pii/S1438463907001812

Gebara B., Goetting M.M. (1994) Life-threatening methemoglobinemia in infants with diarrhea and acidosis. *Clin Pediatr 33* pp. 370–3. Retrieved from http://cpj.sagepub.com/content/33/6/370.extract

Gulis, G., Czompolyova, M., & Cerhan, J. R. (2002). An ecologic study of nitrate in municipal drinking water and cancer incidence in Trnava District, Slovakia. *Environmental research*, *88*(3), 182-187. Retrieved from

https://www.researchgate.net/publication/11321531_An_Ecologic_Study_of_Nitrate_in_Municipal_Drinking_Water_and_Cancer_Incidence_in_Trnava_District_Slovakia

Gupta, S.K., Gupta, R.C., Seth, A.K., Gupta, A.B., Bassin, J.K. & Gupta, A. (1999) Adaptation of cytochrome-b5 reductase activity and methaemoglobinaemia in areas with a high nitrate concentration in drinking-water. Bull.World Health Organ 77(9) pp. 749-753. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2557725/pdf/10534899.pdf

Gupta, S. K., Gupta, R. C., Seth, A. K., Gupta, A. B., Bassin, J. K., Gupta, D. K., & Sharma, S. (1999). Epidemiological evaluation of recurrent stomatitis, nitrates in drinking water, and cytochrome b5 reductase activity1. *The American journal of gastroenterology*, *94*(7), 1808-1812. Available at https://www.sciencedirect.com/science/article/pii/S0002927099001884

Gupta, S.K., Gupta, R.C., Gupta, A.B., Seth, A.K., Bassin, J.K., Gupta, A. (2000) Recurrent acute respiratory tract infections in areas with high nitrate concentrations in drinking water. *Environ.Health Perspect. 108*(4) pp. 363-366. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1638033/

Gupta SK, Gupta RC, Seth AK, Gupta AB, Bassin JK, Gupta A. (2000) Methaemoglobinemia in areas with high nitrate concentration in drinking water. *Natl Med J India 12*(2) pp. 58-61 Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10835850

Gupta, S.K., Gupta, R.C., Gupta, A.B., Seth, A.K., Bassin, J.K., Gupta, A. & Sharma, M.L. (2001) Recurrent diarrhea in children lining in areas with high levels of nitrate in drinking water. Arch of Environ Health 56(4) pp. 369 – 373. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11572282

Formatted: Default Paragraph Font

Hanukoglu A, Danon PN. (1996) Endogenous methemoglobinemia associated with diarrheal disease in infancy. J Pediatr Gastroenterol Nutr. *23* pp. 1–7. Retrieved from http://journals.lww.com/jpgn/Abstract/1996/07000/Endogenous_Methemoglobinemia_Associated_with.1.aspx

Harris J.C., Rumack B.H., Peterson R.G., McGuire B.M. (1979) Methemoglobinemia resulting from absorption of nitrates. *JAMA 242*(26) pp. 2869–71. Retrieved from http://jama.jamanetwork.com/article.aspx?articleid=368092

Hegesh E, Shiloah J. (1982) Blood nitrates and infantile methemoglobinemia. Clin Chim Acta. *125* pp. 107–115. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7139953

Howe, G.R., Burch, D., Chiarelli, A.M., Risch, H.A. & Choi, B.C.K. (1989) An exploratory case-control study of brain tumors in children. Cancer Res. 49(15) pp. 4349-4352. Retrieved from http://cancerres.aacrjournals.org/content/49/15/4349.long

Infante-Rivard, C., Olson, E., & Ayotte, J.L. (2001) Drinking water contaminants and childhood leukemia. *Epidemiology 12*(1) pp. 13-19. http://www.ncbi.nlm.nih.gov/pubmed/11138808

Jensen, O. M. (1982). Nitrate in drinking water and cancer in northern Jutland, Denmark, with special reference to stomach cancer. *Ecotoxicology and environmental safety*, *6*(3), 258-267. Retrieved from https://www.sciencedirect.com/science/article/pii/0147651382900161

Johnson C.J., Kross B.C. (1990) Continuing importance of nitrate contamination of groundwater and wells in rural areas. *American Journal of Industrial Medicine 18*(4) pp. 449–56. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/ajim.4700180416/abstract

Jones, J.H., Sethney, H.T., Schoenhals, G.W., Grantham, R.N. & Riley, H.D. (1973) Grandmother's poisoned well: report of a case of methemoglobinemia in an infant in Oklahoma. *J.Okla.State Med.Assoc. 66*(2) pp. 60-66. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/4688467

Jones, R. R., Weyer, P. J., Dellavalle, C. T., Inoue-Choi, M., Anderson, K. E., Cantor, K. P., ... & Ward, M. H. (2016). Nitrate from drinking water and diet and bladder cancer among postmenopausal women in Iowa. *Environmental health perspectives*, *124*(11), 1751. Retrieved from https://ehp.niehs.nih.gov/wp-content/uploads/124/11/EHP191.alt.pdf

Kean-Cowdin, R., Pogoda, J.M., Lijinsky, W., Holly, E.A., Mueller, B.A. & Preston-Martin, S. (2003) Maternal prenatal exposure to nitrosatable drugs and childhood brain tumours. International Journal of Epidemiology 32(2) pp. 211-217. http://www.ncbi.nlm.nih.gov/pubmed/12714539 and http://ije.oxfordjournals.org/content/32/2/211.long

Keating JP, Lell ME, Strauss AW, Zarkowsky H, Smith GE. (1973) Infantile methemoglobinemia caused by carrot juice. N Engl J Med 288(16) pp. 824–6.Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/4693932

Knobeloch L., Salna B., Hogan A., Postle J., Anderson H. (2000) Blue babies and nitrate-contaminated well water. *Environ Health Perspect 108*(7) Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1638204/pdf/envhper00308-0137.pdf

Knobeloch, L., and M. Proctor (2001) Eight blue babies. *WMJ. 100*(8) pp. 43-47. http://www.wisconsinmedicalsociety.org/_WMS/publications/wmj/issues/wmj_v100n8/100-8-SA-Knobeloch.pdf

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font, Font: Univers

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font, Font: Univers

Formatted: Default Paragraph Font, English (United States)

Kross B.C., Ayebo A.D., Fourtes L.J. (1992) Methemoglobinemia: nitrate toxicity in rural America. *American Family Physician 46* pp. 183–88 retrieved from http://ukpmc.ac.uk/abstract/MED/1621630

Kuijten, R.R., Bunin, G.R., Nass, C.C. & Meadows, A.T. (1990) Gestational and familial risk factors for childhood astrocytoma: results of a case-control study. *Cancer Res. 50*(9) pp. 2608-2612. http://www.ncbi.nlm.nih.gov/pubmed/2328486 and http://cancerres.aacrjournals.org/content/50/9/2608.long

Kumar, M., & Puri, A. (2012). A review of permissible limits of drinking water. *Indian journal of occupational and environmental medicine*, *16*(1), 40. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3482709/

Kuo, H. W., Wu, T. N., & Yang, C. Y. (2007). Nitrates in drinking water and risk of death from rectal cancer in Taiwan. *Journal of Toxicology and Environmental Health, Part A*, *70*(20), 1717-1722. Retrieved from https://www.tandfonline.com/doi/abs/10.1080/15287390701457704

Laitinen, S., Virtanen, S.M., Rasanen, L. & Penttila, P.L. (1993) Calculated dietary intakes of nitrate and nitrite by young Finns" *Food Addit.Contam 10*(4) pp. 469-477. http://www.ncbi.nlm.nih.gov/pubmed/8405586

Law, G., Parslow, R., McKinney, P., & Cartwright, R. (1999) Non-Hodgkin's lymphoma and nitrate in drinking water: a study in Yorkshire, United Kingdom. *Journal of Epidemiological Community Health 53*(6) pp. 383-384. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1756892/pdf/v053p00383.pdf

Lebby T., Roco J.J., Arcinue E.L. (1993) Infantile methemoglobinemia associated with acute diarrheal illness. *American Journal of Emergency Medicine 11* pp. 471–2. Retrieved from http://www.sciencedirect.com/science/article/pii/073567579390086Q

Loomis, J., Bell, P., Cooney, H., & Asmus, C. (2009). A comparison of actual and hypothetical willingness to pay of parents and non-parents for protecting infant health: the case of nitrates in drinking water. *Journal of Agricultural and Applied Economics*, *41*(3), 697-712. Retrieved from https://www.researchgate.net/profile/John_Loomis3/publication/46534234_A_Comparison_of_Actual_and_Hypothetical_Willingness_to_Pay_of_Parents_and_Non-Parents_for_Protecting_Infant_Health_The_Case_of_Nitrates_in_Drinking_Water/links/552d171f0cf2e089a3ad2de6.pdf

Lundberg J.O., Weitzberg E., Cole J.A., Benjamin N. (2004) Nitrate, bacteria and human health. *Nat Rev Microbiol 2*(7) pp. 593–602 Retrieved from http://www.nature.com/nrmicro/journal/v2/n7/full/nrmicro929.html

Manassaram, D.M., Backer, L.C. & Moll, D.M. (2006) A Review of Nitrates in Drinking water: Maternal Exposure and Adverse Reproductive and Developmental Outcomes. Environ Health Perspect. 2006 March; 114(3): 320–327. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1392223/

Mansouri A., Lurie A.A. (1993) Concise review: Methemoglobinemia. *American Journal of Hematology 42* pp. 7–12. http://www.ncbi.nlm.nih.gov/pubmed/8416301

McCredie, M., Maisonneuve, P. & Boyle, P. (1994) Antenatal risk factors for malignant brain tumours in New South Wales children. Int.J.Cancer 56(1) pp. 6-10. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8262678

McKnight G.M., Duncan C.W., Leifert C., Golden M.H. (1999) Dietary nitrate in man: Friend or foe? *British Journal of Nutrition 81*(5) pp. 349–58. Retrieved from

http://journals.cambridge.org/download.php?file=%2F16032_A63A7D5ABC20BC7365F40DBF4A377C7F_journals__BJN_BJN81_05_S000711459900063Xa.pdf&cover=Y&code=940bf72a94083432b5d589f01343f27cbf

Mensinga T.T., Speijers G.J.A., Meulenbelt J. (2003) Health implications of exposure to environmental nitrogenous compounds. Toxicol Rev 22(1) pp. 41–51. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/14579546 and http://adisonline.com/toxicology/Abstract/2003/22010/Health_Implications_of_Exposure_to_Environmental.5.aspx

Moller, H. (1997) Work in agriculture, childhood residence, nitrate exposure, and testicular cancer risk: a case-control study in Denmark. *Cancer Epidemiol.Biomarkers Prev.* *6*(2) pp. 141-144. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9037566

Moltchanova, E., Rytkonen, M., Kousa, A., Taskinen, O., Tuomilehto, J, & Karvonen, M. (2004) Zinc and nitrate in the ground water and the incidence of Type 1 diabetes in Finland. *Diabet.Med.* *21*(3) pp. 256-261. Retrieved form http://www.ncbi.nlm.nih.gov/pubmed/15008836

Morales-Suarez-Varela, M. M., Llopis-Gonzalez, A., & Tejerizo-Perez, M. L. (1995). Impact of nitrates in drinking water on cancer mortality in Valencia, Spain. *European journal of epidemiology*, *11*(1), 15-21. Retrieved from

https://www.researchgate.net/profile/Maria_Morales-Suarez-Varela/publication/226070795_Impact_of_nitrates_in_drinking_water_on_cancer_mortality_in_Valencia_Spain/links/0fcfd50cb503af3128000000.pdf

Morris, R. D. (1995). Drinking water and cancer. *Environmental health perspectives*, *103*(Suppl 8), 225. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1518976/pdf/envhper00368-0223.pdf

Mueller, B.A., Newton, K., Holly, E.A. & Preston-Martin, S. (2001) Residential water source and the risk of childhood brain tumors. *Environmental Health Perspectives 109*(6) pp. 551-556. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240334/pdf/ehp0109-000551.pdf

Mueller, B.A., Searles Nielsen, S., Preston-Martin, S. Holly, E.A., Cordier, S., Filippinin, G., Peris-Bonet, R., Choi, N.W. (2004) Household water source and the risk of childhood brain tumours: results of the SEARCH International Brain Tumor Study. Int.J.Epidemiol. 33(6):1209-1216. http://www.ncbi.nlm.nih.gov/pubmed/15567873 and http://ije.oxfordjournals.org/content/33/6/1209.long

National Research Council, Committee on Toxicology. (1995) Nitrate and nitrite in drinking water. Washington, DC: National Academies Press

Nolan, B. T., & Hitt, K. J. (2006). Vulnerability of shallow groundwater and drinking-water wells to nitrate in the United States. *Environmental science & technology*, *40*(24), 7834-7840. Retrieved from https://pdfs.semanticscholar.org/9499/0f272fea508adcd5f21766d2fbe01a30178c.pdf

Nolan BT, Hitt KJ, Ruddy BC. (2002) Probability of nitrate contamination of recently recharged ground waters in the conterminous United States. U.S.G.S. Environ Sci Technol 36(10) pp. 2138–45. http://water.usgs.gov/nawqa/nutrients/pubs/est_v36_no10/ and http://water.usgs.gov/nawqa/nutrients/pubs/est_v36_no10/est_v36_no10.pdf

Odorog, C. M. (2016). Nitrates and drinking water. *Scientific Papers-Series A, Agronomy*, *59*, 122-126. Retrieved from http://agronomyjournal.usamv.ro/pdf/2016/Art20.pdf

Pacific Groundwater Group (2011) Request for identification Lower Yakima Valley Groundwater Management Area. WA State Department of Ecology. Retrieved from www.yakimacounty.us/NitrateProgram/English/Docs/Lower%20Yakima%20GWMA%20Request%20For%20Identification%20FINAL.pdf

Parslow R.C., McKinney P.A., Law G.R., Staines A., Williams R., Bodansky H.J. (1997) Incidence of childhood diabetes mellitus in Yorkshire, northern England, is associated with nitrate in drinking water: an ecological analysis. Diabetologia 40(5) pp. 550–6. Retrieved from http://www.springerlink.com/content/7d21fcmtmgjj54pt/ and http://www.springerlink.com/content/7d21fcmtmgjj54pt/fulltext.pdf

Pogoda, J.M., and Preston-Martin, S. (2001) Maternal cured meat consumption during pregnancy and risk of paediatric brain tumour in offspring: potentially harmful levels of intake. *Public Health Nutr. 4*(2) pp. 183-189. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11299090

Pollack, E.S. & Pollack, C.V. (1994) Incidence of subclinical methemoglobinemia in infants with diarrhea. Annals of Emergency Medicine. http://www.ncbi.nlm.nih.gov/pubmed/8092592

Preston-Martin, S., Yu, M.C., Benton, B., & Henderson, B.E. (1982) N-Nitroso compounds and childhood brain tumors: a case-control study. *Cancer Res. 42*(12) pp. 5240-5245. Retrieved from http://cancerres.aacrjournals.org/content/42/12/5240.abstract

Preston-Martin, S., Pogoda, J.M., Mueller, B.A., Holly, E.A., Lijinsky, W. & Davis, R.L. (1996) Maternal consumption of cured meats and vitamins in relation to pediatric brain tumors. *Cancer Epidemiol.Biomarkers Prev. 5*(8) pp. 599-605. Retrieved from http://cebp.aacrjournals.org/content/5/8/599.long

Reinik, M., Tamme, T., Roasto, M., Juhkam, K., Jurstenko. S., Tenno, T. & Kiis, A. (2005) Nitrites, nitrates and N-nitrosoamines in Estonian cured meat products: intake by Estonian children and adolescents. *Food Addit.Contam 22*(11) pp. 1098-1105. http://www.ncbi.nlm.nih.gov/pubmed/16332632

Reynolds K.A. (2002) The prevalence of nitrate contamination in the United States. *Water Conditioning and Purification 44*(1). Retrieved from http://www.wcponline.com/ArchiveNewsView.cfm?pkArticleID=1330&AT=T

Sadeq, M., Moe, C.L.,Attarassi, B., Cherkaouil, L., Elaaud, R., & Idrissi, L. (2008) Drinking water nitrate and prevalence of methemoglobinemia among infants and children ages 1-7 years in Moroccan areas. International Journal of Environmental Health http://www.ncbi.nlm.nih.gov/pubmed/18155958

Saito T., Takeichi S., Osawa M., Yukawa N., Huang X.L. (2000) A case of fatal methemoglobinemia of unknown origin but presumably due to ingestion of nitrate. *International Journal of Legal Med 113*(3) pp. 164–7. Retrieved from http://www.springerlink.com/content/34befl8dg6v6p9rr/

Sanchez J., Benito-Fernandez J., Mintegui-Raso S. (2001) Methemoglobinemia and consumption of vegetables in infants. *Pediatrics 107*(5) pp. 1024–8.Retrieved from http://pediatrics.aappublications.org/content/107/5/1024.abstract and http://content.ebscohost.com/pdf13_15/pdf/2001/PDT/01May01/4441433.pdf?T=P&P=AN&K=4441433&S=R&D=aph&EbscoContent=dGJyMNLr40SeprY4y9f3OLCmr0qeqLBSs6a4TLKWxWXS&ContentCustomer=dGJyMPGssk2xqLJNuePfgeyx44Hy

Sandor, J., Kiss, I., Farkas, O., & Ember, I. (2001). Association between gastric cancer mortality and nitrate content of drinking water: ecological study on small area inequalities. *European journal of epidemiology*, *17*(5), 443-447. Retrieved fromhttps://www.researchgate.net/publication/226891543_Association_between_gastric_cancer_mortality_and_nitrate_content_of_drinking_water_Ecological_study_on_small_area_inequalities

Sarasua, S., and Savitz. D.A. (1994) Cured and broiled meat consumption in relation to childhood cancer: Denver, Colorado (United States) *Cancer Causes Control 5*(2) pp. 141-148. http://www.ncbi.nlm.nih.gov/pubmed/8167261

Savino, F., Maccario, S., Guido, C., Castagno, E., Farinasso, D., Cresi, F., Silvestro, L., & Mussa, G.C. (2006) Methemoglobinemia caused by the ingestion of courgette soup given in order to resolve constipation in two formula-fed infants. *Ann Nutr.Metab 50*(4) pp. 368-371. http://www.ncbi.nlm.nih.gov/pubmed/16809905

Schmitz J.T. (1961) Methemoglobinemia—a cause of abortions? Preliminary report. Obstet Gynecol. 17 pp. 413–415. Retrieved from http://journals.lww.com/greenjournal/Citation/1961/04000/Methemoglobinemia_A_Cause_of_Abortions_.2.aspx

Scragg RK, Dorsch MM, McMichael AJ, Baghurst PA. (1982) Birth defects and household water supply. Epidemiological studies in the Mount Gambier region of South Australia. Med J Aust. *2* pp. 577–579. http://www.ncbi.nlm.nih.gov/pubmed/7162445

Shearer L.A., Goldsmith J.R., Young C., Kearns O.A., Tamplin B.R. (1972) Methemoglobin levels in infants in an area with high nitrate water supply. *American Journal of Public Health 62*(9) pp. 1174–80. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1530503/pdf/amjph00731-0006.pdf

Shuval H.I., Gruener N. (1992) Epidemiological and toxicological aspects of nitrates and nitrites in the environment. *American Journal of Public Health 62*(8):1045–52. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1530374/pdf/amjph00730-0007.pdf

Spalding, R. F., & Exner, M. E. (1993). Occurrence of nitrate in groundwater—a review. *Journal of environmental quality*, *22*(3), 392-402. Retrieved from https://nature.berkeley.edu/classes/espm-120/Website/Spalding1993.pdf

Super, M., Heese, H. D. V., MacKenzie, D., Dempster, W. S., Du Plessis, J., & Ferreira, J. J. (1981). An epidemiological study of well-water nitrates in a group of South West African/Namibian infants. *Water Research*, *15*(11), 1265-1270. Retrieved from http://www.sciencedirect.com/science/article/pii/0043135481901032

Tabacova S., Balabaeva L., Little R.E. (1997) Maternal exposure to exogenous nitrogen compounds and complications of pregnancy. *Arch Environ Health 52*(5) pp. 341–7. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9546756

Tajtakova, M., Semanova, Z., Tomkova, Z., Szokeova, E., Majoros, J., RAdikova, Z., Sebokova, E. Klines, I, & Langer, P. (2006) Increased thyroid volume and frequency of thyroid disorders signs in schoolchildren from nitrate polluted area. *Chemosphere 62(*4) pp. 559-564. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16095667

Tamme, T., Reinik, M., Roasto, M., Juhkam, K., Tenno, T., & Kiis, A. (2006) Nitrates and nitrites in vegetables and vegetable-based products and their intakes by the Estonian population. *Food*

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Addit.Contam 23(4) pp. 355-361. http://peer.ccsd.cnrs.fr/docs/00/57/75/75/PDF/PEER_stage2_10.1080%252F02652030500482363.pdf

Terblanche, A. P. S. (1991). Health hazards of nitrate in drinking water. *Water S. A., 17*(1), 77-82. Retrieved from http://www.wrc.org.za/Knowledge%20Hub%20Documents/Water%20SA%20Journals/Manuscripts/1991/WaterSA_1991_17_0612.PDF

Thorpe, N., and Shirmohammadi, A. (2005) Herbicides and nitrates in groundwater of Maryland and childhood cancers: a geographic information systems approach. *J Environ Sci Health C.Environ Carcinog.Ecotoxicol.Rev. 23*(2) pp. 261-278. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16291529

Tirado, R. (2007). Nitrates in drinking water in the Philippines and Thailand. *Greenpeace Research Laboratories Technical Note, 11*, 2007. Retrieved from http://www.greenpeace.to/publications/Nitrates_Philippines_Thailand.pdf

Tricker A.R., Preussmann R. (1991) Carcinogenic *N*-nitrosamines in the diet: occurrence, formation, mechanisms and carcinogenic potential. *Mutat Res 259* pp. 277–89. Retrieved from http://www.sciencedirect.com/science/article/pii/0165121891901234 and http://www.ncbi.nlm.nih.gov/pubmed/2017213

Tsezou, A., Kitsiou-Tzeli, S., Galla, A., Gourgiotis, D., Papageorgiou, J., Mitrou, S., Molybdas, P. A., Sinaniotis, C. (1996) High nitrate content in drinking water: cytogenetic effects in exposed children. *Arch.Environ.Health 51*(6) pp. 458-461. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/9012325

U.S. Department of Agriculture: Food Safety and Inspection Service. (2001) Fact Sheets: Food Labeling - Additives in Meat and Poultry Products. Retrieved from http://www.fsis.usda.gov/Fact_Sheets/Additives_in_Meat_&_Poultry_Products/index.asp

U.S. Environmental Protection Agency. (2006) 2006 Edition of the Drinking Water Standards and Health Advisories. Retrieved from http://www.epa.gov/waterscience/criteria/drinking/dwstandards.pdf

U.S. Environmental Protection Agency (2006) Drinking Water Contaminants. Retrieved from http://www.epa.gov/safewater/contaminants/index.html

U.S. Environmental Protection Agency. (2005) Priority List of Hazardous Substances for the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 104(i). Retrieved form http://www.atsdr.cdc.gov/cercla/

US Environmental Protection Agency. Consumer factsheet on: nitrates/nitrites. Washington, DC: US Environmental Protection Agency; 2004. Available from URL: http://www.epa.gov/safewater/dwh/c-ioc/nitr

US Environmental Protection Agency. Integrated Risk Information System (IRIS) database. Nitrate (CASRN 14797-55-8). Washington, DC: US Environmental Protection Agency. 2002. Available at URL: http://www.epa.gov/iris

U.S. Environmental Protection Agency. 2007. *Nitrates and Nitrites TEACH Chemical Summary.* Retrieved from http://www.epa.gov/teach/chem_summ/Nitrates_summary.pdf

U.S. Environmental Protection Agency (2012) Preliminary data Lower Yakima Valley well testing. Retrieved from ftp://ftp.epa.gov/reg10ftp/sites/yakima/groundwater_data/

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

Formatted: Default Paragraph Font

U.S. Food and Drug Administration. (1998) A Fresh Look at Food Preservatives. Retrieved from http://www.cfsan.fda.gov/~dms/fdpreser.html

US Geological Survey. (1999) The quality of our nation's waters: nutrients and pesticides. Circular 1225. Reston, VA: US Department of the Interior. Retrieved from http://pubs.usgs.gov/circ/circ1225/

VanDerslice, J. (2009). Final Report: Dose-Response of Nitrate and Other Methemoglobin Inducers on Methemoglobin Levels of Infants. National Center for Environmental Research WA State Department of Health. Olympia, WA. Retrieved from http://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/display.abstractDetail/abstract/5379/report/F

Van Grinsven, H. J., Ward, M. H., Benjamin, N., & De Kok, T. M. (2006). Does the evidence about health risks associated with nitrate ingestion warrant an increase of the nitrate standard for drinking water?. *Environmental Health*, *5*(1), 26. Retrieved from https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-5-26

Van Grinsven, H. J., Rabl, A., & de Kok, T. M. (2010). Estimation of incidence and social cost of colon cancer due to nitrate in drinking water in the EU: a tentative cost-benefit assessment. *Environmental health*, *9*(1), 58. Retrieved from https://ehjournal.biomedcentral.com/articles/10.1186/1476-069X-9-58

Van Leeuwen, J. A., Waltner-Toews, D., Abernathy, T., Smit, B., & Shoukri, M. (1999). Associations between stomach cancer incidence and drinking water contamination with atrazine and nitrate in Ontario (Canada) agroecosystems, 1987-1991. *International Journal of Epidemiology*, *28*(5), 836-840. Retrieved from https://oup.silverchair-cdn.com/oup/backfile/Content_public/Journal/ije/28/5/10.1093_ije_28.5.836/1/280836.pdf?Expires=1496077591&Signature=eJKIkjMC7~pHHeXuySz6qz6lisEhIYcisyAgnbw5rBzlcj4WlXuxcDd8zM9nF1REGBKq54N~-RG~OVN0~UFawShZMbJgkZji64HtsX~yzISDdNZqhXv6cevgsgIrHWffbRJ8dllRp8YS8FmiXlVTlxT7RaD62Az5FlSZKUGILgszWLsK13W18Pg3FewdgMxw0S6CfRzKH2I5fIq5RdLRfGpDdVy5UG7TUwhV5bYTVH6t0p1xHEBhD2CTqx462wGSFVqOh~C6KAgc-s5ei6xqfr~kJkb8bmuhb4gQ54mvCb52oQbH3nNSVNjHnCsdOcbU0mfM6FjLHFISf1zWaNQjnA__&Key-Pair-Id=APKAIUCZBIA4LVPAVW3Q

Van Loon A.J., Botterweck A.A., Goldbohm R.A., Brants H.A., van Klaveren J.D., van den Brandt P.A. (1998) Intake of nitrate and nitrite and the risk of gastric cancer: a prospective cohort study. *British Journal of Cancer 78* pp. 129–35. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2062934/pdf/brjcancer00001-0133.pdf

Van Maanen, J. M., Welle, I. J., Hageman, G., Dallinga, J. W., Mertens, P. L., & Kleinjans, J. C. (1996). Nitrate contamination of drinking water: relationship with HPRT variant frequency in lymphocyte DNA and urinary excretion of N-nitrosamines. *Environmental Health Perspectives*, *104*(5), 522. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1469364/pdf/envhper00336-0070.pdf

van Maanen, J.M., Albering, H.J., de Kok, T.M., van Breda, S.G., Curfs, D.M., Vermeer, I. T., Ambergen, A.W., Wolffenbuttel, B.H., Klenjans, J.C. & Reeser, H.M. (2000) Does the risk of childhood diabetes mellitus require revision of the guideline values for nitrate in drinking water? *Environ.Health Perspect. 108*(5) pp. 457-461. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1638059/

van Maanen, J. M., van Dijk, A., Mulder, K., de Baets, M. H., Menheere, P. C., van der Heide, D., ... & Kleinjans, J. C. (1994). Consumption of drinking water with high nitrate levels causes hypertrophy of the thyroid. *Toxicology letters*, *72*(1-3), 365-374. Retrieved from

https://www.researchgate.net/publication/14996221_Consumption_of_drinking_water_with_high_nitrate_levels_causes_hypertrophy_of_the_thyroid

Venkateswari R, Ganesh R, Deenadayalan M, Mahender E, Ramachandran B, Janakiraman (2007) Transient Methemoglobinemia in an infant. *Indian Journal of pediatrics* 74(11). Pp. 1037-1038. Retrieved form http://www.ncbi.nlm.nih.gov/pubmed/18057688

Virtanen, S.M., Jaakkola, L., Rasanen. L., Ylonen, K., Aro, A., Lounamaa, R., Akerblom, H.K., & Tuomilehto, J. (1994) Nitrate and nitrite intake and the risk for type 1 diabetes in Finnish children. Childhood Diabetes in Finland Study Group. *Diabet.Med. 11*(7) pp. 656-662. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/7955990

Volkmer, B.G., Ernst, B., Simon, J., Kuefer, R., Bartsch, G., Bach, D., & Gschwend, J.E. (2005) Influence of nitrate levels in drinking water on urological malignancies: a community-based cohort study. *BJU.Int 95*(7) pp. 972-976. http://www.ncbi.nlm.nih.gov/pubmed/15839916

Walton G. (1951) Survey of literature relating to infant methemoglobinemia due to nitrate-contaminated water. Am J Public Health. 41 pp. 986–996. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1525621/pdf/amjphnation00426-0083.pdf

Ward M.H., Mark S.D., Cantor K.P., Weisenburger D.D., Correa-Villasenor A., Zahm S.H. (1996) Drinking water nitrate and the risk of non-Hodgkin's lymphoma. *Epidemiology7*(5) pp. 465–71. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/8862975

Ward M.H., deKok T.M., Levallois P., Brender J., Gulis G., Nolan B.T., VanDerslice J. (2005) Workgroup report: Drinking-water nitrate and health - - recent findings and research needs. *Environ Health Perspect 113*(11) pp. 1607-1614. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16263519 and http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1310926/pdf/ehp0113-001607.pdf

Ward, M. H., Cantor, K. P., Cerhan, J., Lynch, C. F., & Hartge, P. (2004). Nitrate in public water supplies and risk of cancer: Results from recent studies in the midwestern United States. *Epidemiology*, *15*(4), S214. Retrieved from http://journals.lww.com/epidem/Citation/2004/07000/Nitrate_in_Public_Water_Supplies_and_Risk_of.568.aspx

Ward, M. H., Heineman, E. F., Markin, R. S., & Weisenburger, D. D. (2008). Adenocarcinoma of the stomach and esophagus and drinking water and dietary sources of nitrate and nitrite. *International journal of occupational and environmental health*, *14*(3), 193-197. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2797489/

Ward, L.B. Yakima Herald Republic. (2009) "Hidden Wells, Dirty Water" http://www.yakima-herald.com/stories/2008/10/11/hidden-wells-dirty-water

Washington State Dept. of Ecology (2010) *Lower Yakima Valley groundwater quality: preliminary assessment and recommendations document.* Retrieved from https://fortress.wa.gov/ecy/publications/publications/1010009.pdf

WA State Dept. of Health (2010) Nitrate in Drinking Water – Questions and Answers (English) Retrieved from http://www.doh.wa.gov/ehp/dw/Publications/331-214.pdf

WA State Dept. of Health (2010) Nitrate in Drinking Water – Questions and Answers (Spanish) Retrieved from http://www.doh.wa.gov/ehp/dw/Publications/331-214s.pdf

Wei-Hua, J., Qing-Hua, P., Hai-De, Q., Ya-Fei, X., Guo-Ping, S., Lina, C., Li-Zhen, C., Qi-Sheng, F., Ming-Huang, H., Yi-Xin, A., & Yin Yao, S. (2000) Dietary exposure to nitrite and nitrosamines and risk of nasopharyngeal carcinoma in Taiwan. *International Journal of Cancer 86*(5) pp. 603-609. http://carcin.oxfordjournals.org/content/30/12/2031.full

Weyer, P. J., Cerhan, J. R., Kross, B. C., Hallberg, G. R., Kantamneni, J., Breuer, G., ... & Lynch, C. F. (2001). Municipal drinking water nitrate level and cancer risk in older women: the Iowa Women's Health Study. *Epidemiology*, *12*(3), 327-338. Retrieved from http://s3.amazonaws.com/academia.edu.documents/42632538/Municipal_Drinking_Water_Nitrate_Level_a20160212-31872-gownru.pdf?AWSAccessKeyId=AKIAIWOWYYGZ2Y53UL3A&Expires=1497141341&Signature=2YyjqoK44lfKWXwMm3ycZObtXrU%3D&response-content-disposition=inline%3B%20filename%3DMunicipal_Drinking_Water_Nitrate_Level_a.pdf

Wiklund, G.M., Aastrup, L., Pousette, M., Thunholm, J., Saldeen, B., Wernroth, T., Zaren, & Holmberg, L. (2001) Incidence and geographical distribution of sudden infant death syndrome in relation to content of nitrate in drinking water and groundwater levels. *Eur.J.Clin.Invest 31*(12) pp. 1083-1094. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11903496

World Health Organization. (2003). Nitrate and nitrite in drinking-water: background document for development of WHO guidelines for drinking-water quality. Retrieved from http://apps.who.int/iris/bitstream/handle/10665/75380/WHO_SDE_WSH_04.03_56_eng.pdf?sequence=1

World Health Organization. (2006) International Program on Chemical Safety, Environmental Health Criteria 5: Nitrates, Nitrites, and N-Nitroso Compounds. Retrieved from http://www.inchem.org/documents/pims/chemical/pimg016.htm

World Health Organization. (2008). *Guidelines for drinking-water quality: second addendum. Vol. 1, Recommendations*. World Health Organization. Retrieved from http://www.who.int/water_sanitation_health/dwq/secondaddendum20081119.pdf

World Health Organization. (2010). *Drinking water quality in the South-East Asia region* (No. SEA-EH-567). WHO Regional Office for South-East Asia. Retrieved from http://apps.who.int/iris/bitstream/handle/10665/204999/B4470.pdf?sequence=1&isAllowed=y

Wright R.O., Woolf A.D., Shannon M.W., Magnani B. (1998) *N*-acetylcysteine reduces methemoglobin in an in-vitro model of glucose-6-phosphate dehydrogenase deficiency. *Acad Emerg Med 5*(3) pp. 225–9. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1553-2712.1998.tb02617.x/abstract and http://www.ncbi.nlm.nih.gov/pubmed/9523930

Wright R.O., Lewander W.J., Woolf A.D. (1999) Methemoglobinemia: etiology, pharmacology, and clinical management. *Annals of Emergency Medicine 34*(5) pp. 646–56. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/10533013

Xu G, Song P, Reed P.I. (1992) The relationship between gastric mucosal changes and nitrate intake via drinking water in a high-risk population for gastric cancer in Moping County, China. Eur J Cancer Prev 1992; 1(6):437–43.

Formatted: Default Paragraph Font

http://journals.lww.com/eurjcancerprev/Abstract/1992/10000/The_relationship_between_gastric_mucosal_changes.7.aspx

Yakima County (2011) Nitrate Treatment Pilot Program – Final Report. Retrieved from https://www.yakimacounty.us/DocumentCenter/View/1983/Nitrate-Treatment-Pilot-Program-PDF

Yang, C. Y., Cheng, M. F., Tsai, S. S., & Hsieh, Y. L. (1998). Calcium, magnesium, and nitrate in drinking water and gastric cancer mortality. *Cancer Science*, *89*(2), 124-130. Retrieved from http://onlinelibrary.wiley.com/doi/10.1111/j.1349-7006.1998.tb00539.x/pdf

Yang, C. Y., Wu, D. C., & Chang, C. C. (2007). Nitrate in drinking water and risk of death from colon cancer in Taiwan. *Environment international*, *33*(5), 649-653. Retrieved from https://pdfs.semanticscholar.org/855d/857eea83aad377b815d3aff72cca3e8eedde.pdf

Zeman C.L., Kross B., Vlad M. (2002) A nested case-control study of methemoglobinemia risk factors in children of Transylvania, Romania. *Environmental Health Perspectives 110*(8) pp. 817–22. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240955/pdf/ehp0110-000817.pdf

Zeman, C.L., Vlad, C.L., & Kross, B. (2002) Exposure methodology and findings for dietary nitrate exposures in children of Transylvania, Romania. *J.Expo.Anal.Environ.Epidemiol. 12*(1) pp. 54-63. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11859433

~~Compiled by Jean Mendoza~~

Program Edits – June 2019

Volume I

Cover	Change date
(i)	Address authorship request
(ii)	Add Robert Bland, USGS representative
(iii)	Add Matt Bachmann, past USGS representative
(iv)	Reconcile pages in Table of Contents
P.1	Remove reference to contentious discussions
P.2	Correct spelling, deleted Point of use water systems, updated monitoring well system status
P.3	Appendix H corrected to Appendix I, deleted reference to Lead Agency
P.4	Date correction, removed problem identification reference
P.6	Correct reference from Volume "4" to Volume "III"
P.8	Correct reference from Volume "4" to Volume "III"
P.9	Clarification of Yakama Nation involvement
P.16	Date correction, reference clarification
P.17	Reference clarification
P.21	Mathematical corrections
P.22	Add soil benefit language
P.25	Delete "waste", add "by-products", correct formula
P.26	Correct formula
P.29	Correct acreage, add "(figure 5)"
P.32	Insert legacy nitrate language
P.39	Add "(static level)"
P.42	Insert "Appendix D"
P.50	Clarify reference
P.54	Clarify reference
P.55	Clarify reference
P.56	Clarify reference
P.58	Correct figure numbering, delete reference to Appendix D
P.59	Edit reference
P.60	Edit reference
P.61	Insert "historically", reference edit
P.62	Edit reference, table clarification
P.63	Edit reference, relocate table 11
P.65	Insert "top"
P.66	Edit reference
P.67	Delete references to lined and unlined canals
P.70	Edit reference
P.78	Insert sentence in reference to Figure 23, update monitoring well system status
P.80	Insert reference to figure 22, update monitoring well system status, reference edit
P.84	Insert DSS Quality Assurance Project Plan QAPP language
P.96	Insert description of recommendation 6, substitute "manure" for "waste and wastewater"
P.98	Spell out acronym EQIP

P.100 Insert "manure", delete "waste"

P.105 Insert "manure", delete "waste"

P.107-8 Insert location of alternative management strategies and recommendations list from public comment, add two implementation parties, provide structure clarification of transition period from final Program development to funding implementation

P.109 Insert periodic review language, update monitoring well system status

P.111 Insert reference Drennon, M (2013)

P.114 Delete EPA 2010 reference

P.116 Delete link

P.117 Insert references

P.118 Edit references

P.120 Delete references

P.122 Delete references

P.123 Delete references, add reference

P.126 Delete references

P.127 Delete reference

P.131 Delete reference

P.133 Add reference

P.134 Add reference

P.135 Delete reference

Volume II

Cover Change date

P.63 Insert DSS analysis language

P.221-23 Appendix K – Recommendations Received From Public Comment (for Management Committee and eventual Lead Agency future consideration)

Volume III

Cover Change date

P.3 Insert link Operating Guidelines

Volume IV

Cover Change date

P.4 Insert member contributions disclaimer

Lower Yakima Valley Groundwater Management Area Program Findings

Introduction

The Lower Yakima Valley Groundwater Management Area (GWMA) and Groundwater Advisory Committee (GWAC) formed in 2012 to address the goal of reducing nitrate concentrations in groundwater.

One objective of the Lower Yakima Valley Groundwater Advisory Committee (GWAC) was to develop a program that would achieve the goal of reducing nitrate levels in groundwater.

That draft program, developed as the "Lower Yakima Valley Groundwater Management Program" (Program), was approved by the GWAC to move forward for public review in December 2018.

Yakima County performed SEPA with a Final Threshold Determination of Non-Significance (Final DNS) of the non-project action, determining that adoption of the Program will not have probable significant adverse impact on the environment and an Environmental Impact Statement (EIS) is not required. The Final DNS was not appealed.

Ecology provided a public comment period, accepted comments from February 25, 2019 to March 27, 2019. Yakima County and Ecology held a joint public hearing on March 12, 2019 at the Sunnyside Community Center, 1521 South 1st Street, Sunnyside, WA 98944. Twenty six (26) comment letters were received electronically, by mail, in person, or at the public hearing.

Findings

The Program describes the committee's completed work, including the committee's decisions, recommendations, and accomplishments. The content describes the issue of elevated nitrate in groundwater, how the GWMA was established in the Lower Yakima Valley, and defines the goals and objectives developed for the GWMA.

This Program explains the environmental and health effects of nitrate in the environment, describes sources of nitrate, and the different regulatory authorities that effect nitrate in groundwater. Additionally, the report characterizes the Lower Yakima Valley, it discusses the accomplishments and the recommended actions of the GWAC.

Comments received generally provided implementation suggestions, concerns of bias, or reflected opinions of additional information that could/should be included to provide clarity and context for future audiences. Yakima County and Ecology staff reviewed comments received and created a response to comments. (Attached)

Following the public comment process WAC 173-100-120 requires findings preparation that evaluate the Program's technical soundness, economic feasibility, and consistency with the intent of the chapter and other federal, state and local laws. The findings shall identify any revisions necessary before the program can be certified and shall contain a statement of the agency's concurrence, indicating its intent to adopt implementing policies, ordinances and programs if required.

The 64 recommendations approved by the GWAC provide a technically sound set of best management practices, education and outreach efforts, technology based actions, and inter-agency coordination

initiatives to begin addressing the reduction of nitrate in groundwater within the Lower Yakima Valley Groundwater Management Area (GWMA).

Long-term success of this Program will require reliable funding and human resources to implement the recommendations approved by the GWAC and a coordinated cooperative effort by the agency partners and stakeholders within the GWMA boundary. Although more detailed estimates of project costs may need to be developed to support funding requests, the implementation recommendations approved by the GWAC are economically feasible.

The content of the Program and recommendations meant to address elevated nitrates in groundwater are consistent with the intent of RCW 90.44.400 and WAC 173-100, other federal, state and local laws.

Letters of concurrence from local governments were requested of the South Yakima Conservation District, Yakima Health District, Yakima County, Port of Sunnyside, and the Roza Sunnyside Board of Joint Control. Affected local governments agreed to one document representing Program Findings for all entities with concurrence letters addressing any concerns they may have individually.

Ecology reviewed the Program recommendations finding none that would require adoption of implementation policies, ordinances or programs beyond our existing authority.

Ecology concurrence with the Program is subject to the following technical and spelling corrections, and edits in response to comments (page numbers based on redline versions):

Volume I

Cover	Change date
(i)	Address authorship request
(ii)	Insert Robert Bland, USGS representative
(iii)	Insert Matt Bachmann, past USGS representative
(iv)	Reconcile pages in Table of Contents
P.1	Remove reference to contentious discussions
P.2	Correct spelling, deleted Point of use water systems, updated monitoring well system status
P.3	Appendix H corrected to Appendix I, deleted reference to Lead Agency
P.4	Date correction, removed problem identification reference
P.6	Correct reference from Volume "4" to Volume "III"
P.8	Correct reference from Volume "4" to Volume "III"
P.9	Clarification of Yakama Nation involvement
P.16	Date correction, reference clarification
P.17	Reference clarification
P.21	Mathematical corrections
P.22	Add soil benefit language
P.25	Delete "waste", add "by-products", correct formula
P.26	Correct formula
P.29	Correct acreage, insert "(figure 5)"
P.32	Insert legacy nitrate language
P.39	Insert "(static level)"
P.42	Insert "Appendix D"

P.50 Clarify reference
P.54 Clarify reference
P.55 Clarify reference
P.56 Clarify reference
P.58 Correct figure numbering, delete reference to Appendix D
P.59 Edit reference
P.60 Edit reference
P.61 Insert "historically", edit reference
P.62 Edit reference, table clarification
P.63 Edit reference, relocate table 11
P.65 Insert "top"
P.66 Edit reference
P.67 Delete references to lined and unlined canals
P.70 Edit reference
P.78 Insert sentence in reference to Figure 23, update monitoring well system status
P.80 Insert reference to figure 22, update monitoring well system status, reference edit
P.84 Insert DSS Quality Assurance Project Plan QAPP language
P.96 Insert description of recommendation 6, substitute "manure" for "waste and wastewater"
P.98 Spell out acronym EQIP
P.100 Insert "manure", delete "waste"
P.105 Insert "manure", delete "waste"
P.107-8 Insert location of alternative management strategies and recommendations list from public comment, add two implementation parties, provide structure clarification of transition period from final Program development to funding implementation
P.109 Insert periodic review language, update monitoring well system status
P.111 Insert reference Drennon, M (2013)
P.114 Delete EPA 2010 reference
P.116 Delete link
P.117 Insert references
P.118 Edit references
P.120 Delete references
P.122 Delete references
P.123 Delete references, add reference
P.126 Delete references
P.127 Delete reference
P.131 Delete reference
P.133 Add reference
P.134 Add reference
P.135 Delete reference

Volume II

Cover Change date
P.63 Insert DSS analysis language

P.221-23 Appendix K – Recommendations Received From Public Comment (for Management Committee and eventual Lead Agency future consideration)

Volume III

Cover	Change date
P.3	Insert link Operating Guidelines

Volume IV

Cover	Change date
P.4	Insert member contributions disclaimer

Response to Comments

Lower Yakima Valley Groundwater Management Program

This document is a response to comments received during the public comment period for the Lower Yakima Valley Groundwater Management Program.

This Response to Comments document is being issued to address the public comments received for the Program during the comment period held February 25, 2019 to March 27, 2019.

The purpose of this Response to Comments document is to:

- Describe and document public involvement actions.
- List and respond to all comments received during the public comment period.

Ecology provided a public comment period, accepted comments from February 25, 2019 to March 27, 2019. Yakima County and Ecology held a joint public hearing on March 12, 2019 at the Sunnyside Community Center, 1521 South 1st Street, Sunnyside, WA 98944.

Notice of the public comment period and public hearing was published as follows:

- Notice of the open public comment and public hearing:
  - Yakima Herald: Sunday 02/24/2019
  - Sunnyside Sun: Wednesday 02/27/2019
  - Grandview Herald: Wednesday 02/27/2019
  - El Sol: Thursday 02/28/2019
- Notice of the public hearing was published again:
  - Yakima Herald Sunday 03/10/19
  - Sunnyside Sun Wednesday 03/06/19
  - Grandview Herald Wednesday 03/06/19
  - El Sol Thursday 03/07/19

Twenty-six (26) comment letters were received electronically, by mail, in person, or at the public hearing.

This document consolidates comments by categories and explains how these comments are managed. Comments are addressed using the following process; grouped by topic and addressed collectively. A list of the original comments as received are available in Appendix A

A list of recommendations collected from public comments is provided in Appendix B.

Acronyms

The following is a list of acronyms used in *Ecology Responses to Public Comments Received on the Lower Yakima Valley Groundwater Management Program* and their meanings.

Acronym	Meaning
BMP	Best Management Practice
CAFO	Concentrate Animal Feeding Operation
EPA	Environmental Protection Agency
GIS	Geographic Information System
GWAC	Lower Yakima Valley Groundwater Advisory Committee
GWMA	Lower Yakima Valley Groundwater Management Area
LYV	Lower Yakima Valley
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
OSS	Onsite Sewage Systems
PGG	Pacific Groundwater Group
Program	Lower Yakima Valley Groundwater Management Program
PUD	Public Utility District
PVC	Polyvinyl Chloride
QAPP	Quality Assurance Project Plan
ROSS	Residential Onsite Sewage Systems
USGS	United States Geologic Survey
WAC	Washington Administrative Code
WSDA	Washington State Department of Agriculture
WSU	Washington State University

INTRODUCTION

The Lower Yakima Valley Groundwater Management Area (GWMA) was formed in 2012 to address the goal of reducing nitrate concentrations in groundwater. A groundwater study in the Lower Yakima Valley, which sampled over 150 private domestic wells in 2017, found 20 percent of the wells consistently exceeded the drinking water standard (USGS 2017).

There are many identified potential sources of nitrate in the Lower Yakima Valley GWMA., Nitrate is a nutrient that can be beneficially re-used to grow crops, yet many sources may contribute to nitrates in groundwater. Data collected indicates that human activities at the land surface have affected water quality.

One objective of the Lower Yakima Valley Groundwater Advisory Committee (GWAC), was to develop a program that would achieve the goal of reducing nitrate levels in groundwater. That program was developed as the "Lower Yakima Valley Groundwater Management Program" (Program). It describes the committee's completed work, including the committee's decisions, recommendations, and accomplishments. This work is the foundation for the implementation phase.

The program content describes the issue of elevated nitrate in groundwater, how the GWMA was established in the Lower Yakima Valley, and defines the goals and objectives developed for the GWMA. This report explains the environmental and health effects of nitrate in the environment, describes the sources of nitrate, and the different regulatory authorities that effect nitrate in groundwater. Additionally, the report characterizes the Lower Yakima Valley, it discusses the accomplishments of the GWAC and the recommended actions for implementation.

List of Commenters

Ecology received comments from the following individuals and group representatives listed in the table below. These groups and individuals offered diverse opinions on GWMA-related issues. We appreciate the time and effort each took to review the Lower Yakima Valley Groundwater Management Program, develop comments, and submit them.

Name	**Affiliation**
Bill DeRuyter	Concerned Citizen
Dan De Boer	Concerned Citizen
Dan DeGroot	GWAC Member – Yakima Dairy Federation
David Newhouse	Concerned Citizen
Don Young	Previous Participant GWAC Member – Yakima County Farm Bureau
Department of Ecology	GWAC Members – Department of Ecology
Lucy Edmondson	GWAC Member – U.S. EPA
Frank P. Winslow	Concerned Citizen
James H. Davenport	Concerned Citizen
Jason Rollinger	Concerned Citizen
Jason Sheehan	GWAC Member – Yakima Dairy Federation
Jean Mendoza	GWAC Member – Friends of Toppenish Creek
Joel Koopman	Concerned Citizen
Karen Sheehan	Concerned Citizen
Markus Rollinger	Concerned Citizen
Norman Peck	Concerned Citizen
Patricia Newhouse	GWAC Member – Lower Yakima Representation Pos. 2
Richard V	Concerned Citizen
Robert Stevens	Concerned Citizen
Tanner Winckler	W.S. Farms Inc.
Tony Viega	Concerned Citizen
Trevor Wagenaar	Concerned Citizen
Veldhuis Family	Concerned Citizen
Yakima County Farm Bureau	GWAC Members – Yakima County Farm Bureau
Yakima County	GWAC Members – Yakima County

ATTACHMENT 1: COMMENTS AND RESPONSES

Description of Comments:

This section provides a listing of the comments received during the public comment period and responses. Comments are grouped by topic and addressed collectively.

Comments Related to Dairies or Large Farming:

Agriculture Regulation

Comment 1 – Dan De Boer

If I'm reading the information correctly the increased regulations being discussed will only impact those living North of the Yakima River. This again doesn't appear to align with the committee's goal of addressing all sources of nitrates. This unfairly burdens those North of the river. Although farmers are general friendly with each other, at the end of the day, they do compete in the same market. Increasing regulations on one side of the river makes those folks less competitive than their friends to the South. I warn the committee to guard against potential conflicts of interest in this regard.

Comment 2 – Karen Sheehan

The GWMA report is focused too much on dairy and not enough on the rest of agriculture including hops, mint, row crops, tree fruit, grapes, etc. Dairy farmers are the only part of agriculture that is required to take annual soil samples and have a written nutrient management plan plus have inspections. The rest of agriculture can farm as they please with no oversight or required plans. Dairy is already the most regulated for nutrients.

Response Related to Agriculture Regulation

The GWAC developed a list of recommended actions. These actions were prioritized from the list of alternatives by a voting process from GWAC members. These prioritized actions were collected as "Recommended Actions" within the Program.

The Program does not include any recommendations for new regulations. The Program is the plan for implementation. There are many aspects of the plan, including alternative management strategies as presented in the recommendations section.

The GWAC made a list of approximately 300 potential alternatives, incorporating working group recommendations, ideas raised in working group conversations and reviews of scientific and environmental literature. These can be found in Appendix I of Volume II of the Program.

The GWAC refined these alternatives using a consensus based approach and identified a consensus list of 83 potential recommendations. This list was evaluated by the criteria established by WAC 173-100-100 (4). This smaller list can be found in Appendix J of Volume II of the Program.

Several of the recommendations did recommend developing strategies around soil sampling, however there was no recommendation for new regulations to require annual soil sampling. Recommended action number 24 does recommend to "Establish a multi-year Deep Soil Sampling Program where farmers subscribe for a duration with pre-determined fiscal remuneration for completed sampling. Cost share with farmer. Farmer to provide checklist indicating performance with

BMPs. Test throughout growing year, in order to observe effects of fertilization throughout year. Share data with public."

We agree that any new regulation implemented should be fairly established. No new regulations are recommended as part of the Program.

A recommendation will be added to Appendix B that other agriculture should take annual soil samples, similar to the dairy farmers.

Dairy Effectiveness

Comment 3 – Jason Rollinger

When dairy's buy land it is usually test high but as we farm it we lower the nitrogen levels.

Comment 4 - Tanner Winckler

8. Show dairymen are already doing a lot to lower nitrates and manage nitrates

Comment 5 - Trevor Wagenaar

Dairymen purchase land from other farmers and do reclaim the ground from those who have poured on the fertilizer in years previous.

Dairymen soil test twice a year which is more than most!

Our management practices are pretty efficient because we want to be economical!

Comment 6 - Veldhuis Family

There been fields that we bought throughout the years that been higher nitrogen there then our ground that we own. Seen field with 1000 pounds of N in the ground. We got it all in order now, but it took years without N of our part to do it.

Response Related to Dairy Effectiveness

The GWMA was formed to address the goal of reducing nitrate concentrations in groundwater. Techniques and stories of success help those striving to reduce nitrate concentration in groundwater. Ongoing positive techniques are encouraged to be shared with the community and with GWAC members. If the techniques used to lower nitrate levels are not currently within the Program documents, these can also be shared.

Farming Legacy

Comment 7 – Jim Davenport

10. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not reflect the often-expressed view/opinion within the Advisory Committee that there exists a "legacy" of groundwater contamination within the Lower Yakima Valley due to the length of agricultural activity which has occurred there. Historic data pertaining to the amount of agricultural production, classified by crop variety (measured in volume, economic value or other metric), acreage farmed, and percentage of farmed acreage property actually under tillage, should be assembled and compared against current data of the kind in order to establish trends in agricultural density and use.

Comment 8 – Yakima County Farm Bureau

The report does not focus enough on legacy nitrates from former crops grown in the area and former growing practices that were likely contributors to it such as furrow and rill irrigation practices. This was no fault of producers as they were using the best information and technology at the time. However, the report's slant is that current ag practices are to blame, which is contrary to what the data tells us. In fact, recommendations in the report are for agriculture to implement new irrigation technologies such as sprinkler and drip systems, much of which has already been implemented in the Groundwater area.

Comment 9 - Tanner Winckler

6b. Address legacy nitrates.

Comment 10 - Tanner Winckler

7. What studies are being done to show how legacy nitrates are being brought down?

Comment 11 - Trevor Wagenaar

Looking back in time at the crops grown in this valley such as sugar beets, potatoes, etc. There used to be fertilizer poured on those crops. There was not fertilizer management we have now. It was the "more is better theory." I am just wondering how that might have impacted what we have now???

Comment 12 - Dan DeGroot

3. Farming Legacy issues should have been a substantial portion of this report. The way farming practices were conducted over the first 70-80 years of the Sunnyside Canal system (and the later Rosa Canal system) may have had a substantial effect on the nitrogen load in the soil of the area the Lower Valley GWMA. Tillage practices, fertilization practices and irrigation practices were such that large amounts of Nitrogen were put in the soil and had the strong potential to be moved to the aquifer with the common use of rill (furrow) irrigation. It should also be noted that in the last 30 years there have been many technology changes in all three of these practices that should reduce the amount of available nitrogen in the soil and most importantly not continue to move what nitrogen is in the soil to the aquifer. I believe that this legacy issue should be strongly noted in the report and the fact that the recent changes in common farm practices will have a positive effect on the nitrogen loading of the aquifer.

Comment 13 - Jason Sheehan

1. The report is lacking enough of the farming legacy issue of nitrate buildup in the soil. The majority of the farming in the Yakima Valley when irrigation started was by rill or furrow irrigation. This method saturated the soil and caused 30-50% of the nitrogen applied to the surface to leach past the root zone. Crops such as mint, sugar beets, and potatoes that required high amounts of nitrogen were grown in the area. Nitrogen as commercial fertilizer was cheap and applied at heavy rates, from 600 lbs per acre up to 1000 lbs per acre with removal rates of the crops not nearly that high. Farmers were taught as little as 20 years ago to apply 1 lb of nitrogen per bushel corn yield expected. Easily 300+ lbs in our fertile valley. Now that same crop of corn can be raised for less 2/3 that rate and sometimes higher yields. We have purchased new fields that have been farmed and taken soil samples up to 6' deep and found extremely high nitrogen soil tests below the root zone, often in fields that have not had manure applied ever or in recent times (15 years or more). This nitrogen has been there for some time and not recently applied.

Comment 14 - Joel Koopman

4. Farming practices have made great strides using available nutrients to improve our land, our crops and our future. These strides have eliminated the farming practices of the past but we still deal with the farming practices of the past's legacy. Legacy nitrates are in the ground and has more than likely contributed to the high nitrate issues. Our farming practices of today are helping to resolve these issues by pulling the nitrates out of the ground. It would be a great step forward if farmers were acknowledged for their clean-up efforts rather than only being blamed.

Comment 15 - Karen Sheehan

There is also a legacy issue with nitrates in this area that needs more attention.

Comment 16 - Tony Viega

What about the legacy of farming practices that occurred in the valley multiple decades ago?

Response Related to Farming Legacy

Information now in the Program includes:

Legacy nitrogen was added to the most recent GWMA program plan as a way to describe and acknowledge that residual soil nitrogen may be contributing nitrate to groundwater for an extended period of time. Technically we do not have a way to quantify the extent of legacy nitrogen in groundwater. There have been no studies in the Lower Yakima Valley on legacy nitrogen. The GWAC did not propose research to address this, nor did they draw conclusions or make recommendations on this topic.

Additional information will be added:

Farming practices have made improvements over the years in how nutrients, water and chemicals are applied. It is unclear how the lingering effects of these historical practices effect water quality and it is unclear how the improvements in farming practices translate into improvements in water quality. No scientific studies within the GWMA area were presented or considered by the GWAC to evaluate legacy effects on water quality.

We will include a recommendation in Appendix B that legacy nitrogen in the LYV should be evaluated and quantified.

Manure

Comment 17 – Yakima County Farm Bureau

12. Pg 25- The term "Waste" should be taken out of the title. It should be changed to "Water Storage, Process Water Storage, or Nutrient Water Storage." The term "Contribute" in the first paragraph is misleading. It should be modified to say "can contribute" because there is no evidence that all pens or lagoons do contribute. Again, there is no mention of the engineering that is installed to prevent contamination. Very misleading report writing.

Comment 18 - Trevor Wagenaar

Manure is a fertilizer and not waste!

Comment 19 - Bill DeRuyter

5. Manure is an "organic" product, it is not a 'waste' product as stated in the GWMA report. It is very useful in farming and has been since farming started. Manure contains many natural forms or micronutrient materials that crops need to grow. Commercial Fertilizer do not contain any organic matter and will seep through the soil faster.

Comment 20 – Dan DeGroot

When manure is properly stored in stockyards, compost areas or lagoons it should be referred to as Nutrient Storage, not Waste. There is one whole section of the report titled Waste Storage Facilities. This section should be edited to be Nutrient Storage Facilities or edited out of the report. All recommendations that refer to nutrients as waste should be deleted because they indicate a lack of understanding on farming process and practices.

Comment 21 - Jason Sheehan

4. Manure is referred to as waste numerous times in the GWMA report. Manure is a useful fertilizer that is used to grow crops and add organic matter and micronutrients to the soil. Higher organic matter has been proven to retain water better and help in drought years and to hold nutrients in the root zone for crops. Commercial fertilizer does not have these qualities.

Comment 22 - Joel Koopman

7. A huge part of being a farmer is being stewards of the land. History has proven that farmers are constantly evolving and have met the large demands placed on them, especially in recent years. What could be more sustainable than using cow manure as fertilizer to grow feed for our animals? Cow manure adds organic material to our soil which, in turn, helps our soil to retain water better, retain nutrients for crops better and improve soil quality all around. Commercial fertilizer has not proven to be as effective in these ways.

Comment 23 - Karen Sheehan

Manure is referred to as waste rather than the valuable organic product that it is with nitrogen, phosphorus, potassium and many other micro nutrients. Manure should not be mentioned as waste in the GWMA report.

Response Related to Manure

The word "waste" is used in this report 116 times, 6 of those refer specifically to animal waste. The other 110 times the word "waste" refers to language used in RCWs, WACs, NRCS guidance, referenced literature, or standard language used by other activities to represent by-products as a result of their activity. The word "waste" is a common environmental term to distinguish between a product (French fries, milk) and a by-product of production (processed wastewater, manure). There are many by-products that are beneficially reused (growing crops is common with industrial and municipal wastewater). It is important whether it is a municipality, industry, residential or agricultural activity to distinguish between the product and the by-product. Typically the by-product is called waste.

In the Recommendations section the word "waste" is used 9 times and refers to multiple waste sources. The recommendations were crafted and voted on by the GWAC.

There are six (6) places in the document that refer to animal waste which will be changed to "manure" or "by-products", and are located in the following sections:

- 1 is in the text
- 3 are in the recommendation descriptions
- 2 are in volume II describing BMPs

The USDA Natural Resources Conservation Service (NRCS) publishes standards for Geomembrane or Geosynthetic Clay Liner lagoon construction. Extensive evaluation of lagoon construction at all facilities within the GWMA boundary was not complete when this program was drafted.

The program report has been updated as follows:

On Pg 25- The term "Contribute" in the first paragraph is modified to say "can contribute".

Agriculture Stakeholder Inclusion

Comment 24 - Tony Viega

We are very disappointed that during the GWMA it's seem to lack other stakeholders in our valley such as tree fruit, hops, mint, Vineyard and other commodities. Where was the rest of agriculture/commodities?

Response Related to Agriculture Stakeholder Inclusion

The GWAC is a large and diverse committee, including representatives from all identified groups affected by groundwater quality, including local, state, and federal government agencies; local citizens; farmers, dairy producers, and agronomists; irrigation districts; conservation districts; environmental groups; and other vested parties. This committee and its workgroups met regularly over the past six years. The GWAC is a voluntary group.

Also, any member of the public was invited to each of the meetings through the six years and was provided opportunity to comment.

Dairy and Agriculture Focus

Comment 25 - Yakima County Farm Bureau

The report also has a major focus on animal agriculture, primarily dairies in the area. This focus ends up being a bias that is not backed up with true data or facts, and is contrary to reports from other areas. Maps depict dairy facilities in red which makes them appear to be a larger contributor, when in actuality, engineering, regulations and regulatory inspections negate most of that potential

Comment 26 - Yakima County Farm Bureau

6. Pg 15- Nitrate leaching section is negatively biased toward ag as it does not mention anything about other sources of N. Health effects section does not mention anything about new evidence concerning how nitrates may not be the primary influencer on the very young,

Comment 27 - Don Young

I was on that committee as a retired farmer & cattleman. As I watched things progress I came to the conclusion that this was only to prove that Dairymen were responsible for Nitrates in our soil, initiated by Ecology & the Environmentalists, I concluded that even though I am retired & have time to waste I did not want to waste it there.

Comment 28 - Dan De Boer

According to the home page the goal of the GWAC is to address all sources of nitrates. However, it appears that research thus far has been almost exclusively focused on large farming and livestock operations.

Comment 29 - Dan De Boer

Deep soil sampling, as outlined in the Outcomes and Challenges section, admits that our ability based on the data in making broad observations on the farming operations throughout the GWMA is limited. I also found nothing in this study proving causation between farming practices and ground water nitrates. Yes, farms use nitrogen. And yes, there are nitrates in the ground water. But what scientific evidence links the two? How is nitrogen absorption/uptake from crop growth calculated when calculating the nitrogen cycle in the Lower Valley? Seems like a leap of faith is required to tie farming operations to elevated nitrates in groundwater and no guarantee or proof that changes in farming practices will have a measurable impact to nitrates in groundwater.

Comment 30 - Dan De Boer

A couple theories were mentioned in the study as to why community members are unwilling to participate in well testing. Ignorance was the primary theory. What the committee and Department of Ecology should know is that many very educated and intelligent citizens of this Valley have a growing discontent with environmental agencies 'taxation without representation' practices. Farmers have also been unfairly targeted by out-of-state profit seeking environmental groups adding salt to the wounds.

Comment 31 - Dan De Boer

Lastly, I wanted to mention that being a lifelong resident in the Lower Valley I know many of the farmers and dairymen and women impacted by these regulations. I see every day how they responsibly steward their farms, I see them plowing county roads when snow storms hit, I see how they raise their kids and the work ethic and morals they instill, I see how they chip in to help neighbors, I see the community service they provide to their communities, I hear about the taxes they pay and the hundreds of people they employee.... these are good hard working people and the type of people this Valley needs to keep. Let us not draw hasty conclusions with unknown benefits based on incomplete science because we don't like their smell.

Comment 32 - John Koopmans

I believe that as a dairy farmer that we have made all our land more fertile and more valuable. I believe we have been unfairly judged. <u>We are a target</u>.

Comment 33 - Richard V

I feel that dairys have been really targeted. Yes there is nitrates in the water. How are we gonna find the source? It is easy to point a finger at a farmer that is spreading his cow manure because it

stinks. There is so many other sources. So much white and liquid ferterlizer that has been used for decades. Are we supposed to take the blame for past farming practices?

Comment 34 - Richard V

Our farming community is afraid to speak up because we always get targeted. I agree we need clean water, but figure out where to problem is coming from. Don't point the easy finger.

Comment 35 - Tanner Winckler

1. The well info will be used against dairy industry/cattle industry

Comment 36 - Dan DeGroot

The report seems to focus mainly on only one area of the community, dairies. The report seems to have a bias against dairies in that there are several mentions of animal nutrients referred to as waste.

Comment 37 - Dan DeGroot

The word waste was used because of a bias, not an understanding of what needs to be accomplished. If there is going to be bias written in this report it will give a perception that dairies and their nutrients are the source of the contamination in the aquifer. Not only is this completely unacceptable to me, it will lead the community to focus on this as the sole method to mediate the contamination of the aquifer(s).

Comment 38 - Jason Sheehan

Finger pointing and only focusing on one aspect of the area, like dairy farms, will not address the widespread issues that need to be changed. The bias towards dairy farms in this report will lead to disappointing results of not addressing all factors resulting in high nitrates in groundwater.

Comment 39 - Joel Koopman

GWMA has now turned into an information hack of dairy farms and a way to place blame on the dairy industry for high nitrates with no evidence to back up that claim.

Comment 40 - Joel Koopman

6. If dairy farms are going to be targeted without evidence of their part in this issue, the actual issue cannot be resolved and the studies will provide unsatisfactory results that in turn will leave this issue at large. There are many more factors to consider in this matter that are being ignored because activist groups have placed dairy farming in the spot light due to their agenda against dairy farming.

Comment 41 - Tony Viega

We have been dairy farmers in this valley for the last 38 years. We have always been proud to live in the Yakima valley but what's been going on in regards to targeting dairies as being the sole polluter is wrong.

In our past years experience, when coming to this valley there were sugar beet, potatoes and unlimited amounts of nitrogen applied to fields which were rill irrigated.

Response Related to Dairy and Agriculture Focus

The program content describes the issue of elevated nitrate in groundwater, how the GWMA was established in the Lower Yakima Valley, and defines the goals and objectives developed for the GWMA. This report explains the environmental and health effects of nitrate in the environment, describes the sources of nitrate, and the different regulatory authorities that effect nitrate in groundwater. Additionally, the report characterizes the Lower Yakima Valley, it discusses the accomplishments and the recommended actions of the GWAC.

The Program was not meant to be biased or have an unfair focus on dairies. The Lower Yakima Valley Groundwater Management Area was formed in 2012 to address the goal of reducing nitrate concentrations in groundwater. The GWAC is a large and diverse committee, including representatives from all identified groups affected by groundwater quality, including local, state, and federal government agencies; local citizens; farmers, dairy producers, and agronomists; irrigation districts; conservation districts; environmental groups; and other vested parties. Each of these parties are valuable to the discussion.

The GWAC developed a list of recommended actions (Appendix J). These actions were prioritized from the list of alternatives presented in Appendix I, by a voting process from GWAC members. GWAC members placed a value or -3 to +3 with each recommendation, and the results were totaled. The recommended actions are listed in order of priority within the Program. The approach is meant to be comprehensive. The recommended actions do not only have recommendations for dairies, but include recommendations for the diverse group as a whole. The report and recommendations do not find that dairy farms are the "sole polluter," nor should they be seen as the sole focus to reduce nitrate in groundwater.

This document relied on the expertise of the Washington State Department of Health (WSDOH) and the United States Environmental Protection Agency (USEPA) to draft the health effects section of the Program.

The Program report was edited prior to GWAC draft approval in December 2018, one focus during that process was to try to address any perceived bias or unfair focus on dairies.

This change was made to the Program:

- Pg 17 – A source has been provided for the bullet "Agricultural practices, including the use of fertilizer and the management of manure, are linked to nitrate loading and incidents of nitrate contamination in groundwater." (Ecology 2010 – Preliminary Assessment)

Comments Related to Implementation Phase:

Ongoing Data

Comment 42 – James Davenport

4. The Departments of Ecology, Agriculture and Conservation Commission, as well as Yakima County, the Yakima County Health District and the Southern Yakima Conservation District should not regard the investigation of groundwater contamination in the Lower Yakima Valley as a fait accompli, but rather as a fait ab initio.

Comment 43 – Lucy Edmondson

Second, results from the next steps in the U.S. Geological Survey work listed above could be very useful to implementing the GWMA program. The next phase would be to conduct a reverse-loading analysis based on the 2015 particle tracking study, to estimate how much reduced nitrogen loading would need to occur to decrease nitrate concentrations in downgradient residential wells to meet the drinking water maximum contaminant level. These findings could be used to refine and focus efforts to implement the final GWMA program in the coming years.

Comment 44 – Lucy Edmondson

As you know, this year, the Washington State Conservation Commission awarded competitive grants for demonstration projects statewide to test various technological approaches to recapture or recycle nutrients, including one in the Yakima Valley. The results of these projects could be useful in the implementation phase and EPA encourages the state and county to consider that information moving forward.

Comment 45 – Lucy Edmondson

In closing, new information pertaining to both understanding the nature of groundwater contamination and strategies to reduce it will continue to emerge from research, data gathering, and technology demonstration projects nationwide. EPA hopes that you will continue to take advantage of this information in your work to reduce excess nitrogen loading in the Lower Yakima Valley's groundwater.

Comment 46 - Frank P. Winslow

1. Send a mass mailing to all residents located outside of public water supply service areas within the Lower Yakima Valley. The mailing would explain the problem of nitrates in shallow groundwater, and that it is of particular danger to expecting mothers and infants. The mailing would provide a telephone number for free testing of their well water for nitrates.

Comment 47 - Frank P. Winslow

2. Assign staff dedicated to collection of water samples from domestic wells for nitrate analysis. The staff should be able to respond to requests to sample within one week of a telephone request. Households with infants or expecting mothers (or women of childbearing age) would be bumped to the top of the list. Shallower wells should be given a higher priority than deeper wells. The sampling staff would maintain a database, including available well construction information.

Comment 48 - Frank P. Winslow

3. Identify locations for household collection of free drinking water at each community in the Lower Yakima Valley. Once a household water supply well has been tested, the owner or resident would be provided with a document allowing them to pick up free drinking water (a reasonable weekly allotment could be calculated).

Comment 49 – Frank P. Winslow

4. Begin a grant program for replacement of impacted shallow domestic wells. Such grants could be applied for by homeowners that have a shallow wells with nitrates above cleanup levels. Prioritization of grant recipients should be based on needs of the applicant. A fund for this grant can

be contributed to by taxpayers and groundwater polluters. This recommendation would require legislative action.

Comment 50 - Frank P. Winslow

The collection of nitrate data from domestic wells could substitute for monitoring wells, and provide much more meaningful data in terms of protection of public health than monitoring well data. Collection of additional data, including hydrogeological and water quality data should focus on areas with identified deeper nitrate contamination, with a goal of identifying potential conduits to deeper aquifer zones. Such investigations could use innovative technologies for the detailed characterization of water quality and hydrostratigraphy with depth, in order to better understand inter-aquifer communications and contaminant migration.

Comment 51 - Norman Peck

Formation of rural PUD Water Districts should be considered among the options for replacement water supplies, particularly in "hot spots" within the GMA. Incorporation of recirculating sand filters in areas where high density of ROSS should be considered as one option to reduce N concentrations in OSS discharges.

Comment 52 – Norman Peck

Use of radio educational information on Spanish-language radio stations has been identified as an effective outreach tool to those for whom Spanish is a language used in households in the Yakima Valley. I have been told that many workers who are fluent in Spanish listen to Spanish-language radio at work and while traveling as well as in the home.

Comment 53 – James Davenport

1. Use of the community consultation model for developing solutions to environmental contamination problems is only helpful to the extent that it broadly and proportionately represents the affected community.

Comment 54 – James Davenport

2. Duly authorized governmental agencies and duly elected public officers are charged with a public duty to execute those rules and regulations currently in effect, and exercise those powers with which they are currently authorized, notwithstanding that they are not recommended by public interest groups.

Comment 55 – James Davenport

3. Neither the final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program, nor the recommendations contained therein, are limiting upon the choices available to the public at large or governmental agencies with relevant jurisdiction.

Comment 56 – Robert Stevens

I agree with both summaries that only limited conclusions can be drawn from this data set. The Washington hop commission funded a WSU, three year, deep sampling to 6 ft. in 23 hop yards from 1990-1992. This study showed the variability between spring and fall sampling and explained some of the reasons why this happens. It also demonstrated how variable management practice can effect soil test nitrate over time.

Comment 57 - Robert Stevens

I realize that a diverse group worked to put this plan together and appreciate all the effort. I believe that the greatest reductions in ground water nitrate levels can be achieved by implementing programs that encourage adoption of irrigation and nutrient management practices.

Comment 58 - Dan De Boer

The website mentions the GWAC committee is a community-based group. However, it appears many people living outside the GWMA are being asked to participate and may or may not have a vested interest in the affected areas. I would suggest a higher percentage of the committee be comprised of members who reside in the affected GWMA area so as to more accurately represent their community and neighbors' best interests.

Comment 59 - Tanner Winckler

9. Public outreach more other causes of high nitrates

Comment 60 - Tony Viega

What about if all of agriculture work together to solve this problem?

Comment 62 – Lucy Edmondson

The EPA also offers a few additional suggestions for the implementation phase of the program. First, it is important to ensure that QAPPs are developed for any new work that includes data collection. The development of sound QAPPs will ensure that the information gathered can be used to make scientifically-defensible decisions.

Response Related to Ongoing Data

The GWAC developed a list of recommended actions. These actions were prioritized from the list of alternatives by a voting process from GWAC members. These prioritized actions were collected as "Recommended Actions" within the Program.

The Program is the plan for implementation. There are many aspects of the plan, including alternative management strategies as presented in the recommendations section.

The GWAC made a list of approximately 300 potential alternatives, incorporating working group recommendations, ideas raised in working group conversations and reviews of scientific and environmental literature. These can be found in Appendix I of Volume II of the Program.

A consensus list of potential recommendations was identified as a subset of the potential alternatives by the GWAC. This produced a list of 83 potential recommendations to be evaluated by the criteria established by WAC 173-100-100 (4). This smaller list can be found in Appendix J of Volume II of the Program.

The public comments also provided many recommendations related to the implementation of the program. A list of recommendations collected from the public comments is provided in Appendix B.

As specified in WAC 173-100-030, the Program must be periodically reviewed. The public hearing comments provide a list of potential areas of consideration during these future Program

evaluations and during the implementation phase. These include solutions not voted on by the GWAC and are consolidated in Appendix B.

Comments on Implementation

Comment 63 – Jean Mendoza

The only alternative solution that comes close to addressing safe drinking water is # 44 that asks Yakima County to:

Perform an engineering study of water supply alternatives

There is no reference to funding that would support such an endeavor. Yakima County does not have the resources to do this on our own. Incidentally, in 2015 the County returned $150,000 of state money designated for domestic water treatments. This demonstrates a lack of concern on the part of elected official who are presumed to represent the public.

Comment 62 – Jean Mendoza

2. Alternative Solution # 41 requires:

Identify and support opportunities, including education research institutions for private, public and industry investment in technology and management of fertilizers and manures, including separation of solid and liquid wastes. (17 – WSDA)

WSDA construct GWMA administrative program.

The WSDA lacks the expertise required to construct an administrative program. In addition WSDA lacks the knowledge of human health issues that form the core rationale for groundwater management

Comment 64 – Jean Mendoza

Now WSDA appears poised to perform a follow up Nitrogen Loading Assessment for a million dollars (Alternative Solution # 52) and to construct a follow up GWMA administrative program for $10 million. The WSDA has not acted in good faith during the six-year GWMA program and there is no evidence that this will change in the future.

Response Related to Comments on Implementation

The recommended action within the Program do not currently have a funding source tied to each recommendation. These actions are established as voluntary actions that have been developed and voted on as a GWAC.

Each of the GWAC members were invited to share concerns, thoughts, and vote on the recommended actions. The recommended actions within the Program reflect the outcome of the voting process, as described within the Program.

As specified in WAC 173-100-030, the Program must be periodically reviewed. Each of these recommended actions will be reviewed as the Program is implemented.

Additional detail has been added to the Program describing how the transition from Program development to Implementation will be structured.

Comments on Lawsuits

Comment 65 – Tanner Winckler

4. No protection from citizen lawsuits

Comment 66 - Jason Sheehan

8. Department of Ecology needs to provide more protection from third party lawsuits for those dairy farmers that have a NPDES CAFO permit and are in compliance with the permit. Spending money on lawyers to defend yourself as a dairy farmer when you are in compliance with the law is targeting. This needs to end.

Response Related to Comments on Lawsuits

The CAFO general permits provide a consistent set of operating requirements that permittees are required to maintain compliance with for the protection of water quality. If a permittee is in compliance with their permit, they are protecting water quality and they are not subject to third party lawsuits. Under the combined permit, if a permittee is not following the requirements of their permit, they could be subject to a third party lawsuit under the Clean Water Act directed at bringing the permittee back into compliance with their permit. The State Waste Discharge permit (state only) is authorized by the Washington State Legislature under the provisions of Chapter 90.48 RCW, which does not include citizen lawsuit provisions. These are Federal and State mandated provisions.

Comments on Lead Agency

Comment 68 – Yakima County

Yakima County cannot accept the designation of lead agency for the Program as suggested in the recommended actions.

Comment 69 – Jean Mendoza

5. Yakima County may not have the capacity/expertise/willingness to administer a robust follow up GWMA program. Yakima County has failed to keep many promises to the advisory committee and to the public over the past six years.

Response Related to Lead Agency

Yakima County disagrees that it "has failed to keep many promises to the advisory committee and to the public over the past six years."

Yakima County did indicate they appreciated the faith the GWAC put in them to be Lead Agency in implementation yet realize the expertise and resources needed to successfully implement the Program are likely housed in other organizations.

Some ideas have been developed on how to identify the right agency and provide some structure while funding for implementation is secured, however future further conversations will be required to fully address this issue.

Increased Regulations

Comment 70 – Dan De Boer

Lower Valley citizens are being pushed into corners by increased government regulations – regulations enacted by unelected officials. The more regulations that are imposed, like the ones being discussed currently, the more difficult it will be to get citizens to participate in the process. No amount of education will change this – only logic, reason, and cooperation will.

Response Related to Increased Regulations

The Program does not include any recommendations for new regulations. The Program is the plan for implementation. There are many aspects of the plan, including alternative management strategies as presented in the recommendations section.

The GWAC developed a list of recommended actions. These actions were prioritized from the list of alternatives by a voting process from GWAC members. These prioritized actions were collected as "Recommended Actions" within the Program.

The GWAC made a list of approximately 300 potential alternatives, incorporating working group recommendations, ideas raised in working group conversations and reviews of scientific and environmental literature. These can be found in Appendix I of Volume II of the Program.

Using these 300 potential alternatives the GWAC applied a consensus screen in order to reduce the large list of alternatives to those potential recommendations with which on one would disagree. This produces a shorter list of 83 potential recommendations to be evaluated by the criteria established by WAC 173-100-100 (4). This smaller list can be found in Appendix J of Volume II of the Program.

The GWAC is a large and diverse committee, including representatives from all identified groups affected by groundwater quality, including local, state, and federal government agencies; local citizens; farmers, dairy producers, and agronomists; irrigation districts; conservation districts; environmental groups; and other vested parties. This committee and its workgroups met regularly over the past six years. The tremendous amount of work produced and the ability to reach consensus on many issues, demonstrates the high level of commitment and cooperation by the committee members.

The public comments also provided many recommendations related to the implementation of the program. A list of recommendations collected from the public comments is provided in Appendix B.

Comments Related to Minority Report:

Minority Report

Comment 71 – Robert Stevens

Ms. Mendoza points out that higher soil test nitrate levels were seen with double cropping with triticale following corn. Double cropping, ie a winter cover crop, was designed to take up residual nitrate left in the soil after harvest especially in hops and then corn. Over time the addition of nitrogen to the triticale crop with out recognition of residual soil nitrogen following corn has lead to excess nitrogen addition to the two crops.

The noted range in deep soil test nitrate in alfalfa fields may well be related to high levels where liquid manure has been applied to the alfalfa because of the crops ability to remove large amounts of nitrogen.

Comment 72 - Jason Sheehan

3. The minority report that was written before a final GWAC report was even finished or approved is out of context and very targeted. How can someone even write a minority report before the main report is even finished?

Comment 73 - Bill DeRuyter

6. Minority Report – Jean Mendoza released this report prior to the release of the final GWMA report. Seems that Jean already knew that she would not like the results. In her report if Jean only wants to put blame on the dairy industry. AGAIN, how can you fix the problem when you don't know who is creating it

Comment 74 - Yakima County Farm Bureau

In addition, minority reports should not be part of the GWMA report. They are someone's opinion that should be separate from the report.

Comment 75 - Jason Rollinger

The parts of the report that were put in by a person who has a one sided point of view should be removed.

Comment 76 - John Koopmans

Jean Mendoza shouldn't be let in the process. She is too one sided.

Comment 77 - Markus Rollinger

Jean Mendoza's 400 page report needs to be thrown out.

Comment 78 - Dan DeGroot

This Minority Report is simply one person's opinion and should not have any connection to the work that the whole committee did. It is accusatory and is short on fact, long on fiction. It uses snippets of other reports, takes them out of context to arrive at conclusions that were established based on personal belief. This Minority Report has no place in the final document and should be deleted or risk the Main Report losing its credibility on any of its recommendations.

Comment 79 - David Newhouse

My second point is that a private citizen, that is not a resident of the GWMA should not be allowed to submit a minority statement.

Comment 80 - Joel Koopman

5. The minority report is a biased, premeditated report that has no scientific or factual back-up. How can that information be considered when it was written as a complete ploy against dairy farming before a main report had been concluded? We ask that the minority report not be included because of this bias.

Comment 81 - Patricia Newhouse

First, I do not believe that a private citizen who does not live in the GWMA area should be allowed to submit a minority report that will be attached to the GWAC recommendations.

Response Related to Minority Report

The GWAC voted to allow minority reports to be attached to the GWMA program as a way to allow members to express their opinions about specific topics where there may have been disagreements. While the goal of the GWAC was to try to reach consensus, and often did, they recognize that in some cases it was not possible. The minority report allows a GWAC member to express a dissenting or alternative perspective. Minority reports are contained in Volume IV (Member Contributions) of the plan.

The Program document has been updated with a clarifying statement at the beginning of Appendix 4, which includes all minority reports, that these were done individually and do not necessarily reflect the consensus or opinion of the GWAC.

Specific questions related to the content or science of a minority report should be directed to the author of the minority report.

Comments Related to Monitoring Wells:

Monitoring Wells Criteria

Comment 82 – John Koopmans

We recommend you don't use information on these substandard monitoring wells.

Comment 83 – Jason Rollinger

Why isn't there any test wells near urban growth areas when there should be.

Comment 84 – Tanner Winckler

2. Wells were drilled without knowledge of GWMA

Comment 85 - Tanner Winckler

3. Criteria for drilling additional wells wasn't followed

Comment 86 - Markus Rollinger

All 31 wells are ground level and are open to contamination. I would like to see all of them be at least 2 feet of above ground level.

Comment 87 - Veldhuis Family

What about all the test wells I've seen in the valley are ground level or below. How is this right?

Comment 88 – Bill DeRuyter

3. Test wells - make sure that the test wells were installed correctly. I was told that some of these wells were capped off at ground level. Being capped off does not keep contaminated liquid from entering the tube and therefore causing a higher count of nitrates. If these wells were installed at ground level they should be disallowed in the study.

Comment 89 - Veldhuis Family

It seems like they are targeting us dairymen to fail. Where they got all these wells in the valley are all easily next to dairymen. Why not other places.

If water never goes up hill So with these wells next to dairies it's easy to point a finger at them instead it could be coming from a few miles away higher up with a vein in the ground.

Comment 90 - David Newhouse

I am very concerned about the placement of the second group of sampling wells. The placement does not appear to be random. It looks as if they are intentionally targeted at family dairy farms. If you chose to only target one potential source, you have predetermined what the results will be

Comment 91 - Jason Sheehan

6. The GWAC spent almost 2 years discussing 30 possible test well sites of which were approved. 20 of those wells were funded and drilled. Then in less than 30 days, 11 additional wells that were not approved by the GWAC were funded, sited, and drilled without any communication at all to the GWAC. In 6+ years of being on this GWAC, there has always been numerous emails about every issue. It amazes me that there was no communication at all about the additional wells. Nothing. It's actually quite suspicious since 9 out of 11 of these wells are within 1 mile of dairy farms. Once again, this shows the targeting of dairy farms and the lack of a holistic approach to solving high nitrates in the groundwater.

Comment 92 - Joel Koopman

2. Nitrates have been found to be sporadic in their location. The original well testing from domestic wells indicated no clear evidence as to where nitrates will be found and why.

Monitoring wells were supposed to be a step forward in data collection to determine BMPs. The first 20 wells were more random in location and approved by GWMA but the last 11 were not approved; hardly communicated and 9 of them seem to have targeted dairy farms in their extreme close proximity to the farms. There have been numerous problems with the chosen locations of many of these wells. They have been put next to anomalies and large bodies of moving water. The wells in these locations will not prove to be solid evidence as it will throw off an accurate nitrate sample. If these wells are not for determining BMPs, why were they installed? Information collected from these wells also need to be examined as to the cause of the nitrates. Are they from animals, humans or man-made fertilizers?

Comment 93 - Patricia Newhouse

Second, I am concerned about the placement of the second group of monitoring wells. Even if they were randomly selected, the fact that 9 of the 11 additional wells are in close proximity to dairy farms will skew the results and should have been a disqualifying factor for many of these locations.

Response Related to Monitoring Wells Criteria

The GWAC approved the installation of an ambient groundwater monitoring network with the purpose to establish a baseline of groundwater quality conditions at the water table in the GWMA.

There are other groundwater monitoring options which the GWAC considered:

1. Spatial data gaps
2. Hot spot monitoring
3. Nitrate trends
4. Ambient monitoring network to consider basin wide average concentrations
5. Common water supply aquifers
6. Effects of current and future practices
7. Health effects

With limited resources, the GWAC voted to conduct #4 and #5. #5 was completed (USGS, 2018). #4 involved installation of monitoring wells and is the focus of these comments.

Once the GWAC approved the ambient monitoring network, Pacific Groundwater Group (PGG) developed a document "Lower Yakima Valley GWMA Proposed Ambient Groundwater Monitoring Network" dated June, 2016. This document laid out the methodology for how monitor wells would be located. This document and the methodology were approved by the GWAC in November, 2016.

The methodology included developing a statistically sound random monitoring point pool consisting of 1000 randomly distributed points within the GWMA. From this pool of random points, well locations were selected using the following process; 1) the location point furthest from the GWMA boundary (which acts as the centroid), 2) the second point is the point furthest from the combination of the boundary and first well location (centroid of the largest unsampled area), 3) each subsequent well location is then the point closest to the center of the largest unsampled area. This well selection process evenly distributes the well locations throughout the GWMA and ranks them by the size of the unsampled area. This process assures that wells are randomly located with an even spatial coverage across the GWMA.

Once the preliminary well locations were selected, they were moved, if necessary, to make sure they were located in the closest public right of way (to assure long term access). Final drilling sites also considered the following:

- Existing sampling stations should be considered instead of drilling new wells
- Avoid drill sites within one quarter mile from irrigation canals.
- Avoid drilling within one quarter mile from facilities that may result in anomalous groundwater concentrations.

The approved ambient groundwater monitoring network plan states that final drilling sites may be adjusted after a field visit has been completed.

Additional reasons for adjusting monitoring well locations include the inability to have a drilling rig operate safely onsite.

The goal of the ambient groundwater monitoring network is to monitor the state of the aquifer as a whole over time. It is NOT designed or intended to evaluate BMPs, it is not designed or intended to identify sources of nitrate. This network CANNOT provide information that would link a land use or land owner to specific groundwater conditions.

The initial monitoring well locations were marked as a courtesy to the committee to allow them to see the distribution of the wells. It was never intended that the committee would vote or approve each location.

When these locations were moved, the methodology, which is documented (PGG, 2016), was approved by the GWAC and implemented by the contractors.

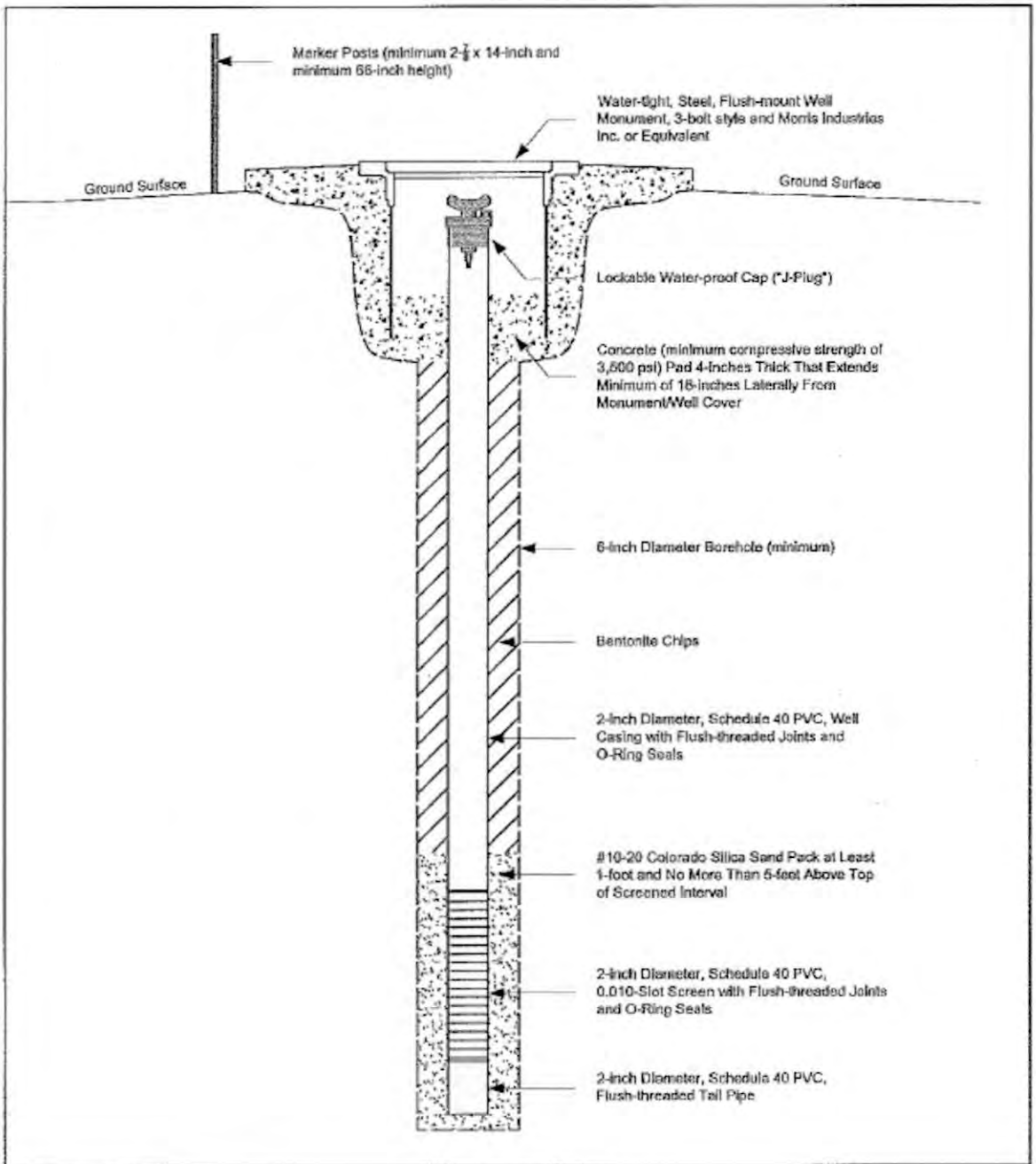
Well Construction -- Rationale for using flush mount monitoring wells

Below ground monitoring wells, or flush mount wells, are common. They are installed in parking lots, gas stations, agricultural fields, and common areas such as parks. The benefit of a below ground monitoring well is that they prevent damage by vehicles backing up or driving over them, including mowers, tractors and other heavy duty vehicles. This below ground construction prevents surface contamination in the event that a vehicle accidently damages or removes the top of the well.

A monitoring well which is constructed below the ground surface has a number of safe guards that prevent contamination and flooding (see figure below). First, a concrete pad that extends laterally around the well with sloped sides prevents ponding at the well site and prevents surface water from migrating directly along the borehole into groundwater. The well access cover at the surface of the well monument is waterproof and is secured with a lock. The monument serves to protect the well which is located inside this protective enclosure. Additionally there is a compression cap on the well casing which seals the well. A diagram of a below ground well is included below, which highlights the construction specifications and water protection elements.

All wells were constructed consistent with Chapter 173-160 WAC Minimum Standards for Construction and Maintenance of Wells. This regulation specifically addresses below ground monitoring wells, WAC 173-160-420 (13)

> *(13) If the well is completed below land surface, a watertight cap with a lock shall be attached to the top of the well casing. A metal monument or equivalent shall be installed over and around the well. The monument shall serve as a protective cover and be installed level with the land surface and be equipped with a waterproof seal to prevent the inflow of any water or contaminants. Drains will be provided, when feasible, to keep water out of the well and below the well cap. The cover must be designed to withstand the maximum expected loading.*



Not To Scale

Any substantive differences between this schematic and WAC 173-160 shall be resolved in favor of the WAC

FIGURE 1
Monitoring Well Schematic

Groundwater Monitoring Well Installation
Yakima County GWMA

PgG

Reviewing contract and agreements related to the monitoring wells, no violation of drilling criteria was found.

The Program is not meant to be biased or have an unfair focus on dairies. Specific facilities or land uses were not targeted when locating well sites.

Additional Monitoring Well Data

Comment 94 – James Davenport

7. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does recommend the collection of data from the Ambient Groundwater Monitoring Well system. The Groundwater Monitoring Well system should:

a. Maintain a longitudinal record of measurements taken from groundwater monitoring wells so as to document trends in improvement or worsening of the present condition.

b. Map the "horizon" of analysis of monitoring well measurements from the groundwater monitoring well system (an undulating plane established by points (elevations) at each monitoring well, with the intervening spaces being calculated with reference to influence from proximate point data) should be mapped. This might indicate how the measured horizon intersects with the geologic regimes already known (theoretically) to exist within the study area.

c. Introduce some sort of non-pollutive tracer in selected monitoring wells in order to ascertain whether that tracer expresses itself in other monitoring wells. This may be possible due to the density and location of monitoring wells within the study area. This may provide information helpful in establishing direction of groundwater flow (albeit at a rather surficial elevation).

Comment 95 – Markus Rollinger

I would like to see all 31 of the test wells be tested for whether the nitrates are coming from human waste or from animals and commercial fertilizer.

Comment 96 – Markus Rollinger

I also think there should be a few wells around the town of Outlook to determine whether the nitrates are coming from people or agriculture.

Comment 97 – Norman Peck

In addition to randomly placed monitoring wells, consideration should be given to more intensive targeted monitoring at and around "hot spots" as changes in N concentrations (improvements and further degradation) will be particularly important in those areas.

Comment 98 – Markus Rollinger

If there is no wells in the urban growth areas around towns there needs to be.

Comment 99 – Tanner Winckler

5. Why can't info from wells deemed anomalies be thrown out

Response Related to Additional Monitoring Well Data

See response to Monitoring Wells Criteria.

As specified in WAC 173-100-030, the Program must be periodically reviewed. The public hearing comments provide a list of potential areas of consideration during these future Program evaluations and during the implementation phase. These include solutions not voted on by the GWAC. These are possible alternative data, information, or analysis to gather within the Program should it be determined that the Program need improvement or determined by the GWAC during implementation to consider. They have been collected into Appendix B.

Comments Related to Program Format or Focus:

Comment 100 – Frank P. Winslow

In my opinion, the root problem is not that there are nitrates in shallow groundwater. The root problem is that people think that shallow groundwater is a viable source of water for drinking water purposes. I would submit that it is generally inappropriate for any water wells to be constructed for drinking water purposes less than one hundred feet deep. Water quality concerns with shallow groundwater include nitrates in agricultural area, nitrates and other constituents in areas where septic systems are used, and various contamination sources from point and non-point sources in urban areas. Very few places do not have a water quality concern with respect to shallow groundwater.

Comment 101 - Frank P. Winslow

Once protection of public health has been ensured (i.e. no ingestion of nitrates in shallow groundwater is taking place), then, and only then, other recommendations can be given priority. These other recommendations should be prioritized. For example "Explore technology to utilize nutrients as energy" is a recommendation that would not have a high priority in terms of protecting public health and the environment.

Comment 102 - Markus Rollinger

I feel that the BMPs need to be voluntary, because as a dairy farm is already has earthen lagoons designed by NRCS and if you want to see them get lined there needs to be some kind of cost share for that.

Comment 103 - Jason Sheehan

The GWMA needs to focus on a voluntary and educational approach for all involved parties to help lower the nitrates in the groundwater. This needs to be a community effort that looks forward and makes changes now that can affect what happens years in the future.

Comment 104 - Karen Sheehan

The whole GWMA area needs to work together and look hard at all areas if they expect to lower the nitrates in our groundwater. Voluntary and education is the best way to fix this problem.

Comment 105 - Frank P. Winslow

The most critical concern with respect to any contamination concern is to eliminate exposure pathways. Eliminating contamination within the environment is a lofty and admirable goal, but removing exposure mechanisms to both human and ecological receptors is of critical importance. In the case of nitrates in shallow groundwater, the exposure pathway is broken by ensuring that contaminated water is not ingested. Other groundwater pathways may be of concern for other types of contaminants (e.g. shower pathway for volatile constituents); however for nitrates, ingestion is the only critical pathway of concern.

Therefore, the greatest need with respect to nitrates in shallow groundwater is ensuring that no people are drinking this water. This can be accomplished with various mechanisms. In order to clearly differentiate between recommendations pertaining to preventing consumption of contaminated groundwater and other less immediate concerns, I recommend splitting recommendations between those pertaining to eliminating potential exposures and other miscellaneous recommendations. This comment applies to the Recommend Actions section and the Executive Summary. Separating immediate concerns from less immediate concerns is important to ensure that protection of public health is of foremost priority.

Comment 106 - Jean Mendoza

In spite of lip service regarding the need for safe drinking water the LYV GWMA provided zero relief to the people whose health is threatened.

Response Related to Format or Focus of Program

Washington State has groundwater quality standards (Chapter 173-200 WAC) which protect all groundwater as a potential source of drinking water. Many private domestic wells are completed in the uppermost aquifer. There are no laws or regulations which would willfully allow a community to contaminate their shallow aquifer. Additionally, it would be expensive, unfair, and illegal to require homeowners to abandon their private wells and obtain their drinking water from deeper sources.

There are no requirements or recommendations to line lagoons.

The BMPs suggested came from GWAC participation and recommendations. No new regulation was proposed to require any certain BMPs mandatory.

Voluntary and educational approaches are both considered in the Program and Recommended Actions. Recommendations made are included in Appendix B.

Comments Related to Science:

Potential Further Information

Comment 107 – Frank P. Winslow

I strongly disagree with a focus on reducing nitrate concentrations in groundwater. As previously stated, nitrates and other contamination in shallow groundwater systems is a ubiquitous global concern. Implementation of best management practices (BMPs) can reduce the amount of loading to aquifers of various contaminants (including nitrates), but the risk to shallow groundwater system will always exist.

Comment 108 - Norman Peck

Because of potential negative effects on fish and fish habitat, ammonia (NH3) should be investigated in irrigation return flows to surface waters. Arid area waters tend to be more alkaline than those in wetter areas, and NH3 toxicity to aquatic organisms increases as pH increases. (EPA Quality Criteria for Water, 1986 as updated). If initial investigations do not indicate a problem, no further monitoring should be required.

Comment 109 - Norman Peck

Consideration should be given to supplemental funding to include nitrogen analysis of groundwater samples from Superfund/MTCA site monitoring wells within the study area. This would potentially increase the number of available data points within the study area at a very modest increase in cost.

Comment 110 – James Davenport

5. Information not provided to the GWAC but obtainable from the Washington State

Department of Agriculture should be analyzed:

a. Growth in agricultural use intensity (density/acre, acreage fanned, production volume)

b. Amount of chemical fertilizer sold or used within GWMA

c. Report of dairy nutrient management plan information on distribution of manure (see RCW 90.64.026(3), RCW 42.56.270(7), WAC 16-06-210(29))

d. Nitrogen Loading Assessment (as distinguished from Nitrogen Availability Assessment, see: June 19, 2014, August 21, 2014, October 16, 2014, and December 18, 2014 GWAC meeting summaries; Yakima County/Department of Agriculture Interagency Agreement

Comment 111 - James Davenport

6. Information not provided to the GWAC but obtainable from the Department of Ecology should be analyzed:

a. Report on enforcement of RCW groundwater standards

b. Report on effect of large scale water usage on groundwater quality

Comment 112 - James Davenport

9. Neither the final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program, nor the recommendations contained therein, identify or analyze information about the amount of chemical fertilizers sold or distributed to managers of orchards and crops, or applied to orchards and crops within the study area. This information should be collected and analyzed.

Comment 113 to 130 - James Davenport

11. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not reflect the often-expressed view/opinion within the Advisory Committee that the effect of groundwater contamination in the Lower Yakima Valley influences the lives and health of human demographic groups disproportionately. Nor does it study or describe the socioeconomic effect of groundwater contamination within the study area upon on future generations. Both effects should be studied.

12. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not correlate the economic benefit derived from the private small industrial, agricultural, urban/suburban residential sector sources' activity within the study area with the economic costs likely to be incurred by the public remedial, corrective, educational, or regulatory activities responding to the problem, nor does it quantify the economic value of the natural resource (groundwater) consumed

through contamination (an unmeasured and undocumented expense incurred as part of the private small industrial, agricultural, and urban/suburban residential sectors' entrepreneurial enterprise). This relationship should be studied in order to determine correlate costs of remediation, if any, with the economic benefits of groundwater consumption.

13. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not evaluate the causal relationship, if any, between the method and volumes of water applied to the ground surface (either generally or at specifically identifiable locations, or the volume of groundwater stored within the ground, within the studied area, and the extent, location or degree of groundwater contamination within the studied area or at specific contaminated wells. This correlation, if any, should be studied.

14. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not evaluate the correlation, if any, of the location, volume or movement of surface water within lined or unlined artificial conveyance systems (irrigation canals) with the extent, location or degree of groundwater contamination within the studied area. This correlation, if any, should be studied.

15. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not correlate changes in concentration, density, intensity, or use of source-related activities within the studied area with changes, if any, in the extent, location or degree of groundwater contamination within the studied area. This correlation should be studied.

16. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not analyze specific deep soil sampling data collected from known locations. More deepsoil sampling data should be collected, with data collection sites located, and that data analyzed.

17. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not analyze trends in well data from Valley Institute for Research and Education Report (2002), Nitrate Pilot Project Well Samples, LVYGWMA High Risk Well Assessment Well Samples, and USGS 2017 Well Testing Data. Trends in this data should be analyzed.

18. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not identify plausible hypotheses of causation, transmission, or accumulation of contaminant between categorical sources and contamination events or locations. These hypotheses should be stated and explored.

19. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not describe the processes of hydrogeologic or chemical transmission or accumulation of contaminant in the area of contamination. These processes should be more completely explored and described.

20. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not investigate or analyze the geologic and hydrogeologic properties of denser locations of contaminated wells ("hotspots). These should be investigated and analyzed.

21. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not investigate or analyze the plausible causal relationship between specifically identifiable sources and specific contamination events. These should be investigated and analyzed.

22. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not explore the correlation, if any, between specific land use types and proximate water supply contamination events. This potential correlation should be explored.

23. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not address the specific land use regulations, or other regulation types, that might used rectify, ameliorate or otherwise alter the general or specific contamination condition within the study area. These should be explored and analyzed.

24. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not address the effect of generic or specific sources on the protection of areas with "critical recharging effect on aquifers used for potable water or areas where a drinking aquifer is vulnerable to contamination that would affect the potability of the water" as designated by Yakima County pursuant to the Growth Management Act or otherwise (RCW 36.70A; WAC 365-190-030 (3); and YCC 16A, 16C), as "environmentally sensitive or special areas" as contemplated by WAC 197-11-330(2)(e)(i), WAC 197-11-305 (l)(a), WAC 197-11-908(l)(b) and the Growth Management Act. These effects should be described and analyzed.

25. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not explore the strategy of taxation on the use or sale of materials containing chemical constituents common to known constituents of groundwater contamination as a means of source reduction. This strategy should be considered.

26. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not explore the strategy of usage limitations, imposed through land use regulation, on the nature, density, or intensity of use (analogous to limitations on industrial development). This strategy should be considered.

27. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not recommend any remedial action. Remedial actions should be studied.

28. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not evaluate the costs or implications of inaction. These should be evaluated.

Comment 131 - Don Young

A study was done 40 to 50 years ago showing Nitrates in the water, I requested that information, it was never searched for!

Comment 132 – Robert Stevens

In reviewing the draft plan I am especially concerned about the presentation of the deep soil sampling data. If this data is to become a permit part of the record, I believe some additional editing needs to be done on both reports. This is especially true in Ms. Mendoza's summary. The units on the tables and grafts are very confusing. Soil test nitrate is reported as nitrogen as nitrate (nitrate-N). Ms. Mendoza uses a number of units such as NO3-N, N lbs/acre, lbs NO3 per acre. The units in the tables and figures should be consistent and an explanation of how they were reached should be presented.

Comment 133 – Robert Stevens

I strongly agree with the plan's stress on nutrient and irrigation management as the two critical BMPs that need to be addressed. On page 189 under Appendix G I would recommend that residual soil nitrogen be included in the list of accounting for all sources on nitrogen. The relative return on investment for most of the other BMPs listed is very small compared to water and nutrient management.

Comment 134 – Lucy Edmondson

The EPA continues to believe that the final GWMA plan would be improved by including a more thorough accounting of the sources and amounts of nitrogen in the GWMA by using scientific data from additional sources. The current draft contains information from the important collaborative work carried out by local, state and federal agencies in 2010, "Lower Yakima Valley Groundwater Quality." Data from other scientific studies are also available. Taking advantage of as much quality-assured/quality controlled available data and information as possible would strengthen the foundation of the report, its policy recommendations and most importantly, its ability to protect and improve the safety of drinking water. A few examples to draw upon include:

• United States Geological Survey (USGS): "Particle tracking for selected groundwater wells in the lower Yakima River Basin, Washington," 2015. The USGS assessed nitrate sources in specific geographic areas within the GWMA with groundwater contamination and identified associated likely nitrogen source areas, https://pubs.er.usizs.izov/publication/sir20155149

• The EPA: "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington," 2013 contains soil information such as permeability data from lagoons, and nitrogen concentrations in manured dairy crop fields, https://www.epa.izov/wa/lower-yakima-vallevgroundwater

• Since a Consent Order was signed with three Lower Yakima Valley dairies in 2013, these dairies have made great strides in reducing the amount of nitrogen accumulating in their fields. In reports submitted under the EPA Consent Order and approved Quality Assurance Project Plan (QAPP), there are several years of biannual data from fields prior to the AOC-required limitations of field applications of manure and the subsequent transition to the present conditions. These dairies are also providing post-harvest data that can inform soil concentration estimates in the draft GWMA Plan.

https://www.epa.gov/wa/lower-vakima-valley-groundwater

These reports contain information on soil permeability, lagoons, and post-harvest deep soil sampling that can contribute to the data in the GWMA program and strengthen its findings.

Comment 135 – Dan De Boer

Prior to imposing regulations on one group, I believe more research needs to be done to discover the proportional impact of all sources so as not to overly burden one group over another without knowing their respect impacts to groundwater nitrates.

Comment 136 - Dan De Boer

Farmers and dairymen have already been subject to increasing waste management regulation over the last couple of decades. Is there any scientific evidence that these regulations are having an impact? If not, then perhaps there are other theories that need consideration.

Response Related to Potential Further Information

This goal of reducing nitrate concentrations in groundwater was established by the GWAC early on when the group was first formed in 2012. Other goals could have been chosen, but this is what the group voted on as their guiding principle. The program supports this goal and is a roadmap for how to achieve this goal.

There are many recommendations. These are included in Appendix B for consideration during program implementation.

One commenter mentioned a historic study. The title, author and date of this study would be useful in tracking down this important information.

Another comment noted units in tables and figures of one DSS analysis were missing. The GWAC did not take an action or use either analysis to draft the Program. The analysis is considered informational only, any clarification or questions can be directed to the author.

Potential Program Error or Misleading

Comment 137 to 145 – Yakima County Farm Bureau

7. Pg 17 - MDL of .03mg/L is misleading and not explained as some areas can have background levels much higher that .03mg/L.

9. Pg 20-The N sources graph is very misleading. Different potential agricultural sources are treated equal, when they should not be. Sources on dairies are subject to regulatory constraints and engineering requirements that serve to contain materials. Having a position that these materials have the same potential to migrate, is not accurate. In addition, there is information available from California that pens and lagoons have less than one percent contribution (0.7 percent), significantly lower than the 31percent noted in the report.

14. Pg 30- Why is there an emphasis on highly regulated bio applications? There was no evidence presented that bio solids play any role.

15. Pg 31- Legacy N section does an incomplete job of describing past uses on N on crops such as potatoes and sugar beets, and the amount of N left in the soil profile 20 to 50 years ago. The current description makes it sound like the problem is with current applications on a current annual basis. For the most part, this is not accurate.

17. Pg 40/41- Groundwater recharge appears faulty or not clearly defined- Little of the irrigated land in the GWMA area recharges groundwater 12 to 48 inches of water. This is not accurate for the farmed lands.

19. Pg 64- The Yakima River is not the "source" of irrigation water for the Yakima Valley. The Yakima River is the conduit for irrigation water. The source of the water is the five storage reservoirs filled by either snow or rainfall precipitation, or natural flow before storage control is implemented.

21. Pg 83 - ID of N sources is not complete. No mention of wholesale commercial N supplies. Only refers to what is "produced" in the GWMA area, not what is imported. Very confusing and negatively biased toward the natural nutrients produced by animal agriculture operations.

22. Pg 85-Graph is biased against certain locations depicted in red (likely dairy lagoons). It does not explain the engineering that these lagoons have and their minimal potential to negatively affect groundwater.

30. Pg 100- Rec 39 Incorporation of fertilizer cannot be done on established crops. Irrigating in can take longer than 24 hrs.

Comment 146 – Jean Mendoza

In 2014-2015 the WSDA insisted upon performing a Nitrogen Loading Assessment for the GWMA at a cost of $58,000. The project was delivered 18 months behind schedule thus delaying completion of the GWMA program. The NLA/NAA (Nitrogen Availability Assessment) is extremely flawed, did not comply with the scope of work for the project and has never been approved by the GWMA advisory committee.

Comment 147 to 148 - Jean Mendoza

3. The GWMA Report and Plan is scientifically indefensible and violates principles of ethical research by omitting the overwhelming data from the LYV "dairy cluster".

4. The GWMA report underestimates the amount of atmospheric nitrogen deposition by a factor of at least five.

Response Related to Potential Program Error or Misleading

We are happy to provide clarity of the role of an MDL or method detection limit, however, a reference to an MDL on pg 17 or in volume 1 was not found. An MDL is a laboratory limit that clarifies how low a lab can reliably achieve a number based on a parameter and method. An MDL has nothing to do with environmental limits or goals.

Reference to bio application is evidence of all sources being considered, an emphasis was not intended.

The Nitrogen Availability Assessment (NAA) (WSDA, 2018) was a study that was contracted by the GWAC to develop a refined estimate of nitrogen sources in the Lower Yakima Valley using local data and literature. It is not intended to be precise, it is still an estimate of nitrogen sources and their loading to the land surface, not potential to migrate. Data included in this study is described in the document as well as limitations of the assessment. Data not included in the NAA is recommended to be considered during implementation. This document was peer reviewed by scientists from WSU and other state agencies.

The GWAC relied on technical experts, such as the USGS, to provide the most technically accurate and reliable information. Further, the GWAC created a data committee to assure that only credible data was considered by the GWAC to make decisions. This process was rigorously followed.

The graph on page 85 does not identify sources, it is a compilation of total nitrogen availability at the surface and not the potential to migrate.

Nitrate Proof

Comment 149 – Don Young

What is ironic to me is that there has never been a case in Yakima County of anyone reporting that diagnosis! And no one wants to talk about Bickelton having the highest nitrates in the Valley! No dairy's & no cows. Explain that! So we have spent over 2 million & we don't know anything, sounds like a Government program!

Comment 150 - Dan De Boer

Having lived in the Lower Valley my whole life I have never heard of a local person suffering the health effects of nitrates in the ground water. I see the committee sent surveys to local health officials asking if they had seen illnesses of the sort but I didn't see any survey results. When will the survey results be posted and will they indicate we have an actual health issue? If we are not going to wait for this data to be collected, why then send out the surveys in the first place?

Comment 151 - Dan De Boer

Only 12% of tested wells have indicated an elevated nitrate level and the study admits the sample size was inadequate to draw meaningful conclusions. Is there any historical evidence of what the groundwater nitrate levels have been over the last 50-100 years? It might be a good idea for the committee to overlay historical nitrate levels against farming practices over the same time and the population growth of the area of both livestock and people. If this long term (more than a decade) historic data is not available, perhaps a trend or timeline should be established prior to making broad decisions. On a side note, I find it ironic that the City of Sunnyside recently drilled groundwater wells to service its residents in the middle of an old 40,000 cow feed lot.

Has there been any elevated nitrate levels in these wells? Have any public wells been analyzed?

Comment 152 - Veldhuis Family

City of Bickleton drilled well. They found it had high nitration. Where does this come from?

Comment 153 - Bill DeRuyter

1. Why are the nitrates not specified - if we do not know what specific nitrates we are dealing with how can we fix the problem.

Comment 154 - Bill DeRuyter

4. If high nitrates are hazardous to the elderly or infants, then what documentation is there that claim this area is the cause for their sickness. I have not heard of any cases of "Blue Baby Syndrome" related to the Lower Yakima Valley.

Comment 155 - Jason Sheehan

5. Through the 6+ years of the GWAC work, I have not heard of any cases of blue baby syndrome or other documented nitrate related illnesses in the Yakima Valley. In fact, many studies are showing that high nitrates foods might be healthy for you.

Comment 156 - Joel Koopman

1. Initially, GWMA was started as a means of a protection against health issues from high nitrates. However, there have been no reported cases linked to high nitrates which begs the question, why are we "protecting" people from an issue that does not exist?

Response Related to Nitrate Proof

The GWMA was not formed in response to medical cases, but rather was formed due to a known issue of high nitrate in groundwater. The GWMA was formed in 2012 to address the goal of reducing nitrate concentrations in groundwater.

Groundwater in the Lower Yakima Valley contains elevated nitrate concentrations. Several historic groundwater studies have documented nitrate concentrations in excess of the drinking water standard of 10 mg N/L. A compilation of data collected between 1988 and 2008 indicated that 12 percent of wells tested in the area had nitrate concentrations above the standard (PGG 2011). This information prompted the formation of the Lower Yakima Valley Groundwater Management Area (GWMA). Since then, a more recent groundwater study in the Lower Yakima Valley sampled over 150 private domestic wells in 2017 and found that 26 percent of the wells had at least one of its six samples exceeding the drinking water standard. Twenty percent of the wells sampled consistently exceeded the drinking water standard for all samples collected. Nitrate was not detected in 13 percent of the wells sampled (USGS 2017).

Nitrate is the most prevalent contaminant in groundwater (Spalding and Exner 1993), and there are health effects associated with elevated nitrate concentrations in drinking water (WDOH 2016).

Nitrate impacts to groundwater are common in agricultural areas (Harter 2009). There are many sources that contribute to nitrates in groundwater, including animal and human wastes, fertilizers, plants, and atmospheric deposition. In the Lower Yakima Valley, agriculture is the primary economic and land use activity, and most cropland is irrigated (PGG 2011).

Articles entitled "Hidden Wells, Dirty Water" written by Leah Beth Ward ran in the *Yakima Herald Republic* in 2008, detailing nitrate issues affecting public and private wells. The articles suggested that a lack of coordination between local, state, and federal agencies aggravated the problem. These newspaper articles prompted a series of public meetings hosted by the Environmental Protection Agency (EPA) along with state and local agencies.

In January 2010, EPA issued a finding in support of Section 1431 of the Safe Drinking Water Act to address groundwater contamination. EPA found that groundwater in the Lower Yakima Valley is contaminated. This water is an underground source of drinking water, and contamination may present an imminent and substantial endangerment to human health. (Ecology 2010).

The goal of GWAC is to bring nitrate concentrations in groundwater to below the state drinking water standard. The groundwater quality standards in Washington State (Chapter 173-200 WAC) protect all groundwater as a drinking water source. Groundwater in the Lower Yakima Valley is a significant source of drinking water for its residents.

We are not aware of groundwater contamination in the City of Bickleton, WA. A recent water quality status report from the municipal water supply indicated that all tested contaminants (including nitrate) are well below the drinking water standards.

Nitrate in water can come from many sources including residential onsite sewage systems and fertilizer use, commercial and industrial businesses, municipal wastewater treatment systems, irrigated agriculture, livestock operations, atmospheric deposition, as well as other sources. One of the objectives of the GWMA was to assess the relative contribution from all sources in the Lower Yakima Valley. All of these sources contribute nitrogen to the environment.

A summary of survey results is included in Vol 1 and the specifics are included in Vol 3.

Suggestions from the public comments related to historic trends of nitrate have been collected into Appendix B.

Comments Related to Septic Systems/Onsite Sewage/Drain Fields:

Comment 157 – Dan DeGroot

I also would recommend that as homes are sold in areas that have a high density of OSS that the county should require the update of a conventional OSS to one that does reduce the nitrogen concentrations in the effluent. If all potential sources of nitrogen are not considered then any efforts to reduce nitrogen in the aquifer(s) will fall short.

Comment 158 – Yakima County Farm Bureau

Maps in the report depict that many of the high N concentrations are where there are higher rural population, but there is little focus on this, nor is there a focus that septic drain fields are designed to leach. Information and focus from other sources about nitrates leaching from drain fields into the groundwater is lacking.

Comment 159 - Yakima County Farm Bureau

5. Pg 10-There is no mention of DOH responsibility to act on WAC 246-272A-015{5) which states "shall develop a written plan that will provide guidance to the local jurisdiction regarding development and management activities for all OSS within the jurisdiction". This has NOT been done.

Comment 160 – Richard V

We bought numerous parcels of ground that had high levels of nitrogen. We get monitored heavily. We double crop. I can't explain well enough how much ground we have cleaned up.

What about all the sub divisions in the valley? What happened to big open farm ground. All these house taking up valuable farms. They all have septics. I hear way too many per section than there should be.

Comment 161 - Tanner Winckler

6. Address septic systems

Comment 162 - Bill DeRuyter

2. It has come to my attention that there are more septic systems per allowed area - there are less acreage used in farming every year. Many pieces of land are split up and sold in smaller lots. People are buying and installing a septic tank. Tanks leach sewage below any root layer and put unusable nitrates in the soil. (So again, let's specify the nitrates).

Comment 163 - Jason Sheehan

7. On site septic systems have not had enough focus or education in this report. The concentration of OSS is increasing with no rules or regulations by Yakima County. OSS is designed to leach all nitrogen to the groundwater. A real threat as the number and concentration of OSS continues to increase in Yakima County.

Comment 164 - Joel Koopman

3. On site septic systems have not been given enough research or monitoring. On site septic systems are designed to leach all of their nitrogen into groundwater while dairy farm's lagoons have been built to government specifications and are NOT designed to leach anything. Dairy lagoons are inspected yearly as well as the land that is farmed by the dairies to ensure no leaching of nitrogen has occurred.

Comment 165 - Karen Sheehan

Septic systems should be looked into more closely with both proper maintenance and also density of septic systems.

Comment 166 - Tony Viega

What about the septic systems in the valley that are not regulated?

Comment 167 - Dan DeGroot

4. Onsite Sewage Systems (OSS) should be controlled by the county and a plan that is required by WAC 246-272A-015(5) should be developed by the Health Department for OSS. I would recommend that any parcel that requests an OSS permit that is less than 20 acres (just under High Density standards) should have an OSS that is designed to reduce the nitrogen flow in its effluent. OSS are designed to return water to the aquifer, in fact a request for an OSS requires that a percolation test be passed proving that the soil for the drain field will indeed return the water to the aquifer, and a conventional OSS does little to treat nitrogen (less than 15% at best). Drain fields on conventional systems are placed below the root zone so there is no uptake of nitrogen from them. The EPA considers more than 40 OSS per square mile (one per 16 acres) to be high density of OSS and a high risk to the aquifer. For many years the EPA considered OSS to be the primary contributor of contaminates to the aquifers of the United States. There are many areas of the United States where there is little to no farming of any sort that have high nitrate concentrations in the aquifers. This should be of great concern to the stakeholders of the Lower Valley GWMA.

Response Related to Septic Systems/Onsite Sewage/Drain Fields

On-site sewage systems were discussed during the Program development, including recommended actions. The Nitrogen Availability Assessment considered OSS across the GWMA, and the relative contribution is included in the graphs and tables from this report on page 20 of the program. On-site sewage systems are discussed starting on page 27 and they are graphically depicted on figure 30. Additionally, the Program does include recommended actions related to septic systems, such as recommendations 12, 43, and 47.

As specified in the WAC, the Program must be periodically reviewed.

Recommendations made by commenters are included in Appendix B for consideration in implementation of the program.

Comments Related to Program Writing:

Ideas to Improve Program Report

Comment 168 to 178 – Yakima County Farm Bureau

31. Pg 102- Rec 49 Oppose, regulatory. DNM plans extended to all lands

10. Pg 22- fifth paragraph left out when describing benefits of using organic fertilizer also include "adding soil structure which enhances moisture holding capacity and soil biological communities."

13. Pg 26- There are discussions about lagoons. But, there is no mention of why lagoons came into existence which was a mandate from DOE to help with nutrient distribution throughout the year, mitigating winter applications.

16. Pg 37- Third paragraph states that natural groundwater flow may be influenced by irrigation practices, structures and dairy structures. However, it does not explain that lagoons are engineered to contain what they hold, therefore they do not have the same "potential" as the others. The lack of this information being provided presents a bias toward a particular structure that has been shown to be a benefit. The term "potentiometric surface" should be explained as the more common term, "static level"

20. Pg 69-Income comparisons very biased, compared to overall state incomes. Education section is biased and misleading. No mention of past or recent immigrants coming here to better themselves. Ethnicity section paints a false picture and is divisive. Aren't we all Americans?

24. Pg 95- Rec 11 and 13 are very similar

25. Pg 97- Rec 23 needs to be voluntary

26. Pg 98 - Rec 27 needs terminology change. "Waste" should be changed to "nutrients."

27. Pg 98- Rec 28 needs to be voluntary

28. Pg 99 - Rec 35 "waste" should be changed to "nutrients"

29. Pg 100- Rec 37 should be voluntary

Comment 179 – Lucy Edmondson

The Washington State Department of Agriculture's report titled "Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area — A Study by the Washington State Department of Agriculture and Yakima County," (June 2018) is an integral part of the GWMA program as it estimates nitrogen availability in the geographic area. It is currently presented as a separate document in Volume III, "member contributions." We recommend that its data and information be incorporated directly into the body of the final GWMA plan to ensure transparency.

Comment 180 - Lucy Edmondson

Uncertainty is inherent in almost every scientific endeavor, especially one of this magnitude and complexity. Considering this, several GWAC members requested that the program include a section that discusses the intrinsic uncertainties in the relevant variables. The EPA appreciates the work to develop this, which is provided in the current draft as a supporting document. Given its importance to understanding the plan, we recommend that it be added to Volume 1, and describe opportunities for additional research to reduce uncertainty.

Response Related to Ideas to Improve Program Report

Recommendations made by commenters are included in Appendix B for consideration in implementation of the program.

The following existing text in the Program is designed to address the agricultural nature and lower cost of living within the GWMA boundary:

"In the GWMA, economics and livelihood play a critical role in the decision to live in a rural area instead of an urban one. Affordable housing is a draw to rural areas, and so is the proximity to agricultural employment."

Edits will be made to the program to clarify:

- Benefits of using organic fertilizer also include adding soil structure which enhances moisture holding capacity and soil biological communities
- The term static level will be added in the discussion of potentiometric surface

Recommendations were voted on by the GWAC via consensus

Potential Program Report Errors

Comment 181 – Jean Mendoza

6. The GWMA report does not comply with the legal mandates for groundwater management programs in RCW 90.44 and WAC 173-100. Legal requirements for a GWMA that are missing from the LYV GWMA plan include:

A. RCW 90.44.410 (1) The groundwater area or sub-area management programs shall include:

(b) A management program based on long-term monitoring and resource management objectives for the area or sub-area;
(d) Projection of water supply needs for existing and future identified user groups and beneficial uses;
(h) Identification of water quality objectives for the aquifer system which recognize existing and future uses of the aquifer and that are in accordance with department of ecology and department of social and health services drinking and surface water quality standards;
(j) Annual withdrawal rates and safe yield guidelines which are directed by the long-term management programs that recognize annual variations in aquifer recharge;
(k) A description of conditions and potential conflicts and identification of a program to resolve conflicts with existing water rights;
(m) A process for the periodic review of the groundwater management program and monitoring of the implementation of the program.

B. WAC 173-100-100 The program for each groundwater management area will be tailored to the specific conditions of the area. The following guidelines on program content are intended to serve as a general framework for the program, to be adapted to the particular needs of each area. Each program shall include, as appropriate, the following:

(1) An area characterization section comprised of:
(g) Estimates of the historical and current rates of groundwater use and purposes of such use within the area;
(h) Projections of groundwater supply needs and rates of withdrawal based upon alternative population and land use projections;
(3) A section identifying water quantity and quality goals and objectives for the area which (a) recognize existing and future uses of the aquifer, (b) are in accordance with water quality standards of the department, the department of social and health services, and the federal environmental protection agency, and (c) recognize annual variations in aquifer recharge and other significant hydrogeologic factors;
(6) An implementation section comprised of:
(a) A detailed work plan for implementing each aspect of the groundwater management strategies as presented in the recommendations section. For each recommended management action, the parties responsible for initiating the action and a schedule for implementation shall be identified. Where possible, the implementation plan should include specifically worded statements such as model ordinances, recommended governmental policy statements, interagency agreements, proposed legislative changes, and proposed amendments to local comprehensive plans, coordinated water system plans, basin management programs, and others as appropriate;
(b) A monitoring system for evaluating the effectiveness of the program;
(c) A process for the periodic review and revision of the groundwater management program.

Comment 182 to 187 - Yakima County Farm Bureau

2. Pg1- third paragraph, citing that the GWAC had contentious discussions and whether or not they were respectful, is not relevant to the report or summary. This statement furthers the divisions of the group.

3. Pg 3- bullet point to "enhance" regulations. There was not an agreement to recommend to enhance or add to regulations.

32. Pg 103- draft recs should be deleted as there was not an agreement on moving them forward. They should not be in the report

4. Pg 4- Formation of the Lower Valley GWMA. Environmental groups were not the first to identify the problem. It was known by government agencies for a number of years. It was also brought to DOE's attention by the dairy industry before there was any talk about formally addressing the problem. Giving so-called environmental groups credit for identifying the issue is biased and not true.

8. Pg 19 - Citing the median N use scenario as most likely may not be accurate. Farmers do not buy any more N than is necessary because it is expensive, so a more accurate scenario could be the low use amount.

11. Pg 23- While farming fruit I rarely applied high amounts of nutrients, especially nitrogen, to producing trees because it makes the tree grow vegetatively. Vegetative growth does not allow for good fruit production. Citing that fruit growers apply high amounts of nitrogen to producing orchards is not accurate.

Comment 188 – Department of Ecology

Provided list of typographical errors

Comment 189 - Dan DeGroot

5. This report should have been written with the average stakeholder of the Lower Valley GWMA in mind. It is too technical in nature and difficult for the average person to comprehend. It has too many tangential issues throughout it that serve to confuse and mislead those who would like to know what the Ground Water Advisory Committee has discussed and concluded over the past 6 1/2 years. It should be written in simple, plain language and if technical issues need to be cited, they should be another section for those who are interested in them, not spread throughout the report.

Comment 190 – James Davenport

8. Neither the final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program, nor the recommendations contained therein, identify the means by which to determine the effectiveness of recommended educational or "best management practices" strategies. These should be identified and implemented ("ambient groundwater monitoring" will not accomplish this).

Comment 191 - Yakima County Farm Bureau

18. Pg 64- Needs clarification. Is the term fertilizers used in the first paragraph "commercial fertilizer?" Fourth paragraph terminology should be changed. The term "manure" should be changed to more accurately reflect the product that is being applied. It is mostly liquid or other nutrients that have had some sort of treatment, either from solids being separated from the liquid or composting and drying.

Comment 192 - Yakima County Farm Bureau

23. Pg 93- Rec 1 needs to be better explained. What does 42 mean, 42 out of what?

Comment 193 - Jason Rollinger

What are the plans for onsight septic systems?

Comment 194 - Jason Rollinger

What kind of help or protection are you providing?

Comment 195 – Jean Mendoza

7. Alternative Solution #25 is to Streamline current regulatory enforcement activities. Improve customer service and protocols, increase clarity of process, escalate enforcement for facilities not following management practices, identify methods to discourage repeatedly unfounded complaints, and improve overall transparency.

This is so vaguely worded that it is meaningless.

Comment 196 - Jean Mendoza

8. Alternative Solution # 32 is to

Adopt and Implement an Adaptive Management Plan. Utilizing data collected, progress made, or lack of progress, to inform the community on adjustments that need to be implemented. Plan would

incorporate necessary adjustments to availability of technology, education and outreach, tracking exports,7 land use regulations, treatment systems, and other changes to inform decision makers regarding management changes necessary for a successful Program.

This is so vaguely worded that it is meaningless.

Comment 197 – Jean Mendoza

10. Where is the plan for analyzing the well samples from the thirty LYV monitoring wells?

A. How often will sampling be done?

B. Will it be passive or active sampling?

C. What is the relationship between individual wells and nitrogen sources?

D. What hypotheses are we testing?

E. Which statistical tests will we use for trend analysis?

F. How will the monitoring "address effects of changes in nutrient application over the agricultural cycle" as described in Alternative Solution #2?

G. How will the monitoring "track whether time-based performance objectives are being met" as described in Alternative Solution #2

H. What are the GWMA approved "time based performance objectives"?

Comment 198 – Yakima County Farm Bureau

Unnecessary verbiage is quite evident when one reads through the Benton County Groundwater report.

In summary, the Yakima report is too long and focuses on items that have nothing to do with the subject.

Comment 199 – Yakima County Farm Bureau

In particular, there is still a biased focus on how depressed the Yakima Groundwater area is, and the number of so-called poor people of color without means. The lower cost of living in our area was not factored into the report. Nor was the fact that many people who came here to work, while not highly educated by today's standards, did have the skills necessary to perform needed tasks and make a living. This depiction paints a false picture. Job opportunities abound in our region and people have flocked here to get them. The number of farm workers coming from other countries expands by thousands every year. People from the south are clamoring to get into our country. Our public and private schools are second to none and every child has an opportunity to attend. These points paint a very different picture than what the report is trying to imply.

Comment 200 - Yakima County Farm Bureau

1. The report is too long. Few rank-and-file citizens will take the time to read it

Response Related to Ideas to Potential Program Report Errors

RCW 90.44 was written originally for water quantity and later modified to include water quality. To implement RCW 90.44.410, WAC 173-100 was developed. In the LYV-GWMA situation, the GWAC focus is specific to nitrate in groundwater, water quality. Groundwater supply, water quantity, is not in the scope of work for the GWAC.

WAC 173-100-100 is written with the knowledge that GWMA programs are site specific issues. The WAC accommodates this need by specifically noting "The program for each groundwater management area will be tailored to the specific conditions of the area and provides guidelines to serve as a general framework adapted to the particular needs of each area. Each program shall include, as appropriate, the following:"

Specific concerns raised:

- 1 (g), (h) are water quantity objectives, not part of the scope of work
- 3 (a) is a water quantity objective, not part of the scope of work
- 6 (a) the Program is an Implementation Plan
- 6 (b) Monitoring systems are in place to evaluate ambient groundwater quality conditions across the basin
- 6 (c) The Plan will be periodically reviewed by the implementation team

Text in the program will be modified:

- Remove statement about contentious discussions in the Executive Summary
- Delete the first sentence on pg 4 under Formation of the GWMA

Groundwater monitoring is summarized on pages 76 and 77 of the program with a more detailed description in documents contained or reference in Volume 3.

The document does not state that regulations will be enhanced, rather there is a recommendation to enhance regulatory and enforcement mechanisms.

The median nitrogen availability was chosen as the most representative way to represent the relative sources of nitrogen in the LYV. The NAA states the reasoning that they chose this scenario.

Recommendations made by commenters are included in Appendix B for inclusion in the program.

Recommendations voted on by the GWAC will not be modified.

From: Bill DeRuyter <viewpoint@bentonrea.com>
Sent: Wednesday, March 27, 2019 3:36 PM
To: Bowen, David (ECY) <dabo461@ECY.WA.GOV>
Subject: letters for GWMA

Hi David
This letter is in regard to the GWMA.

1. Why are the nitrates not specified - if we do not know what specific nitrates we are dealing with how can we fix the problem.

2. It has come to my attention that there are more septic systems per allowed area - there are less acreage used in farming every year. Many pieces of land are split up and sold in smaller lots. People are buying and installing a septic tank. Tanks leach sewage below any root layer and put unusable nitrates in the soil. (So again, let's specify the nitrates).

3. Test wells - make sure that the test wells were installed correctly. I was told that some of these wells were capped off at ground level. Being capped off does not keep contaminated liquid from entering the tube and therefore causing a higher count of nitrates. If these wells were installed at ground level they should be disallowed in the study.

4. If high nitrates are hazardous to the elderly or infants, then what documentation is there that claim this area is the cause for their sickness. I have not heard of any cases of "Blue Baby Syndrome" related to the Lower Yakima Valley.

5. Manure is an "organic" product, it is not a 'waste' product as stated in the GWMA report. It is very useful in farming and has been since farming started. Manure contains many natural forms or micronutrient materials that crops need to grow. Commercial Fertilizer do not contain any organic matter and will seep through the soil faster.

6. Minority Report – Jean Mendoza released this report prior to the release of the final GWMC report. Seems that Jean already knew that she would not like the results. In her report if Jean only wants to put blame on the dairy industry. AGAIN, how can you fix the problem when you don't know who is creating it

Hello,

My name is Dan De Boer and I live in rural Yakima County north of Outlook along with my wife and three kids. After review of the data provided on the Yakima County GWMA website I would like to provide my comments as outlined below for your review and I thank you for your consideration.

Goal and Premise of the GWAC

According to the home page the goal of the GWAC is to address all sources of nitrates. However, it appears that research thus far has been almost exclusively focused on large farming and livestock operations. Prior to imposing regulations on one group, I believe more research needs to be done to discover the proportional impact of all sources so as not to overly burden one group over another without knowing their respect impacts to groundwater nitrates.

Equity

The website mentions the GWAC committee is a community-based group. However, it appears many people living outside the GWMA are being asked to participate and may or may not have a vested interest in the affected areas. I would suggest a higher percentage of the committee be comprised of members who reside in the affected GWMA area so as to more accurately represent their community and neighbors' best interests.

If I'm reading the information correctly the increased regulations being discussed will only impact those living North of the Yakima River. This again doesn't appear to align with the committee's goal of addressing all sources of nitrates. This unfairly burdens those North of the river. Although farmers are general friendly with each other, at the end of the day, they do compete in the same market. Increasing regulations on one side of the river makes those folks less competitive than their friends to the South. I warn the committee to guard against potential conflicts of interest in this regard.

Health & Safety

Having lived in the Lower Valley my whole life I have never heard of a local person suffering the health effects of nitrates in the ground water. I see the committee sent surveys to local health officials asking if they had seen illnesses of the sort but I didn't see any survey results. When will the survey results be posted and will they indicate we have an actual health issue? If we are not going to wait for this data to be collected, why then send out the surveys in the first place?

Science

Deep soil sampling, as outlined in the *Outcomes and Challenges* section, admits that our ability based on the data in making broad observations on the farming operations throughout the GWMA is limited. I also found nothing in this study proving causation between farming practices and ground water nitrates. Yes, farms use nitrogen. And yes, there are nitrates in the ground water. But what scientific evidence links the two? How is nitrogen absorption/uptake from crop growth calculated when calculating the nitrogen cycle in the Lower Valley? Seems like a leap of faith is required to tie farming operations to elevated nitrates in groundwater and no guarantee or proof that changes in farming practices will have a measurable impact to nitrates in groundwater. Farmers and dairymen have already been subject to increasing waste management regulation over the last couple of decades. Is there any scientific evidence that these regulations are having an impact? If not, then perhaps there are other theories that need consideration.

Only 12% of tested wells have indicated an elevated nitrate level and the study admits the sample size was inadequate to draw meaningful conclusions. Is there any historical evidence of what the groundwater nitrate levels have been over the last 50-100 years? It might be a good idea for the committee to overlay historical nitrate levels against farming practices over the same time and the population growth of the area of both livestock and people. If this long term (more than a decade) historic data is not available, perhaps a trend or timeline should be established prior to making broad decisions. On a side note, I find it ironic that the City of Sunnyside recently drilled groundwater wells to service its residents in the middle of an old 40,000 cow feed lot. Has there been any elevated nitrate levels in these wells? Have any public wells been analyzed?

Representation

A couple theories were mentioned in the study as to why community members are unwilling to participate in well testing. Ignorance was the primary theory. What the committee and Department of Ecology should know is that many very educated and intelligent citizens of this Valley have a growing discontent with environmental agencies 'taxation without representation' practices. Farmers have also been unfairly targeted by out-of-state profit seeking environmental groups adding salt to the wounds. Lower Valley citizens are being pushed into corners by increased government regulations – regulations enacted by unelected officials. The more regulations that are imposed, like the ones being discussed currently, the more difficult it will be to get citizens to participate in the process. No amount of education will change this – only logic, reason, and cooperation will.

Final Thoughts

Lastly, I wanted to mention that being a lifelong resident in the Lower Valley I know many of the farmers and dairymen and women impacted by these regulations. I see every day how they responsibly steward their farms, I see them plowing county roads when snow storms hit, I see how they raise their kids and the work ethic and morals they instill, I see how they chip in to help neighbors, I see the community service they provide to their communities, I hear about the taxes they pay and the hundreds of people they employee.... these are good hard working people and the type of people this Valley needs to keep. Let us not draw hasty conclusions with unknown benefits based on incomplete science because we don't like their smell.

Respectfully submitted,
Dan De Boer

Comments on Groundwater Management Area Report

1. Nitrates in the groundwater of the Lower Yakima Valley are a community issue. The report seems to focus mainly on only one area of the community, dairies. The report seems to have a bias against dairies in that there are several mentions of animal nutrients referred to as waste. When manure is properly stored in stockyards, compost areas or lagoons it should be referred to as Nutrient Storage, not Waste. There is one whole section of the report titled Waste Storage Facilities. This section should be edited to be Nutrient Storage Facilities or edited out of the report. All recommendations that refer to nutrients as waste should be deleted because they indicate a lack of understanding on farming process and practices. The word waste was used because of a bias, not an understanding of what needs to be accomplished. If there is going to be bias written in this report it will give a perception that dairies and their nutrients are the source of the contamination in the aquifer. Not only is this completely unacceptable to me, it will lead the community to focus on this as the sole method to mediate the contamination of the aquifer(s). Since the problem of Nitrates in the Aquifer(s) in the Lower Valley were well documented prior to dairy expansion in the late 1980"s and 1990"s mediating the issue by focusing on a narrow portion of the community will not correct the issue over time. There has been livestock husbandry performed in the valley for over 100 years and even to the current time there are approximately twice as many animals raised for beef than there are dairy cattle. This has not been noted in the report and serves to show the bias that the report has in it. Nitrates in the groundwater are a community issue and needs to have a whole community action to correct.
2. A Minority report that has not been reviewed by the Ground Water Advisory Committee has no place in the final report. This Minority Report is simply one person's opinion and should not have any connection to the work that the whole committee did. It is accusatory and is short on fact, long on fiction. It uses snippets of other reports, takes them out of context to arrive at conclusions that were established based on personal belief. This Minority Report has no place in the final document and should be deleted or risk the Main Report losing its credibility on any of its recommendations.
3. Farming Legacy issues should have been a substantial portion of this report. The way farming practices were conducted over the first 70-80 years of the Sunnyside Canal system (and the later Rosa Canal system) may have had a substantial effect on the nitrogen load in the soil of the area the Lower Valley GWMA. Tillage practices, fertilization practices and irrigation practices were such that large amounts of Nitrogen were put in the soil and had the strong potential to be moved to the aquifer with the common use of rill (furrow)

irrigation. It should also be noted that in the last 30 years there have been many technology changes in all three of these practices that should reduce the amount of available nitrogen in the soil and most importantly not continue to move what nitrogen is in the soil to the aquifer. I believe that this legacy issue should be strongly noted in the report and the fact that the recent changes in common farm practices will have a positive effect on the nitrogen loading of the aquifer.

4. Onsite Sewage Systems (OSS) should be controlled by the county and a plan that is required by WAC 246-272A-015(5) should be developed by the Health Department for OSS. I would recommend that any parcel that requests an OSS permit that is less than 20 acres (just under High Density standards) should have an OSS that is designed to reduce the nitrogen flow in its effluent. OSS are designed to return water to the aquifer, in fact a request for an OSS requires that a percolation test be passed proving that the soil for the drain field will indeed return the water to the aquifer, and a conventional OSS does little to treat nitrogen (less than 15% at best). Drain fields on conventional systems are placed below the root zone so there is no uptake of nitrogen from them. The EPA considers more than 40 OSS per square mile (one per 16 acres) to be high density of OSS and a high risk to the aquifer. For many years the EPA considered OSS to be the primary contributor of contaminates to the aquifers of the United States. There are many areas of the United States where there is little to no farming of any sort that have high nitrate concentrations in the aquifers. This should be of great concern to the stakeholders of the Lower Valley GWMA. I also would recommend that as homes are sold in areas that have a high density of OSS that the county should require the update of a conventional OSS to one that does reduce the nitrogen concentrations in the effluent. If all potential sources of nitrogen are not considered then any efforts to reduce nitrogen in the aquifer(s) will fall short.
5. This report should have been written with the average stakeholder of the Lower Valley GWMA in mind. It is too technical in nature and difficult for the average person to comprehend. It has too many tangential issues throughout it that serve to confuse and mislead those who would like to know what the Ground Water Advisory Committee has discussed and concluded over the past 6 1/2 years. It should be written in simple, plain language and if technical issues need to be cited, they should be another section for those who are interested in them, not spread throughout the report. When we are evaluating an aquifer it tends to affect all equally and discussions of ethnicity, education or economic status really have no place in this report and only serve to encourage bias and divisiveness among the stakeholders of the Lower Valley GWMA.

Dan DeGroot

Name: David Newhouse
Address: 700 Wendell Phillips Rd
City: Sunnyside
State: Washington
ZIP: 98944
Email: drnewhouse@usa.net

Draft Lower Yakima Valley Groundwater Management Program

I am very concerned about the placement of the second group of sampling wells. The placement does not appear to be random. It looks as if they are intentionally targeted at family dairy farms. If you chose to only target one potential source, you have predetermined what the results will be

My second point is that a private citizen, that is not a resident of the GWMA should not be allowed to submit a minority statement.

David Newhouse
Sunnyside, WA.

Mr. David Brown, Department of Ecology
1250 W Alder St.
Union Gap WA. 98903-0009

Mr. Brown;

I am writing in regard to GWMA !

I was on that committee as a retired farmer & cattleman. As I watched things progress I came to the conclusion that this was only to prove that Dairymen were responsible for Nitrates in our soil, initiated by Ecology & the Environmentalists, I concluded that even though I am retired & have time to waste I did not want to waste it there.

What is ironic to me is that there has never been a case in Yakima County of anyone reporting that diagnosis ! And no one wants to talk about Bickelton having the highest nitrates in the Valley ! No dairy's & no cows, Explain that ! so we have spent over 2 million & we don't know anything, sounds like a Government program !

A study was done 40 to 50 years ago showing Nitrates in the water, I requested that information, it was never searched for!

You probably do not want this opinion however I decided to send it.

I am an 83 year old Cattleman who was Beef Program Director in 5 States for an A.I. stud, before I purchased a cattle ranch.

Sincerely,

Don Young

RECEIVED
MAR 21 2019
Dept of Ecology
Central Regional Office

Identified Typographical Errors and Clarifications During Review

(These edits will be addressed in the next draft of the plan)

- Add Robert Black, USGS to the list of GWAC Members
- Pg 2, 15, 24 - Replace word effect with affect
- Pg 2, 70 - Point of use treatment systems – clarify, this effort was prior to GWMA formation
- Pg 4 – USGS 2018
- Pg 5 – Missing bullet
- Pg 6 – Volume 4 referenced, edit to Volume 3
- Pg 8 – Volume 4 referenced, edit to Volume 3
- Pg 9 – Clarify a representative for the Yakama Nation was an active participant on the GWAC
- Pg 11 – Add citation to text (Heath, 1983)
- Pg 16 – Add citation to text (Powlson, find year)
- Pg 21 - Number of irrigated ag acres, edit acreage
- Pg 25 – Equation typos, edit equation
- Pg 29 – Check total GWMA acreage, edit acreage ~175,161
- Pg 40 – Correct spelling of Appendix and replace xx with D
- Pg 56 - Yellow highlight, remove yellow & delete last sentence
- Pg 61 - Yellow highlight, remove yellow
- Pg 63 - Remove green highlight
- Pg 65 - SVID – correct lined vs unlined sections
- Pg 82 - Discuss DSS QAPP
- Pg 85 & 86 – Check legends – "Tons Per Acre" or "Tons Per Cell"
- Pg 95 – NRCS Acronym EQIP used. Edit "Environmental Quality Incentives Program"

- Figures
  - Pg 28 – Figure 11 referenced, edit to Figure 12
  - Pg 29 – Figure 5 needs to be discussed in the text
  - Pg 56 – Figure 15 referenced, edit to Figure 16
  - pg 80 – Figure 22 needs to be discussed in the text
  - pg 81 – Figure 23 needs to be discussed in the text
- Tables
  - Pg 61 –Ttable 11 needs to be discussed in the text
- Recommendations
  - Add explanatory text for #6
- References
  - Remove multiple references. Include only references to final documents
  - Consistent formatting – remove double spaces
- Volume 2 - Appendices
  - Pg 3 – Appendix I needs to be discussed in the text

RECEIVED
MAR 27 2019
Dept of Ecology
Central Regional Office

- Pg 3 – Appendix J needs to be discussed in the text
- Pg 35 – add reference for the figure
- Pg 40 – change word "northeastern" to "southeastern"

- Volume 3 - Accomplishments, Add:
  - Public opinion survey results
  - Operating guidelines
  - High risk well survey results
  - Add the link to the USGS drinking water QAPP
  - Add Monitoring Well Information
    - Location
    - Well construction
    - Methodology for siting wells
    - Results of monitor well sampling
- Volume 4 – Member Contributions
  - Rename reference list. Current title appendix J, may confuse with appendix J in Vol. 2
  - Add Minority report(s)

- References needing citation edits or link repairs from original draft document
  - Pg 15 Harter
  - Pg 25 Kellog
  - Pg 35 USGS
  - Pg 42 – Legend in figures 6, 7 and 9 references wrong report. Should be 5152, not 2152
  - Pg 57, 58, 60, 61, 64, 65, 68, – WSDA 2013, edit citation
  - Pg 64 – Sentence regarding 2,874 groundwater rights needs a reference
  - Pg 64 – USGS 2011 which reference? a or b?
  - Pg 101 – Add reference to nitrate treatment pilot program June 2011 to reference list
  - Pg 110 – Reference to EPA 1999 is incorrect. Maybe R-99-002? Rather than 022
  - Pg 110 – Link to EPA 2009 broken, provide updated link
  - Pg 110 – EPA 2010 is also listed as Ecology 2010. This is the preliminary assessment. It has an Ecology publication, reference should be deleted to avoid confusion.
  - Pg 110 – EPA animal waste – link is about nutrient pollution
  - Pg 112 – Two references for the same document Harter et al., 2012a and Harter et al., 2012b. Delete one.
  - Pg 112 – HDR 2013a, attached link is to a memo written by Charlie McKinney. Need correct link
  - Pg 117 – PGG 2018 -- Multiple references and links to what appears to be the same document with slight changes. Need one link to the final document.
  - Pg 119 – Scanlon et al., 2008, listed in text as only Scanlon, 2008. Need to edit.
  - Pg 119 – Scott et al., 2004 is listed in text as only Scott, 2004. Need to edit.
  - Pg 121 – 2 references for USBR 2018. Are they the same or different? Need to clarify.
  - Pg 123 – USGS 1984 broken link.
  - Pg 123 – USGS 1985. Was listed as 1984. Edit references in text to reflect actual year.

- Pg 124 – USGS 1997. Was listed as 1998c. Edit references in text to reflect actual year.
- Pg 129 – State of Vermont 2016 – Text is listed only as (Vermont). Edit citation in text.
- Pg 130 – WDOH 2007b link does not work. Update link
- Pg 130 – Reference for WRCC is incomplete. Provide link or reference details.
- Pg 130 – WSDA, 2010 – Provide link, reference or details.
- Pg 130 – WSDA n.d. – Provide link, reference or details
- Appendices pg 14. Provide date for Richardson citation
- Appendices pg 43 – Provide reference for Foxworthy 1962

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
WASHINGTON OPERATIONS OFFICE
300 Desmond Drive Southeast, Suite 102
Lacey, Washington 98503

March 27, 2019

David Bowen
Washington State Department of Ecology
Central Regional Office
1250 W. Alder Street
Union Gap, Washington 98903-0009

Dear Mr. Bowen:

Thank you for the opportunity to comment on the draft Lower Yakima Valley Groundwater Management Area (GWMA) program. The Lower Yakima Valley Groundwater Advisory Committee (GWAC) was formed in 2012 to develop a program that would achieve the goal of reducing nitrate levels in groundwater, which consistently exceed the United States Environmental Protection Agency's (EPA) health-based drinking water standard of 10 milligrams per liter (mg/L). The GWAC is comprised of representatives from a variety of groups, including local, state, and federal government agencies; local citizens; dairy producers and other farmers, and agronomists; irrigation districts; conservation districts; environmental groups; and other vested parties. An EPA representative has served on the GWAC since its inception in 2012, and I became the primary representative in the fall of 2015.

Developing the GWMA program has been an ambitious project, requiring significant data gathering, complex technical and policy analysis, and a robust stakeholder process. The EPA commends Yakima County, the federal, state, and local agencies, as well as the community members for their commitment and perseverance in developing this draft program. We offer the following comments intended to strengthen the final program to protect public health.

The Washington State Department of Agriculture's report titled "Estimated Nitrogen Available for Transport in the Lower Yakima Valley Groundwater Management Area -- A Study by the Washington State Department of Agriculture and Yakima County," (June 2018) is an integral part of the GWMA program as it estimates nitrogen availability in the geographic area. It is currently presented as a separate document in Volume III, "member contributions." We recommend that its data and information be incorporated directly into the body of the final GWMA plan to ensure transparency.

The EPA continues to believe that the final GWMA plan would be improved by including a more thorough accounting of the sources and amounts of nitrogen in the GWMA by using scientific data from additional sources. The current draft contains information from the important collaborative work carried out by local, state and federal agencies in 2010, "Lower Yakima Valley Groundwater Quality." Data from other scientific studies are also available. Taking advantage of as much quality-assured/quality controlled available data and information as possible would strengthen the foundation of the report, its policy recommendations and most importantly, its ability to protect and improve the safety of drinking water. A few examples to draw upon include:

- United States Geological Survey (USGS): "Particle tracking for selected groundwater wells in the lower Yakima River Basin, Washington," 2015. The USGS assessed nitrate sources in specific geographic areas within the GWMA with groundwater contamination and identified associated likely nitrogen source areas. https://pubs.er.usgs.gov/publication/sir20155149

- The EPA: "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington," 2013 contains soil information such as permeability data from lagoons, and nitrogen concentrations in manured dairy crop fields. https://www.epa.gov/wa/lower-yakima-valley-groundwater

- Since a Consent Order was signed with three Lower Yakima Valley dairies in 2013, these dairies have made great strides in reducing the amount of nitrogen accumulating in their fields. In reports submitted under the EPA Consent Order and approved Quality Assurance Project Plan (QAPP), there are several years of biannual data from fields prior to the AOC-required limitations of field applications of manure and the subsequent transition to the present conditions. These dairies are also providing post-harvest data that can inform soil concentration estimates in the draft GWMA Plan. https://www.epa.gov/wa/lower-yakima-valley-groundwater

These reports contain information on soil permeability, lagoons, and post-harvest deep soil sampling that can contribute to the data in the GWMA program and strengthen its findings.

Uncertainty is inherent in almost every scientific endeavor, especially one of this magnitude and complexity. Considering this, several GWAC members requested that the program include a section that discusses the intrinsic uncertainties in the relevant variables. The EPA appreciates the work to develop this, which is provided in the current draft as a supporting document. Given its importance to understanding the plan, we recommend that it be added to Volume 1, and describe opportunities for additional research to reduce uncertainty.

The EPA also offers a few additional suggestions for the implementation phase of the program. First, it is important to ensure that QAPPs are developed for any new work that includes data collection. The development of sound QAPPs will ensure that the information gathered can be used to make scientifically-defensible decisions.

Second, results from the next steps in the U.S. Geological Survey work listed above could be very useful to implementing the GWMA program. The next phase would be to conduct a reverse-loading analysis based on the 2015 particle tracking study, to estimate how much reduced nitrogen loading would need to occur to decrease nitrate concentrations in downgradient residential wells to meet the drinking water maximum contaminant level. These findings could be used to refine and focus efforts to implement the final GWMA program in the coming years.

As you know, this year, the Washington State Conservation Commission awarded competitive grants for demonstration projects statewide to test various technological approaches to recapture or recycle nutrients, including one in the Yakima Valley. The results of these projects could be useful in the implementation phase and EPA encourages the state and county to consider that information moving forward.

In closing, new information pertaining to both understanding the nature of groundwater contamination and strategies to reduce it will continue to emerge from research, data gathering, and technology demonstration projects nationwide. EPA hopes that you will continue to take advantage of this information in your work to reduce excess nitrogen loading in the Lower Yakima Valley's groundwater.

Thanks for the opportunity to comment.

Sincerely,

Lucy Edmondson, Director
Washington Operations Office

Comments on:

Yakima Valley Groundwater Management Program, dated August 20, 2018

Comments Prepared by: Frank P. Winslow

Comments Dated: February 26, 2018

Statement of Qualifications:

I am a Licensed Professional Geologist (Florida P.G. #2415), and have 31 years of experience in contamination and water resources work. This included 29 years working in environmental consulting as a Senior Hydrogeologist, and almost two years as a Cleanup Site Manager with the Department of Ecology, Toxic Cleanup Program. I have a Bachelor's degree in Geology, and a Master's degree in Environmental Sciences from the Colorado School of Mines. The M.S. studies focused on hydrogeology, water quality, and environmental geochemistry. My work has included studies throughout the United States and Canada, and in the Middle East and South America. One exemplary role was as the Technical Director for the Study of the Water Resources of the Western Coastal Plain of Saudi Arabia, a 23 million dollar study of a 1,800 km long area. That study included the collection of 1,800 groundwater samples, and nitrates proved to be the number one water quality problem within that area.

Nature of the Problem

The problem of nitrates in shallow groundwater is a globally ubiquitous concern. This problem is exacerbated by a traditional separation in managing water into two area; water resources, which has traditional focused on water quantity, and contamination concerns, which are generally separated between point source and non-point source contamination sources. Slowly, the nexus of water quantity of water quality is gaining ground under a new field: Integrated Water Resources Management.

In general, the shallower the water supply well, the greater risk to the well from various sources of contamination (**Figure 1**). The deeper the well, the lower the chance of the aquifer being impacted from point and non-point sources. These principles were summarized within the Lower Yakima Valley Groundwater Quality, Preliminary Assessment and Recommendations Document dated February 2010, as follows:

> *Nitrate-nitrogen concentrations are greatest in shallow groundwater. A significant decrease in nitrate-nitrogen concentrations is found in groundwater samples collected from depths below 300 feet. The highest percentage of samples exceeding state Drinking Water Standards (l0 mg/l nitrate-nitrogen) are obtained from shallow wells (less than 300 feet deep). Most private domestic drinking water wells appear to be shallow wells.*

RECEIVED
MAR 0 1 2019
Dept of Ecology
Central Regional Office

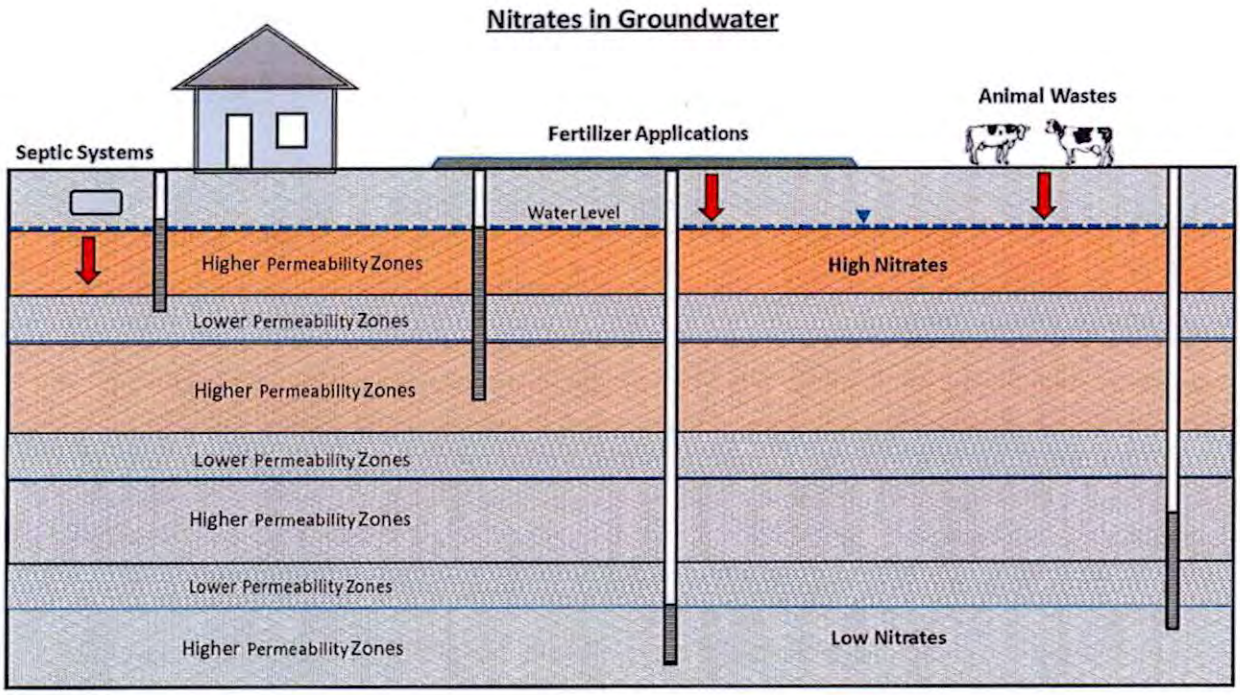


Figure 1: Conceptual Schematic of Distribution of Nitrates in Groundwater

Shallow groundwater is not necessarily easy to define. In assessing individual wells, the top of the well screen or open interval (not total depth of the well) is the critical depth of concern. However, a well that has a total depth of less than 100 feet would have contamination risks much higher than a deeper well. In addition to depth, the number and thickness of lower permeability beds is a critical component of risk to a well. Another factor effecting risk to wells is the potential presence of improperly constructed wells or boring that have breached separating low permeability strata (**Figure 2**). In this case, deeper wells can still have a risk of contamination from surficial releases, especially if there is a downward hydraulic gradient between aquifer zones.

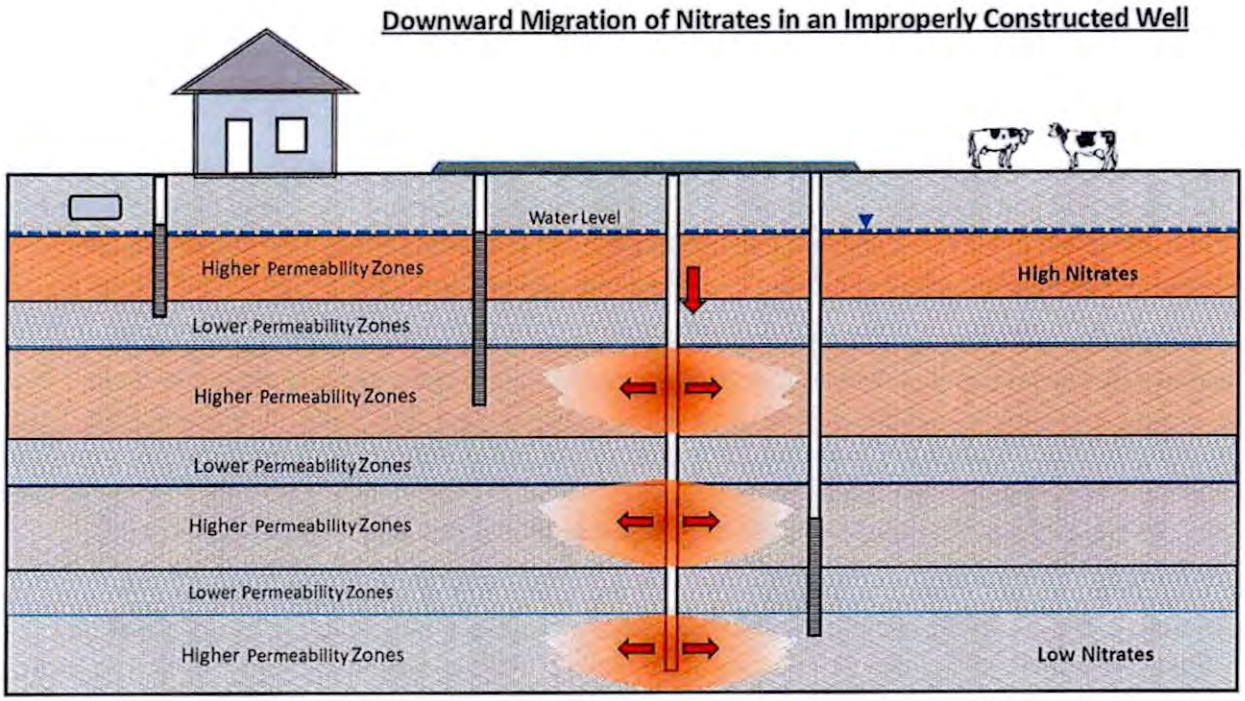


Figure 2: Conceptual Schematic of Downward Migration of Nitrates in an Improperly Constructed Well

Potential Solutions

The program document included the following recommendations:

- *Support the implementation phase of the GWMA*
- *Continue groundwater and soil monitoring*
- *Promote voluntary source reduction strategies for all nitrate sources*
- *Continue education and public outreach strategies for all Lower Yakima Valley residents, including homeowners and farmers*
- *Improve irrigation efficiency*
- *Develop and support research about innovative nitrate reduction strategies*
- *Consider incentives that support nitrate reduction*
- *Explore technology to utilize nutrients as energy*
- *Enhance and streamline regulatory and enforcement mechanisms*
- *Maintain the established GIS database*

The program document also stated:

Implementation

The next phase of the GWMA program is implementation. The GWAC's completed work from the assessment and planning phase provides a solid foundation for this next phase. Within this document are specific recommendations for reducing nitrate concentrations in groundwater.

At one of its final meetings, the GWAC recommended that Yakima County act as lead agency in future Lower Yakima Valley groundwater management.

Implementation of recommendations is subject to future funding.

I strongly disagree with a focus on reducing nitrate concentrations in groundwater. As previously stated, nitrates and other contamination in shallow groundwater systems is a ubiquitous global concern. Implementation of best management practices (BMPs) can reduce the amount of loading to aquifers of various contaminants (including nitrates), but the risk to shallow groundwater system will always exist.

The most critical concern with respect to any contamination concern is to eliminate exposure pathways. Eliminating contamination within the environment is a lofty and admirable goal, but removing exposure mechanisms to both human and ecological receptors is of critical importance. In the case of nitrates in shallow groundwater, the exposure pathway is broken by ensuring that contaminated water is not ingested. Other groundwater pathways may be of concern for other types of contaminants (e.g. shower pathway for volatile constituents); however for nitrates, ingestion is the only critical pathway of concern.

Therefore, the greatest need with respect to nitrates in shallow groundwater is ensuring that no people are drinking this water. This can be accomplished with various mechanisms. In order to clearly differentiate between recommendations pertaining to preventing consumption of contaminated groundwater and other less immediate concerns, I recommend splitting recommendations between those pertaining to eliminating potential exposures and other miscellaneous recommendations. This comment applies to the Recommend Actions section and the Executive Summary. Separating immediate concerns from less immediate concerns is important to ensure that protection of public health is of foremost priority.

The program has an exceptionally high Environmental Justice (EJ), component, as follows:

- Water wells are expensive, and the deeper the well, the more expensive.
- Poor people are less likely to afford a deeper water well.
- Poor people are less likely to afford bottled water.
- Therefore, poor people are more likely to drinking nitrate contaminated shallow groundwater.
- In addition, poor people may be less likely to have a public water supply system in rural areas which would include required water quality testing.

In my opinion, the root problem is not that there are nitrates in shallow groundwater. The root problem is that people think that shallow groundwater is a viable source of water for drinking water purposes. I would submit that it is generally inappropriate for any water wells to be constructed for drinking water purposes less than one hundred feet deep. Water quality concerns with shallow groundwater include nitrates in agricultural area, nitrates and other constituents in areas where septic systems are used, and various contamination sources from point and non-point sources in urban areas. **Very few places do not have a water quality concern with respect to shallow groundwater.**

Recommendations

I believe that public communication is a critical component of the program. If people are aware that their water supply may be contaminated, this might reduce the chance of their ingesting the water. This is particularly true if there are options for alternative drinking water supply. The following are the actions that I would give highest priority:

1. Send a mass mailing to all residents located outside of public water supply service areas within the Lower Yakima Valley. The mailing would explain the problem of nitrates in shallow groundwater, and that it is of particular danger to expecting mothers and infants. The mailing would provide a telephone number for free testing of their well water for nitrates.
2. Assign staff dedicated to collection of water samples from domestic wells for nitrate analysis. The staff should be able to respond to requests to sample within one week of a telephone request. Households with infants or expecting mothers (or women of childbearing age) would be bumped to the top of the list. Shallower wells should be given a higher priority than deeper wells. The sampling staff would maintain a database, including available well construction information.
3. Identify locations for household collection of free drinking water at each community in the Lower Yakima Valley. Once a household water supply well has been tested, the owner or resident would be provided with a document allowing them to pick up free drinking water (a reasonable weekly allotment could be calculated).
4. Begin a grant program for replacement of impacted shallow domestic wells. Such grants could be applied for by homeowners that have a shallow wells with nitrates above cleanup levels. Prioritization of grant recipients should be based on needs of the applicant. A fund for this grant can be contributed to by taxpayers and groundwater polluters. This recommendation would require legislative action.

The collection of nitrate data from domestic wells could substitute for monitoring wells, and provide much more meaningful data in terms of protection of public health than monitoring well data. Collection of additional data, including hydrogeological and water quality data should focus on areas with identified deeper nitrate contamination, with a goal of identifying potential conduits to deeper aquifer zones. Such investigations could use innovative technologies for the detailed characterization of water quality and hydrostratigraphy with depth, in order to better understand inter-aquifer communications and contaminant migration.

Once protection of public health has been ensured (i.e. no ingestion of nitrates in shallow groundwater is taking place), then, and only then, other recommendations can be given priority. These other recommendations should be prioritized. For example "Explore technology to utilize nutrients as energy" is a recommendation that would not have a high priority in terms of protecting public health and the environment.



March 27, 2019

To the WA State Dept. of Ecology:

Please accept and consider the following comments from the Friends of Toppenish Creek regarding the 2018 Lower Yakima Valley Groundwater Management Area (LYV GWMA) plan and report

FOTC is a 501 (C) 3 non-profit group based in the LYV with a mission:

> *FOTC is dedicated to protecting the rights of rural communities and improving oversight of industrial agriculture. FOTC operates under the simple principle that all people deserve clean air, clean water and protection from abuse that results when profit is favored over people. FOTC works through public education, citizen investigations, research, legislation, special events, and direct action.*

We have actively served on the GWMA advisory committee for the past six years and have done our best to support science and common sense while protecting the environment and the people who live in the LYV. We have been especially mindful of the children under the age of 18 who make up 35% of the LYV population, have no voice. These children and their children will pay the price for today's pollution.

FOTC raises valid concerns and asks pertinent questions in the pages that follow. We respectfully ask for serious answers before Ecology certifies the GWMA report and plan.

Sincerely,

Jean Mendoza

Jean Mendoza

Executive Director, Friends of Toppenish Creek

Comments – Lower Yakima Valley Groundwater Management Area

1. People who live in the Lower Yakima Valley (LYV) most likely spend a million dollars per year purchasing bottled water because the people who were supposed to protect the aquifer failed to do their job. This is a million dollar per year hidden tax.

In spite of lip service regarding the need for safe drinking water the LYV GWMA provided zero relief to the people whose health is threatened. On the contrary the GWMA has not confronted the polluters or the careless regulators, but has cruelly launched a public information campaign that transfers responsibility to home owners and renters. The GWMA solution merely instructs people to test their well water at a cost of $30 to $40 per test, another hidden tax.

The only alternative solution that comes close to addressing safe drinking water is # 44 that asks Yakima County to:

> *Perform an engineering study of water supply alternatives*

There is no reference to funding that would support such an endeavor. Yakima County does not have the resources to do this on our own. Incidentally, in 2015 the County returned $150,000 of state money designated for domestic water treatments. This demonstrates a lack of concern on the part of elected official who are presumed to represent the public.

Washington laws that declare citizens' rights to clean drinking water include RCW 90.48.010, RCW 90.48.040, RCW 90.48.240, and RCW 90.48.260.

2. Alternative Solution # 41 requires:

> *Identify and support opportunities, including education research institutions for private, public and industry investment in technology and management of fertilizers and manures, including separation of solid and liquid wastes. (17 – WSDA)*
> *WSDA construct GWMA administrative program.*

The WSDA lacks the expertise required to construct an administrative program. In addition WSDA lacks the knowledge of human health issues that form the core rationale for groundwater management.

In 2014-2015 the WSDA insisted upon performing a Nitrogen Loading Assessment for the GWMA at a cost of $58,000. The project was delivered 18 months behind schedule thus delaying completion of the GWMA program. The NLA/NAA (Nitrogen Availability Assessment) is extremely flawed, did not comply with the scope of work for the project and has never been approved by the GWMA advisory committee.

A. The WSDA did not bring together focus groups of farmers to share their fertilizing practices as promised. Instead WSDA relied on the opinions of a few anonymous experts. For example, one man spoke for 5,000 acres of alfalfa. (See Attachment 1) Who is this man?

B. The WSDA omitted nitrogen from 536 acres of composting in their NAA. Composting is an acknowledged and significant source of nitrate pollution.

C. The WSDA estimated that apple growers apply, on average, 60 lbs per acre of nitrogen to their land at the beginning of the season and end up with an average of 90 lbs of nitrogen per acre at the end of the season. (See Attachment 2). How does this make any sense at all?

Now WSDA appears poised to perform a follow up Nitrogen Loading Assessment for a million dollars (Alternative Solution # 52) and to construct a follow up GWMA administrative program for $10 million. The WSDA has not acted in good faith during the six-year GWMA program and there is no evidence that this will change in the future.

3. The GWMA Report and Plan is scientifically indefensible and violates principles of ethical research by omitting the overwhelming data from the LYV "dairy cluster".

The GWMA target area covers about 271 square miles in the Lower Yakima Valley (LYV). The GWMA report states that 12% to 20% of domestic wells in the area have nitrate levels above the safe standard of 10 mg/L.

The report omits the fact that 61% of domestic wells one mile down gradient from the "dairy cluster" exceed the standard, or that monitoring wells on the "dairy cluster" have nitrate levels over 100 mg/L. This is significant. It is the most compelling data gathered from the GWMA target area and the GWMA report pretends it does not exist.

4. The GWMA report underestimates the amount of atmospheric nitrogen deposition by a factor of at least five.

The GWMA report estimates nitrogen deposition at 2.05 lbs per acre. WSDA states that the data was hard to access.

James Davenport, the GWMA advisor who gathered cost data for discussion of proposed solutions told the advisory committee that estimating emissions from animal agriculture, fertilizer and manure applications is not feasible because the Yakima Regional Clean Air Agency is unwilling to do this. The YRCAA has said they were never asked. Mr. Davenport advised the GWMA advisory committee that such a project would be "big and expensive". (See page 223/226 of GWMA Plan Appendix II)

In fact the work is already being done at Washington State University. See WSU AIRPACT-V at http://lar.wsu.edu/airpact/monthly_depo_ap5.php#

WSU scientists, using the best, most current models, calculate atmospheric deposition in the LYV of about one lb of nitrogen per acre per month for most of the year and over 2 lbs of nitrogen per month for the months August, September and October. This equates to at least five times the amount of atmospheric deposition in the GWMA NAA.

5. Yakima County may not have the capacity/expertise/willingness to administer a robust follow up GWMA program. Yakima County has failed to keep many promises to the advisory committee and to the public over the past six years.

A. At the beginning Yakima County hired a hydrogeologist to oversee the GWMA project. Then, in 2015, Yakima County replaced him with an attorney.
B. The County scheduled no GWMA discussions to develop programs that help impacted people access safe drinking water. At this point in time the only program to help the people is the Clean Drinking Water Project administered by the Community Association for Restoration of the Environment (CARE) and the Friends of Toppenish Creek (FOTC) with funds obtained through litigation.
C. In June of 2014 the GWMA advisory committee approved a Deep Soil Sampling plan with costs not to exceed $245,025. In August of 2014 Yakima County signed a contract for Deep Soil Sampling at a cost of $394,563, an unauthorized increase of nearly $150,000.
D. Yakima County contracted to evaluate the nitrogen contributions from bio-solids in the LYV. The County did not do this and simply ignores requests for that study.
E. Yakima County contracted with the Yakima Health District to perform a survey of LYV domestic wells. The surveys were not completed but the YHD received payment anyway.
F. The GWMA collected data through Deep Soil Sampling in 2014 – 2016 and sampling of 156 domestic wells in 2017. The data was never analyzed and the GWMA simply proceeded without discussing the implications.
G. In 2012 the GWMA advisory committee agreed to form a work group to address *Funding*. That work group was not convened until 2017 and only met three times.
H. The GWMA failed to inform and engage the large community of Spanish speakers in the LYV. The only outreach was a campaign telling people to test their wells and buy bottled water. Outreach to inform non-English speakers about the GWMA discussions is non-existent.
I. At this point in time there is an impressive, interactive GIS map on Yakima County's GWMA website. The data in that map is highly inaccurate. For example, the map states that there is no leaching of nitrogen from alfalfa fields. GWMA DSS data shows

the exact opposite. Many of the fields with the highest levels of nitrate were planted in alfalfa and had been for years.

6. The GWMA report does not comply with the legal mandates for groundwater management programs in RCW 90.44 and WAC 173-100. Legal requirements for a GWMA that are missing from the LYV GWMA plan include:

A. RCW 90.44.410 (1) The groundwater area or sub-area management programs shall include:

(b) A management program based on long-term monitoring and resource management objectives for the area or sub-area;

(d) Projection of water supply needs for existing and future identified user groups and beneficial uses;

(h) Identification of water quality objectives for the aquifer system which recognize existing and future uses of the aquifer and that are in accordance with department of ecology and department of social and health services drinking and surface water quality standards;

(j) Annual withdrawal rates and safe yield guidelines which are directed by the long-term management programs that recognize annual variations in aquifer recharge;

(k) A description of conditions and potential conflicts and identification of a program to resolve conflicts with existing water rights;

(m) A process for the periodic review of the groundwater management program and monitoring of the implementation of the program.

B. WAC 173-100-100 The program for each groundwater management area will be tailored to the specific conditions of the area. The following guidelines on program content are intended to serve as a general framework for the program, to be adapted to the particular needs of each area. Each program shall include, as appropriate, the following:

(1) An area characterization section comprised of:

(g) Estimates of the historical and current rates of groundwater use and purposes of such use within the area;

(h) Projections of groundwater supply needs and rates of withdrawal based upon alternative population and land use projections;

(3) A section identifying water quantity and quality goals and objectives for the area which (a) recognize existing and future uses of the aquifer, (b) are in accordance with water quality standards of the department, the department of social and health services, and the federal environmental protection agency, and (c) recognize annual variations in aquifer recharge and other significant hydrogeologic factors;

(6) An implementation section comprised of:

(a) A detailed work plan for implementing each aspect of the groundwater management strategies as presented in the recommendations section. For each recommended management action, the parties responsible for initiating the action and a schedule for implementation shall be identified. Where possible, the implementation plan should include specifically worded statements such as model ordinances, recommended governmental policy statements, interagency agreements, proposed legislative changes, and proposed amendments to local comprehensive plans, coordinated water system plans, basin management programs, and others as appropriate;

(b) A monitoring system for evaluating the effectiveness of the program;

(c) A process for the periodic review and revision of the groundwater management program.

7. Alternative Solution #25 is to

Streamline current regulatory enforcement activities.
Improve customer service and protocols, increase clarity of process, escalate enforcement for facilities not following management practices, identify methods to discourage repeatedly unfounded complaints, and improve overall transparency.

This is so vaguely worded that it is meaningless.

8. Alternative Solution # 32 is to

Adopt and Implement an Adaptive Management Plan.
Utilizing data collected, progress made, or lack of progress, to inform the community on adjustments that need to be implemented. Plan would incorporate necessary adjustments to availability of technology, education and outreach, tracking exports,

land use regulations, treatment systems, and other changes to inform decision makers regarding management changes necessary for a successful Program.

This is so vaguely worded that it is meaningless. This is like saying we need a floor plan for a house without saying whether it is a $50 cabin or a $1 million castle, whether it is one or three stories, whether it is wood or concrete construction, whether there is indoor plumbing or not.

The GWMA has not discussed what an Adaptive Management Plan would look like. It is a popular buzz word with many interpretations. Thinking people need more clarity before voicing support or rejection for this particular solution. Effective Adaptive Management Plans are complex.

There is no reference to funding that would support such an endeavor. The Alternative Solution requires Yakima County to create an Adaptive Management Plan and the County does not have the resources to do this on our own.

10. Where is the plan for analyzing the well samples from the thirty LYV monitoring wells?

    A. How often will sampling be done?

    B. Will it be passive or active sampling?

    C. What is the relationship between individual wells and nitrogen sources?

    D. What hypotheses are we testing?

    E. Which statistical tests will we use for trend analysis?

    F. How will the monitoring "address effects of changes in nutrient application over the agricultural cycle" as described in Alternative Solution #2?

    G. How will the monitoring "track whether time-based performance objectives are being met" as described in Alternative Solution #2

    H. What are the GWMA approved "time based performance objectives"?

RECEIVED
MAR 25 2019
Dept of Ecology
Central Regional Office

- What are the plans for onsight septic system.

- When dairy's buy land it usually test high but as we farm it we Lower the nitrogen Levels.

- The parts of the report that where put in by a person who has a one sided point of view should be removed.

- Why isn't there any test wells near urban growth area's. When there should be.

- What Kind of help or protection are you providing

Jason Bollinger

3-25-19

Comments on Groundwater Management Area

1. The report is lacking enough of the farming legacy issue of nitrate buildup in the soil. The majority of the farming in the Yakima Valley when irrigation started was by rill or furrow irrigation. This method saturated the soil and caused 30-50% of the nitrogen applied to the surface to leach past the root zone. Crops such as mint, sugar beets, and potatoes that required high amounts of nitrogen were grown in the area. Nitrogen as commercial fertilizer was cheap and applied at heavy rates, from 600 lbs per acre up to 1000 lbs per acre with removal rates of the crops not nearly that high. Farmers were taught as little as 20 years ago to apply 1 lb of nitrogen per bushel corn yield expected. Easily 300+ lbs in our fertile valley. Now that same crop of corn can be raised for less 2/3 that rate and sometimes higher yields. We have purchased new fields that have been farmed and taken soil samples up to 6' deep and found extremely high nitrogen soil tests below the root zone, often in fields that have not had manure applied ever or in recent times (15 years or more). This nitrogen has been there for some time and not recently applied.

2. The GWMA needs to focus on a voluntary and educational approach for all involved parties to help lower the nitrates in the groundwater. This needs to be a community effort that looks forward and makes changes now that can affect what happens years in the future. Finger pointing and only focusing on one aspect of the area, like dairy farms, will not address the widespread issues that need to be changed. The bias towards dairy farms in this report will lead to disappointing results of not addressing all factors resulting in high nitrates in groundwater.

3. The minority report that was written before a final GWAC report was even finished or approved is out of context and very targeted. How can someone even write a minority report before the main report is even finished?

4. Manure is referred to as waste numerous times in the GWMA report. Manure is a useful fertilizer that is used to grow crops and add organic matter and micronutrients to the soil. Higher organic matter has been proven to retain water better and help in drought years and to hold nutrients in the root zone for crops. Commercial fertilizer does not have these qualities.

5. Through the 6+ years of the GWAC work, I have not heard of any cases of blue baby syndrome or other documented nitrate related illnesses in the Yakima Valley. In fact, many studies are showing that high nitrates foods might be healthy for you.

6. The GWAC spent almost 2 years discussing 30 possible test well sites of which were approved. 20 of those wells were funded and drilled. Then in less than 30 days, 11 additional wells that were not approved by the GWAC were funded, sited, and drilled without any communication at all to the GWAC. In 6+ years of being on this GWAC, there has always been numerous emails about every issue. It amazes me that there was no communication at all about the additional wells. Nothing. It's actually quite suspicious since 9 out of 11 of these wells are within 1 mile of

dairy farms. Once again, this shows the targeting of dairy farms and the lack of a holistic approach to solving high nitrates in the groundwater.

7. On site septic systems have not had enough focus or education in this report. The concentration of OSS is increasing with no rules or regulations by Yakima County. OSS is designed to leach all nitrogen to the groundwater. A real threat as the number and concentration of OSS continues to increase in Yakima County.

8. Department of Ecology needs to provide more protection from third party lawsuits for those dairy farmers that have a NPDES CAFO permit and are in compliance with the permit. Spending money on lawyers to defend yourself as a dairy farmer when you are in compliance with the law is targeting. This needs to end

James H. Davenport

Attorney at Law
JHDavenport, LLC

P.O. Box 297
Buena, WA 98921
(509) 969-2141

Washington State Bar # 7879

jhdavenportllc@gmail.com

March 11, 2019

RECEIVED
MAR 11 2019
Dept of Ecology
Central Regional Office

David Bowen
Department of Ecology
Central Regional Office
1250 W. Alder St.
Union Gap, Wash., 98903-0009.

Re: Written submission in connection with March 12 hearing on Lower Yakima Valley Groundwater Management Area Program

Dear David,

I submit this comment today not in the capacity of my prior contracted assistance to Yakima County in the performance of its role as lead agency in the near six-year process of the Lower Yakima Valley Groundwater Advisory Committee, but rather in the capacity of a private citizen resident of the Lower Yakima Valley which is the subject of the Advisory Committee's inquiry. I am no longer contracted to Yakima County in the former capacity.

I write today in order to make the few following observations, none of which, I hope, are inconsistent with the Washington State departments of Ecology's, Agriculture's or Conservation Commission's, or Yakima County's successful implementation of the GWAC's numerous recommendations, to wit:

1. Use of the community consultation model for developing solutions to environmental contamination problems is only helpful to the extent that it broadly and proportionately represents the affected community.

2. Duly authorized governmental agencies and duly elected public officers are charged with a public duty to execute those rules and regulations currently in effect, and exercise those powers with which they are currently authorized, notwithstanding that they are not recommended by public interest groups.

3. Neither the final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program, nor the recommendations contained therein, are limiting upon the choices available to the public at large or governmental agencies with relevant jurisdiction.

4. The Departments of Ecology, Agriculture and Conservation Commission, as well as Yakima County, the Yakima County Health District and the Southern Yakima Conservation District should not regard the investigation of groundwater contamination in the Lower Yakima Valley as a *fait accompli*, but rather as a *fait ab initio*.

5. Information not provided to the GWAC but obtainable from the Washington State Department of Agriculture should be analyzed:

a. Growth in agricultural use intensity (density/acre, acreage farmed, production volume)
b. Amount of chemical fertilizer sold or used within GWMA
c. Report of dairy nutrient management plan information on distribution of manure (see RCW 90.64.026(3), RCW 42.56.270(7), WAC 16-06-210(29))
d. Nitrogen Loading Assessment (as distinguished from Nitrogen Availability Assessment, see: June 19, 2014, August 21, 2014, October 16, 2014, and December 18, 2014 GWAC meeting summaries; Yakima County/Department of Agriculture Interagency Agreement

6. Information not provided to the GWAC but obtainable from the Department of Ecology should be analyzed:

a. Report on enforcement of RCW groundwater standards
b. Report on effect of large scale water usage on groundwater quality

7. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does recommend the collection of data from the Ambient Groundwater Monitoring Well system. The Groundwater Monitoring Well system should:

a. Maintain a longitudinal record of measurements taken from groundwater monitoring wells so as to document trends in improvement or worsening of the present condition.
b. Map the "horizon" of analysis of monitoring well measurements from the groundwater monitoring well system (an undulating plane established by points (elevations) at each monitoring well, with the intervening spaces being calculated with reference to influence from proximate point data) should be mapped. This might indicate how the measured horizon intersects with the geologic regimes already known (theoretically) to exist within the study area.
c. Introduce some sort of non-pollutive tracer in selected monitorin wells in order to ascertain whether that tracer expresses itself in other monitoring wells. This may be possible due to the density and location of monitoring wells within the study area. This may provide information helpful in establishing direction of groundwater flow (albeit at a rather surficial elevation).

8. Neither the final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program, nor the recommendations contained therein, identify the means by which to determine the effectiveness of recommended educational or "best management practices" strategies. These should be identified and implemented ("ambient groundwater monitoring" will not accomplish this).

9. Neither the final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program, nor the recommendations contained therein, identify or analyze information about the amount of chemical fertilizers sold or distributed to managers of orchards and crops, or applied to orchards and crops within the study area. This information should be collected and analyzed.

10. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not reflect the often-expressed view/opinion within the Advisory Committee that there exists a "legacy" of groundwater contamination within the Lower Yakima Valley due to the length of agricultural activity which has occurred there. Historic data pertaining to the amount of agricultural production, classified by crop variety (measured in volume, economic value or other metric), acreage farmed, and percentage of farmed acreage property actually under tillage, should assembled and compared against current data of like kind in order to establish trends in agricultural density and use.

11. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not reflect the often-expressed view/opinion within the Advisory Committee that the effect of groundwater contamination in the Lower Yakima Valley influences the lives and health of human demographic groups disproportionately. Nor does it study or describe the socioeconomic effect of groundwater contamination within the study area upon on future generations. Both effects should be studied.

12. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not correlate the economic benefit derived from the private small industrial, agricultural, urban/suburban residential sector sources' activity within the study area with the economic costs likely to be incurred by the public remedial, corrective, educational, or regulatory activities responding to the problem, nor does it quantify the economic value of the natural resource (groundwater) consumed through contamination (an unmeasured and undocumented expense incurred as part of the private small industrial, agricultural, and urban/suburban residential sectors' entrepreneurial enterprise). This relationship should be studied in order to determine correlate costs of remediation, if any, with the economic benefits of groundwater consumption.

13. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not evaluate the causal relationship, if any, between the method and volumes of water applied to the ground surface (either generally or at specifically identifiable locations, or the volume of groundwater stored within the ground, within the studied area, and the extent, location or degree of groundwater contamination within the studied area or at specific contaminated wells. This correlation, if any, should be studied.

14. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not evaluate the correlation, if any, of the location, volume or movement of surface water within lined or unlined artificial conveyance systems (irrigation canals) with the extent, location or degree of groundwater contamination within the studied area. This correlation, if any, should be studied.

15. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not correlate changes in concentration, density, intensity, or use of source-related activities within the studied area with changes, if any, in the extent, location or degree of groundwater contamination within the studied area. This correlation should be studied.

16. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not analyze specific deep soil sampling data collected from known locations. More deep-soil sampling data should be collected, with data collection sites located, and that data analyzed.

17. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not analyze trends in well data from Valley Institute for Research and Education Report (2002), Nitrate Pilot Project Well Samples, LVYGWMA High Risk Well Assessment Well Samples, and USGS 2017 Well Testing Data. Trends in this data should be analyzed.

18. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not identify plausible hypotheses of causation, transmission, or accumulation of contaminant between categorical sources and contamination events or locations. These hypotheses should be stated and explored.

19. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not describe the processes of hydrogeologic or chemical transmission or accumulation of contaminant in the area of contamination. These processes should be more completely explored and described.

20. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not investigate or analyze the geologic and hydrogeologic properties of denser locations of contaminated wells ("hotspots). These should be investigated and analyzed.

21. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not investigate or analyze the plausible causal relationship between specifically identifiable sources and specific contamination events. These should be investigated and analyzed.

22. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not explore the correlation, if any, between specific land use types and proximate water supply contamination events. This potential correlation should be explored.

23. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not address the specific land use regulations, or other regulation types, that might used rectify, ameliorate or otherwise alter the general or specific contamination condition within the study area. These should be explored and analyzed.

24. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not address the effect of generic or specific sources on the protection of areas with "critical recharging effect on aquifers used for potable water or areas where a drinking aquifer is vulnerable to contamination that would affect the potability of the water" as designated by

Yakima County pursuant to the Growth Management Act or otherwise (RCW 36.70A; WAC 365-190-030 (3); and YCC 16A, 16C), as "environmentally sensitive or special areas" as contemplated by WAC 197-11-330(2)(e)(i), WAC 197-11-305 (1)(a), WAC 197-11-908(1)(b) and the Growth Management Act. These effects should be described and analyzed.

25. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not explore the strategy of taxation on the use or sale of materials containing chemical constituents common to known constituents of groundwater contamination as a means of source reduction. This strategy should be considered.

26. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not explore the strategy of usage limitations, imposed through land use regulation, on the nature, density, or intensity of use (analogous to limitations on industrial development). This strategy should be considered.

27. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not recommend any remedial action. Remedial actions should be studied.

28. The final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program does not evaluate the costs or implications of inaction. These should be evaluated.

The purpose of this letter is <u>not</u> criticism. This is not an easy problem. I make these comments with the hope that they will lead to improvement of the quality of the environment in which I live. Thank you for the opportunity to provide comment on this important project.

Best regards,

James H. Davenport

Groundwater Management Comments:

1. Initially, GWMA was started as a means of a protection against health issues from high nitrates. However, there have been no reported cases linked to high nitrates which begs the question, why are we "protecting" people from an issue that does not exist? GWMA has now turned into an information hack of dairy farms and a way to place blame on the dairy industry for high nitrates with no evidence to back up that claim.

2. Nitrates have been found to be sporadic in their location. The original well testing from domestic wells indicated no clear evidence as to where nitrates will be found and why. Monitoring wells were supposed to be a step forward in data collection to determine BMPs. The first 20 wells were more random in location and approved by GWMA but the last 11 were not approved; hardly communicated and 9 of them seem to have targeted dairy farms in their extreme close proximity to the farms. There have been numerous problems with the chosen locations of many of these wells. They have been put next to anomalies and large bodies of moving water. The wells in these locations will not prove to be solid evidence as it will throw off an accurate nitrate sample. If these wells are not for determining BMPs, why were they installed? Information collected from these wells also need to be examined as to the cause of the nitrates. Are they from animals, humans or man-made fertilizers?

3. On site septic systems have not been given enough research or monitoring. On site septic systems are designed to leach all of their nitrogen into groundwater while dairy farm's lagoons have been built to government specifications and are NOT designed to leach anything. Dairy lagoons are inspected yearly as well as the land that is farmed by the dairies to ensure no leaching of nitrogen has occurred.

4. Farming practices have made great strides using available nutrients to improve our land, our crops and our future. These strides have eliminated the farming practices of the past but we still deal with the farming practices of the past's legacy. Legacy nitrates are in the ground and has more than likely contributed to the high nitrate issues. Our farming practices of today are helping to resolve these issues by pulling the nitrates out of the ground. It would be a great step forward if farmers were acknowledged for their clean-up efforts rather than only being blamed.

5. The minority report is a biased, premeditated report that has no scientific or factual back-up. How can that information be considered when it was written as a complete ploy against dairy farming before a main report had been concluded? We ask that the minority report not be included because of this bias.

6. If dairy farms are going to be targeted without evidence of their part in this issue, the actual issue cannot be resolved and the studies will provide unsatisfactory results that in turn will leave this issue at large. There are many more factors to consider in this matter that are being ignored because activist groups have placed dairy farming in the spot light due to their agenda against dairy farming.

7. A huge part of being a farmer is being stewards of the land. History has proven that farmers are constantly evolving and have met the large demands placed on them, especially in recent years. What could be more sustainable than using cow manure as fertilizer to grow feed for our animals? Cow manure adds organic material to our soil which, in turn, helps our soil to retain water better, retain nutrients for crops better and improve soil quality all around. Commercial fertilizer has not proven to be as effective in these ways.

(1) We recommend you don't use information on These substandard monitering wells

(2) I believe That as a dairy farmer That we have made all our land more fertile and more valuable. I believe we have been unfairly judged We are a Target

(3) Jean Mendoza shouldn't be ~~to~~ let in The process she is to one sided

RECEIVED
MAR 25 2019
Dept of Ecology
Central Regional Office

John Koopmans
3010 Twin Lane
Ellah Wa 98953
3-25-19

From: Bowen, David (ECY) [mailto:dabo461@ECY.WA.GOV]
Sent: Thursday, April 4, 2019 9:48 AM
To: Lisa Freund <lisa.freund@co.yakima.wa.us>; David Haws <davidh@co.yakima.wa.us>
Subject: FW: Draft Lower Yakima Valley Groundwater Management Program comment

From: noreply@smartcomment.com <noreply@smartcomment.com>
Sent: Wednesday, March 27, 2019 3:43 PM
To: jkdairy2003@gmail.com
Subject: Draft Lower Yakima Valley Groundwater Management Program comment

Thank you for your comments on the Draft Lower Yakima Valley Groundwater Management Program. Your comments have been received.

Name: Karen Sheehan
Address: 1641 Harrison Road
City: Sunnyside
State: Washington
ZIP: 98944
Email: jkdairy2003@gmail.com

Draft Lower Yakima Valley Groundwater Management Program

The GWMA report is focused too much on dairy and not enough on the rest of agriculture including hops, mint, row crops, tree fruit, grapes, etc. Dairy farmers are the only part of agriculture that is required to take annual soil samples and have a written nutrient management plan plus have inspections. The rest of agriculture can farm as they please with no oversight or required plans. Dairy is already the most regulated for nutrients. Manure is referred to as waste rather than the valuable organic product that it is with nitrogen, phosphorus, potassium and many other micro nutrients. Manure should not be mentioned as waste in the GWMA report. Septic systems should be looked into more closely with both proper maintenance and also density of septic systems. There is also a legacy issue with nitrates in this area that needs more attention. The whole GWMA area needs to work together and look hard at all areas if they expect to lower the nitrates in our groundwater. Voluntary and education is the best way to fix this problem.

- I would like to see all ~~the~~ 32 of the test wells be tested for weather the nitrates are coming from Human waste or from animals & ~~for~~ commercial fertilizer.

- I feel that the BMPs need to be voluntary, because as a dairy farm is already has earthen lagoons designed by NRCS and if you want to see them get lined there needs to be some kind of cost share for that.

- all 32 wells are ground level and are open to contamination. I would like to see all of them be at least 2 feet of above ground level.

- I also think there should be a few wells around the town of outlook to determine weather ~~it is~~ the nitrates are coming from People or agriculture.

- Jean Mendoza's 400 page Report needs to be thrown out.
- If there is no wells in the urban Growth area's around towns there needs to be.

Markus Rollinger
3/28/19

RECEIVED
MAR 25 2019
Dept of Ecology
Central Regional Office

Norm Peck (03/01/2019): Thank you for the opportunity to comment.

The Lower Yakima Groundwater Management Area Committee should be complimented on the thoroughness of the Draft Plan; obviously a lot of quality work on this controversial topic has been completed by a wide range of stakeholders.

In addition to randomly placed monitoring wells, consideration should be given to more intensive targeted monitoring at and around "hot spots" as changes in N concentrations (improvements and further degradation) will be particularly important in those areas.

Because of potential negative effects on fish and fish habitat, ammonia (NH3) should be investigated in irrigation return flows to surface waters. Arid area waters tend to be more alkaline than those in wetter areas, and NH3 toxicity to aquatic organisms increases as pH increases. (EPA Quality Criteria for Water, 1986 as updated). If initial investigations do not indicate a problem, no further monitoring should be required.

Consideration should be given to supplemental funding to include nitrogen analysis of groundwater samples from Superfund/MTCA site monitoring wells within the study area. This would potentially increase the number of available data points within the study area at a very modest increase in cost.

Formation of rural PUD Water Districts should be considered among the options for replacement water supplies, particularly in "hot spots" within the GMA.
Incorporation of recirculating sand filters in areas where high density of ROSS should be considered as one option to reduce N concentrations in OSS discharges.

Use of radio educational information on Spanish-language radio stations has been identified as an effective outreach tool to those for whom Spanish is a language used in households in the Yakima Valley. I have been told that many workers who are fluent in Spanish listen to Spanish-language radio at work and while traveling as well as in the home.

Name: Patricia Newhouse
Address: 700 Wendell Phillips Road
City: Sunnyside
State: Washington
ZIP: 98944
Email: plnewhouse@gmail.com

Draft Lower Yakima Valley Groundwater Management Program

I have two major concerns at this point in the process.
First, I do not believe that a private citizen who does not live in the GWMA area should be allowed to submit a minority report that will be attached to the GWAC recommendations.
Second, I am concerned about the placement of the second group of monitoring wells. Even if they were randomly selected, the fact that 9 of the 11 additional wells are in close proximity to dairy farms will skew the results and should have been a disqualifying factor for many of these locations.

3-25-2019

I feel that dairys have been really targeted. yes there is nitrates in the water. How are we gonna find the Source? It is easy to point a finger at a farmer that is Spreading his cow manure because it stinks. there is So Many other Sources. So much white and liquid feterlizer that has been used for decades. Are we Supposed to take the blame for past farmly practices?

we bought numerous parcels of ground that had high levels of nitrogen. We get monitered heavily. we double crop. I can't explain well enough how much grand we have cleaned up.

what about ALL the Sub divisions in the valley? what happened to big open farm ground. All these house taking up valueable farms. the All have Septics. I hear way to many per Section then there Should be.

Our farming cuminty is afraid to Speak up because we Always get targeted. I Agree we need clean water, but figure out where to problem is coming from. don't point the easy finger.

RECEIVED
MAR 25 2019
Dept of Ecology
Central Regional Office

RECEIVED
MAR 2 1 2019
Dept of Ecology
Central Regional Office

March 18,2019

Mr. David Brown
Section Manager
Department of Ecology
1250 W Alder St
Union Gap, WA 98903-0009

Dear Mr. Brown,

I writing to comment on the draft Lower Yakima Valley Ground Water Management Program. I live in Prosser and attended the public hearing in Sunnyside. I served as the extension soil scientist with WSU at the Irrigated Agriculture Research and Extension Center at Prosser from 1985 to 2009. I worked extensively in the area of nutrient and irrigation management. I was also active in the Columbia Basin GWMA.

In reviewing the draft plan I am especially concerned about the presentation of the deep soil sampling data. If this data is to become a permit part of the record, I believe some additional editing needs to be done on both reports. This is especially true in Ms. Mendoza's summary. The units on the tables and grafts are very confusing. Soil test nitrate is reported as nitrogen as nitrate (nitrate-N). Ms. Mendoza uses a number of units such as NO_3-N, N lbs/acre, lbs NO_3 per acre. The units in the tables and figures should be consistent and an explanation of how they were reached should be presented.

I agree with both summaries that only limited conclusions can be drawn from this data set. The Washington hop commission funded a WSU, three year, deep sampling to 6 ft. in 23 hop yards from 1990-1992. This study showed the variability between spring and fall sampling and explained some of the reasons why this happens. It also demonstrated how variable management practice can effect soil test nitrate over time.

Ms. Mendoza points out that higher soil test nitrate levels were seen with double cropping with triticale following corn. Double cropping, ie a winter cover crop, was

designed to take up residual nitrate left in the soil after harvest especially in hops and then corn. Over time the addition of nitrogen to the triticale crop with out recognition of residual soil nitrogen following corn has lead to excess nitrogen addition to the two crops.

The noted range in deep soil test nitrate in alfalfa fields may well be related to high levels where liquid manure has been applied to the alfalfa because of the crops ability to remove large amounts of nitrogen.

I strongly agree with the plan's stress on nutrient and irrigation management as the two critical BMPs that need to be addressed. On page 189 under Appendix G I would recommend that residual soil nitrogen be included in the list of accounting for all sources on nitrogen. The relative return on investment for most of the other BMPs listed is very small compared to water and nutrient management.

I realize that a diverse group worked to put this plan together and appreciate all the effort. I believe that the greatest reductions in ground water nitrate levels can be achieved by implementing programs that encourage adoption of irrigation and nutrient management practices.

Please contact me if I can provide any explanation of my comments (509 781 0588).

Sincerely,

Robert G. Stevens

Robert G. Stevens Ph. D.
bobcathys@embarqmail.com

1. The well info will be used against dairy industry/cattle industry.
2. Wells were drilled without knowledge of Gwama.
3. Criteria for drilling additional wells wasn't followed
4. No protection from citizen lawsuits.
5. Why can't info from wells deemed ~~exempt~~ anamolies be thrown out.
6. Address Septic systems, and legacy nitrates.
7. What studies ~~are~~ being done to show how legacy nitrates are being brought down
8. Show dairymen are already doing a lot to ~~effect~~ lower nitrates and manage nitrates
9. Public outreach more other causes of high nitrates.

Tamer Winkler
W.S. Farms inc.
3-25-19

RECEIVED
MAR 25 2019
Dept of Ecology
Central Regional Office

Espinoza, Joy (ECY)

From: Espinoza, Joy (ECY) on behalf of Bowen, David (ECY)
Sent: Wednesday, March 27, 2019 2:03 PM
To: Espinoza, Joy (ECY)
Subject: FW: Groundwater comments

RECEIVED
MAR 27 2019
Dept of Ecology
Central Regional Office

-----Original Message-----
From: Tony Veiga <tony.veiga@yahoo.com>
Sent: Wednesday, March 27, 2019 1:58 PM
To: Bowen, David (ECY) <dabo461@ECY.WA.GOV>
Cc: jkdairy@yahoo.com
Subject: Groundwater comments

Today we are commenting on the ground water report in our valley.

We are very disappointed that during the GWMA it's seem to lack other stakeholders in our valley such as tree fruit,hops,mint Vineyard and other commodities. Where was the rest of agriculture/commodities ?
In this report.

We have been dairy farmers in this valley for the last 38 years. We have always been proud to live in the Yakima valley but what's been going on in regards to targeting dairies as being the sole polluter is wrong. In our past years experience, when coming to this valley there were sugar beet, potatoes and unlimited amounts of nitrogen applied to fields which were rill irrigated.

What about the septic systems in the valley that are not regulated?

What about the legacy of farming practices that occurred in the valley multiple decades ago?

What about if all of agriculture work together to solve this problem?

Tony and Brenda Veiga
7010 e. Edison Rd.
Sunnyside, WA 98944

Sent from my iPhones

Trevor Wagenaar 3/25/19

in time

Looking back at the crops grown in this valley such as sugar beets, potatoes, etc., there used to be fertilizer poured on those crops. There was not fertilizer management we have now. It was the "more is better theory." I am just wondering how that might have impacted what we have now ?????

Dairymen purchase land from other farmers and do reclaim the ground from those who have poured on the fertilizer in years previous.

Dairymen soil test twice a year which is more than most!

Our management practices are pretty effient because we want to be economical!

Manure is a fertilizer and not waste!

RECEIVED
MAR 25 2019
Dept of Ecology
Central Regional Office

The Veldhuis family

City of Bickleton drilled well.
they found it had high Nitrotion.
where does this come from.

March 25,
Hessel Veldhuis
Jacob Veldhuis
Anna Veldhuis
Ruud Veldhuis

RECEIVED
MAR 25 2019
Dept of Ecology
Central Regional Office

There been fields that we bought throughout the years that been higher nitrogen there then our ground that we own. Seen field with 1000 pounds of N in the ground. We got it all in order nowbut it took years without N of our part to do it.

It seems like they are targeting us dairymen to fail.
Where they got all these wells in the valley are all easily next to dairymen. Why not other places.

water never goes up hill.
So with these wells next to dairies it's easy to point a finger at them instead it could be coming from a few miles away higher up with a vein in the ground

What about all the testwells, ive seem in the valley are ground level or below, how is this right.

RECEIVED
MAR 12 2019
Dept of Ecology
Central Regional Office

TO: David Bowen, Washington State Dept. of Ecology
Central Regional Office
1250 W. Alder St.
Union Gap, WA 98903-0009

FROM: Yakima County Farm Bureau

RE: Comments on Lower Yakima Valley Groundwater Management Plan

March 12, 2019

Yakima County Farm Bureau represents over 3,000 Yakima County members on agricultural related issues in Yakima County, and is the largest agricultural organization in Yakima County. It is a voluntary, grassroots advocacy group representing the social and economic interests of farm and ranch families at the local, state and national levels. Yakima County produces over $1 billion farm gate value in agricultural products annually and is one the most diversified agricultural producing counties in the country.

We would like to take this opportunity to thank DOE staff for their willingness to review and rewrite the Yakima GWMA report. This was the fourth rewrite. Overall, we found it to be much more succinct and technical. It is also more concise and does not contain as much controversial opinionated material as previous draft versions. Since Yakima County did not retain a professional water quality contractor to write this report as other Ground Water Management Areas have done, but instead hired a retired attorney to do it, made this process take almost an extra year to complete.

There are still a number of items that are expressed improperly, show a considerable bias or do not provide all of the information related to the particular topic being discussed. *For these reasons that are explained in further detail below, Yakima County Farm Bureau voted against accepting this report.*

Unnecessary verbiage is quite evident when one reads through the Benton County Groundwater report. Benton County originally was part of Lower Yakima GWMA effort. They opted out after about a year and went on their own contracting directly with the DOE, with the Benton County Conservation District as Lead Entity. While both Yakima and Benton Counties were dealing with the exact same issue, the Benton County Groundwater report released a few months ago, is approximately 40 pages long, while the Yakima report is over 130 pages long. This is very compelling as to the nature of the Yakima report. In summary, the Yakima report is too long and focuses on items that have nothing to do with the subject.

In particular, there is still a biased focus on how depressed the Yakima Groundwater area is, and the number of so-called poor people of color without means. The lower cost of living in our area was not factored into the report. Nor was the fact that many people who came here to work, while not highly educated by today's standards, did have the skills necessary to perform needed tasks and make a living. This depiction paints a false picture. Job opportunities abound in our region and people have flocked here to get them. The number of farm workers coming from other countries expands by thousands

every year. People from the south are clamoring to get into our country. Our public and private schools are second to none and every child has an opportunity to attend. These points paint a very different picture than what the report is trying to imply.

The report also has a major focus on animal agriculture, primarily dairies in the area. This focus ends up being a bias that is not backed up with true data or facts, and is contrary to reports from other areas. Maps depict dairy facilities in red which makes them appear to be a larger contributor, when in actuality, engineering, regulations and regulatory inspections negate most of that potential.

Maps in the report depict that many of the high N concentrations are where there are higher rural population, but there is little focus on this, nor is there a focus that septic drain fields are designed to leach. Information and focus from other sources about nitrates leaching from drain fields into the groundwater is lacking.

The report does not focus enough on legacy nitrates from former crops grown in the area and former growing practices that were likely contributors to it such as furrow and rill irrigation practices. This was no fault of producers as they were using the best information and technology at the time. However, the report's slant is that current ag practices are to blame, which is contrary to what the data tells us. In fact, recommendations in the report are for agriculture to implement new irrigation technologies such as sprinkler and drip systems, much of which has already been implemented in the Groundwater area.

Particular items of concern:

1. The report is too long. Few rank-and-file citizens will take the time to read it.
2. Pg 1 – third paragraph, citing that the GWAC had contentious discussions and whether or not they were respectful, is not relevant to the report or summary. This statement furthers the divisions of the group.
3. Pg 3 – bullet point to "enhance" regulations. There was not an agreement to recommend to enhance or add to regulations.
4. Pg 4 – Formation of the Lower Valley GWMA. Environmental groups were not the first to identify the problem. It was known by government agencies for a number of years. It was also brought to DOE's attention by the dairy industry before there was any talk about formally addressing the problem. Giving so-called environmental groups credit for identifying the issue is biased and not true.
5. Pg 10 – There is no mention of DOH responsibility to act on WAC 246-272A-015(5) which states "shall develop a written plan that will provide guidance to the local jurisdiction regarding development and management activities for all OSS within the jurisdiction". This has NOT been done.
6. Pg 15 – Nitrate leaching section is negatively biased toward ag as it does not mention anything about other sources of N. Health effects section does not mention anything about new evidence concerning how nitrates may not be the primary influencer on the very young.
7. Pg 17 - MDL of .03mg/L is misleading and not explained as some areas can have background levels much higher that .03mg/L.

8. Pg 19 - Citing the median N use scenario as most likely may not be accurate. Farmers do not buy any more N than is necessary because it is expensive, so a more accurate scenario could be the low use amount.
9. Pg 20 – The N sources graph is very misleading. Different potential agricultural sources are treated equal, when they should not be. Sources on dairies are subject to regulatory constraints and engineering requirements that serve to contain materials. Having a position that these materials have the same potential to migrate, is not accurate. In addition, there is information available from California that pens and lagoons have less than one percent contribution (0.7 percent), significantly lower than the 31 percent noted in the report.
10. Pg 22 – fifth paragraph left out when describing benefits of using organic fertilizer also include "adding soil structure which enhances moisture holding capacity and soil biological communities."
11. Pg 23 – While farming fruit I rarely applied *high* amounts of nutrients, especially nitrogen, to producing trees because it makes the tree grow vegetatively. Vegetative growth does not allow for good fruit production. Citing that fruit growers apply high amounts of nitrogen to producing orchards is not accurate.
12. Pg 25 – The term "Waste" should be taken out of the title. It should be changed to "Water Storage, Process Water Storage, or Nutrient Water Storage." The term "Contribute" in the first paragraph is misleading. It should be modified to say "can contribute" because there is no evidence that all pens or lagoons do contribute. Again, there is no mention of the engineering that is installed to prevent contamination. Very mis leading report writing.
13. Pg 26 – There are discussions about lagoons. But, there is no mention of why lagoons came into existence which was a mandate from DOE to help with nutrient distribution throughout the year, mitigating winter applications.
14. Pg 30 – Why is there an emphasis on highly regulated bio applications? There was no evidence presented that bio solids play any role.
15. Pg 31 – Legacy N section does an incomplete job of describing past uses on N on crops such as potatoes and sugar beets, and the amount of N left in the soil profile 20 to 50 years ago. The current description makes it sound like the problem is with current applications on a current annual basis. For the most part, this is not accurate.
16. Pg 37 – Third paragraph states that natural groundwater flow may be influenced by irrigation practices, structures and dairy structures. However, it does not explain that lagoons are engineered to contain what they hold, therefore they do not have the same "potential" as the others. The lack of this information being provided presents a bias toward a particular structure that has been shown to be a benefit.
    The term "potentiometric surface" should be explained as the more common term, "static level"
17. Pg 40/41 – Groundwater recharge appears faulty or not clearly defined – Little of the irrigated land in the GWMA area recharges groundwater 12 to 48 inches of water. This is not accurate for the farmed lands.
18. Pg 64 – Needs clarification. Is the term fertilizers used in the first paragraph "commercial fertilizer?" Forth paragraph terminology should be changed. The term "manure" should be changed to more accurately reflect the product that is being applied. It is mostly liquid or other nutrients that have had some sort of treatment, either from solids being separated from the liquid or composting and drying.

19. Pg 64 – The Yakima River is not the "source" of irrigation water for the Yakima Valley. The Yakima River is the conduit for irrigation water. The source of the water is the five storage reservoirs filled by either snow or rainfall precipitation, or natural flow before storage control is implemented.
20. Pg 69 – Income comparisons very biased, compared to overall state incomes. Education section is biased and misleading. No mention of past or recent immigrants coming here to better themselves. Ethnicity section paints a false picture and is divisive. Aren't we all Americans?
21. Pg 83 – ID of N sources is not complete. No mention of wholesale commercial N supplies. Only refers to what is "produced" in the GWMA area, not what is imported. Very confusing and negatively biased toward the natural nutrients produced by animal agriculture operations.
22. Pg 85 – Graph is biased against certain locations depicted in red (likely dairy lagoons). It does not explain the engineering that these lagoons have and their minimal potential to negatively affect groundwater.
23. Pg 93 – Rec 1 needs to be better explained. What does 42 mean, 42 out of what?
24. Pg 95 – Recs 11 and 13 are very similar
25. Pg 97 – Rec 23 needs to be voluntary
26. Pg 98 – Rec 27 needs terminology change. "Waste" should be changed to "nutrients."
27. Pg 98 – Rec 28 needs to be voluntary
28. Pg 99 – Rec 35 "waste" should be changed to "nutrients"
29. Pg 100 – Rec 37 should be voluntary
30. Pg 100 – Rec 39 Incorporation of fertilizer cannot be done on established crops. Irrigating in can take longer than 24 hrs.
31. Pg 102 – Rec 49 Oppose, regulatory. DNM plans extended to all lands
32. Pg 103 – draft recs should be deleted as there was not an agreement on moving them forward. They should not be in the report.

<u>In addition, minority reports should not be part of the GWMA report. They are someone's opinion that should be separate from the report.</u>

Public Services

128 North Second Street • Fourth Floor Courthouse • Yakima, Washington 98901
(509) 574-2300 • 1-800-572-7354 • FAX (509) 574-2301 • *www.co.yakima.wa.us*

LISA H. FREUND – Director

March 22, 2019

Department of Ecology Central Regional Office
David Bowen
1250 West Alder Street
Union Gap, WA 98903

Re: Lower Yakima Valley Groundwater Management Program

Dear David Bowen:

Yakima County submits the following comments for the Lower Yakima Valley Groundwater Management Program (Program).

Yakima County cannot accept the designation of lead agency for the Program as suggested in the recommended actions.

Please find attached the previously submitted letter to Ecology from the Board of County Commissioners regarding this item.

Sincerely,

Lisa Freund, Director
Yakima County Public Services

cc: Board of Yakima County Commissioners
Director Sage Park, Department of Ecology

Attachment

BOARD OF YAKIMA COUNTY COMMISSIONERS

Michael D. Leita	Ron Anderson	Norm Childress
District 1	District 2	District 3

February 14, 2019

Department of Ecology Central Regional Office
Director Sage Park
1250 West Alder Street
Union Gap, WA 98903

Re: Lower Yakima Valley Groundwater Management Program – Lead Agency Designation

Dear Director Park:

After considerable thought, we have concluded that Yakima County cannot accept the designation of lead agency for the Lower Yakima Valley Groundwater Management Program (Program) as suggested in the Program recommended actions. We appreciate the opportunity and confidence bestowed by the GWAC in recommending that Yakima County serve as lead during the implementation phase. However, Yakima County lacks the necessary resources to implement the health and environmental actions recommended to the lead agency of the Program.

Please be assured that Yakima County will continue to serve as lead agency for the Program through the adoption process. We remain committed to the GWMA Program's implementation and will support the lead agency ultimately selected.

Sincerely,

Michael D. Leita, Chairman
District 1

Ron Anderson
District 2

Norm Childress
District 3

cc: David Bowen, Department of Ecology

APPENDIX B: COLLECTED RECOMMENDATIONS RECIEVED FROM PUBLIC COMMENT

These recommendations came out of the public comments (as presented above) and have been collected here. In many instances the exact statement have been pasted, however some have been edited for length.

During the Program creation process, the GWAC met for 6 years, spending many hours drafting, analyzing, and voting on potential recommended actions for the program. Some of the items in Appendix B have previously been discussed by the committee, however all items have been included as documentation for future use.

Recommendations Related to Dairies or Large Farming:

All agriculture (including hops, mint, row crops, tree fruit, grapes) should be required to take annual soil samples and have a written nutrient management plan plus inspections.

Encourage adoption of irrigation and nutrient management practices.

Create means for all agriculture to work together.

Create a cost share program for earthen lagoons.

Recommendations Related to Ongoing Data:

The Departments of Ecology, Agriculture and Conservation Commission, as well as Yakima County, the Yakima County Health District and the Southern Yakima Conservation District should not regard the investigation of groundwater contamination in the Lower Yakima Valley as a fait accompli, but rather as a fait ab initio.

Results from the next steps in the U.S. Geological Survey work could be useful to implementing the GWMA program. The next phase would be to conduct a reverse-loading analysis based on the 2015 particle tracking study, to estimate how much reduced nitrogen loading would need to occur to decrease nitrate concentrations in downgradient residential wells to meet the drinking water maximum contaminant level. These findings could be used to refine and focus efforts to implement the final GWMA program in the coming years.

The Washington State Conservation Commission awarded competitive grants for demonstration projects statewide to test various technological approaches to recapture or recycle nutrients, including one in the Yakima Valley. The results of these projects could be useful in the implementation phase.

Use new information from research, data gathering, and technology demonstration projects nationwide pertaining to both understanding the nature of groundwater contamination and strategies to reduce it.

Collect nitrate data from domestic wells as a substitute for monitoring wells. Collection of additional data, including hydrogeological and water quality data should focus on areas with identified deeper nitrate contamination, with a goal of identifying potential conduits to deeper aquifer zones.

Seek to broadly and proportionately represents the affected community.

Duly authorized governmental agencies and duly elected public officers are charged with a public duty to execute those rules and regulations currently in effect, and exercise those powers with which they are currently authorized, notwithstanding that they are not recommended by public interest groups.

Neither the final draft of the Lower Yakima Valley Groundwater Advisory Committee's Program, nor the recommendations contained therein, are limiting upon the choices available to the public at large or governmental agencies with relevant jurisdiction.

The Washington hop commission funded a WSU, three year, deep sampling to 6 ft. in 23 hop yards from 1990-1992. This study showed the variability between spring and fall sampling and explained some of the reasons why this happens. It also demonstrated how variable management practice can effect soil test nitrate over time. Take this into account.

Ensure that QAPPs are developed for any new work that includes data collection.

Overlay historical nitrate levels against farming practices over the same time and the population growth of the area of both livestock and people. If this long term (more than a decade) historic data is not available, perhaps a trend or timeline should be established prior to making broad decisions.

Recommendations Related to Public Outreach and Education:

Send a mass mailing to all residents located outside of public water supply service areas within the Lower Yakima Valley. The mailing would explain the problem of nitrates in shallow groundwater, and that it is of particular danger to expecting mothers and infants. The mailing would provide a telephone number for free testing of their well water for nitrates.

Use Spanish-language radio educational information as an outreach tool.

Provide education on double cropping and agronomic application of nitrogen

Recommendations Related to Gathering Additional Data:

Assign staff dedicated to collection of water samples from domestic wells for nitrate analysis. The staff should be able to respond to requests to sample within one week of a telephone request. Households with infants or expecting mothers (or women of childbearing age) would be bumped to the top of the list. Shallower wells should be given a higher priority than deeper wells. The sampling staff would maintain a database, including available well construction information.

A higher percentage of the committee be comprised of members who reside in the affected GWMA area so as to more accurately represent their community and neighbors' best interests.

Because of potential negative effects on fish and fish habitat, ammonia (NH_3) should be investigated in irrigation return flows to surface waters. Arid area waters tend to be more alkaline than those in wetter areas, and NH_3 toxicity to aquatic organisms increases as pH increases. (EPA Quality Criteria for Water, 1986 as updated). If initial investigations do not indicate a problem, no further monitoring should be required.

Consideration should be given to supplemental funding to include nitrogen analysis of groundwater samples from Superfund/MTCA site monitoring wells within the study area. This would

potentially increase the number of available data points within the study area at a very modest increase in cost.

Information not provided to the GWAC but obtainable from the Washington State

Department of Agriculture should be analyzed:

a. Growth in agricultural use intensity (density/acre, acreage fanned, production volume)

b. Amount of chemical fertilizer sold or used within GWMA

c. Report of dairy nutrient management plan information on distribution of manure (see RCW 90.64.026(3), RCW 42.56.270(7), WAC 16-06-210(29))

d. Nitrogen Loading Assessment (as distinguished from Nitrogen Availability Assessment, see: June 19, 2014, August 21, 2014, October 16, 2014, and December 18, 2014 GWAC meeting summaries; Yakima County/Department of Agriculture Interagency Agreement

Information not provided to the GWAC but obtainable from the Department of Ecology should be analyzed:

a. Report on enforcement of RCW groundwater standards

b. Report on effect of large scale water usage on groundwater quality

Identify or analyze information about the amount of chemical fertilizers sold or distributed to managers of orchards and crops, or applied to orchards and crops within the study area.

Reflect the often-expressed view/opinion within the Advisory Committee that the effect of groundwater contamination in the Lower Yakima Valley influences the lives and health of human demographic groups disproportionately. Study or describe the socioeconomic effect of groundwater contamination within the study area upon on future generations. Both effects should be studied.

Correlate the economic benefit derived from the private small industrial, agricultural, urban/suburban residential sector sources' activity within the study area with the economic costs likely to be incurred by the public remedial, corrective, educational, or regulatory activities responding to the problem. Quantify the economic value of the natural resource (groundwater) consumed through contamination (an unmeasured and undocumented expense incurred as part of the private small industrial, agricultural, and urban/suburban residential sectors' entrepreneurial enterprise). Study this relationship in order to determine correlate costs of remediation, if any, with the economic benefits of groundwater consumption.

Evaluate the causal relationship, if any, between the method and volumes of water applied to the ground surface (either generally or at specifically identifiable locations, or the volume of groundwater stored within the ground, within the studied area, and the extent, location or degree of groundwater contamination within the studied area or at specific contaminated wells.

Evaluate the correlation, if any, of the location, volume or movement of surface water within lined or unlined artificial conveyance systems (irrigation canals) with the extent, location or degree of groundwater contamination within the studied area.

Correlate changes in concentration, density, intensity, or use of source-related activities within the studied area with changes, if any, in the extent, location or degree of groundwater contamination within the studied area.

Analyze specific deep soil sampling data collected from known locations. Collect more deep soil sampling data, with data collection sites located, and that data analyzed.

Analyze trends in well data from Valley Institute for Research and Education Report (2002), Nitrate Pilot Project Well Samples, LVYGWMA High Risk Well Assessment Well Samples, and USGS 2017 Well Testing Data. Analyze trends in this data.

Identify plausible hypotheses of causation, transmission, or accumulation of contaminant between categorical sources and contamination events or locations. These hypotheses should be stated and explored.

Describe the processes of hydrogeologic or chemical transmission or accumulation of contaminant in the area of contamination. These processes should be more completely explored and described.

Investigate or analyze the geologic and hydrogeologic properties of denser locations of contaminated wells ("hotspots). These should be investigated and analyzed.

Investigate or analyze the plausible causal relationship between specifically identifiable sources and specific contamination events. These should be investigated and analyzed.

Explore the correlation, if any, between specific land use types and proximate water supply contamination events.

Address the specific land use regulations, or other regulation types, that might use, rectify, ameliorate or otherwise alter the general or specific contamination condition within the study area.

Address the effect of generic or specific sources on the protection of areas with "critical recharging effect on aquifers used for potable water or areas where a drinking aquifer is vulnerable to contamination that would affect the potability of the water" as designated by Yakima County pursuant to the Growth Management Act or otherwise (RCW 36.70A; WAC 365-190-030 (3); and YCC 16A, 16C), as "environmentally sensitive or special areas" as contemplated by WAC 197-11-330(2)(e)(i), WAC 197-11-305 (l)(a), WAC 197-11-908(l)(b) and the Growth Management Act. These effects should be described and analyzed.

Explore the strategy of taxation on the use or sale of materials containing chemical constituents common to known constituents of groundwater contamination as a means of source reduction.

Explore the strategy of usage limitations, imposed through land use regulation, on the nature, density, or intensity of use (analogous to limitations on industrial development).

Recommend any remedial action. Remedial actions should be studied.

Evaluate the costs or implications of inaction. These should be evaluated.

Locate and evaluate any past nitrate studies done for this area, specifically an unspecified study done approximately 40-50 years previous.

Use scientific data from additional sources, including: Collaborative work carried out by local, state and federal agencies in 2010, "Lower Yakima Valley Groundwater Quality." Data from other scientific studies are also available. Quality-assured/quality controlled available data. A few examples to draw upon include:

- United States Geological Survey (USGS): "Particle tracking for selected groundwater wells in the lower Yakima River Basin, Washington," 2015. The USGS assessed nitrate sources in specific geographic areas within the GWMA with groundwater contamination and identified associated likely nitrogen source areas, https://pubs.er.usizs.izov/publication/sir20155149
- The EPA: "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington," 2013 contains soil information such as permeability data from lagoons, and nitrogen concentrations in manured dairy crop fields, https://www.epa.izov/wa/lower-yakima-vallevgroundwater
- Since a Consent Order was signed with three Lower Yakima Valley dairies in 2013, these dairies have made great strides in reducing the amount of nitrogen accumulating in their fields. In reports submitted under the EPA Consent Order and approved Quality Assurance Project Plan (QAPP), there are several years of biannual data from fields prior to the AOC-required limitations of field applications of manure and the subsequent transition to the present conditions. These dairies are also providing post-harvest data that can inform soil concentration estimates in the draft GWMA Plan. https://www.epa.gov/wa/lower-vakima-valley-groundwater

Study proportional impact of all sources of nitrate so as not to overly burden one group over another without knowing their respect impacts to groundwater nitrates.

Study scientific evidence of impacts related to regulations on farmers and dairymen.

Recommendations Related to Monitoring Wells:

Maintain a longitudinal record of measurements taken from groundwater monitoring wells so as to document trends in improvement or worsening of the present condition.

Map the "horizon" of analysis of monitoring well measurements from the groundwater monitoring well system (an undulating plane established by points (elevations) at each monitoring well, with the intervening spaces being calculated with reference to influence from proximate point data) should be mapped. This might indicate how the measured horizon intersects with the geologic regimes already known (theoretically) to exist within the study area.

Introduce some sort of non-pollutive tracer in selected monitoring wells in order to ascertain whether that tracer expresses itself in other monitoring wells. This may be possible due to the density and location of monitoring wells within the study area. This may provide information helpful in establishing direction of groundwater flow (albeit at a rather surficial elevation).

Test monitoring wells whether the nitrates are coming from human waste or from animals and commercial fertilizer.

Place some wells around the town of Outlook to determine whether the nitrates are coming from people or agriculture.

In addition to randomly placed monitoring wells, consideration should be given to more intensive targeted monitoring at and around "hot spots" as changes in N concentrations (improvements and further degradation) will be particularly important in those areas.

Include wells in the urban growth areas.

Wells deemed anomalies to be discontinued.

Recommendations Related to Providing Resources:

Identify locations for household collection of free drinking water at each community in the Lower Yakima Valley. Once a household water supply well has been tested, the owner or resident would be provided with a document allowing them to pick up free drinking water (a reasonable weekly allotment could be calculated).

Begin a grant program for replacement of impacted shallow domestic wells. Such grants could be applied for by homeowners that have a shallow wells with nitrates above cleanup levels. Prioritization of grant recipients should be based on needs of the applicant. A fund for this grant can be contributed to by taxpayers and groundwater polluters. This recommendation would require legislative action.

Formation of rural PUD Water Districts for replacement water supplies, particularly in "hot spots" within the GWMA.

Use recirculating sand filters in areas where high density of ROSS.

Coordinate with DOH on WAC 246-272A-015 (5) which states "shall develop a written plan that will provide guidance to the local jurisdiction regarding development and management activities for all OSS within the jurisdiction".

Recommendations Related to Additional Regulations:

Drinking water wells required depth of greater than one hundred feet deep.

Onsite Sewage Systems (OSS) should be controlled by the county and a plan that is required by WAC 246-272A-015(5) should be developed by the Health Department for OSS. I would recommend that any parcel that requests an OSS permit that is less than 20 acres (just under High Density standards) should have an OSS that is designed to reduce the nitrogen flow in its effluent.

Recommendations Related to Additional Approaches:

Provide greater focus on eliminate exposure pathways.

Make providing drinking water to affected the top priority.

South Yakima Conservation District
200 Cheyne Road, PO Box 1766 (mailing), Zillah, WA 98953
Phone (509)-829-9025
Fax (509)-829-9027

May 8, 2019

David Bowen
Washington State Department of Ecology
Central Regional Office
1250 W. Alder Street
Union Gap, WA 98903-0009

Regarding: Lower Yakima Valley Groundwater Management Plan

Mr. Bowen,

It's very important for everyone to recognize this plan is a long-term groundwater management program. Currently, there is not funding in place. In order for the program to be successful, we need stable resources available to implement the recommendations put forth by the Groundwater Advisory Committee (GWAC).

We understand that the draft plan is undergoing minor edits and some revisions may be necessary. With that understanding, we concur with the GWAC water quality goals and objectives adopted on February 6, 2013.

The above concurrence will be withdrawn if this plan is substantially changed. Any alterations should only be done by a vote of the Groundwater Advisory Committee members.

We look forward to working with agency partners to implement the recommendations identified in the plan that are tasked to our agency.

Sincerely,

5/8/19

Dirk Van Slageren, Chairman Date
South Yakima Conservation District



SUNNYSIDE DIVISION BOARD OF CONTROL

ESTABLISHED 1945

YAKIMA RECLAMATION PROJECT

June 4, 2019

David Bowen
Washington State Department of Ecology
Central Regional Office
1250 W. Alder Street
Union Gap, WA 98903-0009
Regarding: Lower Yakima Valley Groundwater Management Plan

Mr. Bowen,

The Sunnyside Division Board of Control (SDBOC)/Sunnyside Valley Irrigation District (SVID) generally concur with the recommended action for the irrigation districts described in the Lower Yakima Valley Groundwater Management Program dated November 2018. The Roza Irrigation District along with SDBOC through the Roza Sunnyside Board of Joint Control (RSBOJC) currently perform the recommended action of monitoring nitrate levels at our two headworks. The RSBOJC plans to continue this monitoring program into the future but it could be impacted due to lack of funding.

Sincerely,

H. Douglas Simpson

Doug Simpson, Chairman
SDBOC/SVID

120 S 11th Street—PO Box 239—Sunnyside, WA 98944

Phone-509/837-6980 Fax-509837-2088

www.svid.org

BOARD OF YAKIMA COUNTY COMMISSIONERS

Michael D. Leita	Ron Anderson	Norm Childress
District 1	District 2	District 3

June 10, 2019

Dear Director Park:

The Board of Yakima County Commissioners concurs with the Lower Yakima Valley Groundwater Management Program as revised and approved by the Lower Yakima Valley Groundwater Advisory Committee (GWAC) on December 13, 2018.

Yakima County recognizes the importance of the Program's stated goal of reducing nitrate in groundwater. Groundwater is a highly valued natural resource that should be protected and preserved.

We appreciate the Department of Ecology's commitment and diligence in bringing the Program document to a successful conclusion.

Sincerely,

Michael D. Leita
Chairman
Board of Yakima County Commissioners

BOARD OF YAKIMA COUNTY COMMISSIONERS

IN THE MATTER OF PROVIDING A LETTER OF CONCURRENCE TO THE DEPARTMENT OF ECOLOGY FOR THE LOWER VALLEY GROUNDWATER PROGRAM	)))))	**RESOLUTION 185-2019**

WHEREAS, a Lower Yakima Valley Groundwater Management Area (GWMA) was formed in response to elevated nitrate concentrations in the groundwater in the Lower Yakima Valley; and

WHEREAS, a Groundwater Advisory Committee was established to develop a Lower Yakima Valley Groundwater Management Area Program; and

WHEREAS, the Groundwater Advisory Committee is a large and diverse committee, including representatives from all identified groups affected by groundwater quality, including local, state, and federal government agencies; local citizens; farmers, dairy producers, and agronomists; irrigation districts; conservation districts; environmental groups; and other vested parties; and

WHEREAS, the Lower Yakima Valley Groundwater Advisory Committee has overseen the development of the Lower Yakima Valley Groundwater Management Program; and

WHEREAS, Yakima County was designated as the lead agency responsible for coordinating and undertaking the activities necessary for development of a groundwater management program, in accordance with WAC 173-100-080; and

WHEREAS, a joint public hearing with the Department of Ecology and Yakima County within the designated groundwater management area for the purpose of taking public testimony on the proposed program was held on March 12, 2019; and

WHEREAS, WAC 173-100-120 stipulates that following the public hearing each affected local government shall prepared findings on the groundwater management program within ninety days. The findings shall evaluate the program's technical soundness, economic feasibility, and consistency with the intent of WAC 173-100 and other federal, state and local laws; and

WHEREAS, WAC 173-100-120 also stipulates that the findings shall identify any revisions necessary before the program can be certified and shall contain a statement of the agency's concurrence, indicating its intent to adopt implementing policies, ordinances and programs if required, or a statement of nonconcurrence with the program if such be the case; now, therefore,

BE IT HEREBY RESOLVED by the Board of Yakima County Commissioners that a letter be transmitted to the Department of Ecology, identifying the county's findings and statement of concurrence.

DONE this 18th day of June 2019

Michael D. Leita, Chairman

Norm Childress, Commissioner

Ron Anderson, Commissioner

Constituting the Board of County Commissioners for Yakima County, Washington

Attest: Melissa Paul, Clerk of the Board

SEAL OF THE BOARD OF YAKIMA COUNTY COMMISSIONERS STATE OF WASHINGTON

YAKIMA HEALTH DISTRICT

Prevention Is Our Business

May 3, 2019

David Bowen
Water Quality Section Manager, CRO
Washington State Department of Ecology

RE: Lower Yakima Valley Groundwater Management Area Report

Dear Mr. Bowen:

Thank you for the opportunity to review the draft report of Lower Yakima Valley Groundwater Management Area. Yakima Health District concurs with the plan as written without the minority report included in the published report.

After the report is finalized and funding is secure, we look forward to participating on the implementation of the recommended tasks involving Yakima Health District.

Sincerely,

Ryan Ibach
Chief Operating Officer
Yakima Health District

Attachment C

- Lower Yakima Valley Groundwater Management Area Ambient Groundwater Monitoring Well Installation Report prepared by Pacific Groundwater Group

PACIFIC groundwater GROUP

LOWER YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA AMBIENT GROUNDWATER MONITORING WELL INSTALLATION REPORT

APRIL, 2019

LOWER YAKIMA VALLEY GROUNDWATER MANAGEMENT AREA
AMBIENT GROUNDWATER MONITORING
WELL INSTALLATION REPORT

Prepared for:

Yakima County Public Services
128 North Second Street
Yakima, WA 98901
(509) 574-2300
http://www.yakimawa.gov

Prepared by:

Pacific Groundwater Group
2377 Eastlake Avenue East, Suite 200
Seattle, Washington 98102
206.329.0141
www.pgwg.com

April 2019
JE1803
Yakima GWMA Well Installation Report.docx

TABLE OF CONTENTS

1.0 INTRODUCTION 1

2.0 WELL LOCATING METHOD 1

3.0 FIELD METHODS 2

3.1 WELL DRILLING, CONSTRUCTION, AND GEOLOGIC LOGS 2
3.1.1 Well Construction 2
3.1.2 Screen Placement Method 2
3.1.3 Well Development 3
3.2 GROUNDWATER SAMPLING 3
3.3 PUMPING TESTS 4

4.0 FIELD NARRATIVE 4

4.1 YC-MW-01 4
4.2 YC-MW-02 5
4.3 YC-MW-05 6
4.4 YC-MW-06 6
4.5 YC-MW-07 7
4.6 YC-MW-08 8
4.7 YC-MW-09 8
4.8 YC-MW-10 9
4.9 YC-MW-11 9
4.10 YC-MW-12 10
4.11 YC-MW-14 11
4.12 YC-MW-15 11
4.13 YC-MW-16 12
4.14 YC-MW-17 12
4.15 YC-MW-19 13
4.16 YC-MW-21 14
4.17 YC-MW-23 14
4.18 YC-MW-24 15
4.19 YC-MW-25 15
4.20 YC-MW-26 16
4.21 YC-MW-27 17
4.22 YC-MW-28 17
4.23 YC-MW-31 18
4.24 YC-MW-33 18
4.25 YC-MW-35 (BOREHOLE ONLY) 19
4.26 YC-MW-38 19
4.27 YC-MW-39 20
4.28 YC-MW-41 20
4.29 YC-MW-42 21
4.30 YC-MW-44 22
4.31 YC-MW-46 22

5.0 REFERENCES 23

LIST OF TABLES

Table 1. Well Construction Summary, Yakima GWMA
Table 2. Groundwater Quality Sampling Results, Yakima GWMA

LIST OF FIGURES

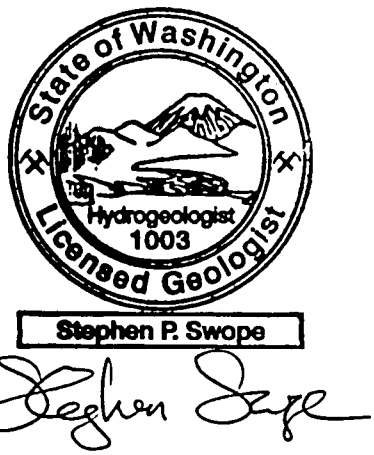
Figure 1. Yakima GWMA Monitoring Well Locations
Figure 2. Yakima GWMA Groundwater Nitrate Concentrations
Figure 3. Yakima GWMA Groundwater Elevations

LIST OF APPENDICES

Appendix A: Boring Location Maps
Appendix B: Well Logs and As-Builts
Appendix C: Wellhead Completion Photos
Appendix D: Pumping Test Data
Appendix E: Groundwater Sampling Chain-of-Custody Sheets

SIGNATURE

This report, and Pacific Groundwater Group's work contributing to this report, were reviewed by the undersigned and approved for release.



Stephen Swope
Washington State Hydrogeologist No. 1008

1.0 INTRODUCTION

The Lower Yakima Valley (LYV) Groundwater Management Area (GWMA) was formed in 2011 in response to elevated nitrate concentrations in groundwater. The GWMA project is a multi-agency, citizen-based, coordinated effort to reduce groundwater nitrate concentrations in the LYV to below Washington State drinking water standards. The GWMA extends from Union Gap southeast to the Yakima County boundary, minus the Yakama Reservation (Figure 1).

The purpose of the ambient groundwater monitoring program was to develop a network of wells to measure baseline water quality conditions representative of the Groundwater Management Area. To achieve this goal, the Groundwater Advisory Committee (GWAC) for the Lower Yakima Valley Groundwater Management Area (GWMA) requested the design and installation of a purpose-built groundwater monitoring system to establish a baseline of groundwater quality conditions near the water table. The water table was targeted since little data from this zone exists, and because water quality changes associated with land use change will occur there before it occurs in deeper aquifers.

PGG was contracted by Yakima County to record geologic logs, observe monitoring well installations, perform short duration aquifer tests, and collect groundwater samples from 30 wells. PGG staff conducted field work on the initial 24 wells between October 24 and December 6, 2018. Yakima County then authorized another six monitoring well locations. PGG staff conducted the remainder of the field work between January 14 and February 27, 2019. PGG field personnel included David Wampler, Inger Jackson, Koshlan Mayer-Blackwell, Theo Fehsenfeld, and Travis Klaas. Steve Swope acted as project Manager for PGG.

This work was performed, and this report prepared, in accordance with hydrogeologic practices generally accepted at this time in this area, for the exclusive use of Yakima County and the Lower Yakima Valley Groundwater Advisory Committee, for specific application to the project. This is in lieu of other warranties, express or implied.

2.0 WELL LOCATING METHOD

The well locating method was developed under a separate scope of work (PGG, 2016). Generally, the wells were located using an objective, randomized method to distribute well locations across the GWMA while minimizing bias. The network was designed to be appropriate for calculating basin wide average conditions at the water table, and for tracking concentration changes at the water table over time. The network can also be used for mapping of the variation in concentrations at the water table.

The monitoring well installation workplan describes the method used to locate "preliminary drill sites." An initial set of 30 preliminary drill sites was randomly selected, sited, and mapped as part of the workplan. Most of the preliminary points occurred on private property; therefore, the next step was to move the points to the closest public right-of-way to streamline access. Preliminary drill sites were also set back from irrigation canals and drains. Adjustments to preliminary drill sites were made in two other locations where water quality anomalies were possible and monitoring wells already existed. Well 7 was moved away from Port of Sunnyside's spray field and Well 23 was moved to avoid the EPA dairy cluster. The Port of Sunnyside's spray field and EPA dairy cluster both have their own set of purpose-built monitoring wells.

After approval of the workplan, Yakima County surveyed road rights-of-way in the vicinity of each preliminary drill site to confirm sufficient width to accommodate a drill rig. The sites were also field checked for overhead or underground utilities and to confirm that the site was sufficiently level to accommodate

the drill rig. In some cases, several sites were reviewed and rejected before an acceptable site was found. Well installations were canceled if no acceptable location could be identified near the preliminary drill site, which was the case for 8 of the 30 preliminary drill sites (3, 4, 13, 18, 20, 22, 29, and 30).

During the first well installation effort in November 2018, project cost tracking identified that additional wells could be installed within the project budget. Yakima County requested that PGG locate additional wells to augment the network. PGG and Yakima County coordinated to rapidly locate drill sites for wells 31 through 49 while drilling was on going. The process included randomized GIS selection of preliminary drill sites, selection of proximate rights-of-way, setbacks from certain irrigation features, utility clearances, surveying of rights-of-way widths, and field verification. Specific facilities or land uses were not targeted when locating well sites.

3.0 FIELD METHODS

In addition to observing and documenting well installation, PGG performed aquifer tests and collected groundwater samples from monitoring wells consistent with the scope of work. Resulting nitrate concentrations are presented in Figure 2. A monitoring well was not installed at one location (YC-MW-35) because groundwater was not encountered within the drilled depth, which was limited by bedrock.

3.1 WELL DRILLING, CONSTRUCTION, AND GEOLOGIC LOGS

3.1.1 Well Construction

All monitoring wells were drilled, installed, and developed by Yellow Jacket Drilling of Portland, Oregon, a Washington State licensed driller, in accordance with WAC 173-160. Drilling was completed with a sonic drilling rig by Casey Wallace as the lead driller. Individual maps of each boring location are included in Appendix A.

All borings were advanced to depth using a four-inch inner core barrel, and six-inch outer casing. Continuous soil cores were extracted from borings in five or ten-foot increments. Borehole drilling was terminated after encountering the regional water table. Soil cores were captured using 6-inch diameter plastic sleeves directly from the core barrel. PGG logged cores for hydrogeologic project objectives. Geologic logs are included in Appendix B. A well construction summary is provided in Table 1.

A well was not constructed at YC-MW-35 and the boring was backfilled due to insufficient water. No well was installed, and no groundwater sample was collected. The boring was decommissioned in accordance with WAC 173-160.

All wells were completed as two-inch PVC monitoring wells with 0.010-inch slotted PVC screens, #12/20 silica sand packs, and bentonite surface seals. Well heads were housed in flush-to-grade steel vaults, and J-plugs are used to secure the PVC casings inside the vaults. Boring logs and as-builts are included in Appendix B.

3.1.2 Screen Placement Method

The ambient groundwater monitoring network targeted groundwater quality at the water table, which is shallower than typical water supply wells that have provided GWMA data to date. The strategy outlined in the bullets below was used during drilling and well construction to meet this goal. The wells were drilled in November 2018 through January 2019 – a season of falling groundwater levels in this area dominated by irrigation recharge that ceases in October. Review of limited historic water level records

indicated that the average seasonal water level fluctuation was about 10 ft, with the maximum in fall, and minimum in spring. That seasonal water level trend was considered in the well screen strategy. Predictions of the depth to the regional water table at each location, developed from USGS and EPA groundwater level data, also served as a guide to drilling depths. The strategy used to locate well screen during drilling included the following components:

- Moisture contents and soil stratigraphy revealed by drill cores were qualitatively logged by the on-site hydrogeologist.
- Water levels were measured within the outer drill casing between every coring run. Water levels measured by this means are termed "at time of drilling" (ATD) and may differ from water levels in constructed wells.
- Borings generally penetrated about 20 ft below the ATD water level to allow screening as much as 20 ft below the regional water table if saturated soils were not highly stratified. If soils were highly stratified, shorter well screens were often used to avoid screening across aquitards.
- The regional water table occurred within thin permeable zones with low water levels in a few locations. In cases where such a zone was the only screened zone, wells may contain groundwater sometimes of the year, and may be dry at other times of the year. Constructing wells that yield samples solely from the shallowest seasonally saturated zone, but that may not yield samples at all times of the year, was intentional. Alternatives to by-pass such zones, or screen across an aquitard with a long well screen were considered but were rejected because they are not consistent with project objectives.
- At YC-MW-02, very shallow perched groundwater was by-passed in favor of screening at the regional water table. The GWMA might consider constructing perched-groundwater monitoring well at this location.

3.1.3 Well Development

Wells were developed (cleaned after construction) by Yellow Jacket Drilling using a surge block and submersible pump. PGG was not present to observe well development. Wells were developed until water was visually clean if possible. Well development times ranged from 30 to 60 minutes. YC-MW-14 was not developed due to insufficient water. In some cases, turbidity was still relatively high at the termination of sampling. Turbidity values are included in Table 2.

3.2 GROUNDWATER SAMPLING

Groundwater samples were generally collected using a 2-inch diameter submersible pump and dedicated tubing. Submersible pumps included a Proactive Tempest DC purge pump and a Geotech Geosub pump. The depth to water at monitoring wells YC-MW-11, YC-MW-15, and YC-MW-25 was beyond the capabilities of either two-inch submersible pumps, so these samples were collected using a decontaminated stainless-steel bailer. A water quality sample was not collected at YC-MW-14 because there was insufficient water during the December 2018 sampling event.

Groundwater samples were collected into laboratory-provided HDPE bottles and placed in coolers with ice. pH, conductivity, turbidity, temperature, and oxidation reduction potential were measured in the field using an Oakton multimeter. Aquifer testing was performed immediately prior and resulted in purging for approximately 30 – 70 minutes prior to collection of samples. Field parameters were recorded during testing and parameter stabilization was noted. Sampling pumping rates are given in Table 2.

Groundwater sampling sheets and analytical chain of custody have been included in Appendix E.

All sampling and screening equipment was decontaminated with liquinox and distilled water prior to each use. Clean nitrile gloves were used while deploying pumps and were changed again before each sample collection.

Groundwater samples were collected into a laboratory provided bottle and placed on ice in a cooler immediately after collection. Chain of custody was maintained, and samples were submitted for nitrate analysis to Cascade Analytical Inc. in Union Gap, WA, a Washington State Accredited Lab.

3.3 PUMPING TESTS

Single well pumping tests were completed at 29 of the 30 monitoring wells to evaluate the pumping methods and rates for subsequent water quality sample collection. Single well pumping tests were generally conducted using a submersible pump. Depths to water during pumping tests were measured from the top of the PVC casing (MP). Table 2 includes measured distances between these MPs and the top of the steel flush-to-grade monuments that were surveyed by Yakima County, and includes calculated MP elevations. The depth to water at monitoring wells YC-MW-11, YC-MW-15, and YC-MW-25 was beyond the lift capabilities of two-inch submersible pumps so aquifer testing was not performed at YC-MW-14, because there was insufficient water during the December 2018 sampling event.

Short-term constant-rate pumping tests were performed in wells with depths to water generally less than 120 feet using submersible pumps with new, disposable discharge lines. Pumping rates were measured using a bucket and stopwatch. Purge water was discharged to the ground in the rights-of-way near the wellheads. During the pumping tests, water levels were measured continuously with a transducer and manually with a sounder; and pH, specific conductance, temperature, and oxidation-reduction potential were measured in the field using hand meters. At the end of each pumping test, a water quality sample was collected directly from the pump discharge line into a laboratory-provided bottle and was submitted to Cascade Analytical, Inc. for nitrate analysis. The submersible pumps, transducer, and sounder were decontaminated in the field before use in each monitoring well. A summary of final pumping rates is provided in Table 2. Appendix D includes plots of drawdown and recover. The drawdown curve is plotted against elapsed pumping time (t, minutes). The recovery curve is plotted against dimensionless time, which is the elapsed time since pumping began divided by time since pumping stopped (t/t'). Therefore, recovery data from early time plots to the right of recovery data from later time on the graph.

4.0 FIELD NARRATIVE

PGG observed drilling at 31 locations, installed 30 wells, and collected groundwater samples at 29 wells. Work at each location is described below. Well construction details and water levels during sampling are summarized in Table 1, and water quality results are summarized in Table 2. Geologic logs and as-built diagrams are included in Appendix B. Wellhead completion photos are included in Appendix D.

4.1 YC-MW-01

Monitoring well YC-MW-01 was drilled and installed on November 11, 2018 in the road-way adjacent to East Lincoln Avenue near the intersection of Yakima Valley Highway in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet below ground surface (bgs). A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 26 feet bgs.

The upper 6 feet of material consists of moist to wet dark brown silt, overlaying material generally consisting of a silty fine sand to fine sand from 6 to 24 feet bgs.

Monitoring well YC-MW-01 was completed with a 0.010-inch slot PVC screen from 10 to 25 feet bgs surrounded by a #12-20 silica sand pack that extends up to 8 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-01 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-01 is BKB-745. The elevation of the top of the steel monument is 735.53 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.31 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-01 on December 4, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 8.03 bmp. The well was pumped at a constant rate of approximately 1.17 gpm for 40 minutes and water was discharged to ground in the right-of-way approximately 50 feet northwest from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-01 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 68.3 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-01 sample was 22.2 mg/L.

4.2 YC-MW-02

Monitoring well YC-MW-02 was drilled and installed on October 28, 2018 in the right-of-way adjacent to Arrowsmith Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 7 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 76 feet bgs.

The upper 21 feet of material generally consisted of dry to moist, sandy and clayey silt. A layer of semi-consolidated siltstone or possibly ash was encountered from 21 to 29 feet bgs, which was water-bearing. When the borehole had been advanced into the semi-consolidated siltstone, the depth to water was approximately 11.4 feet bgs. The siltstone was underlain by a thin layer of gravelly sand and a more significant thickness of sandy silt from 30 to 59 feet bgs that appeared oxidized between 40 and 47 feet. A clean, fine to medium sand unit was encountered at 59 feet bgs that extended to the total borehole depth of 76 feet bgs. When the borehole had been advanced into this fine to medium sand unit, the depth to water was 46.7 feet bgs. Based on the stratigraphic sequence observed during drilling, and predictions of the regional water table developed from USGS and EPA groundwater level data, the water level in the semi-consolidated siltstone was interpreted to be perched by the underlying sandy silt and the water level in the fine to medium sand was interpreted to be the regional water table.

Monitoring well YC-MW-02 was completed with a 0.010-inch slot PVC screen from 61 to 76 feet bgs surrounded by a #12-20 silica sand pack that extends up to 59 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-02 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-02 is BKB-726. The elevation of the top of the steel monument is 875.67 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.41 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-02 on November 15, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 56.25 bmp. The well was

pumped at a constant rate of approximately 2.14 gpm for 43 minutes and water was discharged to ground in the right-of-way approximately 25 feet east from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-02 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 374.5 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-02 sample was 17.2 mg/L.

4.3 YC-MW-05

Monitoring well YC-MW-05 was drilled and installed on October 27, 2018 in the right-of-way adjacent to South Lester Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.75 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 46 feet bgs.

The upper 16 feet of material was generally a sandy silt that was moist below 6 feet bgs and wet from 11 to 13 feet bgs. A moist to wet slightly sandy silt was encountered between 16 and 34.5 feet bgs that was underlain by wet, fine to medium sand from 34.5 to 36 feet bgs. A moist, slightly sandy silt unit was encountered at 36 feet bgs that extended to the total borehole depth of 46 feet bgs.

Based on water levels measured during drilling and the observed stratigraphy, monitoring well YC-MW-05 was completed with a 0.010-inch slot PVC screen from 23 to 38 feet bgs surrounded by a #12-20 silica sand pack that extends up to 21 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 39.5 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-05 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-05 is BKB-725. The elevation of the top of the steel monument is 797.56 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.38 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-05 on November 15, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 14.13 bmp. The well was pumped at a constant rate of approximately 0.43 gpm for 57 minutes and water was discharged to ground in the right-of-way approximately 60 feet north from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-05 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 16.7 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-05 sample was 3.14 mg/L.

4.4 YC-MW-06

Monitoring well YC-MW-06 was drilled and installed on November 18, 2018 in the right-of-way adjacent to Hanford Road near the intersection of Sli Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to approximately 7 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 76 feet bgs.

The upper 16 feet of material consisted of moist fine, sandy silt. An interval of gravely silt and rocks was encountered from 18 to 23 feet bgs overlaying a moist, olive gray silt to 56 feet bgs transitioning to a moist reddish-brown sandy silt from 56 to 61 feet bgs. Saturated conditions were encountered in wet silty sand from 61 to 74 feet bgs and wet very fine sandy silt below 74 feet bgs.

Monitoring well YC-MW-06 was completed with a 0.010-inch slot PVC screen from 58 to 68 feet bgs surrounded by a #12-20 silica sand pack that extends up to 56 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 70 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-06 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-06 is BKB-744. The elevation of the top of the steel monument is 944.62 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.29 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-06 on December 5, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 48.14 bmp. The well was pumped at a constant rate of approximately 0.39 gpm for 48 minutes and water was discharged to ground in the right-of-way approximately 45 feet west from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-06 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 13.6 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-06 sample was 58.4 mg/L.

4.5 YC-MW-07

Monitoring well YC-MW-07 was drilled and installed on November 13, 2018 in the right-of-way adjacent to Linderman Road near the intersection of Murray Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 46 feet bgs.

The upper 8 feet of material consisted of fine sand overlaying approximately 4 feet of silt from 8 to 12 feet bgs. The silt interval was underlain by fine to medium sand coarsening with depth. A 4-foot interval of saturated wet coarse sand was encountered from 23 to 30 feet bgs underlain by fine to medium sand to the total depth of 46 feet bgs.

Monitoring well YC-MW-07 was completed with a 0.010-inch slot PVC screen from 24 to 44 feet bgs surrounded by a #12-20 silica sand pack that extends up to 22 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-07 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-07 is BKB-736. The elevation of the top of the steel monument is 693.11 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.31 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-07 on November 26, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 16.27 bmp. The well was pumped at a constant rate of approximately 0.55 gpm for 65 minutes and water was discharged to ground in the right-of-way approximately 40 feet south from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-07 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 385 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-07 sample was 4.34 mg/L.

4.6 YC-MW-08

Monitoring well YC-MW-08 was drilled and installed on November 9, 2018 in the right-of-way adjacent to Van Belle Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 36 feet bgs.

The upper 6 feet of material consisted of moist silty sand. Wet brown sandy silt continues from 6 to 18 feet bgs. Underlying this unit was silty sand to 36 feet bgs. This silty sand was targeted for screening.

Monitoring well YC-MW-08 was completed with a 0.010-inch slot PVC screen from 16 to 36 feet bgs surrounded by a #12-20 silica sand pack that extends up to 14 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-08 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-08 is BKB-733. The elevation of the top of the steel monument is 786.59 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.32 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-08 on November 15, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 5.85 bmp. The well was pumped at a constant rate of approximately 2.19 gpm for 50 minutes and water was discharged to ground in the right-of-way approximately 50 feet east from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-08 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 153.3 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-08 sample was 15.4 mg/L.

4.7 YC-MW-09

Monitoring well YC-MW-09 was drilled and installed on October 29-30, 2018 in the right-of-way adjacent to Sheller Road near the intersection with Bethany Road in Sunnyside, WA. A hand auger was used as a pilot hole to 6 feet bgs, and a 6-inch outer diameter sonic-drilling core barrel with a 4-inch inner diameter barrel was used to advance the borehole to a total depth of 72 feet bgs.

The materials penetrated in the upper 21 feet were dry and consisted of sandy silt overlying fine sand. A semi-consolidated layer of fine sandstone or possibly ash was encountered between 22.5 and 24 feet bgs. The material underlying the semi-consolidated sandstone was wet sand from 24 to 29 feet bgs with varying amounts of gravel. The material between 29 and 43.5 feet bgs was generally finer grained than above, varying from sandy silt to clayey silt with the exception of a gravelly sand layer between 33 and 35 feet bgs. Coarser-grained fine sand and gravelly fine sand was encountered from 43.5 to 53 feet bgs, which was underlain by silt, cobbles, and boulders. The bottom of the borehole was drilled into unfractured rock between 71 and 72 feet bgs.

Monitoring well YC-MW-09 was screened from 26 to 36 ft, which included the shallowest saturated materials observed during drilling. Depth to water prior to the start of testing was observed at 23.72 bmp. A #12-20 silica sand pack extends up to 24 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 37.5 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-09 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-09 is BKB-727. The elevation of the top of the steel monument

is 926.89 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.44 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-09 on December 3, 2018 using a GeoSub submersible pump. The well was pumped at a constant rate of approximately 0.39 gpm for 18 minutes and water was discharged to ground in the right-of-way approximately 50 feet west from the wellhead. The pump test results were inconclusive but sustainable pumping rate during sampling is below 0.39 gpm. Water quality results from the sampling event are summarized in Table 2. The nitrate concentration in the YC-MW-09 sample was 1.7 mg/L.

4.8 YC-MW-10

Monitoring well YC-MW-10 was drilled and installed on October 26, 2018 in the right-of-way adjacent to Roza Drive in Zillah, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 85 feet bgs.

The upper 26 feet of material generally consisted of fine sand, underlain by silt from 26 to 34 feet bgs. The material from 34 to 66 feet bgs consisted of sand and sandy silt, with saturated wet sand and sandy silt encountered at from 66 to 76 feet bgs. The water bearing interval is underlain by clayey silt from 77 to 85 feet bgs.

Monitoring well YC-MW-10 was completed with a 0.010-inch slot PVC screen from 66 to 76 feet bgs surrounded by a #12-20 silica sand pack that extends up to 64 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 78 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-10 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-10 is BKB-739. The elevation of the top of the steel monument is 1034.09 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.40 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-10 on November 13, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 62.08 bmp. The well was pumped at a constant rate of approximately 1.11 gpm for 47 minutes and water was discharged to ground in the right-of-way approximately 5-7 feet south from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-10 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 12.1 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-10 sample was 11.5 mg/L.

4.9 YC-MW-11

Monitoring well YC-MW-11 was drilled and installed on November 7-8, 2018 in the right-of-way adjacent to Eagle Peak Road in Zillah, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 180 feet bgs.

The upper 6 feet consisted of moist silty sand, underlain by moist sandy silt from 6 to 12 feet bgs. Predominantly sandy gravel extended from 12 to 21 feet bgs. Between 21 and 75 feet bgs were

predominantly sands, varying from silty sand to coarse gravelly sand. Increased oxidization was present from 56 to 74 feet. Between 74 and 118 feet bgs were predominantly silts, varying from sandy silt to clayey silt. Clayey silt layers in this section were often especially dense and were interpreted to represent aquitards. Coarser units of gravelly sand and sandy gravels extended from 118 feet to the total boring depth of 180 feet bgs.

Monitoring well YC-MW-11 was completed with a 0.010-inch slot PVC screen from 164 to 179 feet bgs surrounded by a #12-20 silica sand pack that extends from 162 to 180 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-11 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-11 is BKB-731. The elevation of the top of the steel monument is 974.49 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.36 feet as measured in the field by PGG during pump testing and sampling.

Depth to water prior to the start of testing on December 2, 2018 was observed at 162.55 bmp. This depth to water exceeded the lift capacity of the pumps so no drawdown test was performed. The groundwater sampled was collected with a decontaminated stainless-steel bailer. The nitrate concentration in the YC-MW-11 sample was 1.74 mg/L

4.10 YC-MW-12

Monitoring well YC-MW-12 was drilled and installed on November 16-17, 2018 in the parking lot at Dykstra Park accessible from South Euclid Road in Grandview, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 7 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 62 feet bgs.

The upper 21 feet of material generally consisted of fine sand with wet gravelly silt from 21 to 26 feet bgs underlain by clayey silt from 26 to 62 feet bgs.

Monitoring well YC-MW-12 was completed with a 0.010-inch slot PVC screen from 22 to 42 feet bgs surrounded by a #12-20 silica sand pack that extends up to 20 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 43 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-12 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-12 is BKB-742. The elevation of the top of the steel monument is 790.73 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.37 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-12 on December 3, 2018 using a Proactive Tempest submersible pump. Depth to water prior to the start of testing was observed at 25.48 bmp. The well was pumped at a constant rate of approximately 0.16 gpm for 43 minutes and water was discharged to ground in the right-of-way approximately 10 feet east from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-12 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 0.76 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-12 sample was 0.38 mg/L.

4.11 YC-MW-14

Monitoring well YC-MW-14 was drilled and installed on November 6, 2018 in the right-of-way adjacent to Harrison Road near the intersection of Alexander Extension in Grandview, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 48 feet bgs.

The upper 9.5 feet of material was composed of moist well-sorted fine sand. Silty sand continued from 9.5 to 19 feet bgs followed by alternating gravelly sand and sandy gravel between 19 and 27 feet bgs. This sandy gravel was significantly oxidized from 25.5 to 27 feet bgs. Between 27 and 48 feet bgs basalt was encountered. This basalt contained a trace of moderately oxidized fractures and was interpreted as an aquitard.

Monitoring well YC-MW-14 was completed with a 0.010-inch slot PVC screen from 22 to 27 feet bgs surrounded by a #12-20 silica sand pack that extends up to 20 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 28 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-14 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-14 is BKB-729. The elevation of the top of the steel monument is 938.32 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.27 feet as measured in the field by PGG during pump testing and sampling. No aquifer test was performed, no depth to water measured, and no water quality sample was collected due to insufficient water during the December 2018 field mobilization.

4.12 YC-MW-15

Monitoring well YC-MW-15 was drilled and installed on November 10-11, 2018 in the right-of-way adjacent to Chaffee Road near the intersection of Scoon Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 200 feet bgs.

The upper 9 feet was composed of sand and gravelly sand. Underlying these sands was finer silty sand from 9 to 17.5 feet bgs. Between 17.5 and 80 feet bgs were alternating layers of predominantly silty fine sands and fine sandy silts, with an overall slight trend of coarsening downward, followed by finer units of silt and fine sandy silt to 117 feet bgs. Between 117 and 136.5 feet bgs, a general coarsening downward trend was observed, transitioning from alternating fine sandy silt and silty fine sand into silty fine sand and fine to medium sand. Units further below ground surface continued to coarsen into predominantly sandy gravels and gravelly sands, with units between 145 and 156 feet bgs commonly displaying slight to moderate oxidization. These sandy gravels and gravelly sands continued from 136.5 feet to the total boring depth of 200 feet bgs.

Monitoring well YC-MW-15 was completed with a 0.010-inch slot PVC screen from 185 to 200 feet bgs surrounded by a #12-20 silica sand pack that extends up to 183 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-15 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-15 is BKB-734. The elevation of the top of the steel monument is 1168.49 feet

(NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.31 feet as measured in the field by PGG during pump testing and sampling.

Depth to water prior to the start of testing on December 5, 2018 was observed at 188.68 bmp. This depth to water exceeded the lift capacity of the pumps so no drawdown test was performed. The groundwater sampled was collected with a decontaminated stainless-steel bailer. The nitrate concentration in the YC-MW-15 sample was 1.02 mg/L.

4.13 YC-MW-16

Monitoring well YC-MW-16 was drilled and installed on October 27, 2018 in the right-of-way adjacent to Van Belle Road in Outlook, WA. A hand auger was used as a pilot hole to 5 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was then used to advance the borehole to a total depth of 36 feet bgs.

Moist, slightly silty, fine sand was encountered in the upper 12 feet of material that overlay wet, fine sand between 12 and 14 feet bgs, and moist, slightly silty to silty fine sand between 14 and 16 feet bgs. The materials penetrated between 16 and 23.5 feet bgs decreased in moisture with depth although the grain sized coarsened downwards from sandy silt to slightly silty fine with trace medium sand. Layers of silt, fine sand, and slightly silty sand were observed between 23.5 and 27.5 feet bgs and then slightly sandy silt to a total depth of 36 feet bgs.

YC-MW-16 was completed with a 0.010-inch slot PVC screen from 13 to 23 feet bgs surrounded by a #12-20 silica sand pack that extends up to 11 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 24.5 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-16 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-16 is BKB-740. The elevation of the top of the steel monument is 775.96 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.34 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-16 on November 14, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 9.99 bmp. The well was pumped at a constant rate of approximately 0.70 gpm for 51 minutes and water was discharged to ground in the right-of-way approximately 40 feet east from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-16 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 122.5 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-16 sample was 6.3 mg/L.

4.14 YC-MW-17

Monitoring well YC-MW-17 was drilled and installed on October 24, 2018 in the right-of-way adjacent to Konnowac Pass Road near the intersection of Brooks Road in Donald, WA. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 127 feet bgs.

The upper most portion of this boring consisted of rock that is believed to be a fill material and was encountered down to 11 feet bgs. Between 11 and 83 feet bgs, the boring consisted of predominantly silt with varying clays, sands and gravels. Between 60 and 83 feet bgs there were zones of oxidation observed. Between 83 and 120 feet bgs, a coarsening downward sequence was observed, starting as a silty

sand, grading to medium sands. Zones of oxidation were observed from 100 to 120 feet bgs. The bottom of the boring from 120 to 127 feet bgs transitioned back to dense clayey silt.

Monitoring well YC-MW-17 was completed with a 0.010-inch slot PVC screen from 100 to 120 feet bgs surrounded by a #12-20 silica sand pack that extends up to 97.5 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-17 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-17 is BKB-737. The elevation of the top of the steel monument is 1037.03 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.33 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-17 on November 12, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 85.67 bmp. The well was pumped at a constant rate of approximately 2.12 gpm for 67 minutes and water was discharged to ground in the right-of-way approximately 15 feet east from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-17 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 1,060 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-17 sample was 6.85 mg/L.

4.15 YC-MW-19

Monitoring well YC-MW-19 was drilled and installed on October 25, 2018 in the right-of-way adjacent to Darby Lane near the intersection of Blue Goose Road in Sunnyside, WA. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 87 feet bgs.

The upper 47 feet of the boring consisted of silt with varying sand and gravel content. Oxidation was observed at 43 feet bgs. Sandy silt and fine to medium sand layers continued from 47 to 61 feet bgs. Clayey silt was observed from 61 to 67.5 feet bgs, followed by sandy silt to the total boring depth of 87 feet bgs.

Monitoring well YC-MW-19 was completed with a 0.010-inch slot PVC screen from 47 to 62 feet bgs surrounded by a #12-20 silica sand pack that extends up to 45 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 63.5 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-19 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-19 is BKB-738. The elevation of the top of the steel monument is 913.23 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.32 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-19 on November 13, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 49.41 bmp. The well was pumped at a constant rate of approximately 0.94 gpm for 38 minutes and water was discharged to ground in the right-of-way approximately 5 feet west from the wellhead into a sloping ditch. A semi-logarithmic plot of drawdown in YC-MW-19 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 822.5 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-19 sample was 15.1 mg/L.

4.16 YC-MW-21

Monitoring well YC-MW-21 was drilled and installed on November 12, 2018 in the right-of-way adjacent to Belma Road in Grandview, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 66 feet bgs.

The upper 20 feet of material was sand, with a thin layer of silty sand from 14 to 15 feet bgs. Underlying these units, sandy silt was observed from 20 to 65 feet bgs, with one layer of silty fine sand from 22 to 24 feet bgs. An extremely dense layer of pinkish sandy silt was observed between 61 and 65 feet bgs, which was interpreted as an aquitard. Underlying this aquitard was a unit of sandy gravel from 65 to 66 feet bgs. The aquitard was sealed with bentonite and a screen was installed in the fine sandy silt overlying the aquitard.

Monitoring well YC-MW-21 was completed with a 0.010-inch slot PVC screen from 41 to 61 feet bgs surrounded by a #12-20 silica sand pack that extends from 39 to 62 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 62 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-21 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-21 is BKB-735. The elevation of the top of the steel monument is 724.68 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.31 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-21 on November 27, 2018 using a Proactive Tempest submersible pump. Depth to water prior to the start of testing was observed at 30.18 bmp. The well was pumped at a constant rate of approximately 0.27 gpm for 58 minutes and water was discharged to ground in the right-of-way approximately 30 feet west from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-21 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 15.8 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-21 sample was 0.66 mg/L.

4.17 YC-MW-23

Monitoring well YC-MW-23 was drilled and installed on November 8-9, 2018 in the right-of-way adjacent to North Granger Road in Zillah, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 116 feet bgs.

The upper 17.5 feet were composed of silty sand and very-well sorted sand layers, underlain by a sequence of silt from 17.5 to 19 feet bgs followed by sand from 19 to 22.5 feet bgs, and coarsening-downward sandy silt from 22.5 to 28 feet bgs. Material between 28 and 116 feet bgs was predominantly composed of sand, gravelly sand, and sandy gravel.

Monitoring well YC-MW-23 was completed with a 0.010-inch slot PVC screen from 94 to 114 feet bgs surrounded by a #12-20 silica sand pack that extends from 92 to 114.5 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 114.5 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-23 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-23 is BKB-732. The elevation

of the top of the steel monument is 890.12 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.30 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-23 on November 14, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 94.95 bmp. The well was pumped at a constant rate of approximately 1.97 gpm for 70 minutes and water was discharged to ground in the right-of-way approximately 70 feet south from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-23 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 2,298 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-23 sample was 6.0 mg/L.

4.18 YC-MW-24

Monitoring well YC-MW-24 was drilled and installed on November 13, 2018 in the right-of-way adjacent to Wilson Highway in Grandview, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 7 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 60 feet bgs.

The upper 30 feet consisted of fine sand to a silty fine sand, underlain by sandy silt and silts from 30 to 43 feet bgs. Wet silty sand containing gravel and gravely sandy silt was encountered from 43 to 57 feet bgs, underlain by non-fractured basalt at 57 feet bgs.

Monitoring well YC-MW-24 was completed with a 0.010-inch slot PVC screen from 46 to 56 feet bgs surrounded by a #12-20 silica sand pack that extends up to 45 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 57 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-24 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-24 is BKB-741. The elevation of the top of the steel monument is 815.73 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.28 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-24 on December 3, 2018 using a Proactive Tempest submersible pump. Depth to water prior to the start of testing was observed at 37.66 bmp. The well was pumped at a constant rate of approximately 0.92 gpm for 33 minutes and water was discharged to ground in the right-of-way approximately 50 feet south from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-24 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 644 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-24 sample was 6.32 mg/L.

4.19 YC-MW-25

Monitoring well YC-MW-25 was drilled and installed on November 27-29, 2018 in the right-of-way adjacent to Bailey Road near the intersection of Highland Drive in Zillah, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 7 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 275 feet bgs.

The upper 13 feet consisted of fine to medium sand. The material from 13 to 76 feet bgs consisted primarily of sand with variable content silt. A silt occurred from 77 to 79 feet bgs, underlain by sand with gravel from 79 to 126 feet bgs including a 3 ft gravely silt from 106 to 109 feet bgs. The material from 126 to 217 feet bgs generally consists of silty sand, with some sandy silt zones, underlain by a gravelly medium sand from 217 to 246 feet bgs. From 246 to 253 feet bgs, material consisted of moist sandy silt transitioning to wet silty fine sand (with some gravel and rocks) at 253 to 257 feet bgs, underlain by moist-to-wet very fine sand to sandy silt from 257 to 265 feet bgs and silty sand to medium sand from 265 to 273 feet bgs.

Monitoring well YC-MW-25 was completed with a 0.010-inch slot PVC screen from 253 to 273 feet bgs surrounded by a #12-20 silica sand pack that extends up to 251 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-25 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-25 is BKB-747. The elevation of the top of the steel monument is 1204.93 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.26 feet as measured in the field by PGG during pump testing and sampling.

Depth to water prior to the start of testing on December 6, 2018 was observed at 263.55 bmp. This depth to water exceeded the lift capacity of the pumps so no drawdown test was performed. The groundwater sampled was collected with a decontaminated stainless-steel bailer. The nitrate concentration in the YC-MW-25 sample was 3.58 mg/L

4.20 YC-MW-26

Monitoring well YC-MW-26 was drilled and installed on November 5, 2018 in the right-of-way adjacent to Riggins Road in Sawyer, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 116 feet bgs.

The upper 6 feet was composed of dry to moist gravelly sand, underlain by sandy silt to 14 feet bgs. From 14 to 39 feet bgs coarsening downward layers of silty sand to sand with a gravel fraction were observed. Clayey silt and sandy silt were observed from 39 to 53 feet bgs, followed by alternating sequences of predominantly silty sand and sandy silt to 95 feet bgs. Gravel fractions were common between 78 and 95 feet bgs in both the sand and silt layers. Below 95 feet was a sequence of clayey silt and sandy silt to 112.5 feet bgs, underlain by gravelly sand to 116 feet bgs. The clayey silt and sandy silt layers beginning at 95 feet were interpreted as a probable aquitard.

Monitoring well YC-MW-26 was completed with a 0.010-inch slot PVC screen from 76 to 96 feet bgs surrounded by a #12-20 silica sand pack that extends from 74 to 97 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 97 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-26 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-26 is BKB-728. The elevation of the top of the steel monument is 1039.52 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.39 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-26 on November 13, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 73.77 bmp. The well was

pumped at a constant rate of approximately 0.22 gpm for 47 minutes and water was discharged to ground in the right-of-way approximately 25 feet northwest from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-26 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 10.3 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-26 sample was 3.26 mg/L.

4.21 YC-MW-27

Monitoring well YC-MW-27 was drilled and installed on November 6, 2018 in the right-of-way adjacent to Tear Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 36 feet bgs.

The upper 2.5 feet of material was fine sandy silt, underlain by fine to medium sand from 2.5 to 3.5 feet bgs. The remaining material from 3.5 feet to 36 feet bgs was entirely composed of alternating layers of fine sandy silt and silty fine sand.

Monitoring well YC-MW-27 was completed with a 0.010-inch slot PVC screen from 21 to 36 feet bgs surrounded by a #12-20 silica sand pack that extends up to 19 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-27 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-27 is BKB-730. The elevation of the top of the steel monument is 719.52 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.35 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-27 on November 27, 2018 using a Proactive Tempest submersible pump. Depth to water prior to the start of testing was observed at 9.08 bmp. The well was pumped at a constant rate of approximately 1.39 gpm for 91 minutes and water was discharged to ground in the right-of-way approximately 25 feet southeast from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-27 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 8.0 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-27 sample was 24.6 mg/L.

4.22 YC-MW-28

Monitoring well YC-MW-28 was drilled and installed on November 17, 2018 in the right-of-way adjacent to Rusk Road in Grandview, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 7 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 46 feet bgs.

The upper 9 feet consisted of sandy silt, underlain by silt with coarse sand and rounded gravel from 11 to 20 feet bgs. Groundwater was encountered in gravely sand at 26 to 28 feet bgs, underlain by wet sandy silt, sand, and gravelly sand from 28 to 46 feet bgs.

Monitoring well YC-MW-28 was completed with a 0.010-inch slot PVC screen from 22 to 42 feet bgs surrounded by a #12-20 silica sand pack that extends up to 21 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 43 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-28 is below land surface, a 2-inch, water-tight expanding well cap was installed in the

top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-28 is BKB-743. The elevation of the top of the steel monument is 731.62 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.24 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-28 on December 4, 2018 using a Proactive Tempest submersible pump. Depth to water prior to the start of testing was observed at 25.25 bmp. The well was pumped at a constant rate of approximately 1.41 gpm for 41 minutes and water was discharged to ground in the right-of-way approximately 50 feet east from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-28 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 653 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-28 sample was 3.1 mg/L.

4.23 YC-MW-31

Monitoring well YC-MW-31 was drilled and installed on January 17, 2019 in the right-of-way adjacent to Murray Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 5 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 45 feet bgs.

The upper 10 feet of material was composed of silty fine sand and fine sand. A thin layer of fine sandy silt was observed from 10 to 11.5 feet bgs, followed by sand from 11.5 feet to the total boring depth of 45 feet bgs. These sand layers were predominantly well sorted and overall coarsened downward from fine to medium sand into medium and medium to coarse sand.

Monitoring well YC-MW-31 was completed with a 0.010-inch slot PVC screen from 30 to 45 feet bgs surrounded by a #12-20 silica sand pack that extends up to 29 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-31 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-31 is BKB-756. The elevation of the top of the steel monument is 693.23 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.39 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-31 on February 26, 2019 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 29.04 bmp. The well was pumped at a constant rate of approximately 2.80 gpm for 38 minutes and water was discharged to ground in the right-of-way approximately 40 feet west from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-31 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 4,900 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-31 sample was 5.94 mg/L.

4.24 YC-MW-33

Monitoring well YC-MW-33 was drilled and installed on January 16, 2019 in the right-of-way adjacent to Hudson Road in Granger, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 36 feet bgs.

The upper 29 feet of material was composed of silty fine sand. From 29 to the total boring depth of 36 feet bgs alternating layers of fine sandy silt and silty fine sand were observed.

Monitoring well YC-MW-33 was completed with a 0.010-inch slot PVC screen from 14 to 29 feet bgs surrounded by a #12-20 silica sand pack that extends up to 13 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 29.5 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-33 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-33 is BKB-754. The elevation of the top of the steel monument is 763.16 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.27 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-33 on February 27, 2019 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 6.23 bmp. The well was initially pumped at approximately 0.9 gpm for 12 minutes, which was reduced to approximately 0.69 gpm for the remaining 31 minutes of the test to avoid excessive drawdown in the well. Pumping test water was discharged to ground in the right-of-way approximately 40 feet west from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-33 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 2.6 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-33 sample was 24.2 mg/L.

4.25 YC-MW-35 (BOREHOLE ONLY)

A borehole was drilled at location YC -MW-35 on January 19, 2019 in the right-of-way adjacent to Gould Road near the intersection of Sli Road in Sunnyside, WA. A 6-inch outer-diameter sonic-drilling core barrel and 4-inch inner core barrel was used to advance the borehole to a total depth of 24 feet bgs.

The upper 10 feet of material was composed of sandy silt that was wet between 3.5 and 9 feet bgs. A layer of moist, gravelly, sandy silt was observed from 10 to 12 feet bgs that had increasing angular rock with depth and was underlain by dry angular gravel/fractured rock. Competent basalt was encountered at 14 feet bgs to the total boring depth of 24 feet bgs.

Although a monitoring well was originally intended to be installed at YC-MW-35, a well was not constructed based on field observations of insufficient water above the basalt. The boring was backfilled with hydrated bentonite 3/8 holeplug chips to ground surface and decommissioned in accordance with WAC 173-160. Because a well was not installed, hydraulic tests were not performed, and a groundwater quality sample was not collected.

4.26 YC-MW-38

Monitoring well YC-MW-38 was drilled and installed on January 17-18, 2019 in the right-of-way adjacent to Robinson Road in Grandview, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 5 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 140 feet bgs.

The upper 81 feet of material was composed of sandy gravel, with layers commonly including a moderate presence of calcium carbonate accumulation on gravel clasts and/or trace to moderate presence of oxidization. Between 81 and 140 feet bgs alternating layers of gravelly sand and sandy gravel were observed, including two thin layers of fine to medium sand from 91 to 93.5 feet bgs and from 100 to 103 feet bgs.

Monitoring well YC-MW-38 was completed with a 0.010-inch slot PVC screen from 120 to 135 feet bgs surrounded by a #12-20 silica sand pack that extends from 116 to 137 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-38 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-38 is BKB-758. The elevation of the top of the steel monument is 766.97 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.22 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-38 on February 26, 2019 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 120.39 bmp. The well was pumped at a constant rate of approximately 1.5 gpm for 33 minutes and water was discharged to ground in the right-of-way approximately 44 feet west from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-38 is presented in Appendix D. An estimated lower-end value of transmissivity based on the drawdown response is 5,250 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-38 sample was 10.3 mg/L.

4.27 YC-MW-39

Monitoring well YC-MW-39 was drilled and installed on January 14-15, 2019 in the right-of-way adjacent to Smith Road in Zillah, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 116 feet bgs.

The upper 13 feet of material was composed of silty fine sand and well-sorted medium sand, underlain by a layer of coarse sandy gravel from 13 to 16 feet bgs. Between 16 and 71.5 feet bgs, layers of silty fine sand and fine sandy silt were observed. Beneath these layers was a thin layer of medium to coarse sand from 71.5 to 74 feet bgs, followed by predominantly sandy gravel and gravel to the total boring depth of 116 feet bgs, with common signs of oxidation.

Monitoring well YC-MW-39 was completed with a 0.010-inch slot PVC screen from 100 to 115 feet bgs surrounded by a #12-20 silica sand pack that extends from 99 to 116 feet bgs. Bentonite 3/8 holeplug chips were used to fill the annular space between the sand pack and approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-39 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-39 is BKB-753. The elevation of the top of the steel monument is 880.92 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.29 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-39 on February 27, 2019 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 107.11 bmp. The pump test results were inconclusive, but sustainable pumping rate appears to be 350 mL/min. The nitrate concentration in the YC-MW-39 sample was 18.1 mg/L.

4.28 YC-MW-41

Monitoring well YC-MW-41 was drilled and installed on November 30, 2018 in the right-of-way adjacent to Factory Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of

the borehole and a hand auger was used as a pilot hole to 7 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 72 feet bgs.

The upper 15 feet consisted of sand and sandy silt, underlain by dry vesicular basalt from 15 to 55 feet bgs. Wet, fractured basalt was encountered from 55 to 72 feet bgs.

Monitoring well YC-MW-41 was completed with a 0.010-inch slot PVC screen from 56 to 66 feet bgs surrounded by a #12-20 silica sand pack that extends up to 54 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 67 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-41 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-41 is BKB-748. The elevation of the top of the steel monument is 965.95 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.29 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-41 on December 5, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 44.29 bmp. The well was pumped at a constant rate of approximately 2.64 gpm for 38 minutes and water was discharged to ground in the right-of-way approximately 60 feet west from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-41 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 924 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-41 sample was 26.9 mg/L.

4.29 YC-MW-42

Monitoring well YC-MW-42 was drilled and installed on November 26, 2018 in the right-of-way adjacent to East Euclid Road in Grandview, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 7 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 50 feet bgs.

The upper 30 feet consisted of fine to coarse sand and silty sand, underlain by moist-to-wet silt containing rounded gravels from 30 to 45 feet bgs. Dry fractured basalt was encountered from 45 to 50 feet bgs.

Monitoring well YC-MW-42 was completed with a 0.010-inch slot PVC screen from 32 to 47 feet bgs surrounded by a #12-20 silica sand pack that extends up to 48 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 48 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-42 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-42 is BKB-746. The elevation of the top of the steel monument is 699.70 feet (NAV88) as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.29 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-42 on December 4, 2018 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 33.39 bmp. The well was pumped at a constant rate of approximately 1.05 gpm for 32 minutes and water was discharged to ground in the right-of-way approximately 50 feet east from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-42 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 7.5

ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-42 sample was 7.04 mg/L.

4.30 YC-MW-44

Monitoring well YC-MW-44 was drilled and installed on January 15, 2019 in the right-of-way adjacent to East Allen Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 27 feet bgs.

The upper 20 feet of material consisted primarily of fine to medium sand, underlain by saturated sandy gravel from 20 to 22 feet bgs and silt from 22 to 27 feet bgs.

Monitoring well YC-MW-44 was completed with a 0.010-inch slot PVC screen from 12 to 22 feet bgs surrounded by a #12-20 silica sand pack that extends up to 11 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 23 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-44 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-44 is BKB-755. The elevation of the top of the steel monument is 754.70 feet NAV88 as surveyed by Yakima County and the stick down from the top of the monument to the top of the PVC well is 0.29 feet as measured in the field by PGG during pump testing and sampling.

A short-term pumping test was performed at YC-MW-44 on February 26, 2019 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 13.85 bmp. The well was pumped at a constant rate of approximately 3.44 gpm for 35 minutes and water was discharged to ground in the right-of-way approximately 40 feet west from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-44 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 1,204 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-44 sample was 30.2 mg/L.

4.31 YC-MW-46

Monitoring well YC-MW-46 was drilled and installed on January 18, 2019 in the right-of-way adjacent to Chute Road in Sunnyside, WA. A 24-inch diameter core barrel was used to drill the upper 1.5 feet of the borehole and a hand auger was used as a pilot hole to 6 feet bgs. A 6-inch outer-diameter sonic-drilling core barrel was used to advance the borehole to a total depth of 40 feet bgs.

The upper 13 feet consisted of medium sand transitioning to wet sand from 14 to 36 feet bgs, underlain by sandy silt from 36 to 40 feet bgs.

Monitoring well YC-MW-46 was completed with a 0.010-inch slot PVC screen from 18 to 33 feet bgs surrounded by a #12-20 silica sand pack that extends up to 16 feet bgs. Bentonite 3/8 holeplug chips were used to backfill the borehole below 35 feet bgs, and to fill the annular space above the sand pack to approximately 1-foot bgs. Water was added to the borehole to hydrate chips above the water table. Because the top of YC-MW-46 is below land surface, a 2-inch, water-tight expanding well cap was installed in the top of the PVC casing and a metal flush-to-grade monument set in a concrete pad protects the wellhead. Ecology's Unique Well Identification (UWID) for YC-MW-46 is BKB-757. The elevation of the top of the steel monument is 824.48 feet (NAV88) as surveyed by Yakima County and the stick down from the

top of the monument to the top of the PVC well is 0.30 feet as measured in the field by PGG during pump testing and sampling

A short-term pumping test was performed at YC-MW-46 on February 27, 2019 using a GeoSub submersible pump. Depth to water prior to the start of testing was observed at 12.78 bmp. The well was pumped at a constant rate of approximately 0.75 gpm for 51 minutes and water was discharged to ground in the right-of-way approximately 40 feet south from the wellhead. A semi-logarithmic plot of drawdown in YC-MW-46 is presented in Appendix D. The estimated transmissivity based on the drawdown response is 3.9 ft^2/day. Water quality results from the pump-test event are summarized in Table 2. The nitrate concentration in the YC-MW-46 sample was 18.1 mg/L.

5.0 REFERENCES

Pacific Groundwater Group. June 2016. Lower Yakima Valley GWMA Proposed Ambient Groundwater Monitoring Network. Consultant report to Yakima County.

USGS. 2009. Estimated water-level elevation contours for the Yakima Valley, Washington. SIR 2009-5152.

Table 1. Well Construction Summary, Yakima GWMA

Sample ID	Screen Depth (feet bgs)	Total Well Depth (feet bgs)	Total Borehole Depth (feet bgs)	Northing (feet NAD83)	Easting (feet NAD83)	Measuring Point (MP) Elevation [1] (feet NAVD88)	Stick Down (feet from Surveyed Ref. Point [2] to MP)	Depth to Water [3] (feet bmp)
YC-MW-01	10 - 25	25.2	26	359237.334	1770045.871	735.22	0.31	8.03
YC-MW-02	61 - 76	76	76	374757.932	1757182.650	875.26	0.41	56.25
YC-MW-05	23 - 38	39.2	46	358146.766	1753715.120	797.18	0.38	14.13
YC-MW-06	58 - 68	68.2	76	375010.934	1771956.787	944.33	0.29	48.14
YC-MW-07	24 - 44	46	46	342923.197	1759069.666	692.80	0.31	16.27
YC-MW-08	16 - 36	36.2	36	369502.468	1742525.475	786.27	0.32	5.85
YC-MW-09	26 - 36	36.2	72	364486.635	1785256.122	926.45	0.44	23.72
YC-MW-10	66 - 76	78.2	85	404973.197	1700493.573	1033.69	0.40	62.08
YC-MW-11	164 - 179	179.2	180	393333.483	1713616.447	974.13	0.36	162.55
YC-MW-12	22 - 42	42.2	62	333677.572	1788570.848	790.36	0.37	25.48
YC-MW-14	22 - 27	27.2	48	353843.614	1788172.966	938.04	0.27	27.05
YC-MW-15	185 - 200	200.2	200	388100.116	1761377.267	1168.18	0.31	188.68
YC-MW-16	13 - 23	23.2	36	369623.515	1731005.323	775.62	0.34	9.99
YC-MW-17	100 - 120	120	127	422577.081	1675477.030	1036.70	0.33	85.67
YC-MW-19	47 - 62	62.5	87	403733.504	1691142.457	912.91	0.32	49.41
YC-MW-21	41 - 61	61.2	66	332464.159	1776332.565	724.37	0.31	30.18
YC-MW-23	94 - 114	114.2	116	386455.508	1716288.296	889.82	0.30	94.95
YC-MW-24	46 - 56	56.2	60	343838.572	1790793.076	815.45	0.28	37.66
YC-MW-25	253 - 273	275	275	401363.813	1711060.025	1204.67	0.26	263.55
YC-MW-26	76 - 96	96.2	116	415545.787	1681988.644	1039.13	0.39	73.77
YC-MW-27	21 - 36	36.2	36	348483.147	1775485.346	719.17	0.35	9.08
YC-MW-28	22 - 42	43.2	46	313832.248	1778744.707	731.38	0.24	25.25
YC-MW-31	30 - 45	45.2	45	343074.772	1752292.157	692.84	0.39	29.04
YC-MW-33	14 - 29	29.2	36	374861.697	1721596.356	762.89	0.27	6.23
YC-MW-38	120 - 135	135.2	140	324604.962	1794427.124	766.75	0.22	120.39
YC-MW-39	100 - 115	115.2	116	395749.623	1703378.774	880.63	0.29	107.11
YC-MW-41	56 - 66	66.2	72	359036.960	1789145.667	965.66	0.29	44.29
YC-MW-42	32 - 47	47.2	50	321854.004	1778078.378	699.42	0.29	33.39
YC-MW-44	12 - 22	22.2	27	356483.938	1777955.978	754.41	0.29	13.85
YC-MW-46	18 - 33	33.2	40	372869.717	1748379.578	824.19	0.30	12.78

bgs - below ground surface

bmp - below measuring point on top of 2-inch well casing

NM = not measured

[1] *Top of steel flush-to-grade monument surveyed by Yakima County. Measuring Point (MP) elevation calculated using stick-down field measurements between top of monument and top of 2-inch casing made by PGG using a steel tape with 1/100th foot increments.*

[2] *Surveyed Ref. Point = top of stell flush-to-grade monument surveyed by Yakima County*

[3] *Static depth to water measurements made during hydraulic testing/sampling event.*

[4] *The measuring point elevation for YC-MW-46 provided by Yakima County; surveyed elevation of top of steel flush-to-grade monument is 824.49 feet NAVD88*

Table 2. Groundwater Quality Sampling Results, Yakima GWMA

Sample ID	Aquifer Test/ Sampling Purge Rate (gpm)	pH, Field (S.U.)	Specific Conductance, Field (uS/cm)	Oxidation Reduction Potential, Field (mV)	Temperature, Field (°C)	Turbidity, Field (NTU)	Nitrate, EPA Method 300.0 (mg/L)	Depth to Water [1] (feet bmp)
YC-MW-01	1.17	7.71	1872	-53	18.3	9.94	22.2	8.03
YC-MW-02	2.14	7.8	1008	-54.9	13.7	14.6	17.2	56.25
YC-MW-05	0.43	8.05	790.7	-68.6	14.3	158.7	3.14	14.13
YC-MW-06	0.39	7.6	880.5	-51.8	13	38.52	58.4	48.14
YC-MW-07	0.55	7.63	1278	-49.1	13.8	0.21	4.34	16.27
YC-MW-08	2.19	7.8	944	-55.8	12.9	56.31	15.4	5.85
YC-MW-09	0.39	7.89	493.1	-63.9	13.9	482.5	1.7	23.72
YC-MW-10	1.11	7.6	1093	-46.3	14	221.8	11.5	62.08
YC-MW-11	B	8.38	559.5	[2]	14.1	35.98	1.74	162.55
YC-MW-12	0.16	8.18	267.1	-79.1	15.6	119.1	0.38	25.48
YC-MW-14	[3]	[3]	[3]	[3]	[3]	[3]	[3]	27.05
YC-MW-15	B	8.61	377.6	-102.8	14	179.4	1.02	188.68
YC-MW-16	0.7	7.55	1299	-43.3	13.5	1.15	6.3	9.99
YC-MW-17	2.12	7.27	929.2	-28.4	14.1	1.65	6.85	85.67
YC-MW-19	0.94	7.6	1102	-46	13.9	3.29	15.1	49.41
YC-MW-21	0.27	8.07	483.6	-63.7	14.3	44.32	0.66	30.18
YC-MW-23	1.97	7.71	817.8	-52.5	13.8	6.5	6	94.95
YC-MW-24	0.92	7.71	531.1	-54.4	13.9	14.49	6.32	37.66
YC-MW-25	B	7.82	544.7	-66.7	15.4	506	3.58	263.55
YC-MW-26	0.22	7.83	624.6	-58.4	15.3	27.59	3.26	73.77
YC-MW-27	1.39	8.13	834.8	-67.7	15.3	198.3	24.6	9.08
YC-MW-28	1.41	8.07	250.5	-72	15.2	3.09	3.1	25.25
YC-MW-31	2.8	7.94	376.6	-67.1	15.2	1.64	5.94	29.04
YC-MW-33	0.69 [4]	7.91	1102	-57.5	12.5	2.43	24.2	6.23
YC-MW-38	1.5	7.43	629.1	-38.7	14.9	3.88	10.3	120.39
YC-MW-39	0.09	7.81	972.3	-51.7	10.9	738	18.1	107.11
YC-MW-41	2.64	7.48	968.9	-45.2	13.3	1.37	26.9	44.29
YC-MW-42	1.05	7.67	542.8	-51	13.2	>1100	7.04	33.39
YC-MW-44	3.44	7.51	815.9	-43	12.9	2.1	30.2	13.85
YC-MW-46	0.75	7.53	1089	-36.8	11.3	117	18.1	12.78

B - well was hand bailed, no purge rate was determined

bmp- below measuring point

°C - degrees celsius.

mg/L = milligrams/liter

mV = millivolts

NTU = Nephelometric Turbidity Units

S.U. - standard units

uS/cm - microSiemens/centimeter

[1] *Static depth to water measurements made during hydraulic testing/sampling event.*

[2] *Field parameter not measured.*

[3] *No aquifer test was performed at monitoring well YC-MW-14, this well had insufficient water during the December 2018 sampling event.*

[4] *YC-MW-33 initially pumped at approximately 0.9 gpm for 12 minutes, which was reduced to approximately 0.69 gpm for the remaining 31 minutes of the test to avoid excessive drawdown in the well.*

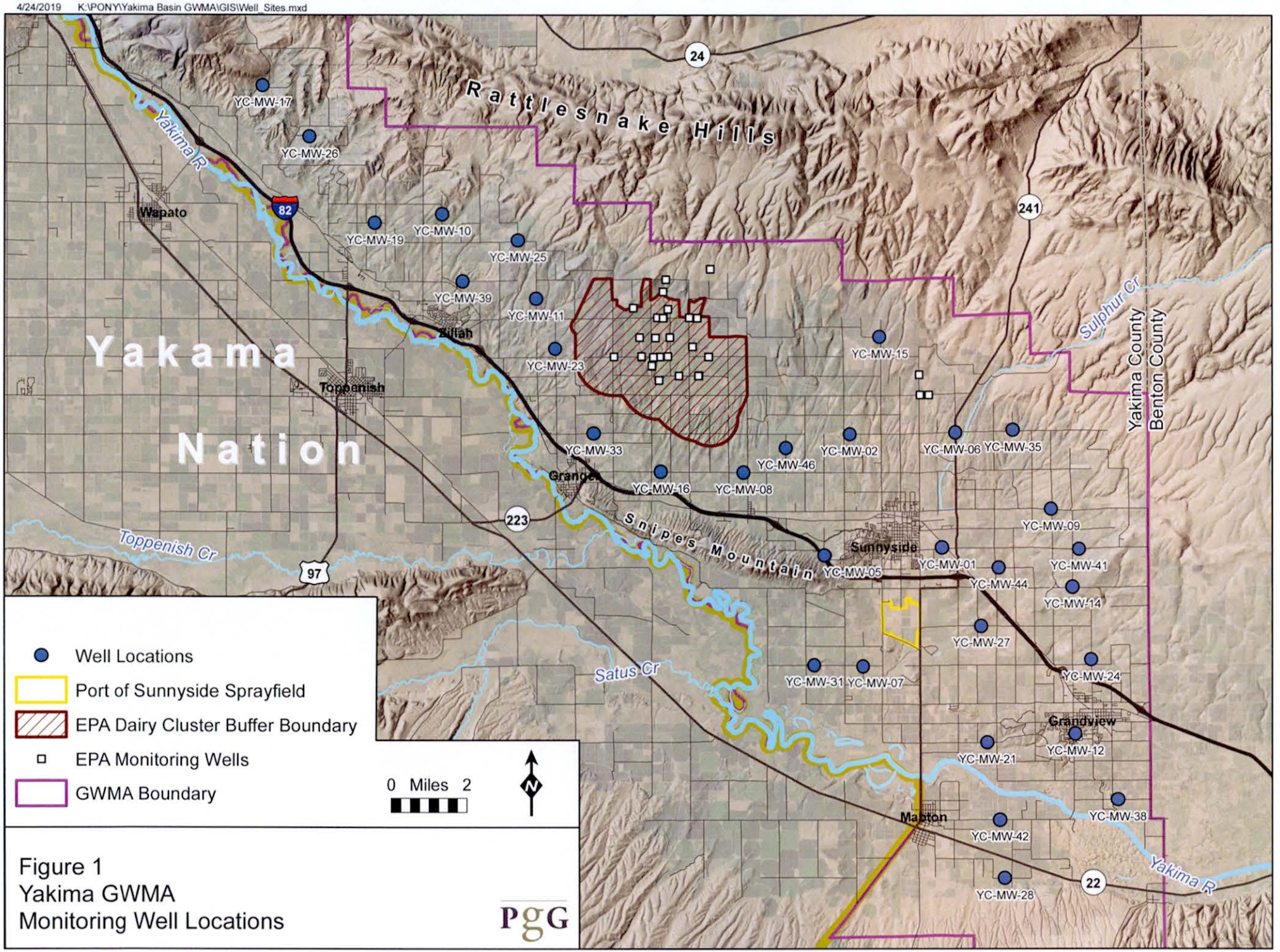


Figure 1
Yakima GWMA
Monitoring Well Locations

PgG

6/3/2019 K:\PONY\Yakima Basin GWMA\GIS\Well_Sites.mxd

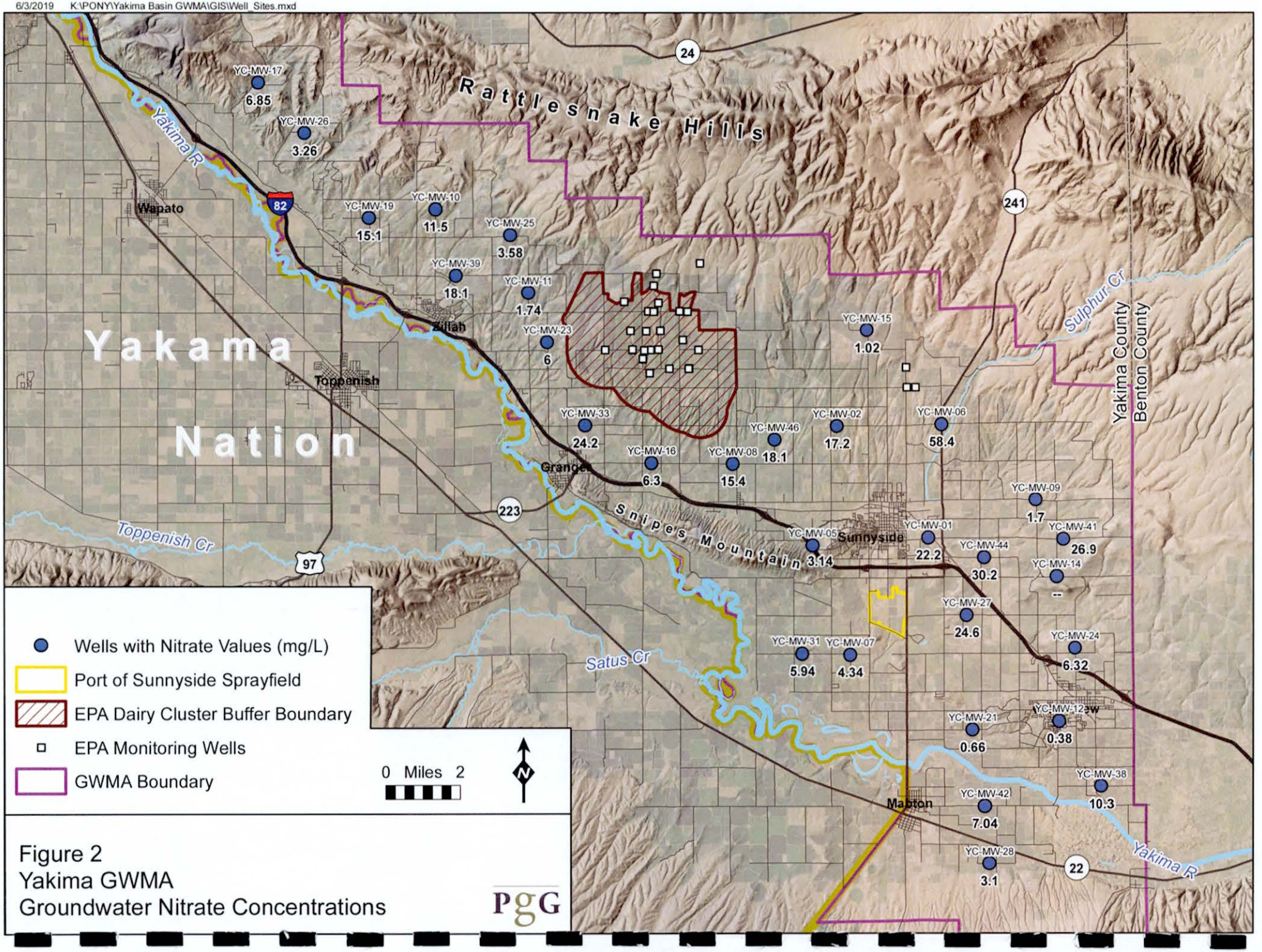


Figure 2
Yakima GWMA
Groundwater Nitrate Concentrations

PgG

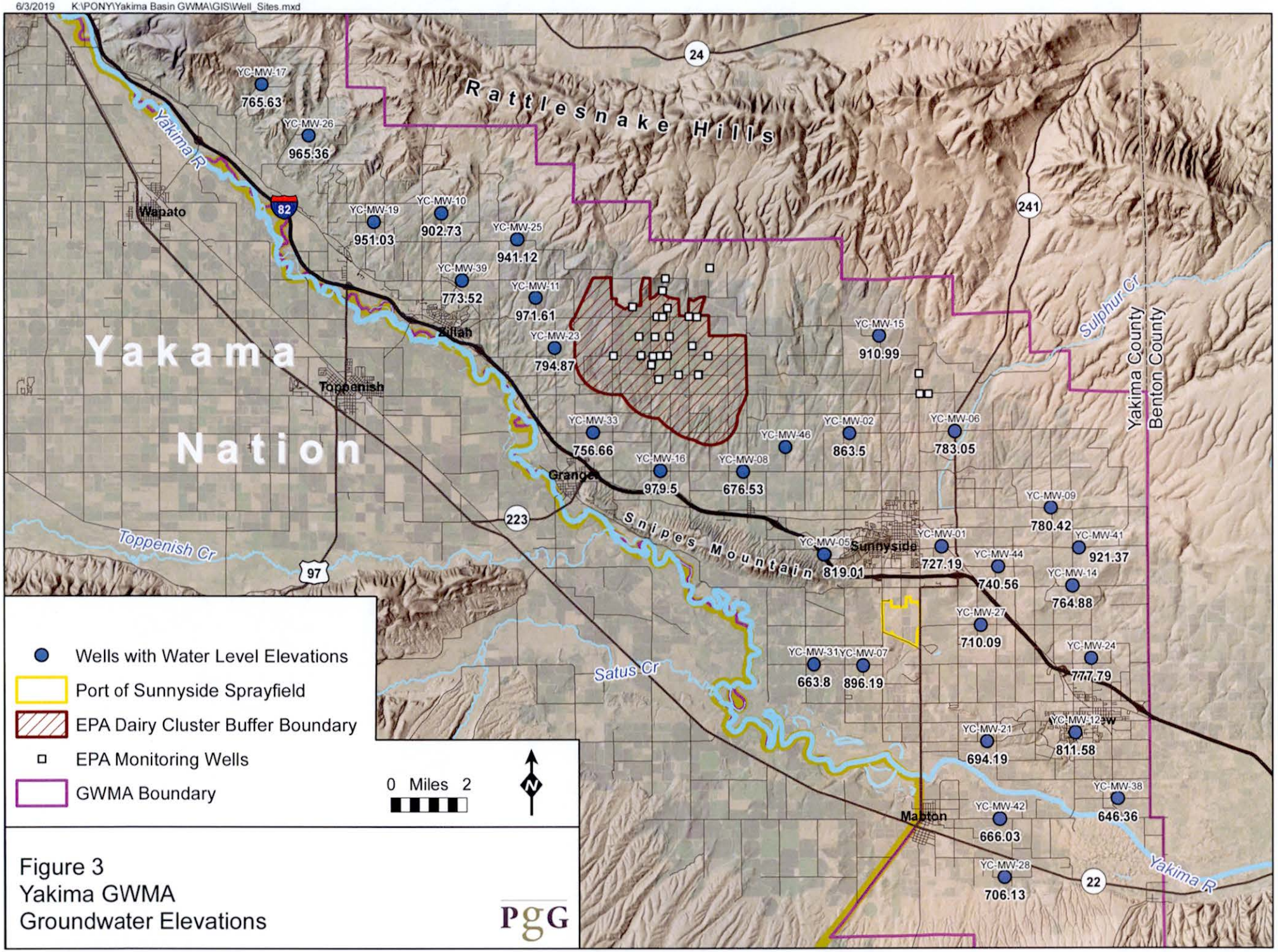
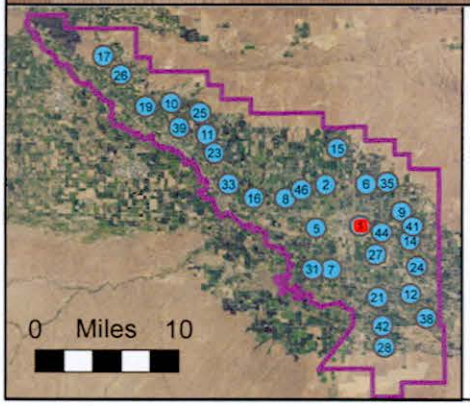


Figure 3
Yakima GWMA
Groundwater Elevations

PgG

APPENDIX A
BORING Location Maps





Well Location

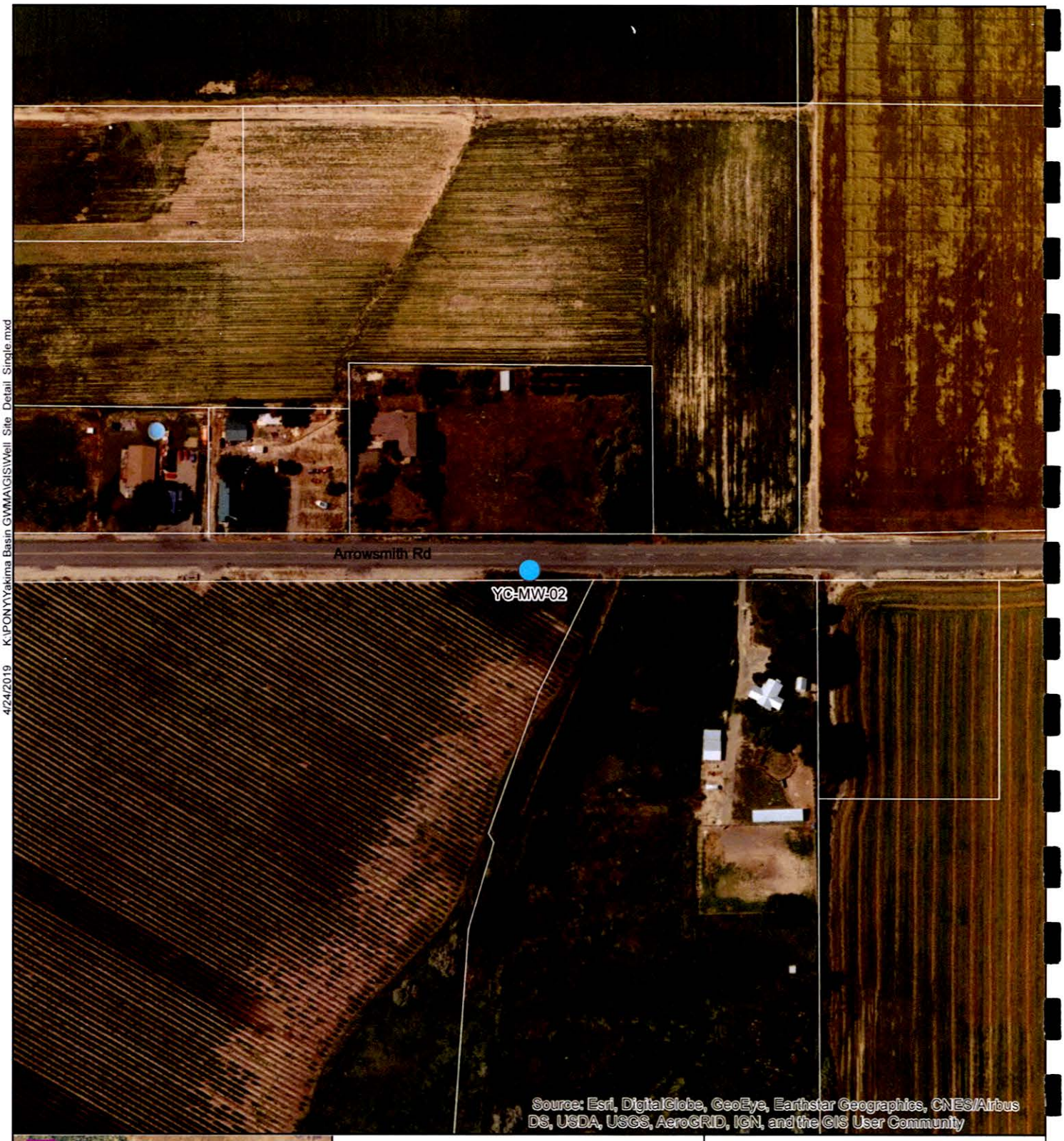
N

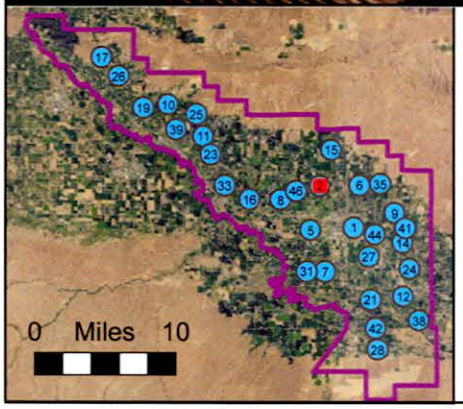
0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-01

PgG

4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd





Well Location

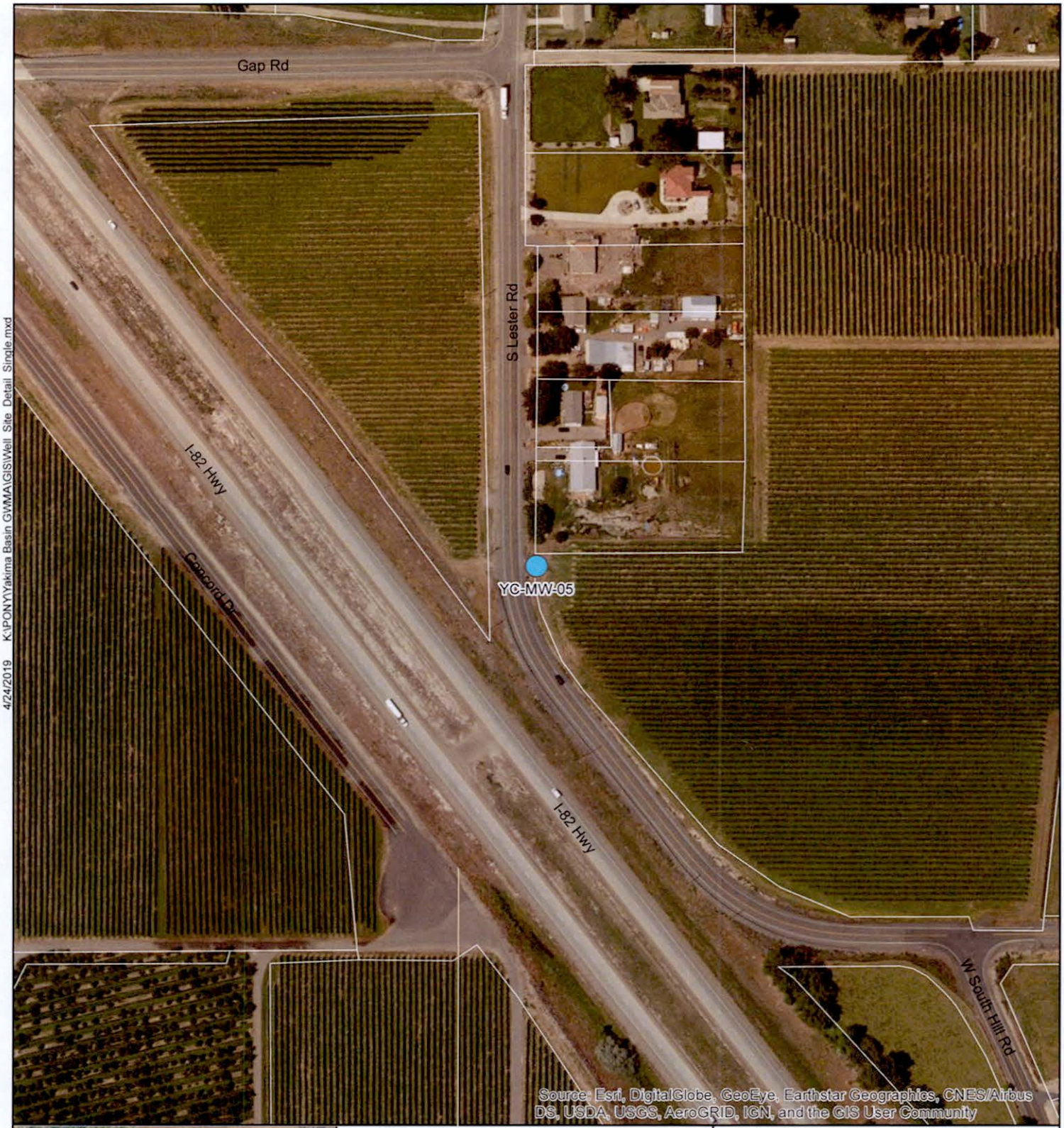
N

0 Feet 200

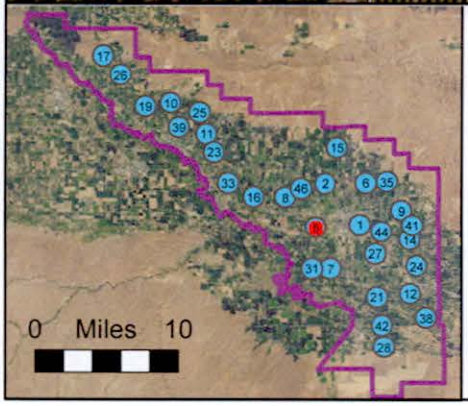
Yakima GWMA
Monitoring Well
YC-MW-02

PgG

4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



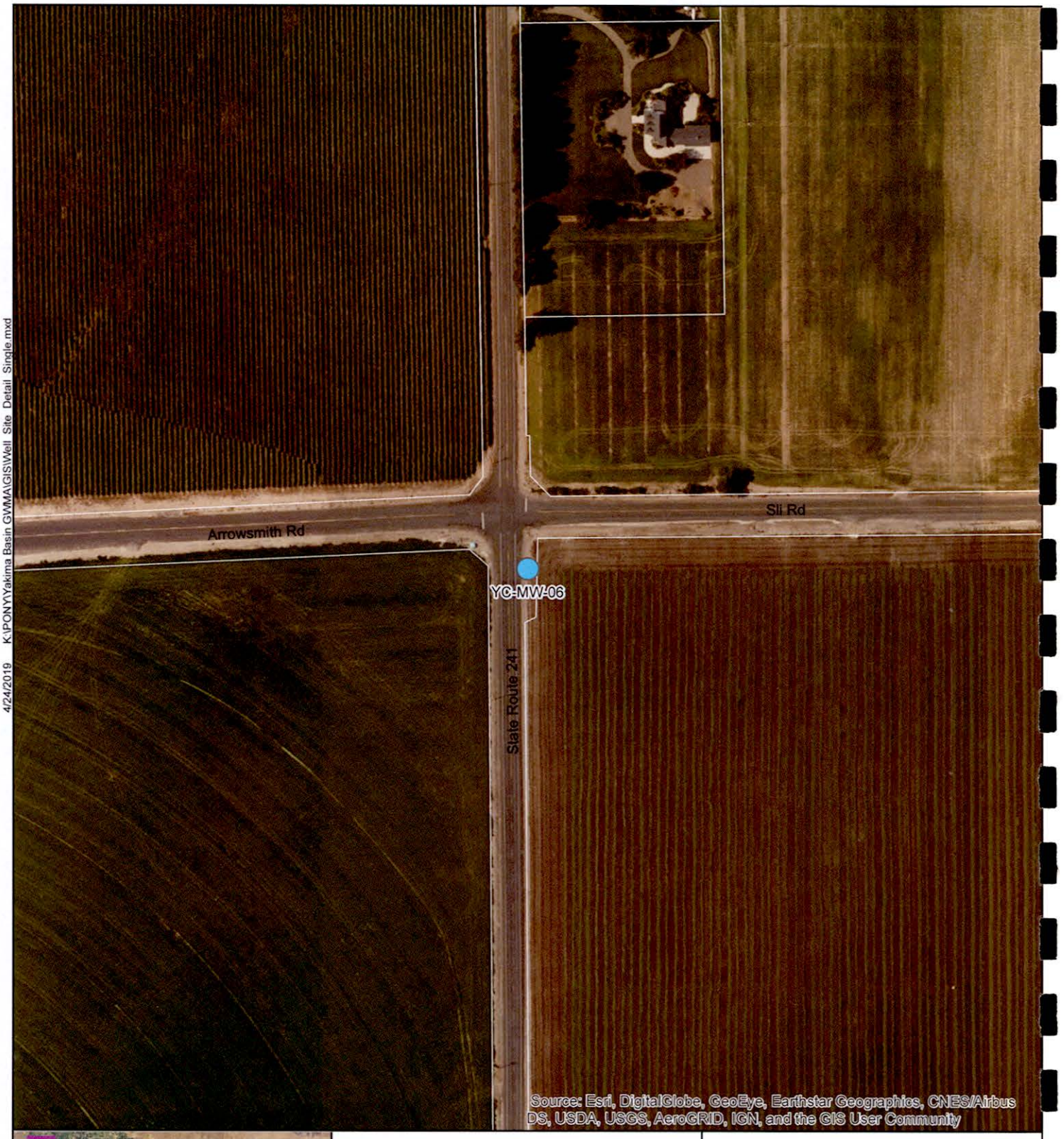
Well Location

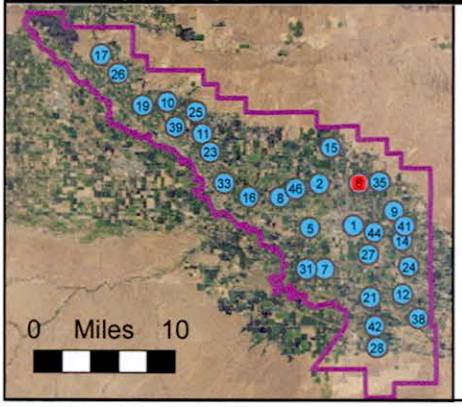
N

0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-05

PgG





Well Location

N

0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-06

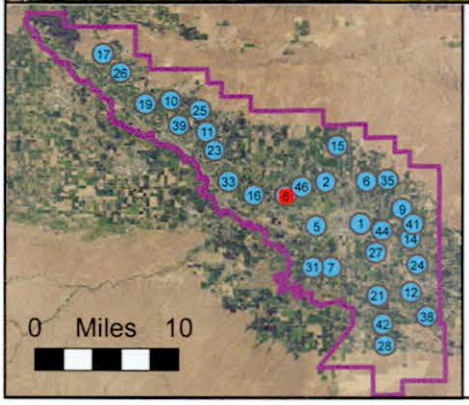
PgG

4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd


Murray Rd
YC-MW-07
Linderman Rd
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 Miles 10
Well Location
N
0 Feet 200
Yakima GWMA
Monitoring Well
YC-MW-07
PgG
4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd

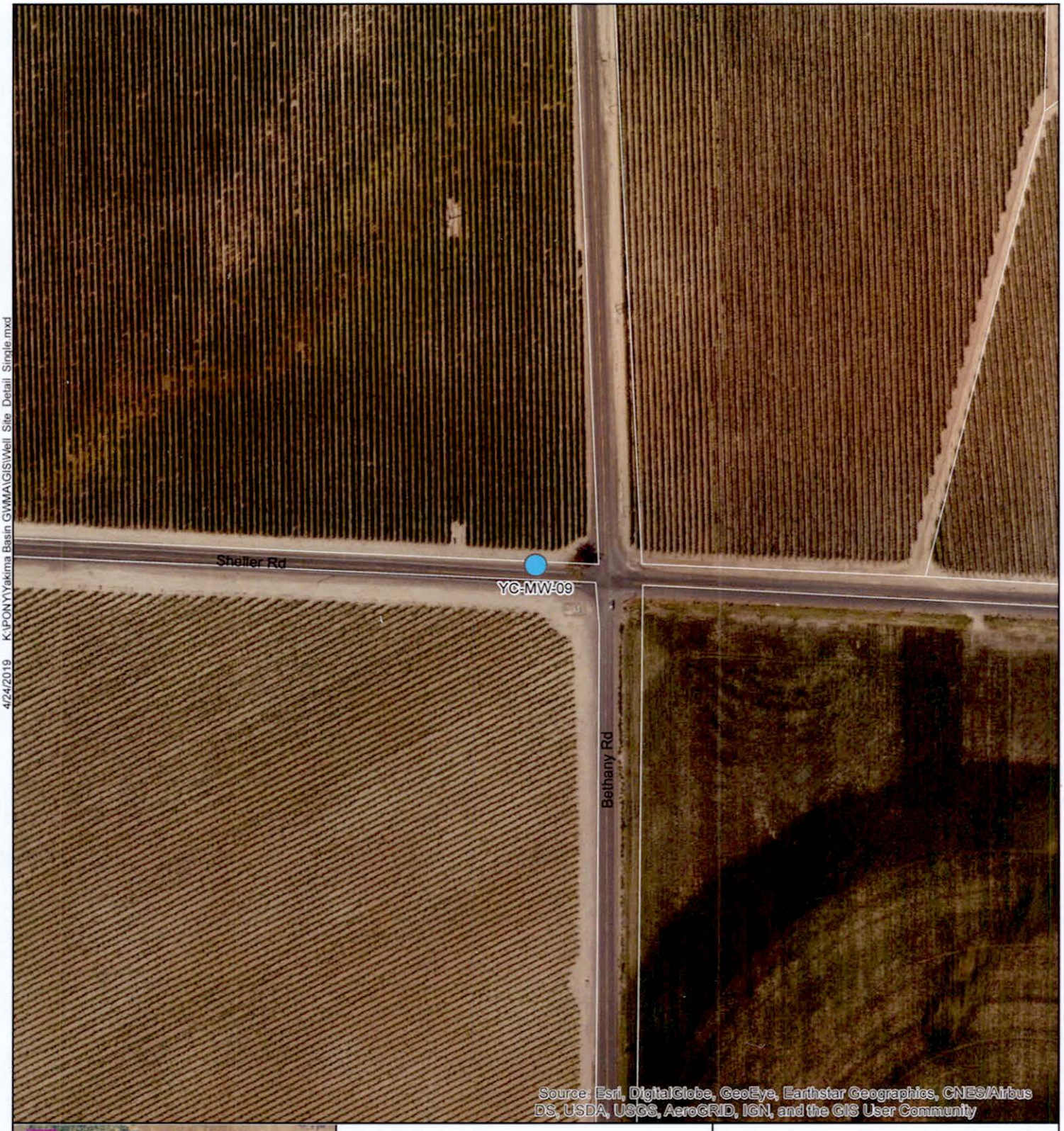


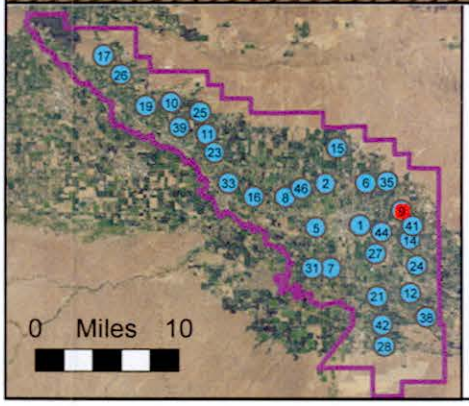
Well Location

0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-08

PgG





Well Location

N

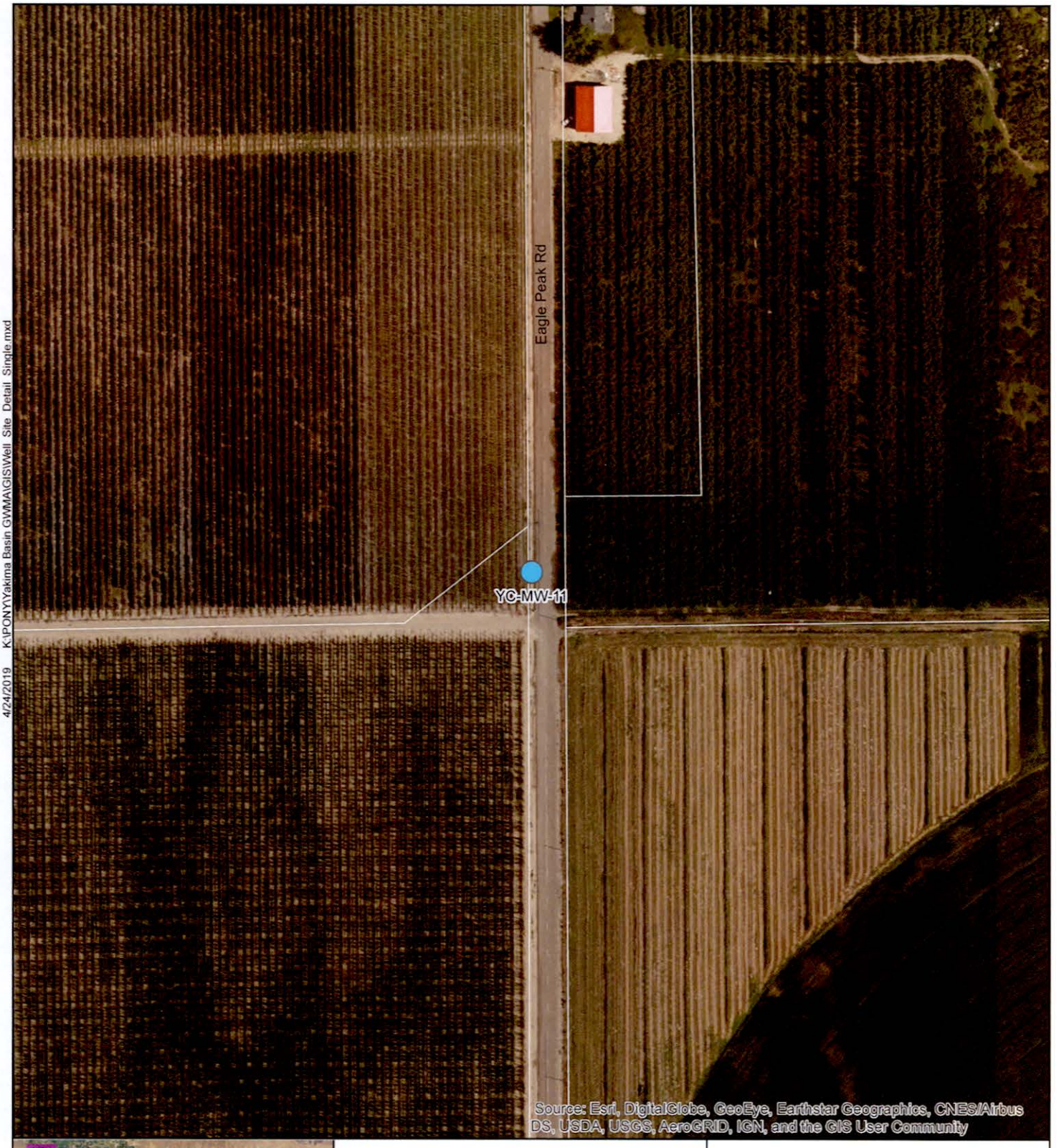
0 Feet 200

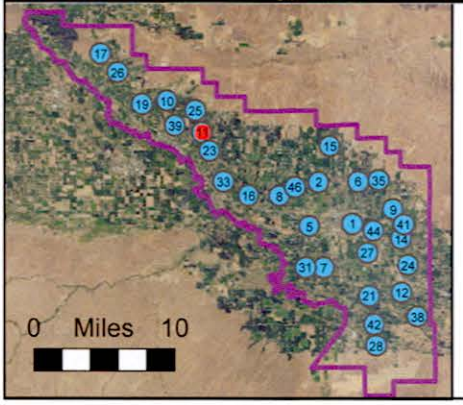
Yakima GWMA
Monitoring Well
YC-MW-09

PgG

4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd


4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd
YC-MW-10
Roza Dr
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 Miles 10
Well Location
N
0 Feet 200
Yakima GWMA
Monitoring Well
YC-MW-10
PgG





Well Location

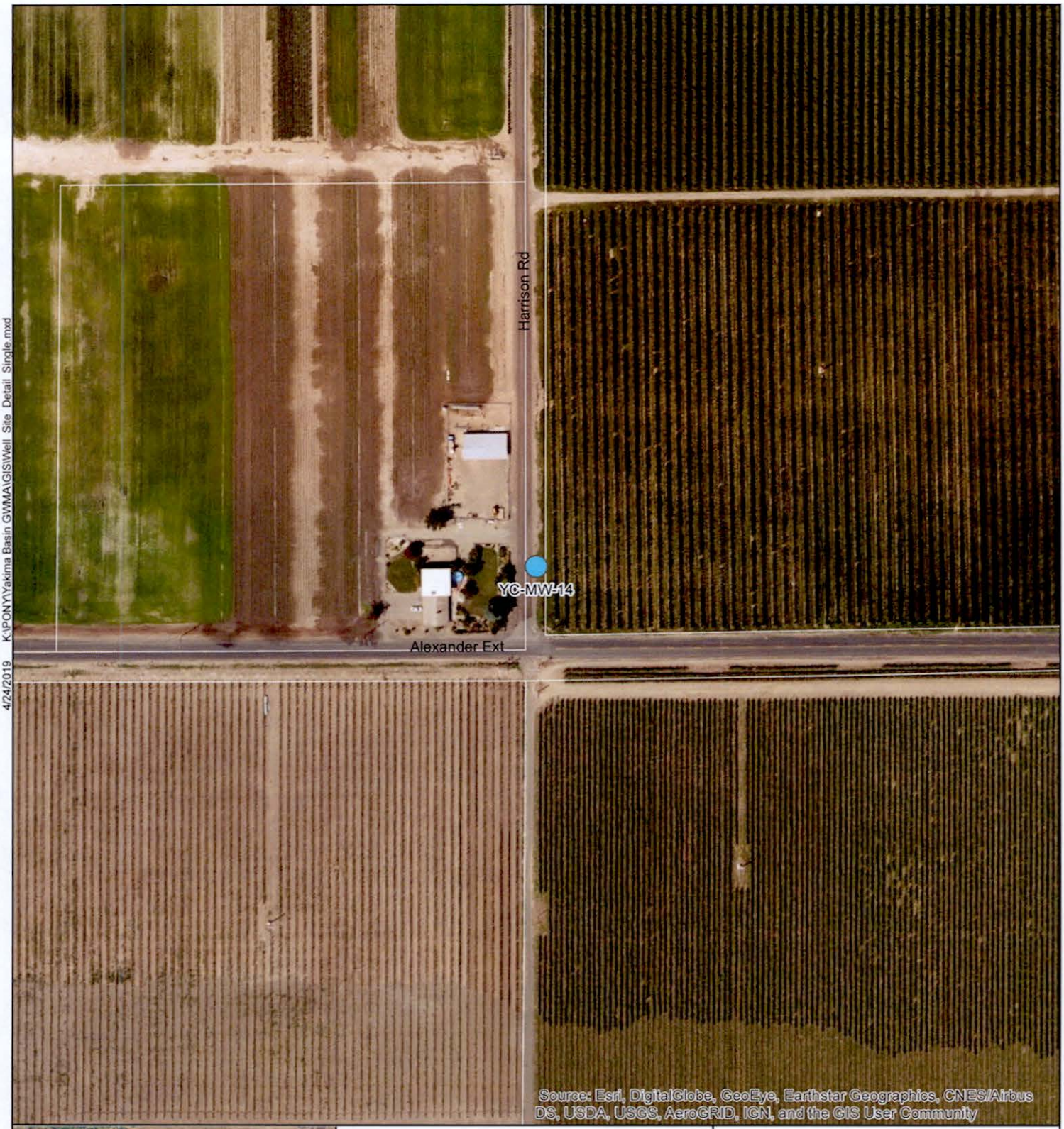
0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-11

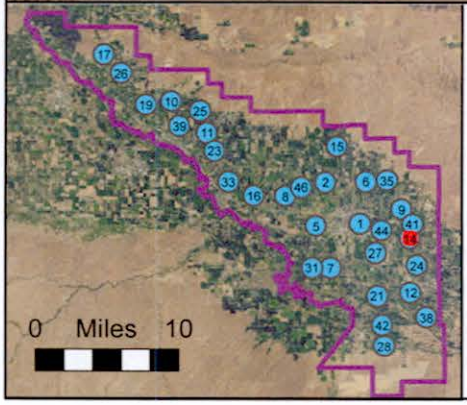
PgG

4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd


E Concord Ave
King St
King St
Stassen Wy
Rocky Ford Ln
Euclid Rd
YC-MW-12
Vivian Dr
Heidi Ln
Ora Dr
Heather Wy
S Euclid Rd
Carriage Square Dr
Coach Ct
Conestoga
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd
0 Miles 10
Well Location
N
0 Feet 200
Yakima GWMA
Monitoring Well
YC-MW-12
PgG



4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



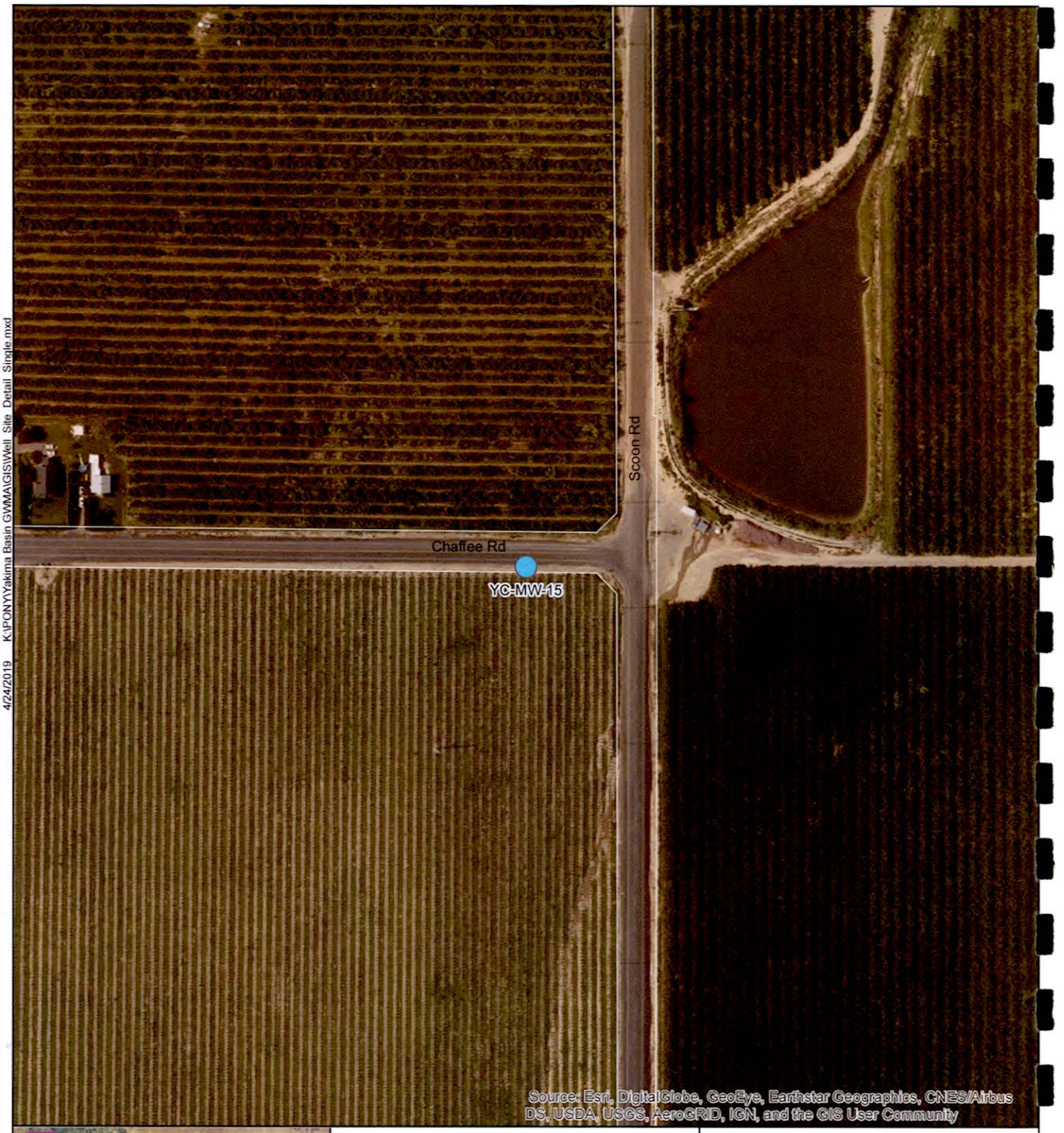
Well Location

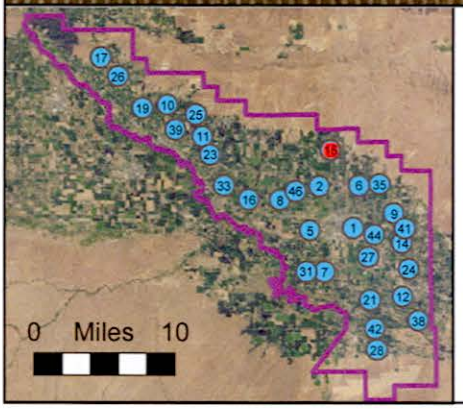
N

0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-14

PgG





Well Location

0 Feet 200

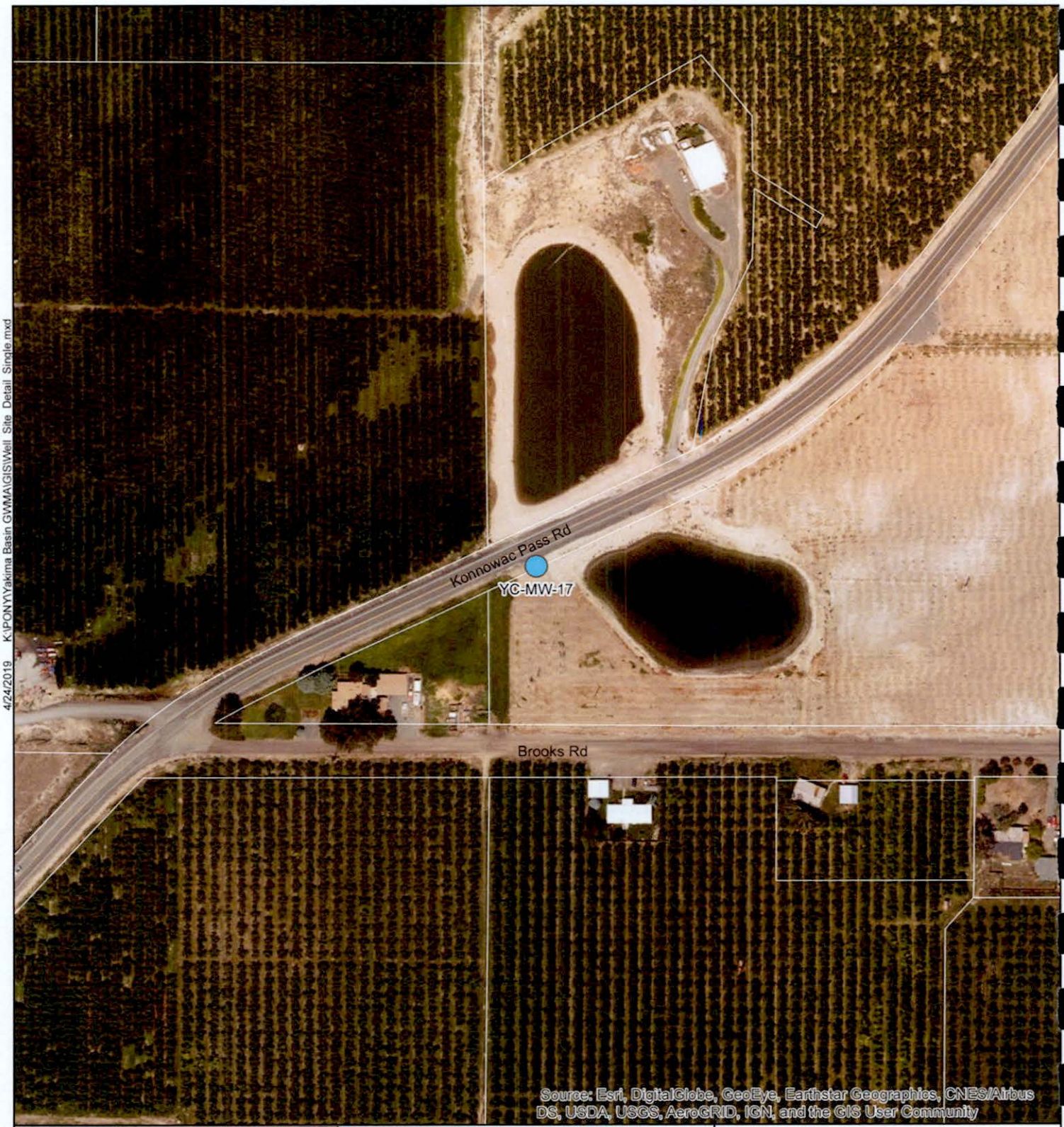
Yakima GWMA Monitoring Well YC-MW-15

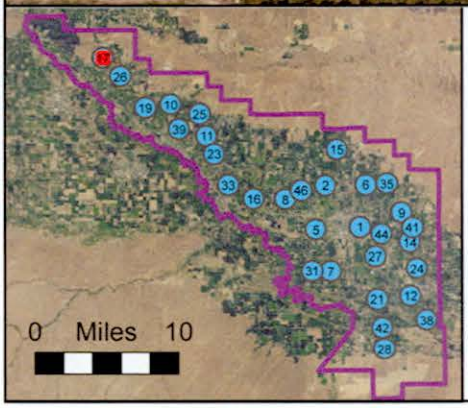
PgG

4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd





Well Location

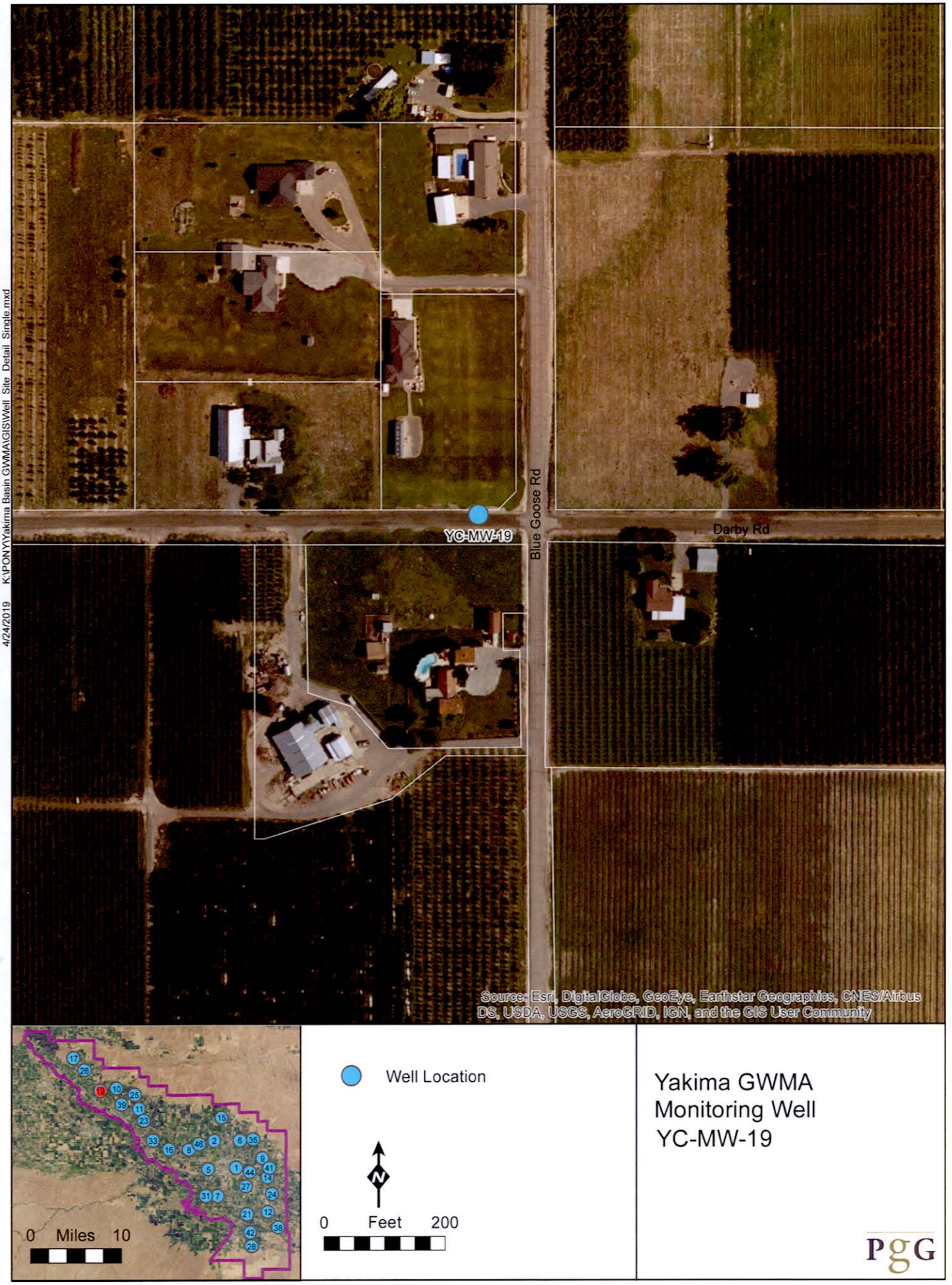
N

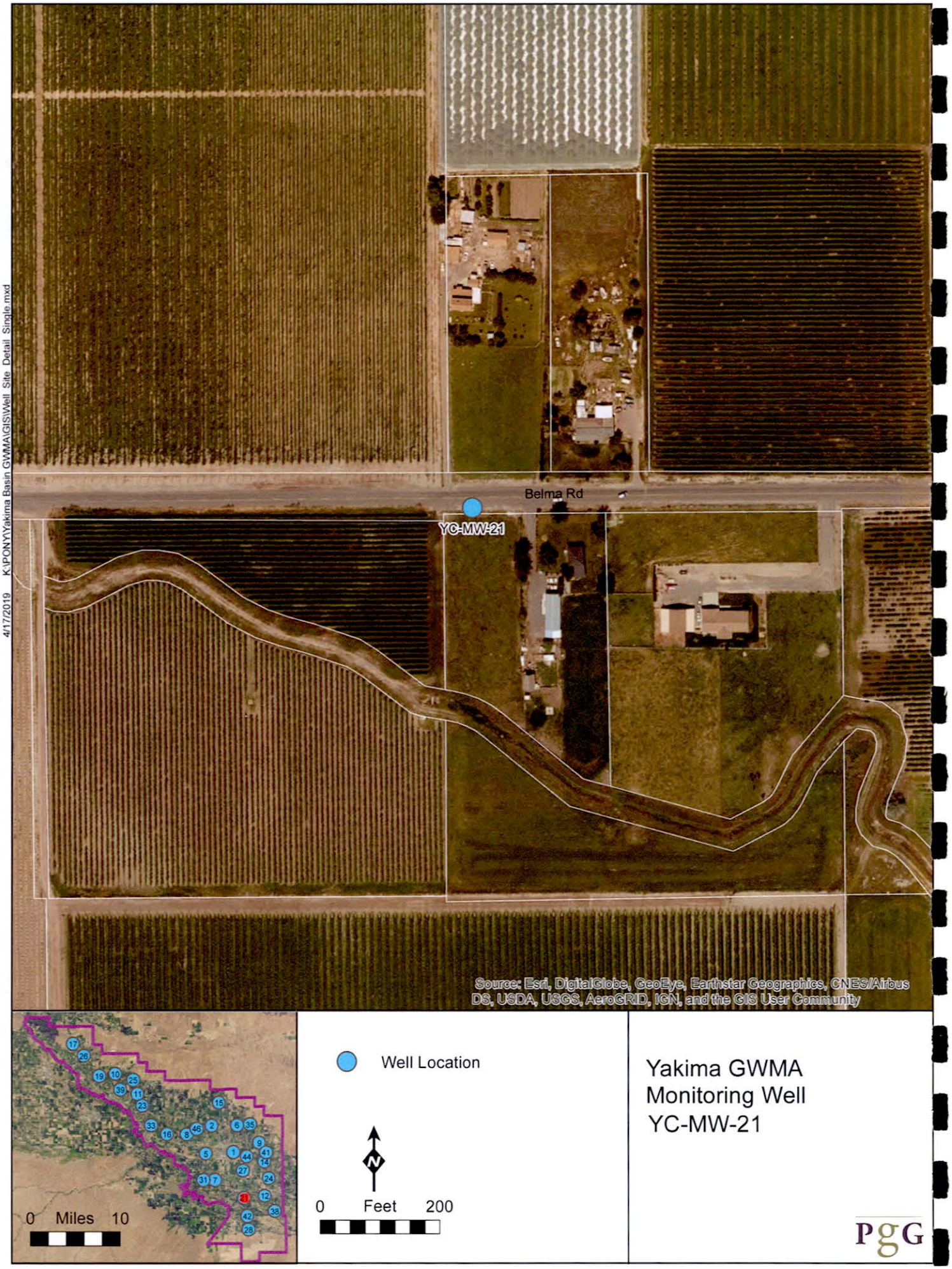
0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-17

PgG

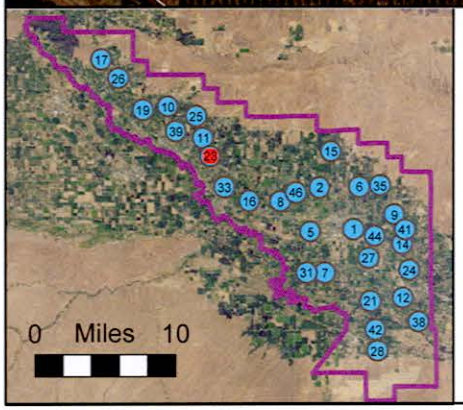
4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd


YC-MW-19
Blue Goose Rd
Darby Rd
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 Miles 10
Well Location
N
0 Feet 200
Yakima GWMA
Monitoring Well
YC-MW-19
PgG
4/24/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd


Belma Rd
YC-MW-21
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Well Location
0 Miles 10
0 Feet 200
Yakima GWMA
Monitoring Well
YC-MW-21
PgG
4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



Well Location

N

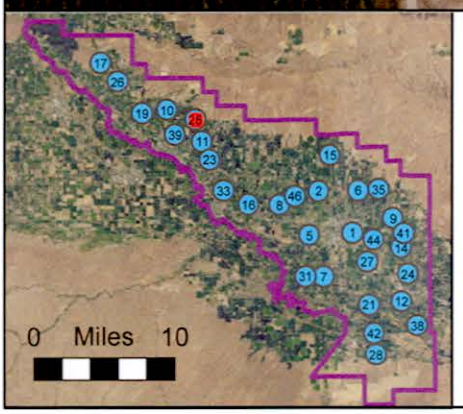
0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-23

PgG


4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd
YC-MW-24
Wilson Hwy
E Stover Rd
Olmstead Rd
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 Miles 10
Well Location
N
0 Feet 200
Yakima GWMA
Monitoring Well
YC-MW-24
PgG





Well Location

0 Feet 200

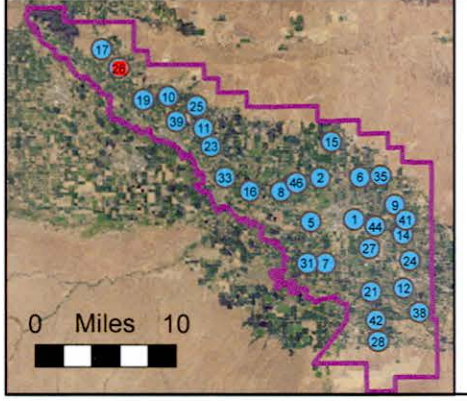
Yakima GWMA
Monitoring Well
YC-MW-25

PgG

4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd

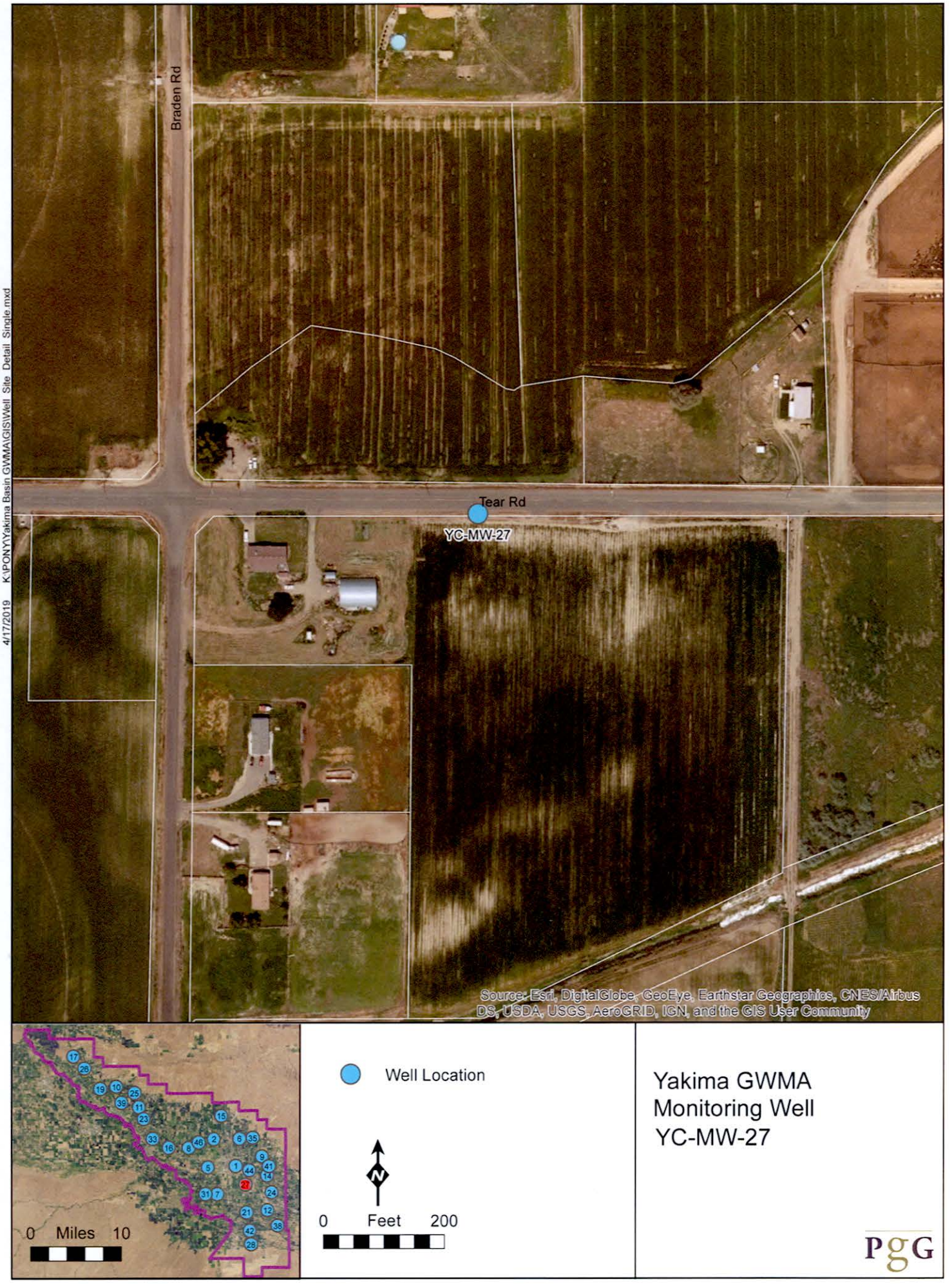


Well Location

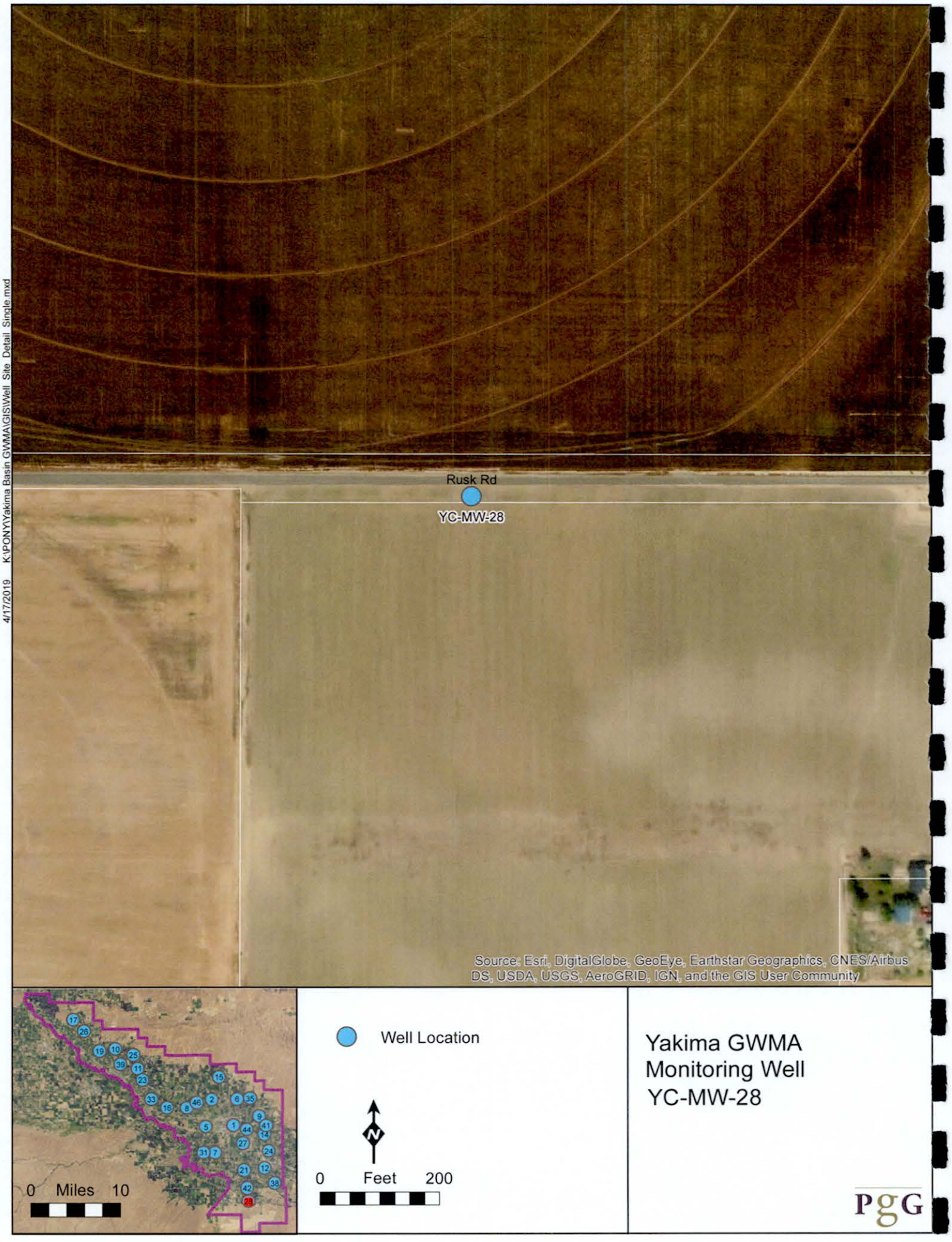
0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-26

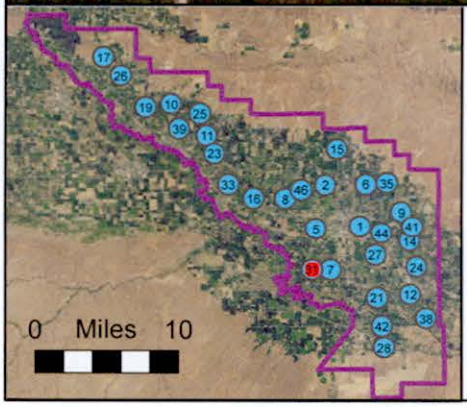
PgG



4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd


Rusk Rd
YC-MW-28
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 Miles 10
Well Location
N
0 Feet 200
Yakima GWMA
Monitoring Well
YC-MW-28
PgG
4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd





Well Location

N

0 Feet 200

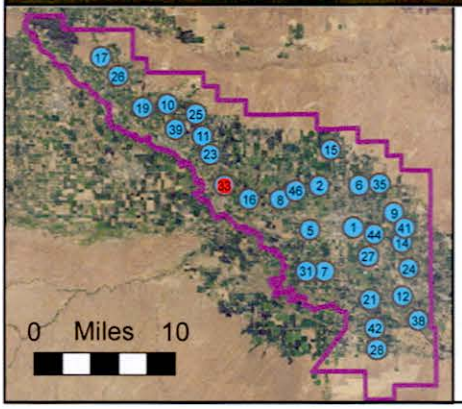
Yakima GWMA
Monitoring Well
YC-MW-31

PgG

4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



Well Location

0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-33

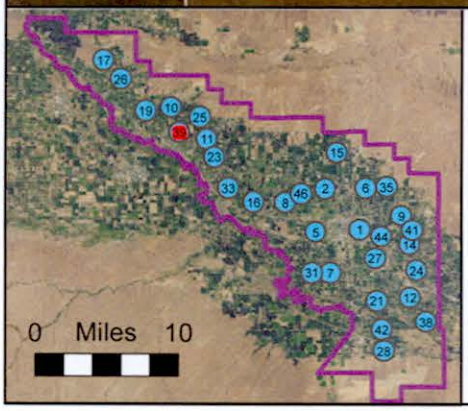
PgG



4/17/2019 K:\PONYY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd


Robinson Rd
YC-MW-38
Old Prosser Rd
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
0 Miles 10
Well Location
N
0 Feet 200
Yakima GWMA
Monitoring Well
YC-MW-38
PgG
4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd





Well Location

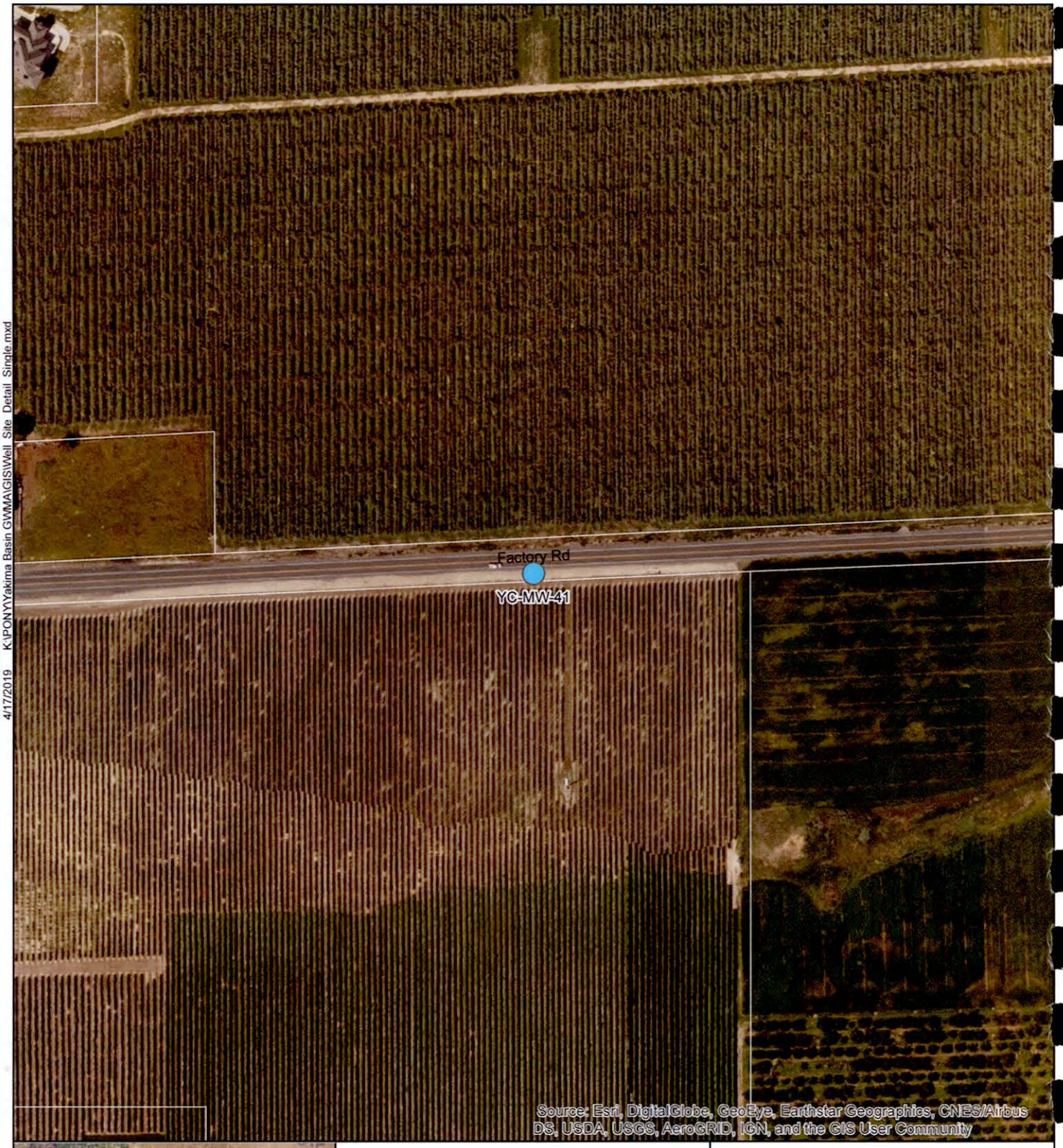
N

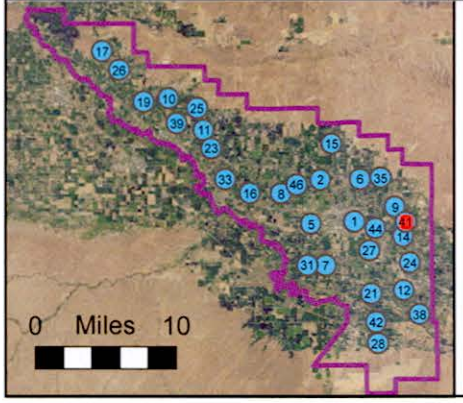
0 Feet 200

Yakima GWMA
Monitoring Well
YC-MW-39

PgG

4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd





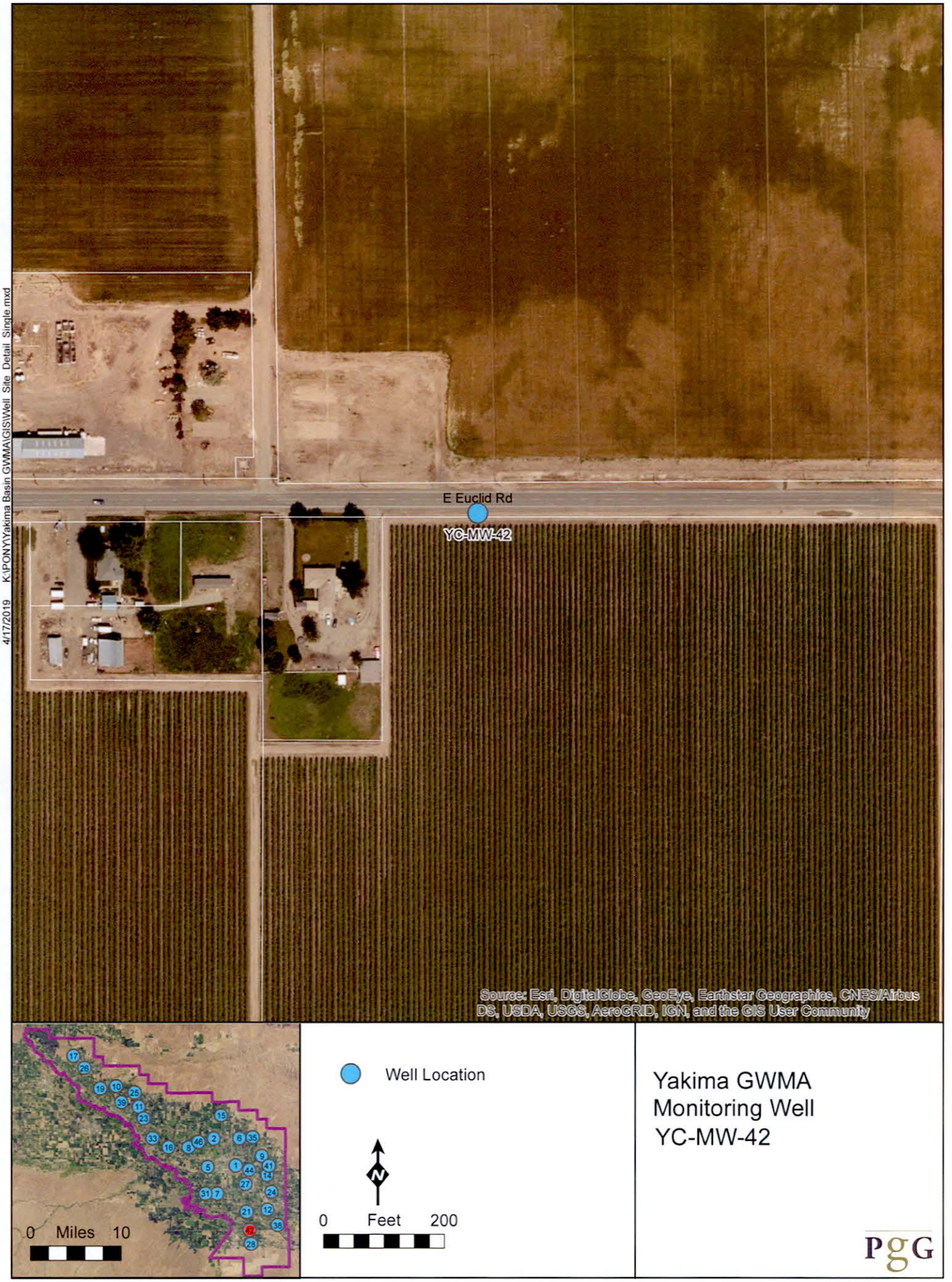
Well Location

0 Feet 200

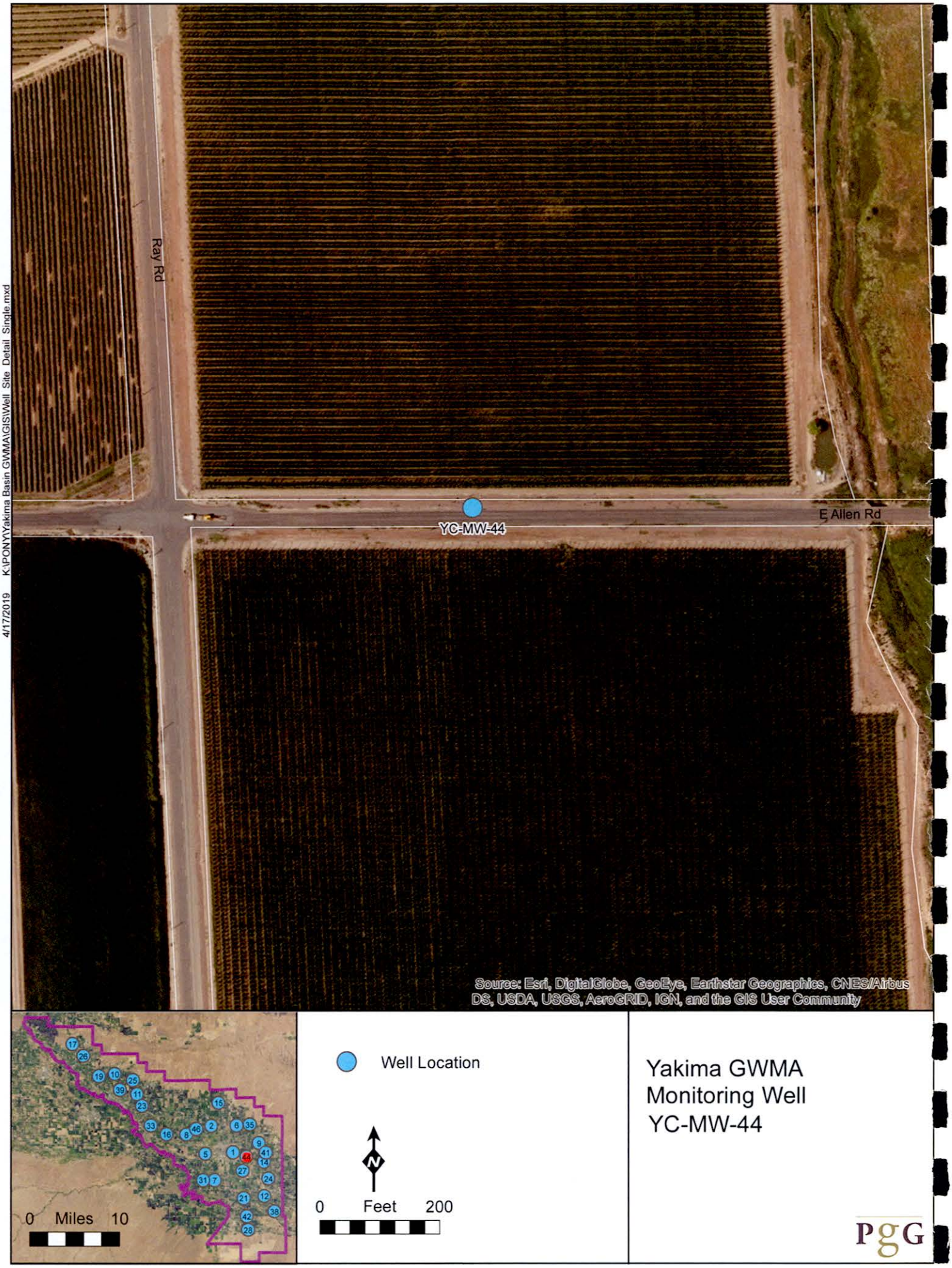
Yakima GWMA
Monitoring Well
YC-MW-41

PgG

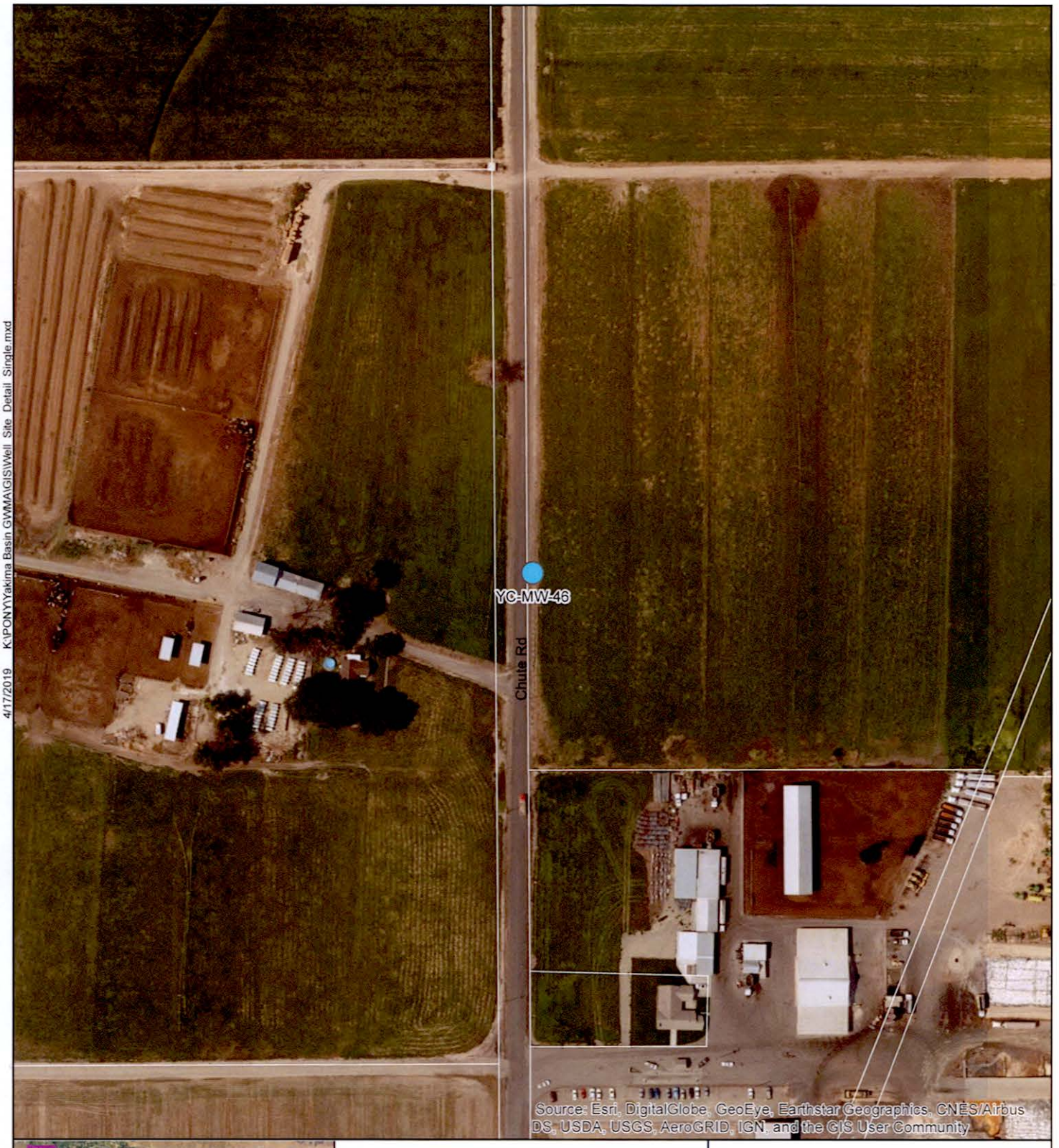
4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd

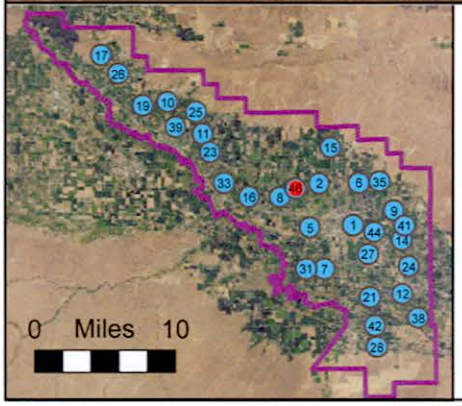


4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd



4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd





Well Location

N

0 Feet 200

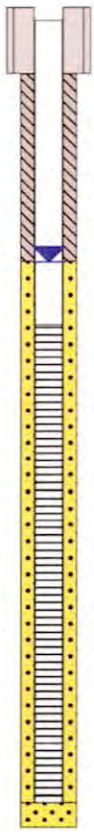
Yakima GWMA
Monitoring Well
YC-MW-46

PgG

4/17/2019 K:\PONY\Yakima Basin GWMA\GIS\Well Site Detail Single.mxd

APPENDIX B
BORING LOGS AND WELL CONSTRUCTION DIAGRAMS

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
0				Moist to wet, dark brown SILT.	Flush mount monument with concrete pad Top of PVC is 0.31 feet below top of steel monument Hydrated bentonite annular seal 2-8 feet.
5				Wet, dark brown, silty, fine SAND.	12-20 silica sand pack 8-25.2 feet 2-inch 10 slot PVC screen 10-25 feet with a flush thread tail pipe
10				Wet, dark brown, fine SAND.	Borehole diameter 6-inches 2-inch schedule 40 flush thread PVC blank well casing 0.31-25.2 feet
15					
20					
25				Wet, light brown, sandy SILT.	Bottom of the well 25.2 feet Bottom of the boring 26 feet
30					
35					
40					
45					



Location (TRS): T10R23-30
Northing/Easting: N 359237.3 ft, E 1770045.9 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/18/2018
Ecology ID: BKB-745

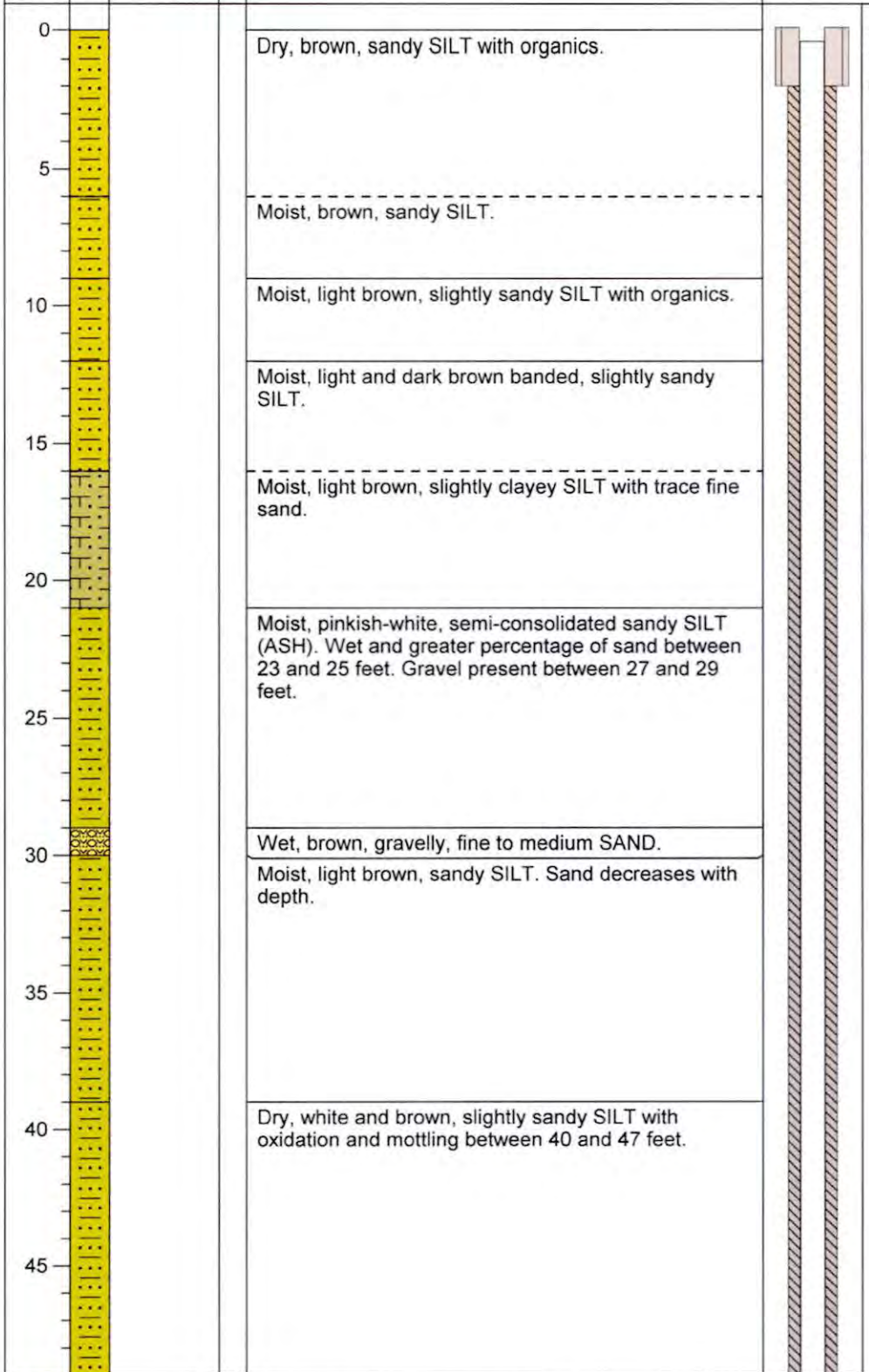
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 8.03 ft
MP Elevation: 735.22 ft
V. Datum: NAD88

YC-MW-01
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R22-14 NW Qtr QW QtrQtr
Northing/Easting: N 374757.9 ft, E 1757182.7 ft
Logged by: Inger Jackson, PGG
Completion Date: 10/28/2018
Ecology ID: BKB-726

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 56.25 ft
MP Elevation: 875.26 ft
V. Datum: NAD88

YC-MW-02
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
50					
55					
60				Wet, brown, micaceous, fine with medium SAND.	12-20 silica sand pack 59-76 feet 2-inch 10 slot PVC screen 60.8-75.8 feet with a flush thread tail pipe
65					
70					
75					Bottom of the well 76 feet Bottom of the boring 76 feet
80					
85					
90					
95					

Location (TRS): T10R22-14 NW Qtr QW QtrQtr
Northing/Easting: N 374757.9 ft, E 1757182.7 ft
Logged by: Inger Jackson, PGG
Completion Date: 10/28/2018
Ecology ID: BKB-726

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 56.25 ft
MP Elevation: 875.26 ft
V. Datum: NAD88

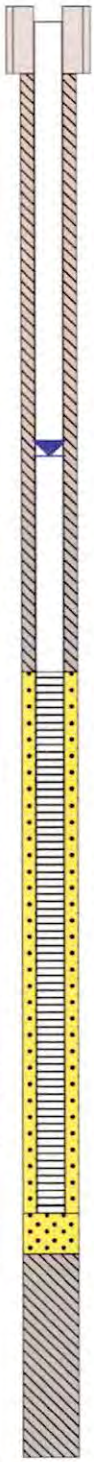
YC-MW-02
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Dry to moist, dark brown, sandy SILT. Moist below 6 feet and wet from 11 to 13 feet.
15				Moist to wet, light brown, slightly sandy SILT.
35				Wet, brown, medium with fine SAND.
				Moist, light brown, slightly sandy SILT. Minor oxidation at 44 feet. Silty medium sand lens approximately 2-inchs thick at 45 feet.
45				



Well Construction

- Flush mount monument with concrete pad
- Top of PVC is 0.38 feet below top of steel monument
- Hydrated bentonite annular seal 2-21 feet
- Borehole diameter 6-inches
- 2-inch schedule 40 flush thread PVC blank well casing 0.38-38.2 feet
- 12-20 silica sand pack 21-39.5 feet
- 2-inch 10 slot PVC screen 21-38 feet with a flush thread tail pipe
- Bottom of the well 38.2 feet
- Bentonite bottom seal 39.5-46 feet
- Bottom of the boring 46 feet

Location (TRS): T10R22-34 NE Qtr NW QtrQtr
Northing/Easting: N 358146.8 ft, E 1753715.1 ft
Logged by: Inger Jackson, PGG
Completion Date: 10/27/2018
Ecology ID: BKB-725

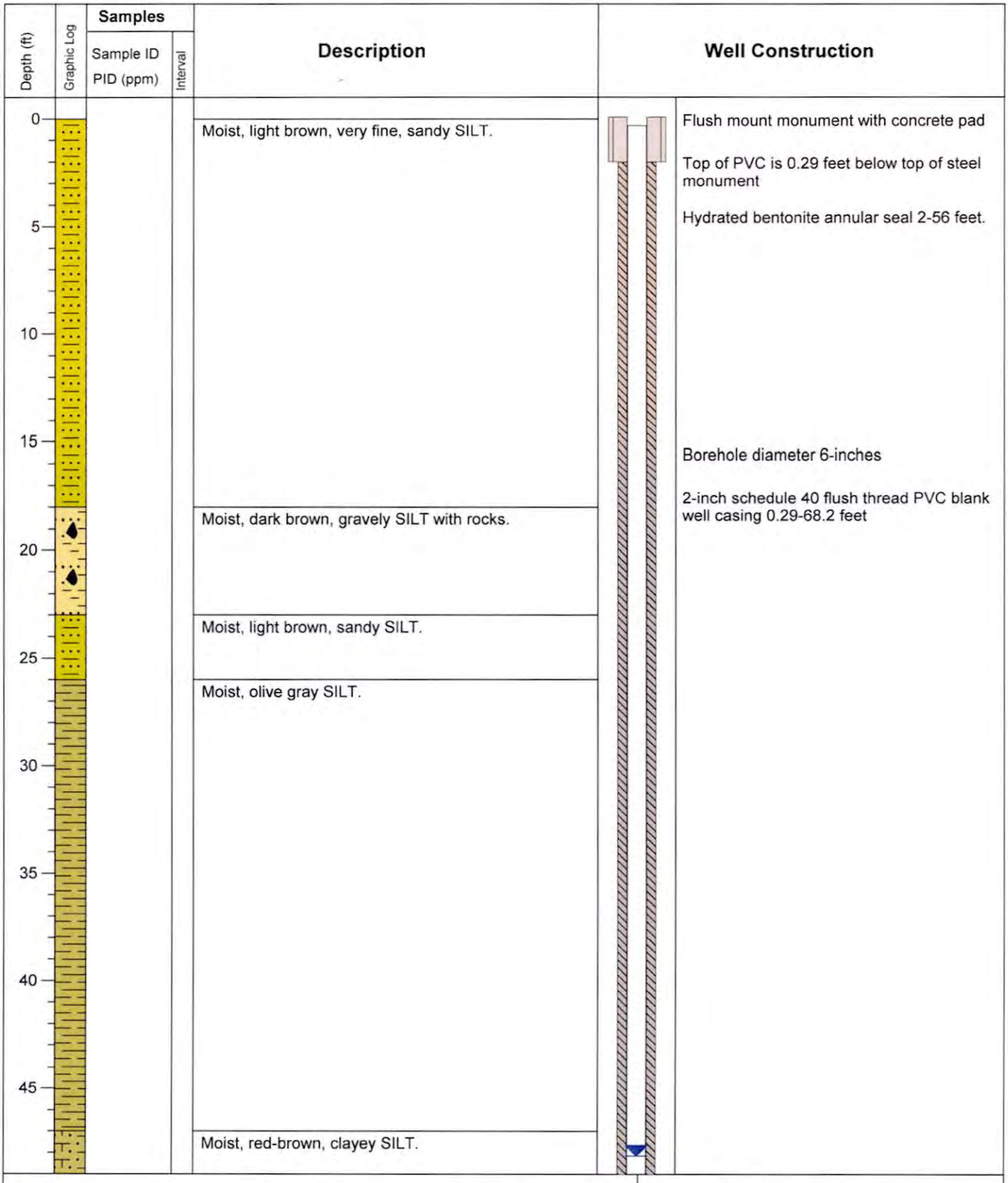
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 14.13 ft
MP Elevation: 797.18 ft
V. Datum: NAD88

YC-MW-05
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R23-17
Northing/Easting: N 375010.9 ft, E 1771956.8 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/18/2018
Ecology ID: BKB-744

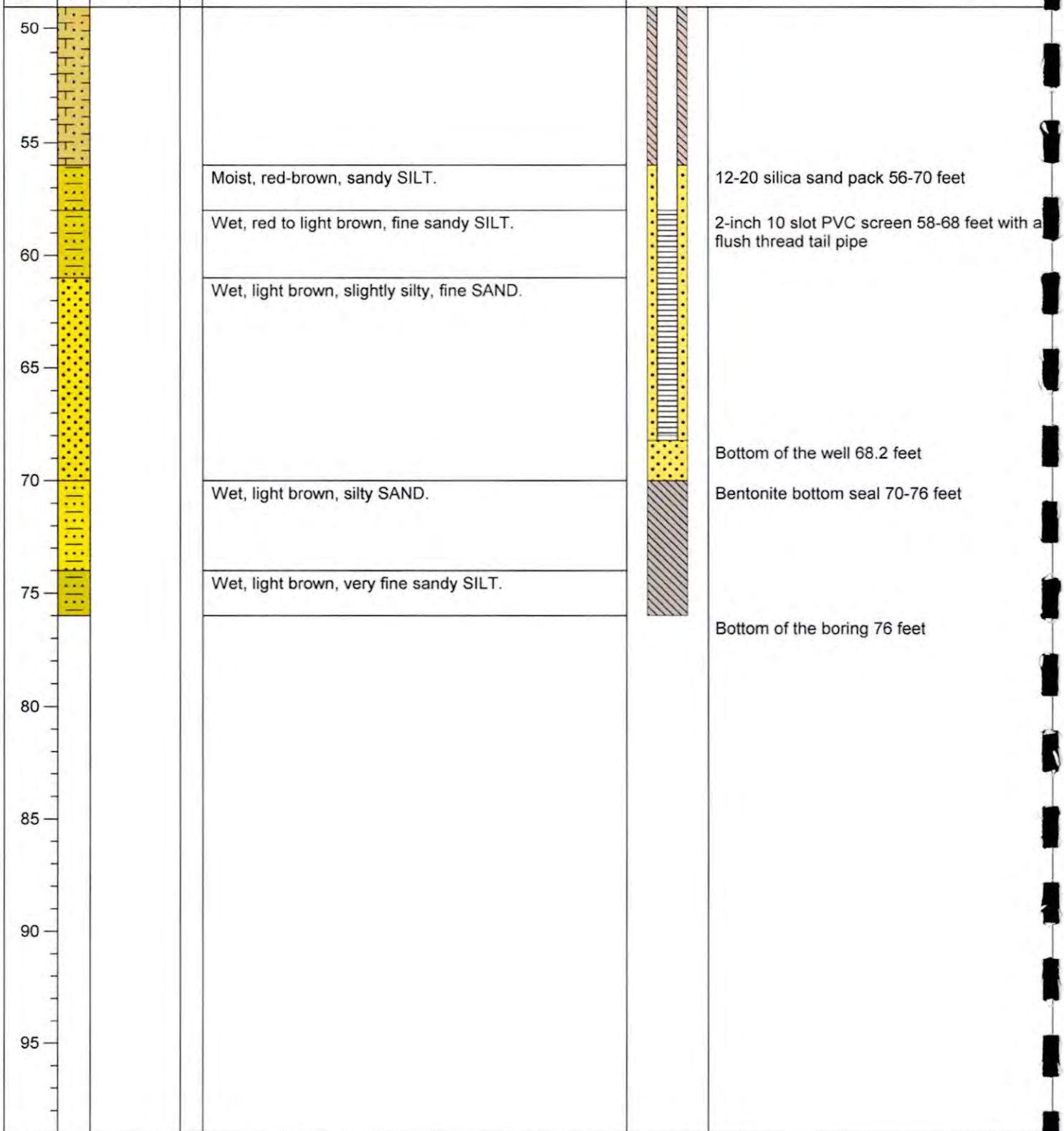
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 48.14 ft
MP Elevation: 944.33 ft
V. Datum: NAD88

YC-MW-06
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R23-17
Northing/Easting: N 375010.9 ft, E 1771956.8 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/18/2018
Ecology ID: BKB-744

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 48.14 ft
MP Elevation: 944.33 ft
V. Datum: NAD88

YC-MW-06
Boring Log and As-Built

Yakima GWMA

JE1803

PGG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
0				Moist, brown, fine SAND.	Flush mount monument with concrete pad Top of PVC is 0.3 feet below top of steel monument
5					Hydrated bentonite annular seal 2-22 feet.
10				Moist to wet, brown SILT.	
15				Moist, olive brown, fine to medium SAND.	Borehole diameter 6-inches 2-inch schedule 40 flush thread PVC blank well casing 0.3-68.2 feet
20					12-20 silica sand pack 22-46 feet
25					2-inch 10 slot PVC screen 24-44 feet with a flush thread tail pipe
30				Moist to wet, dark brown and black coarse SAND.	
35				Wet, brown, fine to medium SAND. (Some coarse grain sand observed at 45-46ft).	
40					
45					Bottom of the well 46 feet Bottom of the boring 46 feet

Location (TRS): T9R22-14
Northing/Easting: N 342923.2 ft, E 1759069.7 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/13/2018
Ecology ID: BKB-736

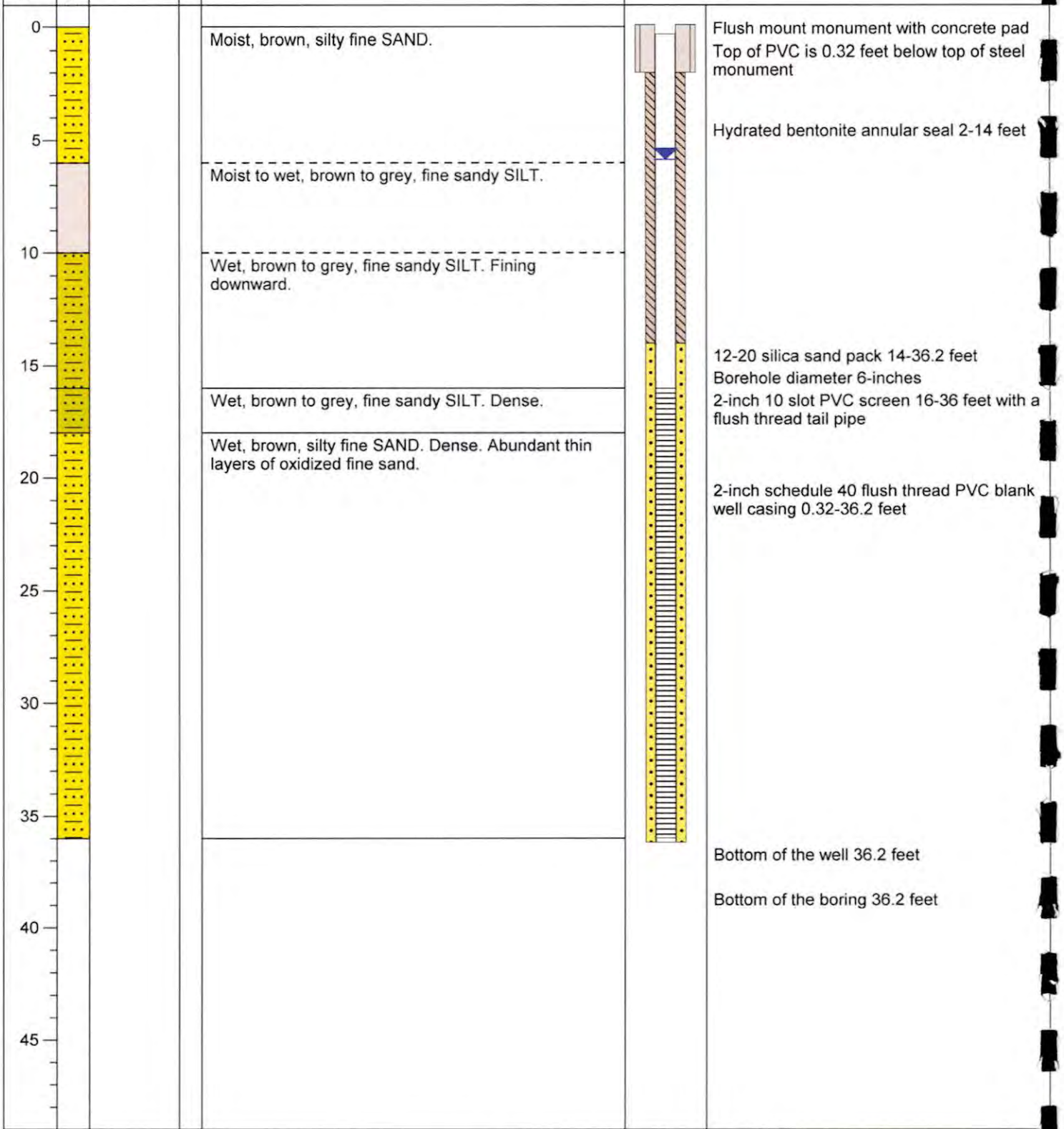
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 16.27 ft
MP Elevation: 692.8 ft
V. Datum: NAD88

YC-MW-07
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R22-20
Northing/Easting: N 369502.5 ft, E 1742525.5 ft
Logged by: David Wampler, PGG
Completion Date: 11/10/2018
Ecology ID: BKB-733

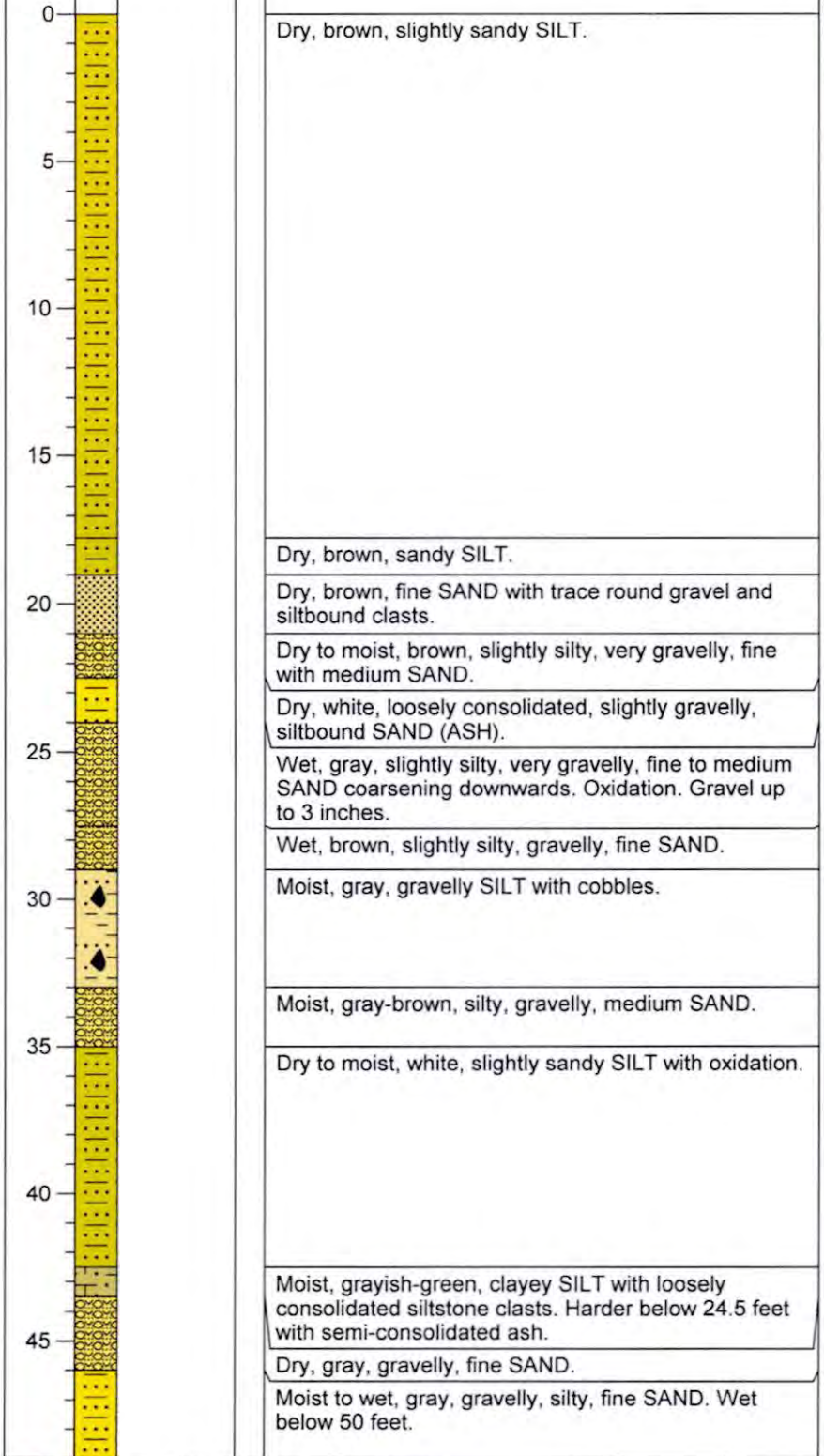
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 5.85 ft
MP Elevation: 786.27 ft
V. Datum: NAD88

YC-MW-08
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R23-22 SW Qtr SE QtrQtr
Northing/Easting: N 364486.6 ft, E 1785256.1 ft
Logged by: I. Jackson and K. Mayer-Blackwell, PGG
Completion Date: 10/29/2018
Ecology ID: BKB-727

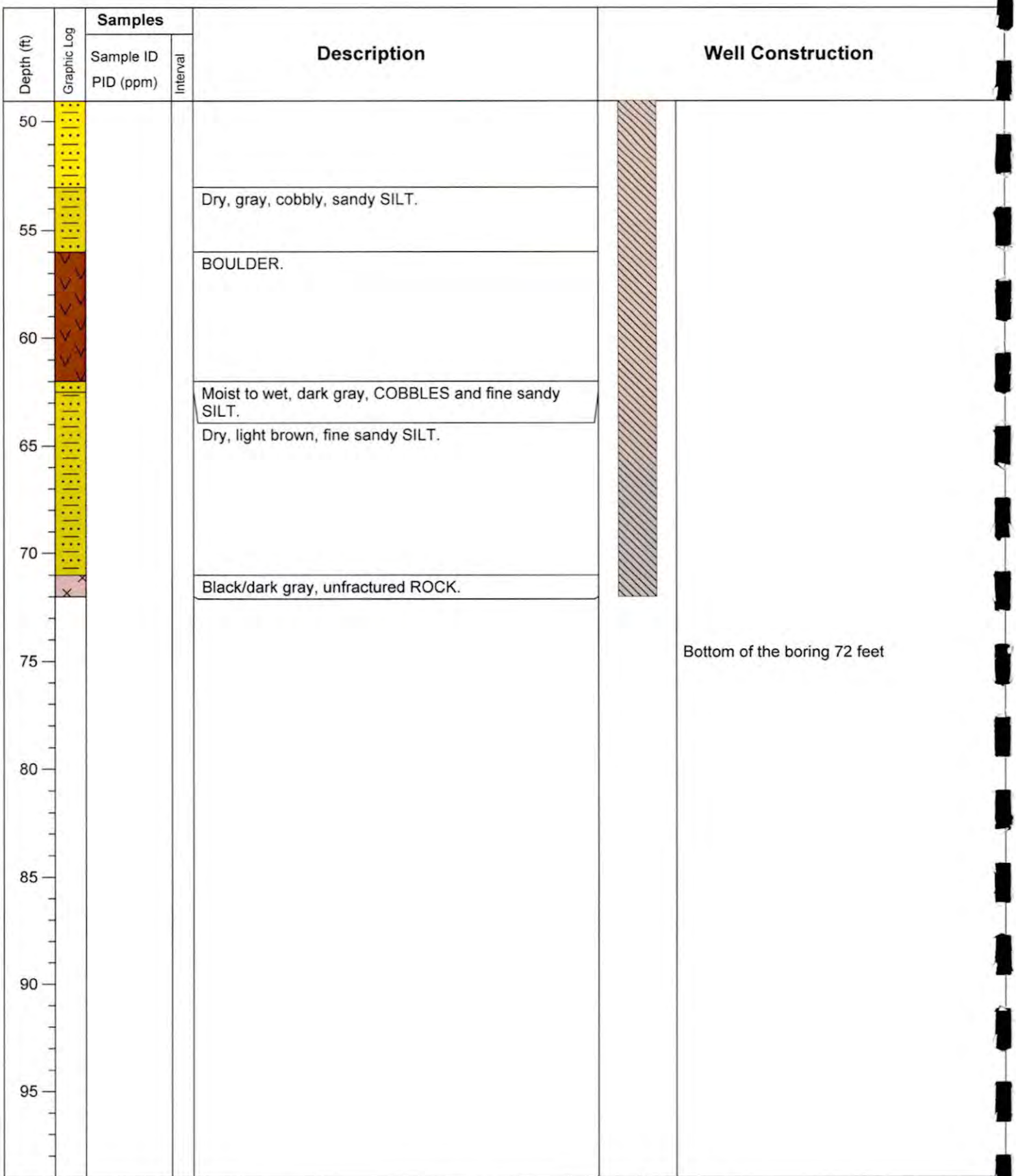
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 23.72 ft
MP Elevation: 926.45 ft
V. Datum: NAD88

YC-MW-09
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R23-22 SW Qtr SE QtrQtr
Northing/Easting: N 364486.6 ft, E 1785256.1 ft
Logged by: I. Jackson and K. Mayer-Blackwell, PGG
Completion Date: 10/29/2018
Ecology ID: BKB-727

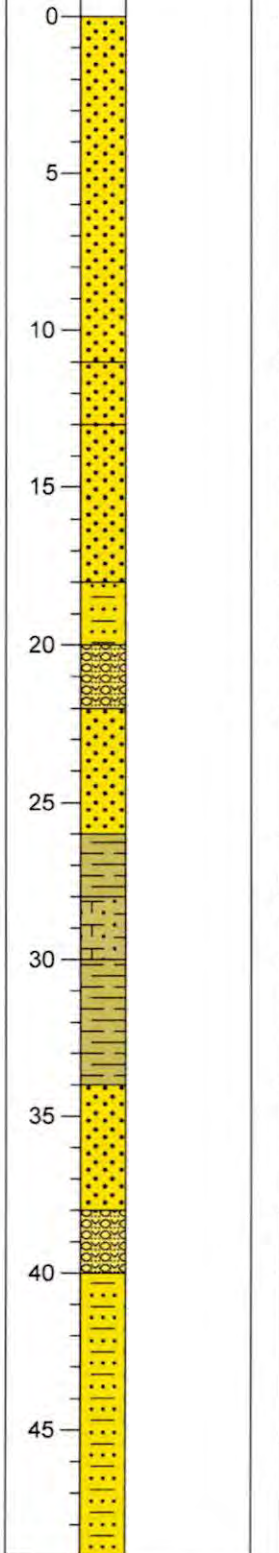
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 23.72 ft
MP Elevation: 926.45 ft
V. Datum: NAD88

YC-MW-09
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Samples			Description	Well Construction
Sample ID	PID (ppm)	Interval		
			Dry to moist, light gray to light brown, fine to medium SAND.	Flush mount monument with concrete pad Top of PVC is 0.3 feet below top of steel monument Hydrated bentonite annular seal 2-64 feet
			Moist, light gray, fine SAND.	
			Moist, light brown, fine SAND.	Borehole diameter 6-inches 2-inch schedule 40 flush thread PVC blank well casing 0.3-78.18 feet
			Moist, brown, silty, very fine SAND.	
			Moist, brown, silty, fine SAND with small to large gravel.	
			Moist, light brown, medium SAND.	
			Moist, light brown SILT.	
			Moist, light brown, clayey SILT.	
			Moist to dry, brown SILT (with some very fine sand).	
			Moist, fine to medium SAND.	
			Moist, fine to medium SAND (with sporadic gravels up to 25%).	
			Moist, light gray, silty, fine SAND (with some sporadic gravel).	

Location (TRS): T11R20-13
Northing/Easting: N 404973.2 ft, E 1700493.6 ft
Logged by: Koshlan Mayer-Blakcwell, PGG
Completion Date: 10/26/2018
Ecology ID: BKB-739

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 62.08 ft
MP Elevation: 1033.69 ft
V. Datum: NAD88

YC-MW-10
Boring Log and As-Built

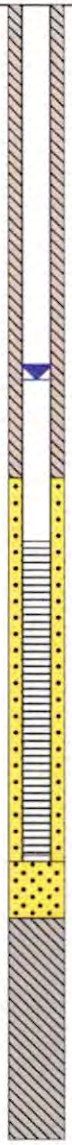
Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
50				Moist, light brown, silty, fine to medium SAND.
55				Moist, light brown, silty, medium SAND (with < 5% sand and pebbles).
60				Moist, light brown, sandy SILT (with gravel).
				Moist, light brown, compressed sandy SILT.
65				Wet, light brown, medium to fine SAND.
				Wet, light brown, silty fine SAND.
70				Wet, light brown, sandy SILT.
75				
				Wet, light brown, clayey SILT (color changes to greenish gray 81-85 ft).
80				
85				
90				
95				

Well Construction



12-20 silica sand pack 64-78 feet

2-inch 10 slot PVC screen 66-76 feet with a flush thread tail pipe

Bottom of the well 78.18 feet

Bentonite bottom seal 78-85 feet

Bottom of the boring 85 feet

Location (TRS): T11R20-13
Northing/Easting: N 404973.2 ft, E 1700493.6 ft
Logged by: Koshlan Mayer-Blakcwell, PGG
Completion Date: 10/26/2018
Ecology ID: BKB-739

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 62.08 ft
MP Elevation: 1033.69 ft
V. Datum: NAD88

YC-MW-10
Boring Log and As-Built

Yakima GWMA

JE1803

PGG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Moist, light brown, silty fine SAND.
5				Moist, brown, fine sandy SILT. Moderately dense. Increased density and slight gravel fraction from 11.5 to 12 feet.
10				Moist, reddish-brown sandy medium GRAVEL. Very dense layer of silty sand from 12.5 to 13 feet.
15				Moist, brown, silty fine SAND.
				Dry to moist, light brown, fine to medium sandy medium to coarse GRAVEL.
20				Dry to moist, light brown, fine to medium SAND. Slight softening downward.
25				Moist, light brown, silty fine SAND.
30				Moist, light brown, fine to medium SAND.
				Moist, light brown, medium to coarse gravelly fine to medium SAND.
35				Moist, light brown, medium sand. Very well sorted. Fining downward to fine to medium sand.
40				Moist, light brown, gravelly fine to medium SAND. Sand fraction coarsening downward. Gravel fraction includes moderate CaCO3 accumulation.
				Moist, grey to light brown, fine to medium SAND.
45				Moist, grey to light brown, coarse gravelly fine to medium SAND.
				Moist, light brown, fine to medium SAND with gravel fraction. Sand fraction slightly to moderately oxidized. Gravel fraction includes slight to moderate CaCO3



Well Construction

Flush mount monument with concrete pad
Top of PVC is 0.36 feet below top of steel monument

Hydrated bentonite annular seal 2-162 feet

Borehole diameter 6-inches

2-inch schedule 40 flush thread PVC blank well casing 0.36-179.2 feet

Location (TRS): T11R21-29
Northing/Easting: N 393333.5 ft, E 1713616.4 ft
Logged by: David Wampler, PGG
Completion Date: 11/7/2018
Ecology ID: BKB-731

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 162.55 ft
MP Elevation: 974.13 ft
V. Datum: NAD88

YC-MW-11
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
50				accumulation.	
55				Moist, reddish-brown, clayey SILT. Silt fraction moderately oxidized.	
60				Moist, light brown, fine to medium SAND. Well sorted. Fining downward. Trace gravel fraction.	
65				Moist, light brown to reddish brown, fine to medium SAND. Well sorted. Moderate to significant presence of oxidization.	
70				Moist, light brown to reddish brown, fine to medium SAND. Well sorted. Slight presence of oxidization.	
75				Moist, light brown, silty fine to medium SAND. Interbedded sandy silt.	
				Dry to moist, brown to grey, fine sandy SILT.	
80				Moist to wet, reddish brown to grey, clayey SILT.	
				Moist, grey, fine sandy SILT.	
85				Moist, grey, clayey SILT.	
				Moist, grey, fine sandy SILT. Interbedded dense clayey silt layers.	
90				Moist, reddish brown, fine sandy SILT. Slight clay fraction. Slight presence of thin beds with significant oxidization.	
95				Moist, brown to grey, clayey SILT. Hardening downward from slightly to moderately dense.	

Location (TRS): T11R21-29
Northing/Easting: N 393333.5 ft, E 1713616.4 ft
Logged by: David Wampler, PGG
Completion Date: 11/7/2018
Ecology ID: BKB-731

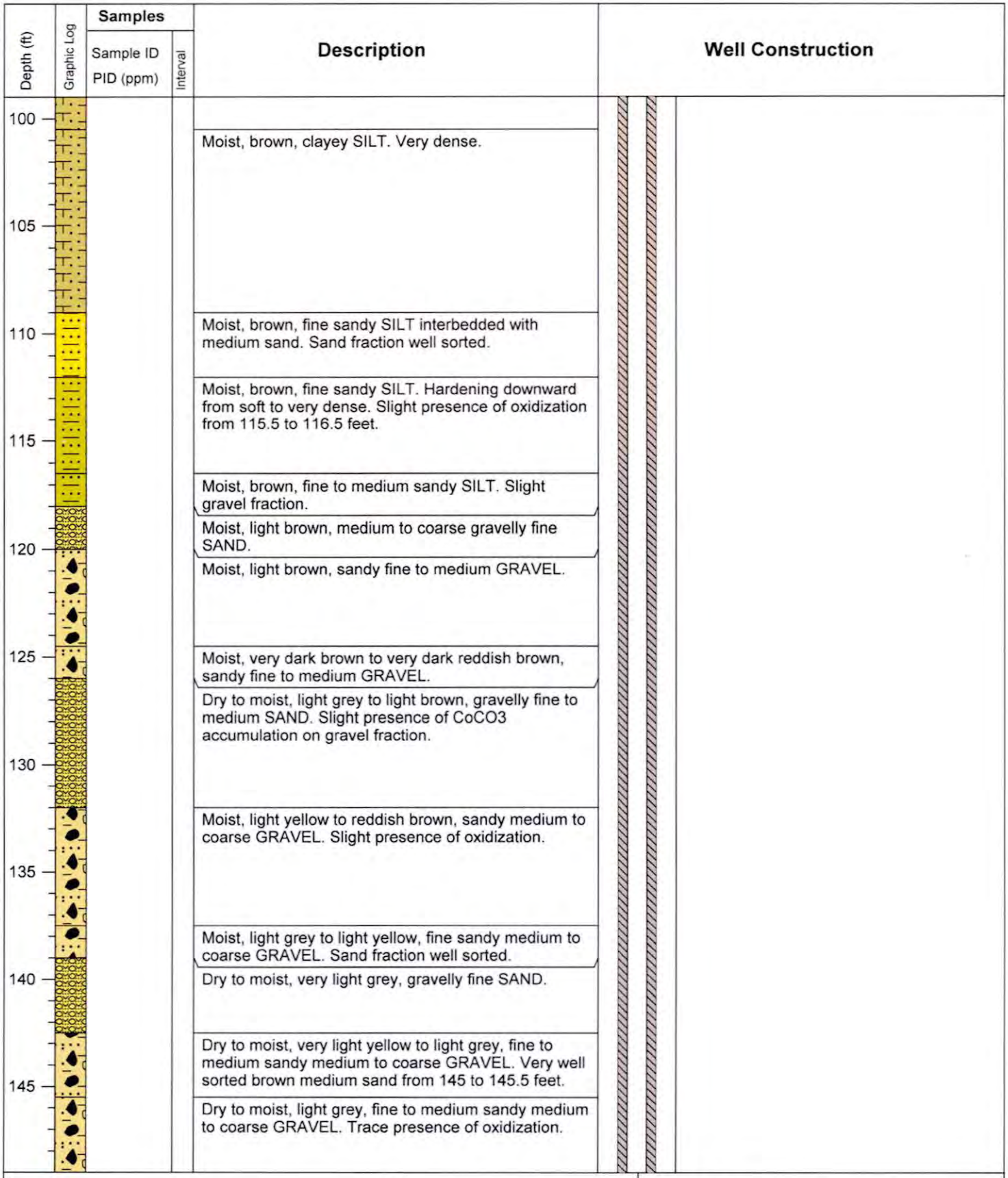
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 162.55 ft
MP Elevation: 974.13 ft
V. Datum: NAD88

YC-MW-11
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R21-29
Northing/Easting: N 393333.5 ft, E 1713616.4 ft
Logged by: David Wampler, PGG
Completion Date: 11/7/2018
Ecology ID: BKB-731

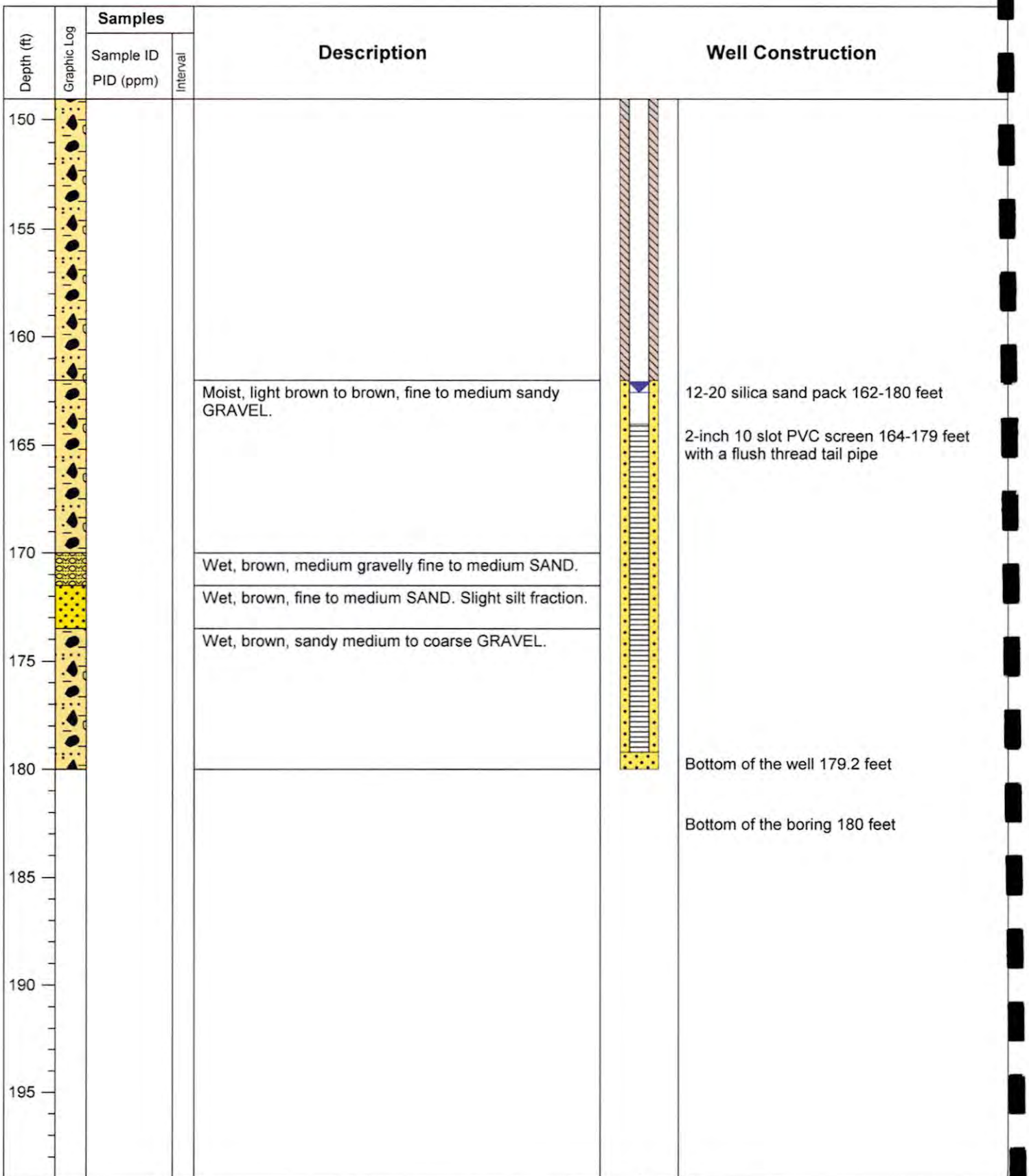
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 162.55 ft
MP Elevation: 974.13 ft
V. Datum: NAD88

YC-MW-11
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R21-29
Northing/Easting: N 393333.5 ft, E 1713616.4 ft
Logged by: David Wampler, PGG
Completion Date: 11/7/2018
Ecology ID: BKB-731

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 162.55 ft
MP Elevation: 974.13 ft
V. Datum: NAD88

YC-MW-11
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
0				Heterogeneous FILL.	Flush mount monument with concrete pad Top of PVC is 0.37 feet below top of steel monument
5				Dry to moist, brown fine sandy SILT. (Moisture content increases with depth)	Hydrated bentonite annular seal 2-20 feet
10					
15					Borehole diameter 6-inches
20				Moist to wet, red-brown, SILT.	2-inch schedule 40 flush thread PVC blank well casing 0.37-42.2 feet 12-20 silica sand pack 20-43 feet
25				Wet, brown SILT with tan gravel.	2-inch 10 slot PVC screen 22-42 feet with a flush thread tail pipe
30				Moist, greenish gray, clayey SILT.	
35				Moist, dark brown, clayey SILT (iron mottling at 34-36 ft).	
40				Moist, light gray SILT (with fractured vesicated rock).	Bottom of the well 42.2 feet Bentonite bottom seal 43-62 feet
45				Moist to wet SILT and fractured rock.	

Location (TRS): T9R23-23
Northing/Easting: N 333677.6 ft, E 1788570.8 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/16/2018
Ecology ID: BKB-742

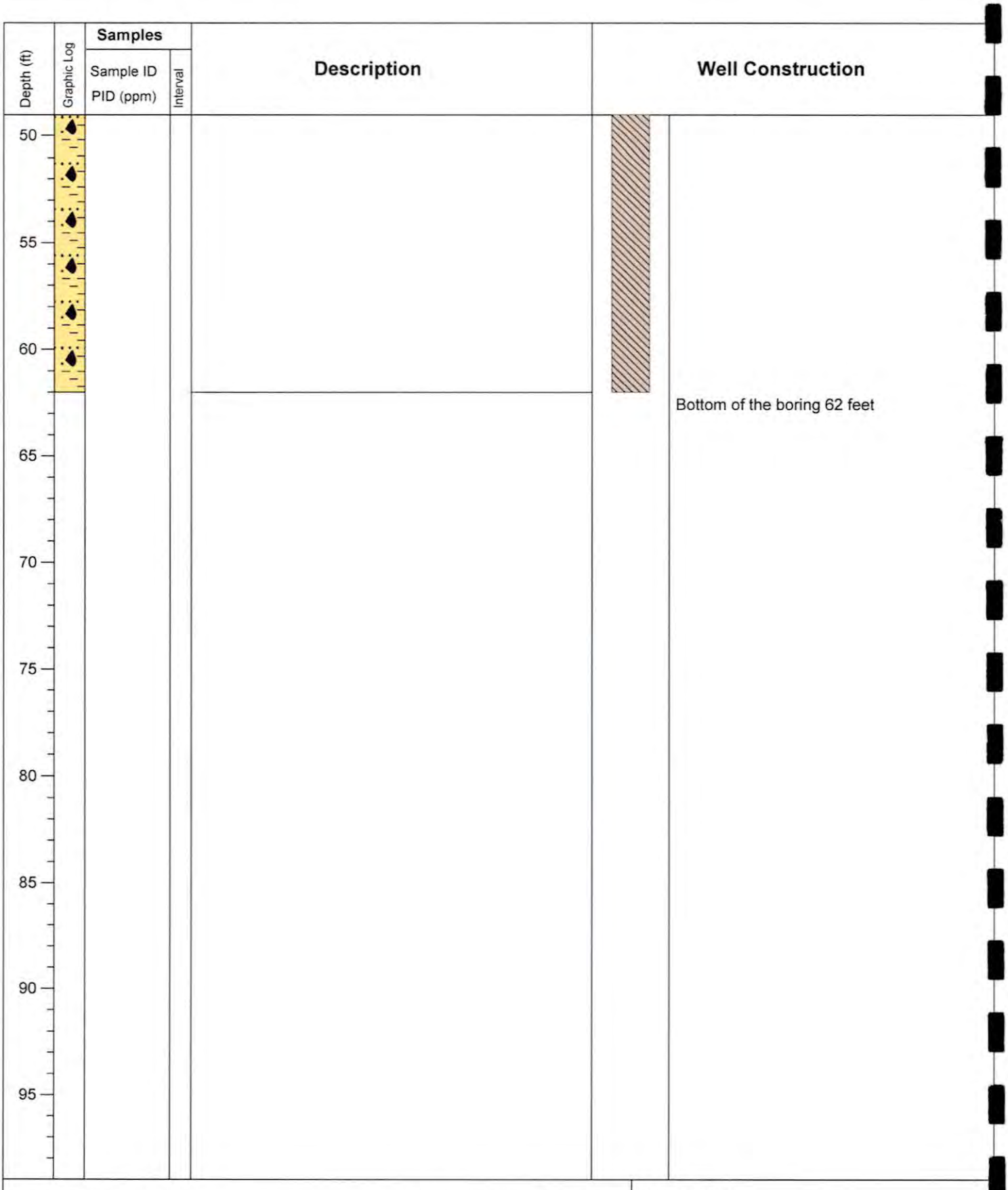
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 25.48 ft
MP Elevation: 790.36 ft
V. Datum: NAD88

YC-MW-12
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T9R23-23
Northing/Easting: N 333677.6 ft, E 1788570.8 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/16/2018
Ecology ID: BKB-742

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 25.48 ft
MP Elevation: 790.36 ft
V. Datum: NAD88

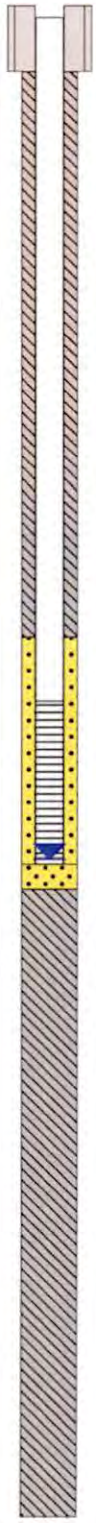
YC-MW-12
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				No recovery.
5				Moist, light brown, fine SAND. Massive structure.
10				Moist, light brown, silty fine SAND.
15				
20				Moist, brown, gravelly SAND with silt fraction.
25				Moist, brown, sandy GRAVEL. Gravel fraction predominantly basalt. Gravel fraction is significantly oxidized and has CaCO3 accumulation.
				Moist, brown, gravelly SAND.
				Moist, brown, sandy GRAVEL. Gravel fraction predominantly basalt. Gravel fraction is significantly oxidized and has CaCO3 accumulation.
30				Dry, dark brown to dark grey, BASALT. Trace to slight presence of oxidized fractures.
35				
40				
45				



Well Construction

- Flush mount monument with concrete pad
- Top of PVC is 0.27 feet below top of steel monument
- Hydrated bentonite annular seal 2-20 feet
- Borehole diameter 6-inches
- 2-inch schedule 40 flush thread PVC blank well casing 0.27-27.2 feet
- 12-20 silica sand pack 20-28 feet
- 2-inch 10 slot PVC screen 22-27 feet with a flush thread tail pipe
- Bottom of the well 27.2 feet
- Bentonite bottom seal 28-48 feet

Location (TRS): T10R23-35
Northing/Easting: N 353843.6 ft, E 1788173 ft
Logged by: David Wampler, PGG
Completion Date: 11/6/2018
Ecology ID: BKB-729

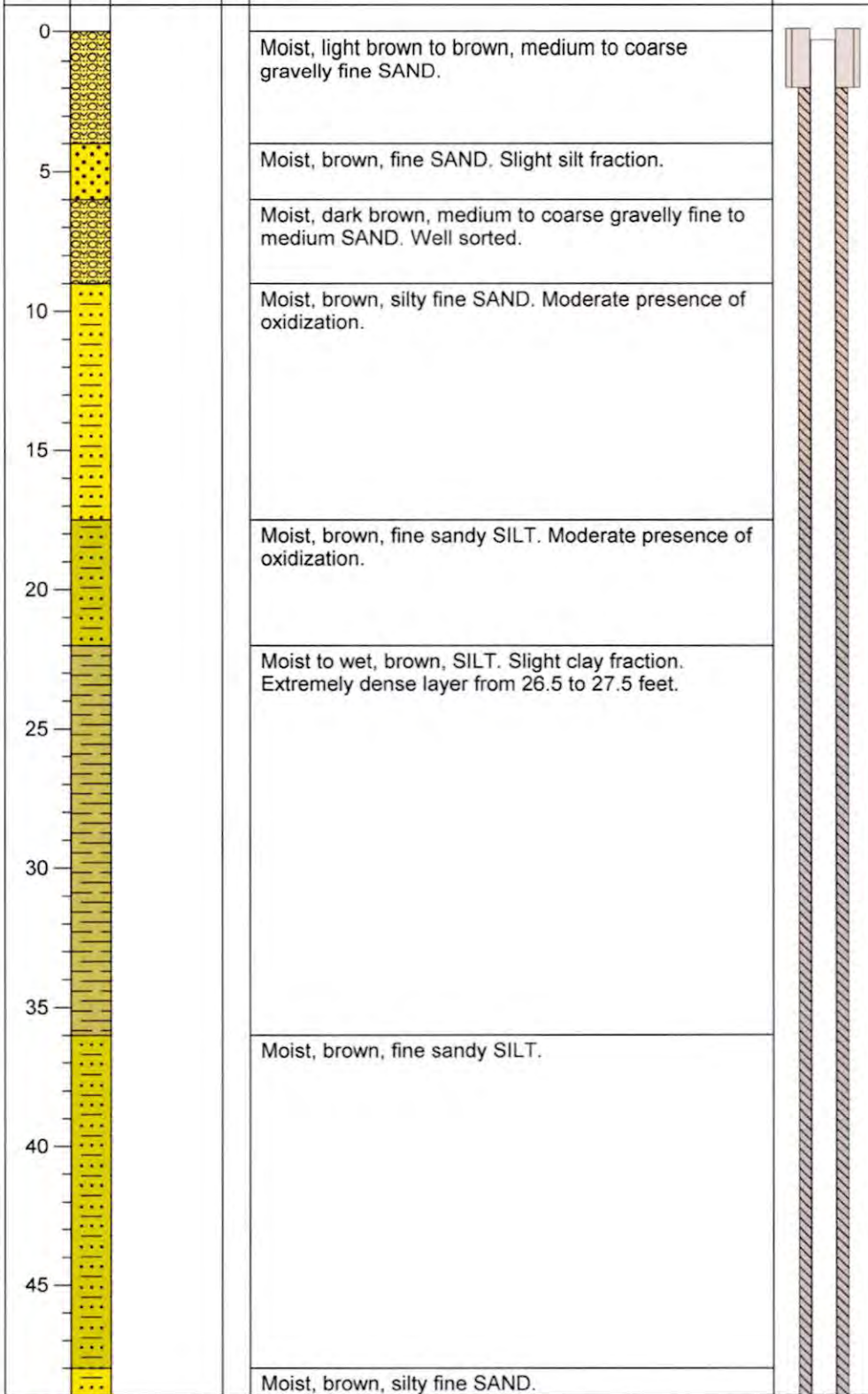
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 27.05 ft
MP Elevation: 938.04 ft
V. Datum: NAD88

YC-MW-14
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R22-35
Northing/Easting: N 388100.1 ft, E 1761377.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/12/2018
Ecology ID: BKB-734

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 188.68 ft
MP Elevation: 1168.18 ft
V. Datum: NAD88

YC-MW-15
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
50				Moist, brown, fine sandy SILT.	
				Moist, brown, silty fine SAND.	
55				Moist, brown, fine SAND. Well sorted.	
				Moist, brown, silty fine SAND. Fining downward.	
60					
65					
				Moist, brown, fine sandy SILT.	
70					
				Moist, brown, silty fine SAND.	
				Moist, brown, fine sandy SILT. Thin bed of moderately oxidized silt at bottom of layer.	
75				Moist, brown, silty fine SAND. Moderate presence of oxidization.	
80				Moist, light brown to grey, SILT with clay and fine sand fractions.	
85				Moist, light grey, fine sandy SILT.	
90					
				Moist, light grey, SILT. Very dense. Hardening downward. Trace presence of clayey silt beds. Slight presence of oxidization.	
95					

Location (TRS): T11R22-35
Northing/Easting: N 388100.1 ft, E 1761377.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/12/2018
Ecology ID: BKB-734

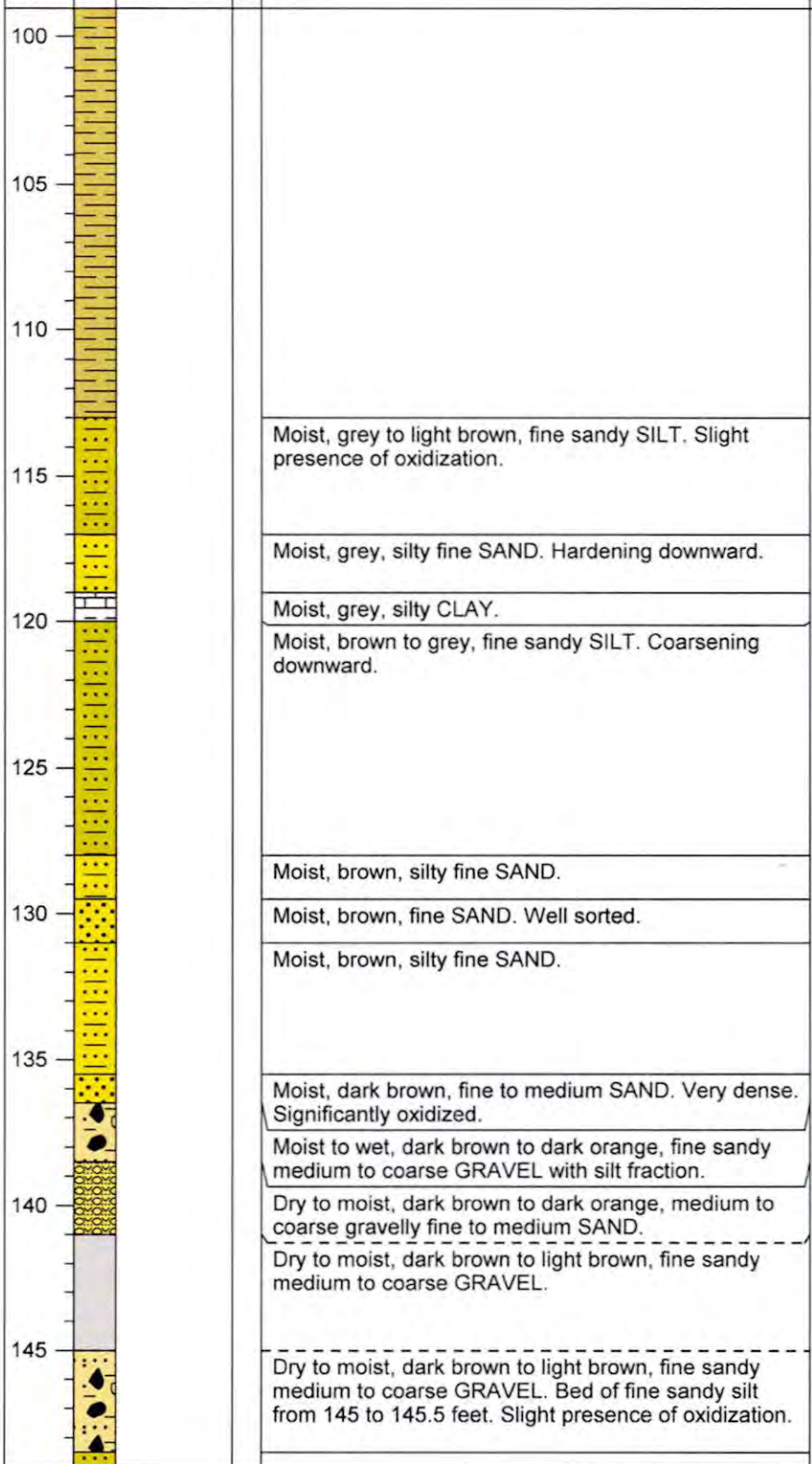
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 188.68 ft
MP Elevation: 1168.18 ft
V. Datum: NAD88

YC-MW-15
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R22-35
Northing/Easting: N 388100.1 ft, E 1761377.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/12/2018
Ecology ID: BKB-734

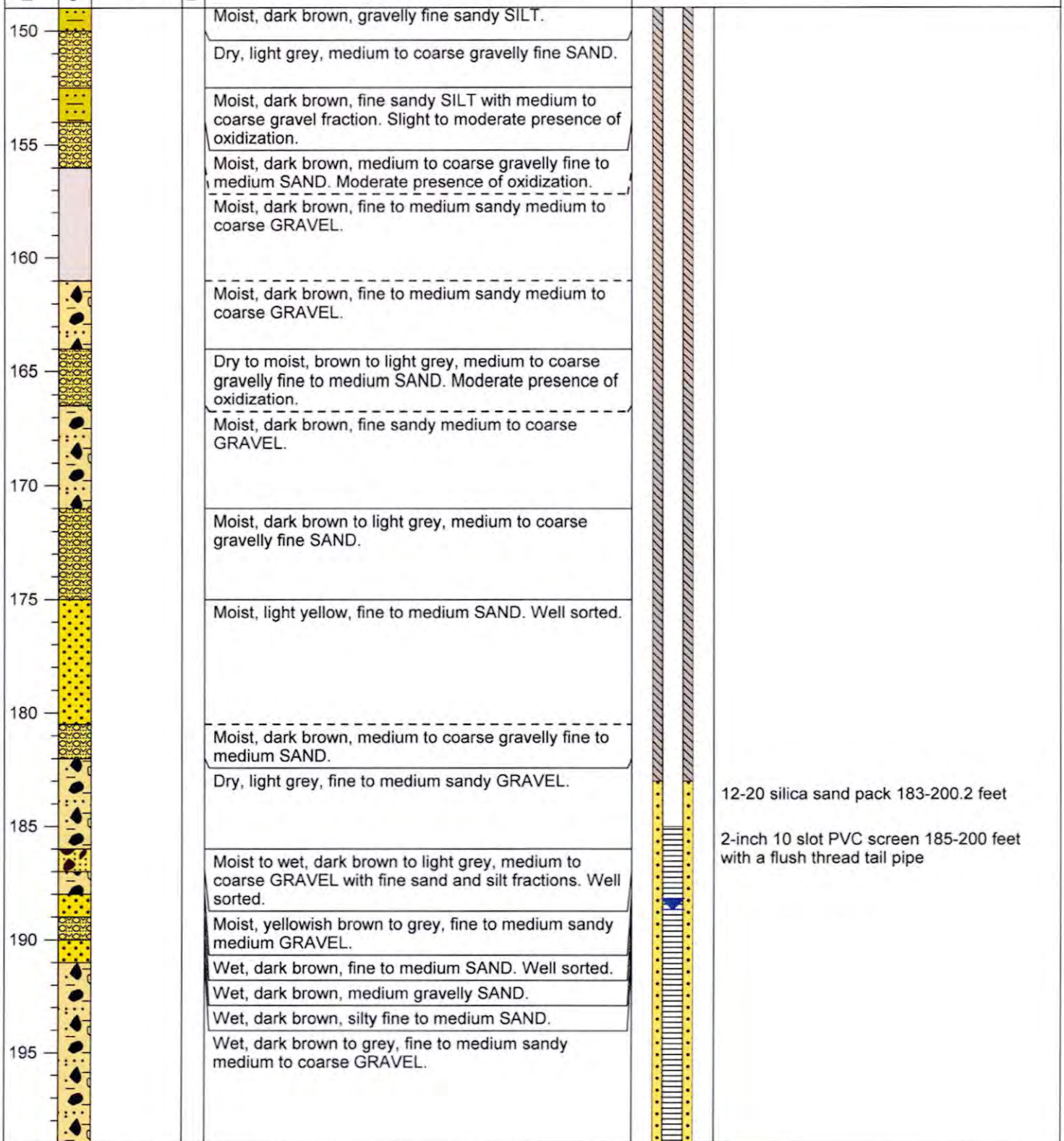
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 188.68 ft
MP Elevation: 1168.18 ft
V. Datum: NAD88

YC-MW-15
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R22-35
Northing/Easting: N 388100.1 ft, E 1761377.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/12/2018
Ecology ID: BKB-734

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 188.68 ft
MP Elevation: 1168.18 ft
V. Datum: NAD88

YC-MW-15
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
200					Bottom of the well 200.2 feet Bottom of the boring 200.2 feet
205					
210					
215					
220					
225					
230					
235					
240					
245					

Location (TRS): T11R22-35
Northing/Easting: N 388100.1 ft, E 1761377.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/12/2018
Ecology ID: BKB-734

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 188.68 ft
MP Elevation: 1168.18 ft
V. Datum: NAD88

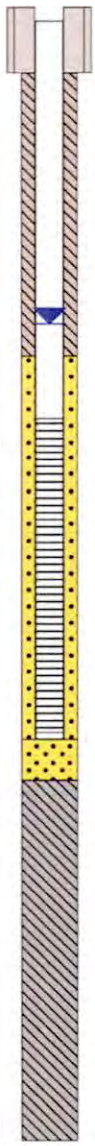
YC-MW-15
Boring Log and As-Built

Yakima GWMA

JE1803

PGG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Dry to moist, dark brown, slightly silty, fine SAND. Moist below 5 feet.
10				
11				Wet, dark brown, fine SAND with trace silt.
13				Moist, dark brown, slightly silty to silty, fine SAND.
15				Wet, brown, sandy SILT with minor oxidation at 18 feet.
20				Wet, brown, slightly silty, fine SAND with trace medium sand below 20 feet.
23				Moist, light brown, SILT.
24				Moist, brown, slightly silty, fine SAND.
25				Moist, lightly brown, SILT.
26				Moist, slightly silty to silty, fine SAND.
30				Moist, light brown, slightly sandy SILT. Layer of sandy silt approx. 4 inches thick at 32 feet.
35				
36				
40				
45				



Well Construction

- Flush mount monument with concrete pad
- Top of PVC is 0.34 feet below top of steel monument
- Hydrated bentonite annular seal 2-11 feet
- 12-20 silica sand pack 11-24.5 feet
- 2-inch 10 slot PVC screen 13-23 feet with a flush thread tail pipe
- Borehole diameter 6-inches
- 2-inch schedule 40 flush thread PVC blank well casing 0.34-23.2 feet
- Bottom of the well 23.2 feet
- Bentonite bottom seal 24.5-36 feet
- Bottom of the boring 36 feet

Location (TRS): T10R21-13 SW Qtr SE QtrQtr
Northing/Easting: N 369623.5 ft, E 1731005.3 ft
Logged by: Inger Jackson, PGG
Completion Date: 10/27/2018
Ecology ID: BKB-740

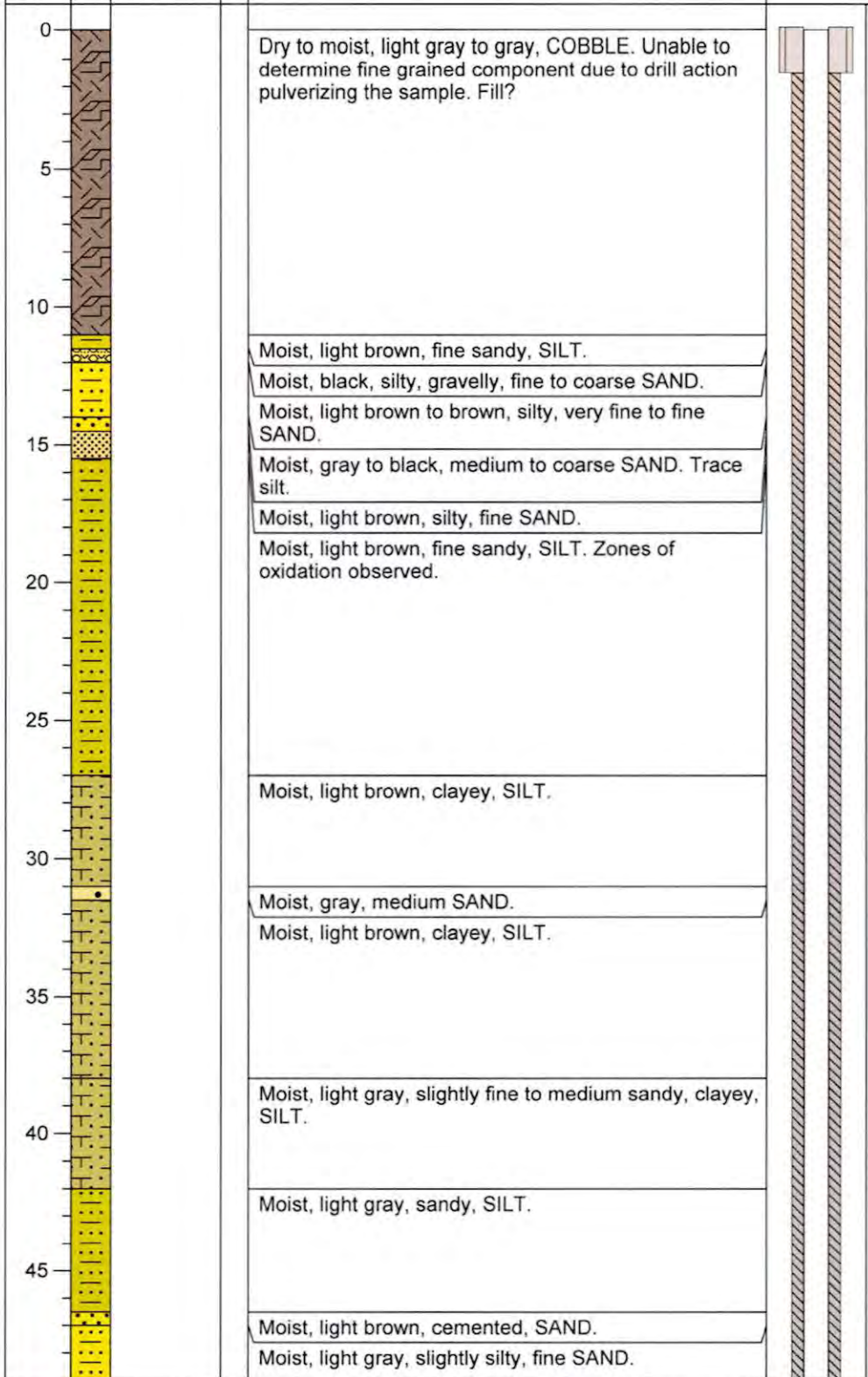
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 9.99 ft
MP Elevation: 775.62 ft
V. Datum: NAD88

YC-MW-16
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS):
Northing/Easting: T12R20-30
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 10/24/2018
Ecology ID: 85.67 ft

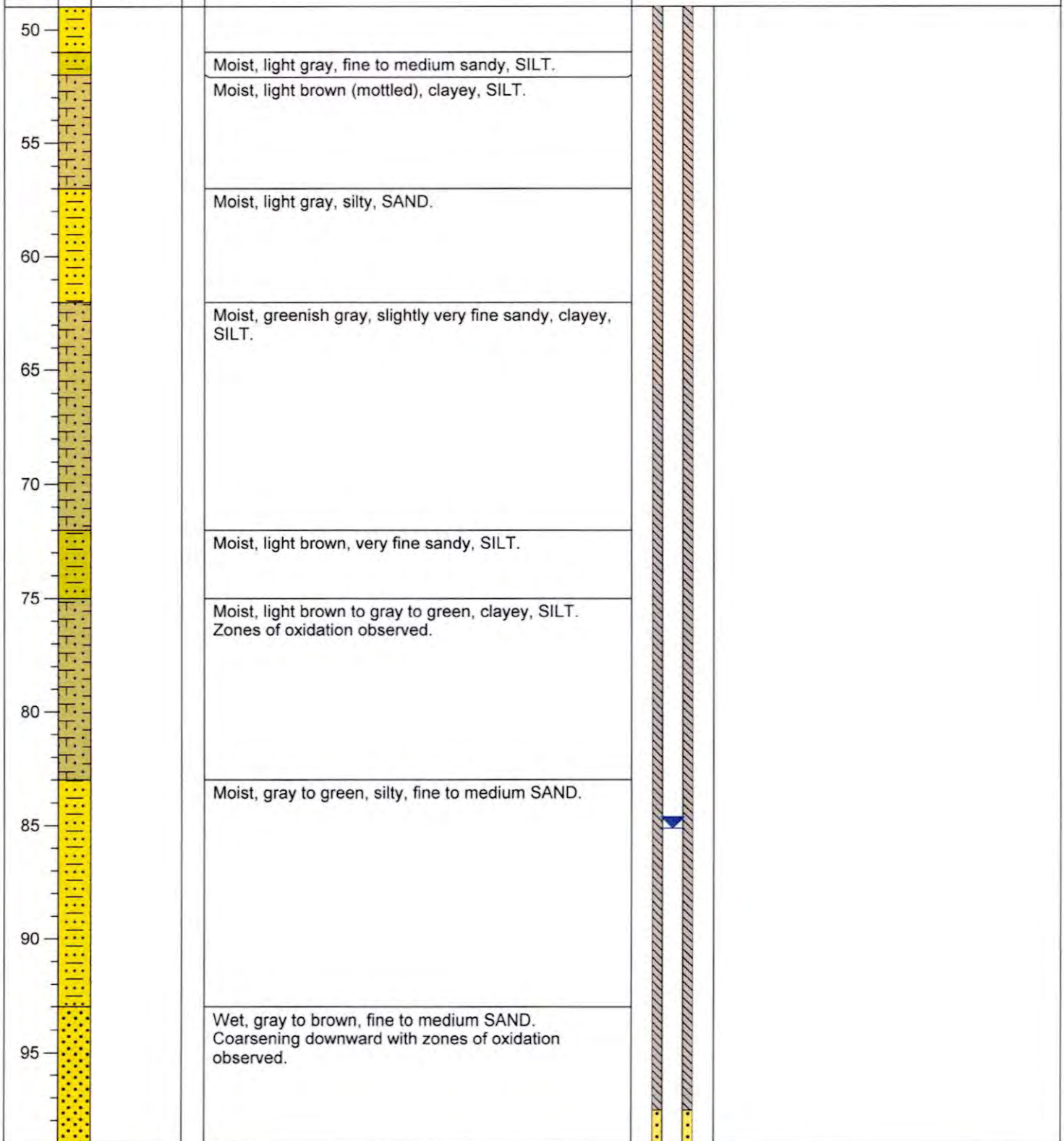
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 1036.7 ft
MP Elevation: NAD88
V. Datum: BKB-737

YC-MW-17
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS):
Northing/Easting: T12R20-30
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 10/24/2018
Ecology ID: 85.67 ft

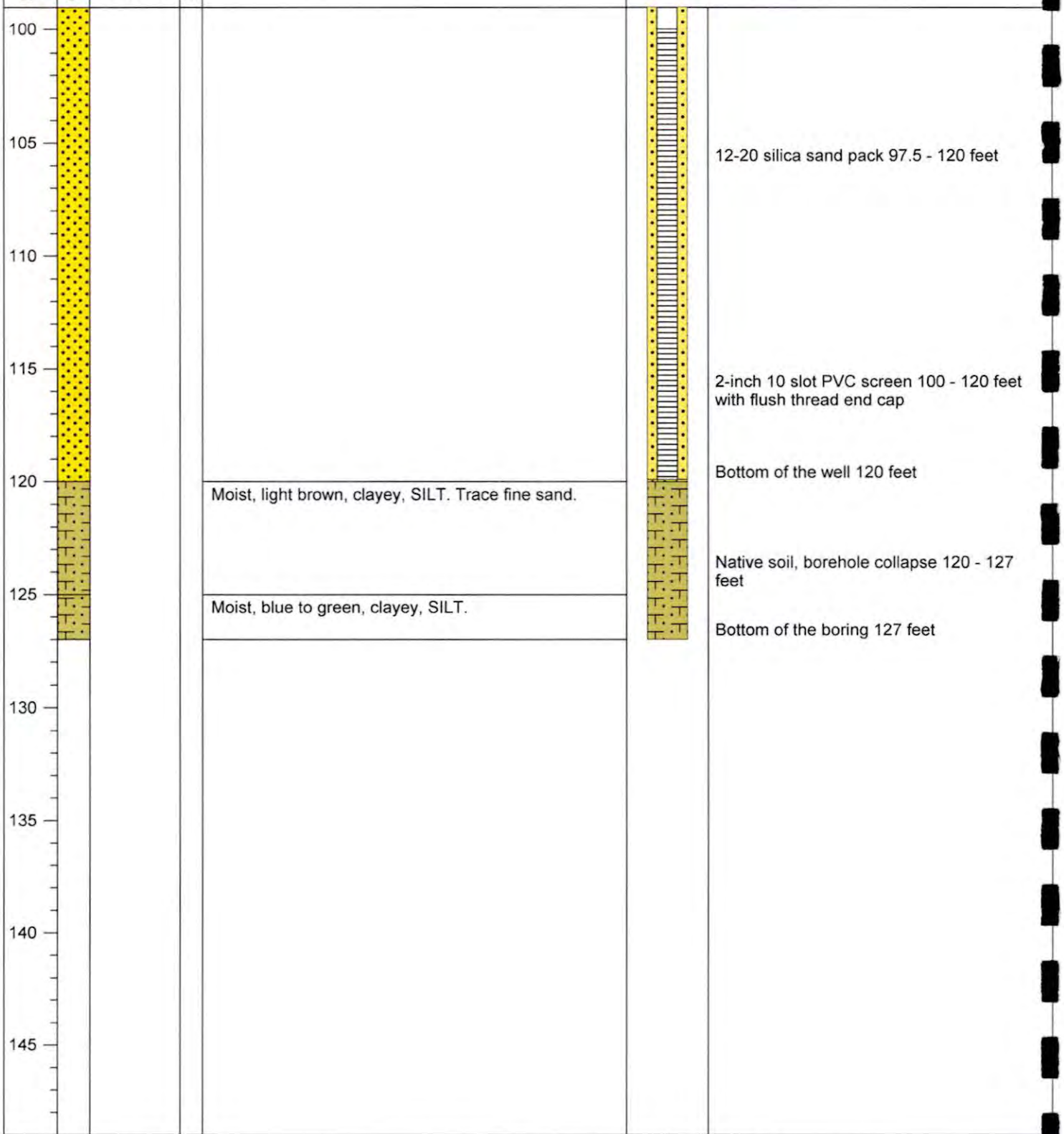
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 1036.7 ft
MP Elevation: NAD88
V. Datum: BKB-737

YC-MW-17
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS):
Northing/Easting: T12R20-30
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 10/24/2018
Ecology ID: 85.67 ft

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 1036.7 ft
MP Elevation: NAD88
V. Datum: BKB-737

YC-MW-17
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Moist, ligth brown, SILT. Sporadic gravels
5				
10				
15				
20				Moist, light brown, clayey, SILT.
25				Moist, gray, silty, GRAVEL. Sporadic cobbles, sample pulverized by drill action.
30				
35				Moist, light brown to brown, silty, very fine to fine SAND.
40				Moist, light brown, medium to coarse sandy, GRAVEL. Trace silt
45				Moist, light brown to red (mottled), clayey, SILT.
				Moist, light brown, fine to medium SAND. Trace silt, sporadic gravels
				Moist, light brown, clayey, SILT. Zones of oxidation observed.
				Moist, gray, fine to medium SAND. Sporadic gravels.



Well Construction

- Flush mount monument with concrete pad
  Top of PVC is 0.2 feet below top of steel monument
- Hydrated bentonite annular seal 1 - 45 feet
- Borehole diameter 6-inches
- 2-inch schedule 40 flush thread PVC blank well casing. 0.2 - 47 feet
- 12-20 silica sand pack 45 - 63.5 feet

Location (TRS):
Northing/Easting: T11R20-15
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 10/25/2018
Ecology ID: 49.41 ft

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 912.91 ft
MP Elevation: NAD88
V. Datum: BKB-738

YC-MW-19
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
50				Moist to wet, light brown, fine to medium sandy, SILT.	
				Wet, light brown, fine to medium SAND. Trace silt.	
				Moist, light brown, fine sandy, SILT.	2-inch 10 slot PVC screen 47 - 62 feet with a flush thread tail pipe
55				Wet, light brown, slightly silty, fine to medium SAND.	
				Wet, light brown, gravelly, SILT.	
				Wet, light brown, slightly silty, cemented fine to medium SAND.	
60				Moist, light brown to brown, clayey, SILT. Trace fine sand, dense, hard drilling.	Bottom of the well 62.48 feet
65				Moist, brown, gravelly, clayey, SILT.	
				Moist, light brown, siltbound Cobble.	
				Moist, light brown to brown, slightly fine sandy, SILT. Sporadic gravel.	
70					
75					
80					Bentonite bottom seal 63.5 - 87 feet
85					Bottom of the boring 87 feet
90					
95					

Location (TRS):
Northing/Easting: T11R20-15
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 10/25/2018
Ecology ID: 49.41 ft

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 912.91 ft
MP Elevation: NAD88
V. Datum: BKB-738

YC-MW-19
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
0				Moist, brown to light brown, fine SAND. Moderately well sorted.	Flush mount monument with concrete pad Top of PVC is 0.31 feet below top of steel monument
5					Hydrated bentonite annular seal 2-39 feet
10					
15				Moist, brown, silty fine SAND. Moist, brown, fine to medium SAND. Well sorted.	Borehole diameter 6-inches 2-inch schedule 40 flush thread PVC blank well casing 0.31-61.2 feet
20				Moist, brown, fine sandy SILT. Moist, brown to light brown, silty fine SAND. Interbedded with well-sorted fine to medium sand.	
25				Very moist, brown, fine sandy SILT. Interbedded with fine to medium sand. Slight hardening downward.	
30					
35					
40					12-20 silica sand pack 39-62 feet 2-inch 10 slot PVC screen 41-61 feet with a flush thread tail pipe
45					

Location (TRS): T9R23-29
Northing/Easting: N 332464.2 ft, E 1776332.6 ft
Logged by: David Wampler, PGG
Completion Date: 11/12/2018
Ecology ID: BKB-735

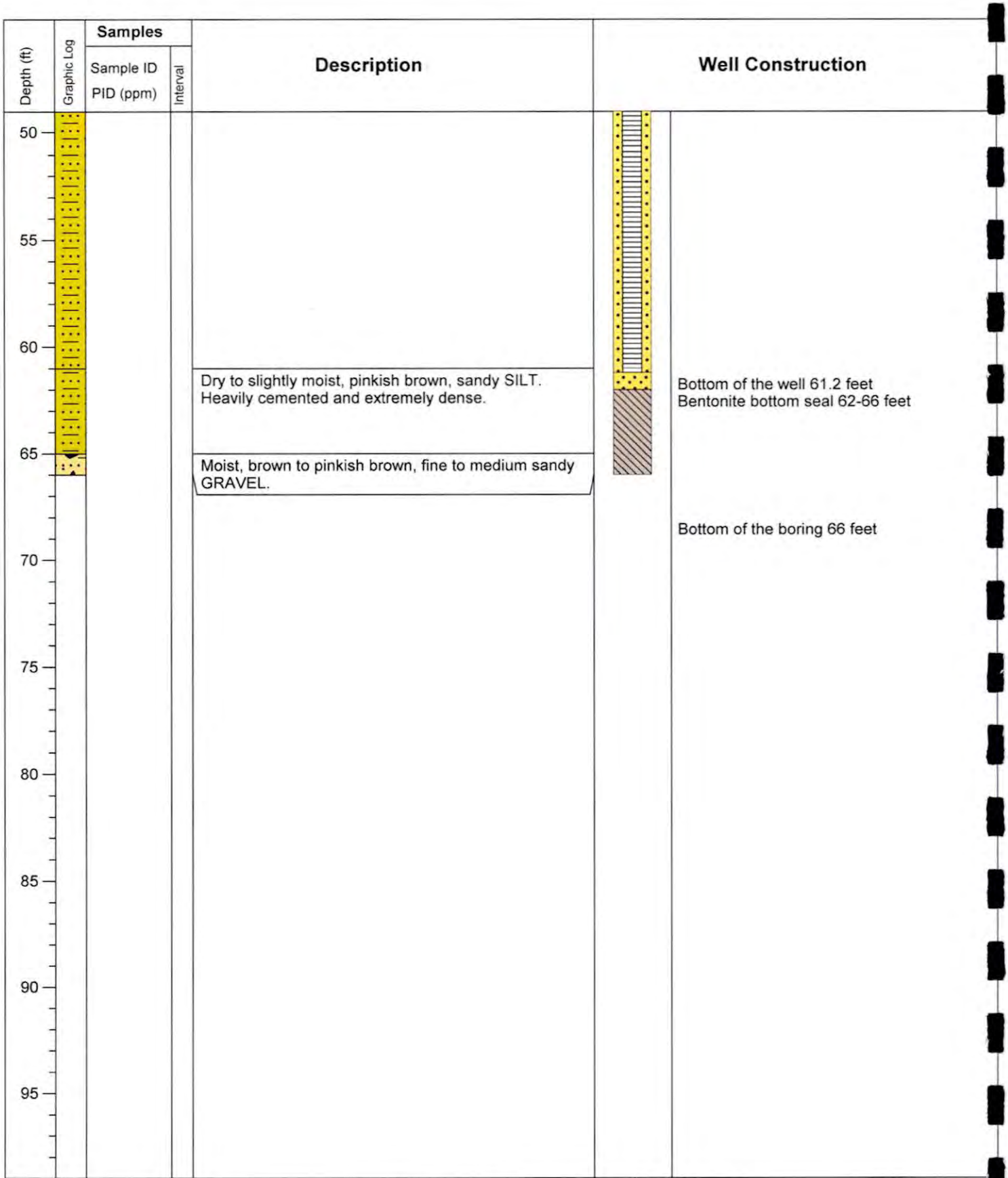
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 30.18 ft
MP Elevation: 724.37 ft
V. Datum: NAD88

YC-MW-21
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T9R23-29
Northing/Easting: N 332464.2 ft, E 1776332.6 ft
Logged by: David Wampler, PGG
Completion Date: 11/12/2018
Ecology ID: BKB-735

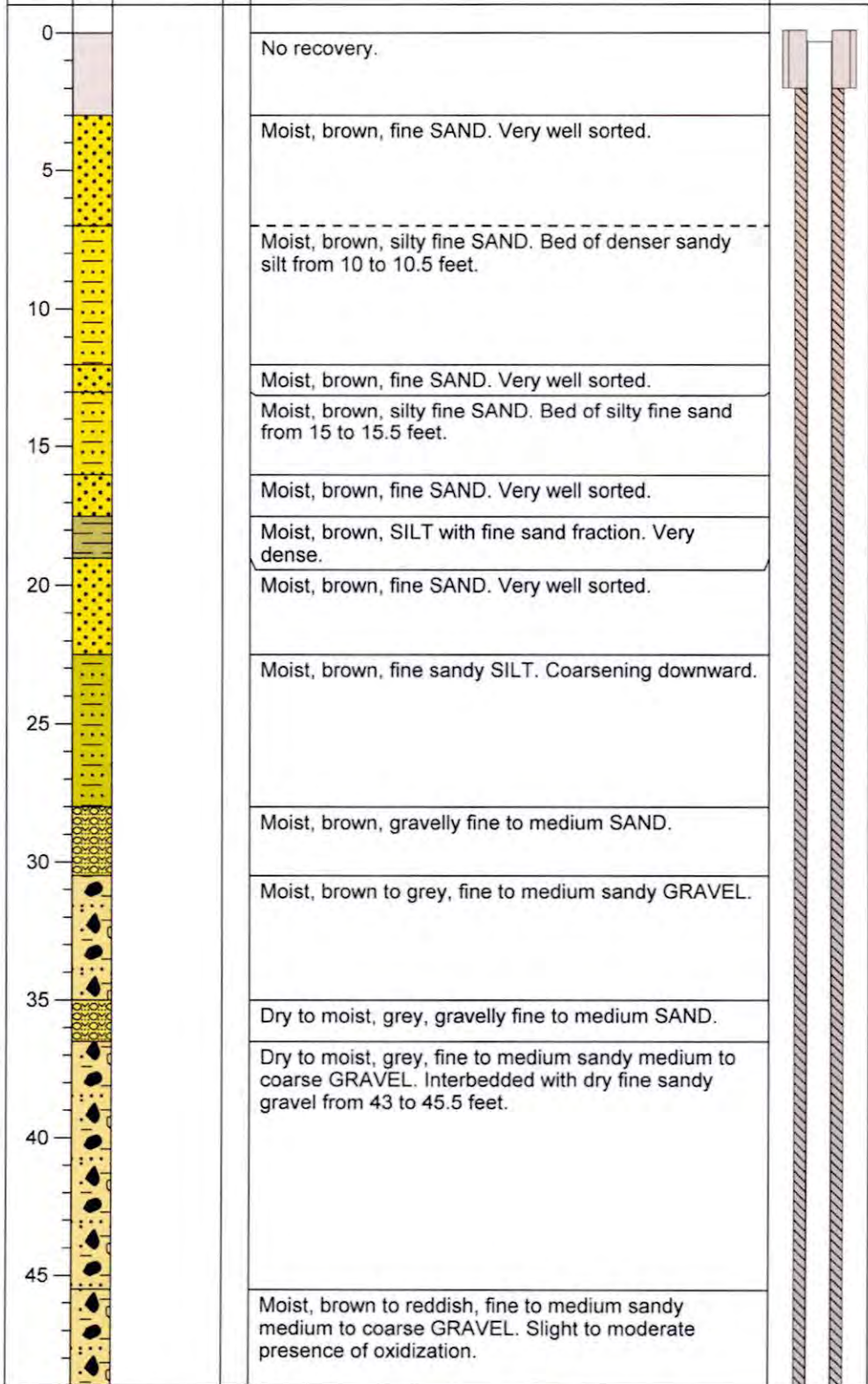
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 30.18 ft
MP Elevation: 724.37 ft
V. Datum: NAD88

YC-MW-21
Boring Log and As-Built

Yakima GWMA

JE1803

PGG



Location (TRS): T11R21-33
Northing/Easting: N 386455.5 ft, E 1716288.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/9/2018
Ecology ID: BKB-732

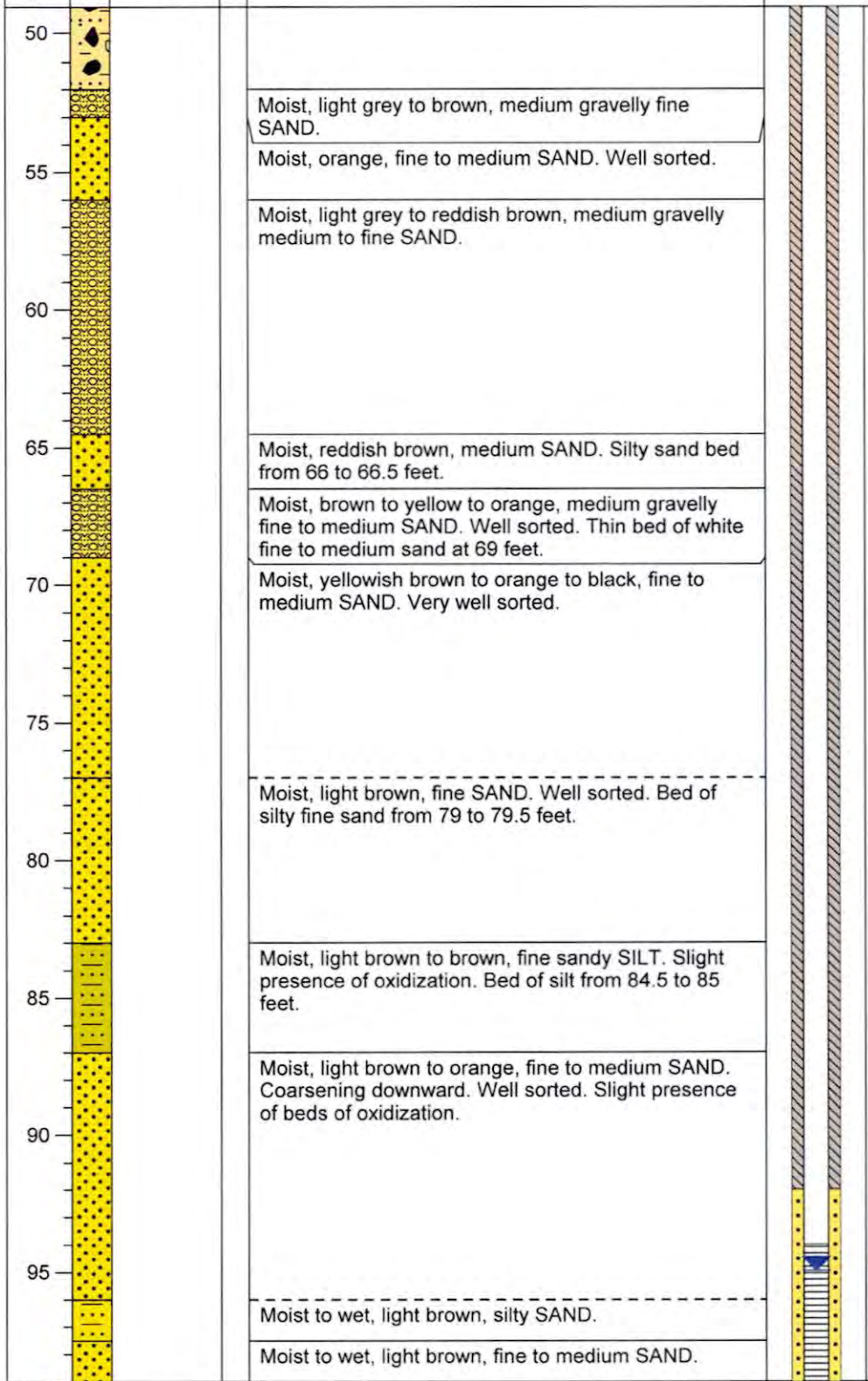
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 94.95 ft
MP Elevation: 889.82 ft
V. Datum: NAD88

YC-MW-23
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R21-33
Northing/Easting: N 386455.5 ft, E 1716288.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/9/2018
Ecology ID: BKB-732

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 94.95 ft
MP Elevation: 889.82 ft
V. Datum: NAD88

YC-MW-23
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
100				Coarsening downward. Very well sorted. Bed of black to grey fine to medium sand with gravel fraction from 113.5 to 114 feet.	
105					
110					
115				Moist, light brown, fine sandy SILT. Moderate presence of oxidization.	Bottom of the well 114.2 feet Bentonite bottom seal 114.5-116 feet
				Moist to wet, dark brown to orangish brown, fine to medium SAND. Thin gravel bed from 115.25 to 115.5 feet.	Bottom of the boring 116 feet
120					
125					
130					
135					
140					
145					

Location (TRS): T11R21-33
Northing/Easting: N 386455.5 ft, E 1716288.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/9/2018
Ecology ID: BKB-732

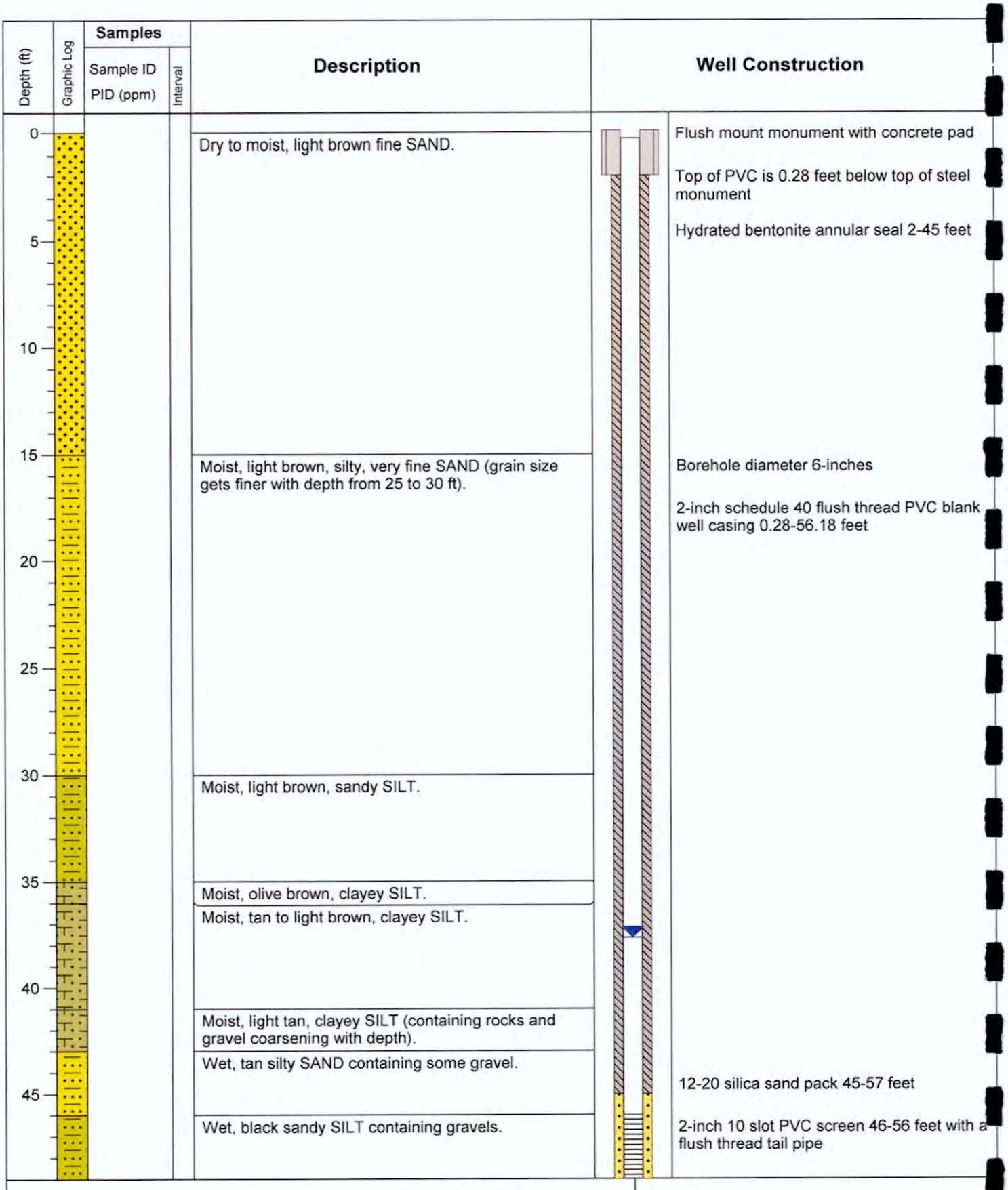
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 94.95 ft
MP Elevation: 889.82 ft
V. Datum: NAD88

YC-MW-23
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T9R23-11
Northing/Easting: N 343838.6 ft, E 1790793.1 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/14/2018
Ecology ID: BKB-741

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 37.66 ft
MP Elevation: 815.45 ft
V. Datum: NAD88

YC-MW-24
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
50					
55					
				Dry, non-fractured BASALT.	Bottom of the well 56.18 feet Bentonite bottom seal 57-60 feet
60					Bottom of the boring 60 feet
65					
70					
75					
80					
85					
90					
95					

Location (TRS): T9R23-11
Northing/Easting: N 343838.6 ft, E 1790793.1 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/14/2018
Ecology ID: BKB-741

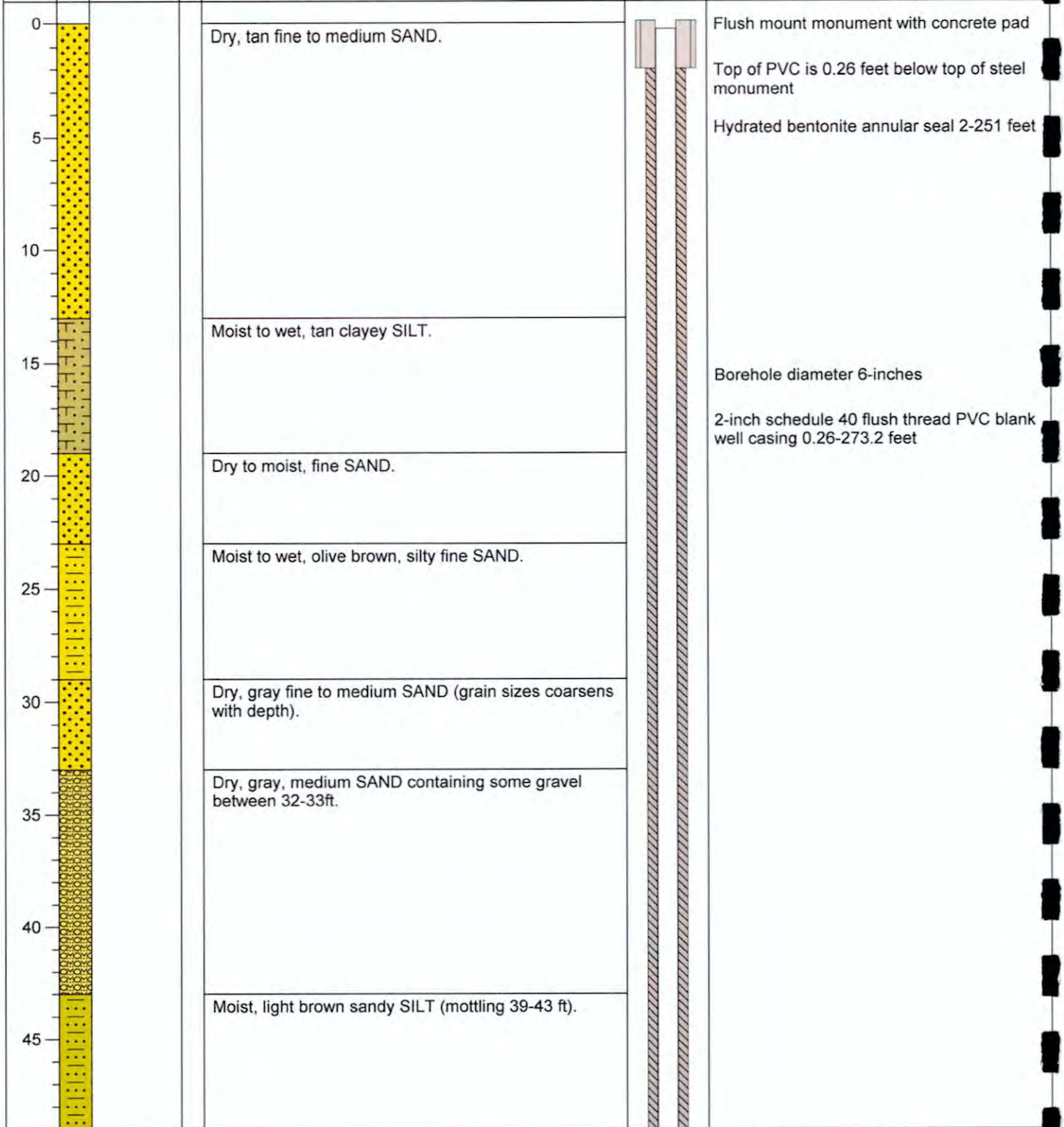
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 37.66 ft
MP Elevation: 815.45 ft
V. Datum: NAD88

YC-MW-24
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R21-17
Northing/Easting: N 401363.8 ft, E 1711060 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/29/2018
Ecology ID: BKB-747

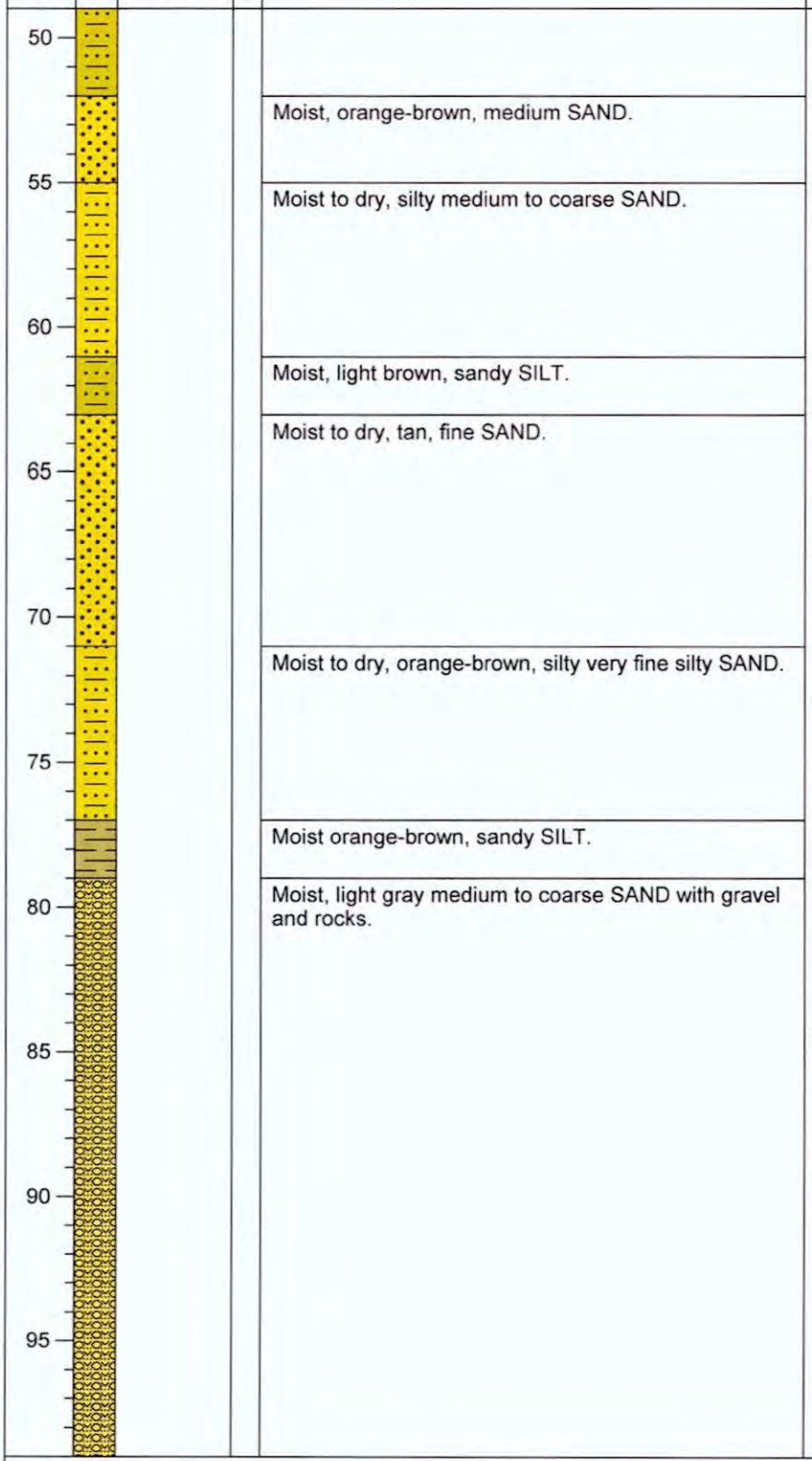
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 263.55 ft
MP Elevation: 1204.67 ft
V. Datum: NAD88

YC-MW-25
Boring Log and As-Built

Yakima GWMA

JE1803

PGG



Location (TRS): T11R21-17
Northing/Easting: N 401363.8 ft, E 1711060 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/29/2018
Ecology ID: BKB-747

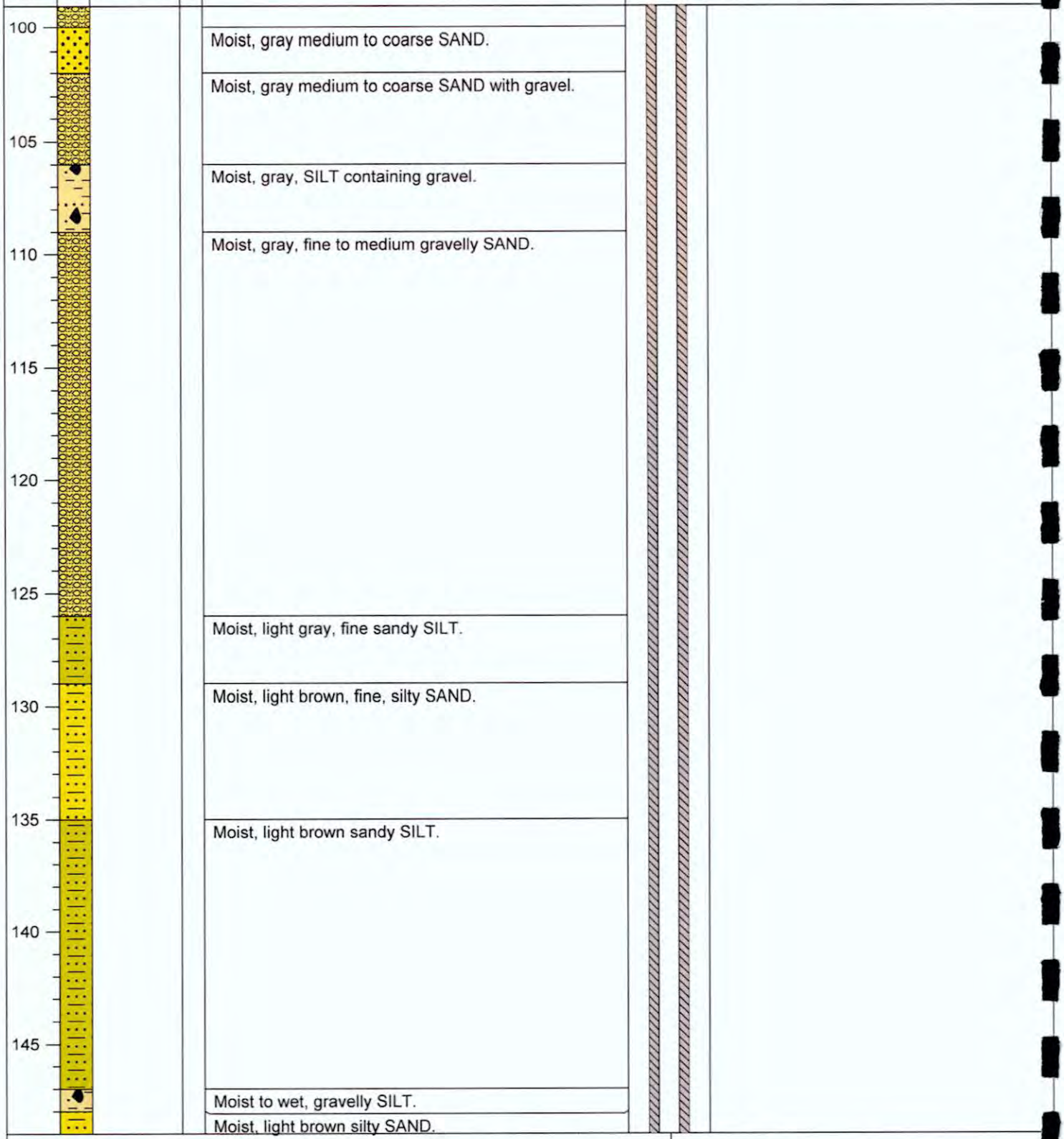
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 263.55 ft
MP Elevation: 1204.67 ft
V. Datum: NAD88

YC-MW-25
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R21-17
Northing/Easting: N 401363.8 ft, E 1711060 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/29/2018
Ecology ID: BKB-747

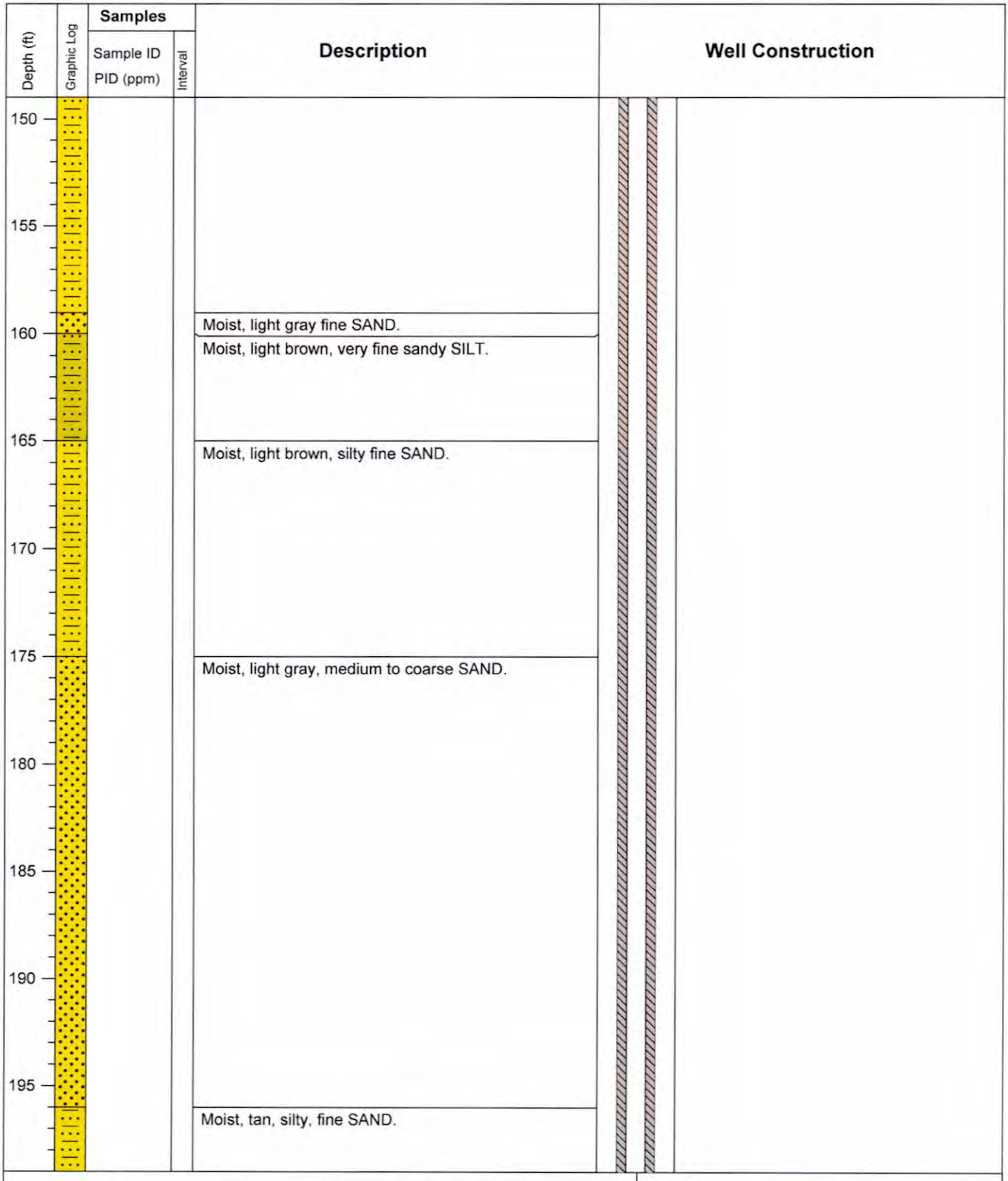
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 263.55 ft
MP Elevation: 1204.67 ft
V. Datum: NAD88

YC-MW-25
Boring Log and As-Built

Yakima GWMA

JE1803

PGG



Location (TRS): T11R21-17
Northing/Easting: N 401363.8 ft, E 1711060 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/29/2018
Ecology ID: BKB-747

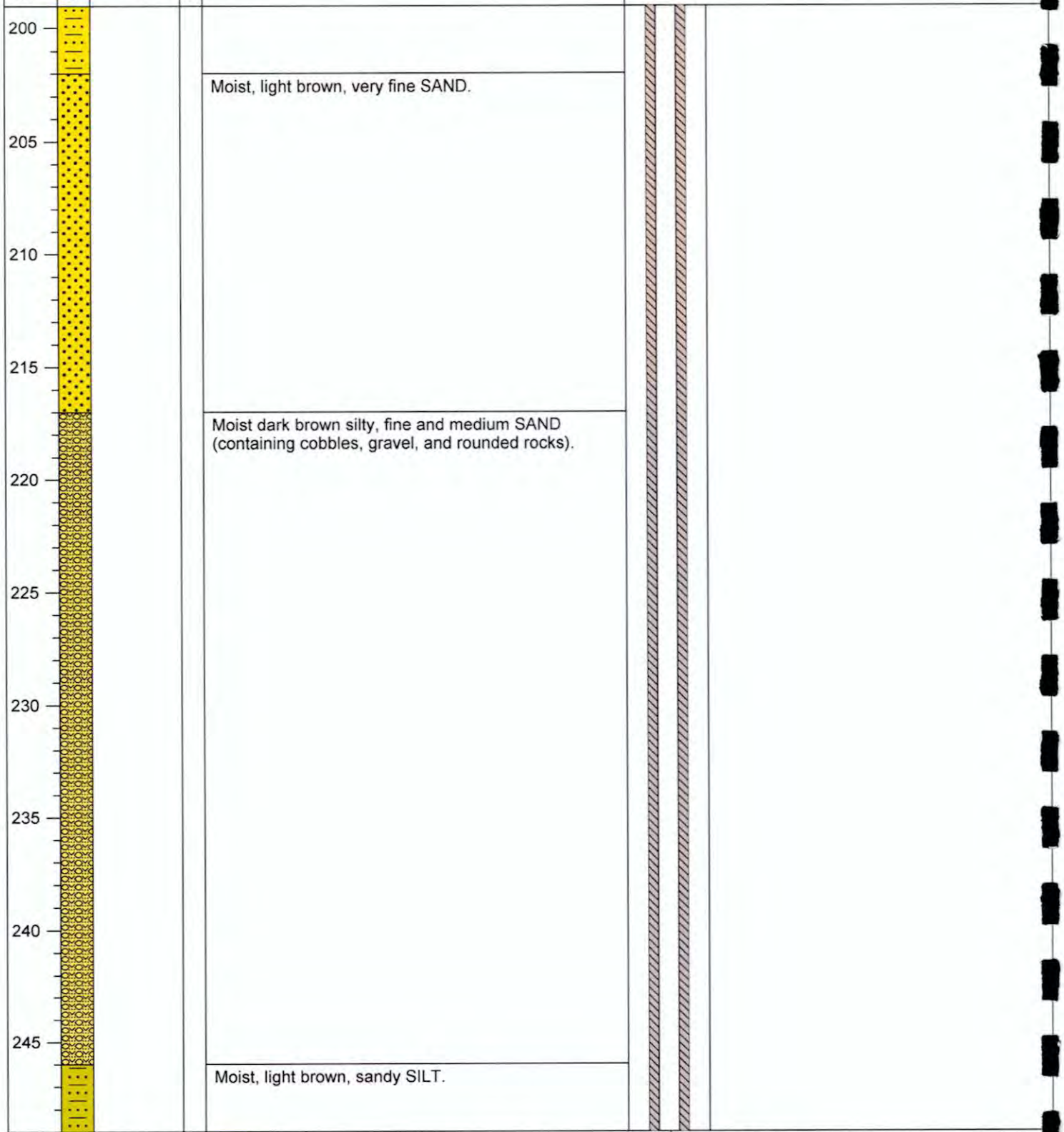
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 263.55 ft
MP Elevation: 1204.67 ft
V. Datum: NAD88

YC-MW-25
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R21-17
Northing/Easting: N 401363.8 ft, E 1711060 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/29/2018
Ecology ID: BKB-747

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 263.55 ft
MP Elevation: 1204.67 ft
V. Datum: NAD88

YC-MW-25
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
250					12-20 silica sand pack 251-275 feet
255				Wet, dark brown, silty fine SAND (contains some gravel and rocks).	2-inch 10 slot PVC screen 253-273 feet with a flush thread tail pipe
260				Moist to wet, light brown, very fine SAND to sandy SILT (finer with depth).	
265				Moist to wet, dark brown, silty SAND.	
270				Moist to wet, dark brown fine to medium SAND.	
275				Moist, light brown, silty medium to find SAND.	Bottom of the boring 275 feet
280					
285					
290					
295					

Location (TRS): T11R21-17
Northing/Easting: N 401363.8 ft, E 1711060 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/29/2018
Ecology ID: BKB-747

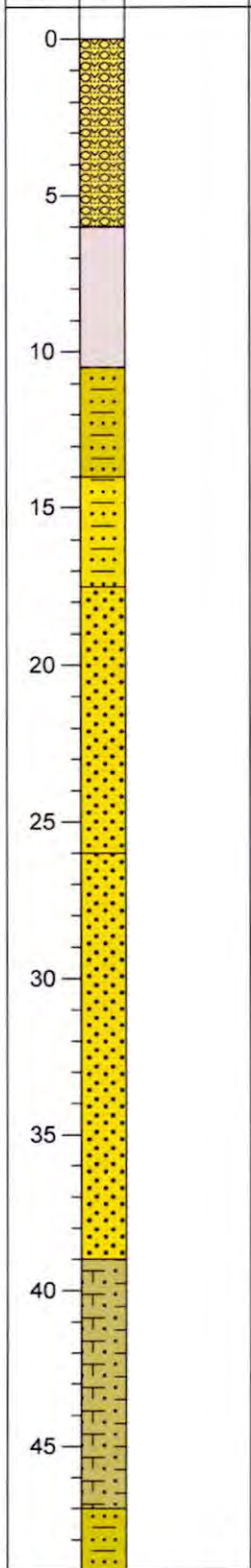
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 263.55 ft
MP Elevation: 1204.67 ft
V. Datum: NAD88

YC-MW-25
Boring Log and As-Built

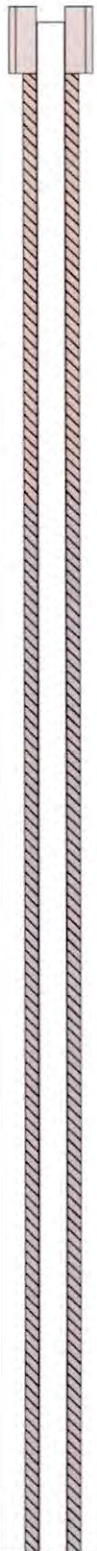
Yakima GWMA

JE1803

PgG



Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Dry to moist, light brown, medium to coarse gravelly fine SAND.
5				Moist, light brown, very fine sandy SILT.
10				Moist, light brown, very fine sandy SILT.
15				Moist, light brown, silty SAND with gravel fraction.
20				Moist, light brown, SAND with slight silt fraction. Coarsening downward.
25				
30				Moist, light brown, medium to coarse SAND. Fine to medium gravel fraction.
35				
40				Moist, light brown, clayey SILT.
45				Moist, light brown, sandy SILT. Interbedded silty sand.



Well Construction

Flush mount monument with concrete pad
Top of PVC is 0.39 feet below top of steel monument

Hydrated bentonite annular seal 2-74 feet

Borehole diameter 6-inches

2-inch schedule 40 flush thread PVC blank well casing 0.39-96.2 feet

Location (TRS): T11R20-05
Northing/Easting: N 415545.8 ft, E 1681988.6 ft
Logged by: David Wampler, PGG
Completion Date: 11/5/2018
Ecology ID: BKB-728

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 73.77 ft
MP Elevation: 1039.13 ft
V. Datum: NAD88

YC-MW-26
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
50					
				Moist, greenish yellow, silty SAND. Interbedded yellowish brown sand.	
55				Moist, light brown, coarse to very coarse gravelly medium SAND. Basalt boulder.	
				Moist, light brown, clayey SILT. Sand and fine to medium gravel fractions.	
60				Moist, light brown, silty very fine to fine SAND. Clay fraction.	
65				Moist, light brown to grey, fine to medium SAND. Silt fraction. Slight presence of oxidization.	
70				Moist, yellowish grey, sandy SILT.	
75				Moist, brownish red, silty SAND.	12-20 silica sand pack 74-97 feet
				Dry, light brown, sandy SILT.	2-inch 10 slot PVC screen 76-96 feet with a flush thread tail pipe
				Very wet, brown, very coarse SAND.	
80				Wet, dark brown, silty SAND. Moderate presence of yellowish grey clayey silt clumps.	
				Moist, light brown, sandy SILT. Clay and medium to very coarse gravel fractions.	
85				Moist to wet, brown, silty SAND. Clay and medium to very coarse gravel fractions.	
90				Moist to wet, brown, very fine sandy SILT.	
				Moist to wet, brown, silty SAND. Fine to coarse gravel fraction.	
95				Moist, brown, clayey SILT. Slight and gravel fractions.	
				Moist, brown, sandy SILT. Gravel fraction. Coarsening downward.	Bottom of the well 96.2 feet Bentonite bottom seal 97-116 feet

Location (TRS): T11R20-05
Northing/Easting: N 415545.8 ft, E 1681988.6 ft
Logged by: David Wampler, PGG
Completion Date: 11/5/2018
Ecology ID: BKB-728

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 73.77 ft
MP Elevation: 1039.13 ft
V. Datum: NAD88

YC-MW-26
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
100					
105					
110				Moist, dark brown to very dark brown, sandy SILT. Slight presence of breccia gravels composed of sand and pebbles.	
115				Wet, dark brown, gravelly SAND. Slight presence of heavily oxidized clumps of sand.	
120					Bottom of the boring 116 feet
125					
130					
135					
140					
145					

Location (TRS): T11R20-05
Northing/Easting: N 415545.8 ft, E 1681988.6 ft
Logged by: David Wampler, PGG
Completion Date: 11/5/2018
Ecology ID: BKB-728

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 73.77 ft
MP Elevation: 1039.13 ft
V. Datum: NAD88

YC-MW-26
Boring Log and As-Built

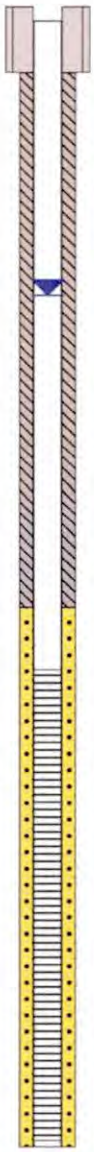
Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Moist to wet, brown, fine sandy SILT.
				Moist, brown, fine to medium SAND.
5				Moist, brown, fine sandy SILT.
				Moist, brown, silty fine SAND.
10				
				Moist, brown, fine sandy SILT.
				Moist, brown, silty fine SAND.
15				Moist, brown, fine sandy SILT.
				Moist, brown, silty fine SAND.
				Moist, brown, fine sandy SILT.
20				Moist, brown, silty fine SAND.
				Moist, brown, fine sandy SILT.
				Moist, brown, silty fine SAND.
				Moist, brown, fine sandy SILT.
25				Moist, brown, silty fine SAND. Hardening downward.
				Moist, brown, fine sandy SILT.
				Moist, brown, silty fine SAND.
30				
				Moist, brown, fine sandy SILT.
				Moist, brown, silty fine SAND.
35				
40				
45				

Well Construction



Flush mount monument with concrete pad
Top of PVC is 0.35 feet below top of steel monument

Hydrated bentonite annular seal 2-19 feet

Borehole diameter 6-inches

2-inch schedule 40 flush thread PVC blank well casing 0.35-36.2 feet

12-20 silica sand pack 19-36.2 feet

2-inch 10 slot PVC screen 21-36 feet with a flush thread tail pipe

Bottom of the well 36.2 feet

Bottom of the boring 36.2 feet

Location (TRS): T9R23-08
Northing/Easting: N 348483.1 ft, E 1775485.3 ft
Logged by: David Wampler, PGG
Completion Date: 11/6/2018
Ecology ID: BKB-730

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 9.08 ft
MP Elevation: 719.17 ft
V. Datum: NAD88

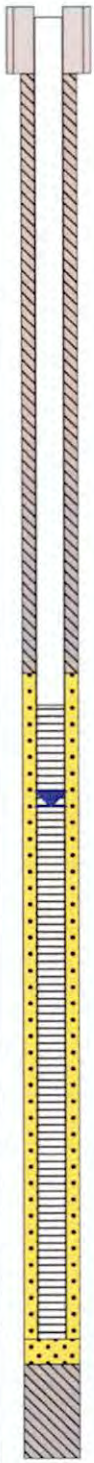
YC-MW-27
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Dry to moist, light brown, sandy SILT.
10				Moist, brown SILT containing coarse sand and rounded black gravel (0.1-3 cm).
20				Moist, brown, very fine sandy SILT (3" gravel lens at 21 ft).
25				Wet, dark brown, gravelly, medium to coarse SAND.
30				Wet, dark brown, fine sandy SILT (coarsens with depth).
35				Wet, dark brown, very fine SAND.
40				Wet, dark brown, very fine SAND (containing gravel and rocks up to 5 cm diameter).
45				Moist, light brown, very fine sandy SILT.



Well Construction

- Flush mount monument with concrete pad
- Top of PVC is 0.24 feet below top of steel monument
- Hydrated bentonite annular seal 2-21 feet
- Borehole diameter 6-inches
- 2-inch schedule 40 flush thread PVC blank well casing 0.24-43.18 feet
- 12-20 silica sand pack 21-43 feet
- 2-inch 10 slot PVC screen 22-42 feet with a flush thread tail pipe
- Bottom of the well 43.18 feet
- Bentonite bottom seal 43-46 feet
- Bottom of the boring 46 feet

Location (TRS): T8R23-08
Northing/Easting: N 313832.2 ft, E 1778744.7 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/17/2018
Ecology ID: BKB-743

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 25.25 ft
MP Elevation: 731.38 ft
V. Datum: NAD88

YC-MW-28
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Moist, dark brown, silty fine SAND.
5				Moist, dark brown, fine SAND.
10				Moist, dark brown, silty fine SAND. Fining downward. Thin bed of significant oxidization at 10 feet.
				Moist, dark brown, very fine sandy SILT. Moderate presence of oxidization.
15				Moist, dark brown, fine to medium SAND. Well sorted. Coarsening downward. Moderate presence of oxidization.
				Moist, dark brown, fine to medium SAND.
20				
				Moist, dark brown, fine to medium SAND. Coarsening downward.
25				
				Moist to wet, dark grey to dark brown, medium to coarse SAND. Well sorted.
30				Moist to wet, dark grey to dark brown, medium SAND. Very well sorted.
35				
40				
45				



Well Construction

- Flush mount monument with concrete pad
- Top of PVC is 0.39 feet below top of steel monument
- Hydrated bentonite annular seal 2-29 feet
- Borehole diameter 6-inches
- 2-inch schedule 40 flush thread PVC blank well casing 0.39-45.2 feet
- 12-20 silica sand pack 29-45.2 feet
- 2-inch 10 slot PVC screen 30-45 feet with a flush thread tail pipe
- Bottom of the well 45.2 feet
- Bottom of the boring 45.2 feet

Location (TRS): T9R22-10
Northing/Easting: N 343074.8 ft, E 1752292.2 ft
Logged by: David Wampler, PGG
Completion Date: 1/16/2019
Ecology ID: BKB-756

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 29.04 ft
MP Elevation: 692.84 ft
V. Datum: NAD88

YC-MW-31
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
0				Moist, dark brown, silty fine SAND.	Flush mount monument with concrete pad Top of PVC is 0.27 feet below top of steel monument
				Moist to wet, dark brown, silty fine SAND.	
5					Hydrated bentonite annular seal 2-13 feet
				Moist to wet, brown to dark brown, silty fine SAND. Slightly hardens downward.	
10					
					12-20 silica sand pack 13-29.5 feet 2-inch 10 slot PVC screen 14-29 feet with a flush thread tail pipe
15					
					Borehole diameter 6-inches
20					2-inch schedule 40 flush thread PVC blank well casing 0.27-29.2 feet
25					
30				Moist, brown, fine sandy SILT.	Bottom of the well 29.2 feet
				Moist to wet, dark brown, silty fine SAND.	
				Moist, brown, fine sandy SILT.	Bentonite bottom seal 29.5-36 feet
				Moist to wet, dark brown, silty fine SAND.	
35				Moist, brown, fine sandy SILT.	
					Bottom of the boring 36 feet
40					
45					

Location (TRS): T10R21-15
Northing/Easting: N 374861.7 ft, E 1721596.4 ft
Logged by: David Wampler, PGG
Completion Date: 1/14/2019
Ecology ID: BKB-754

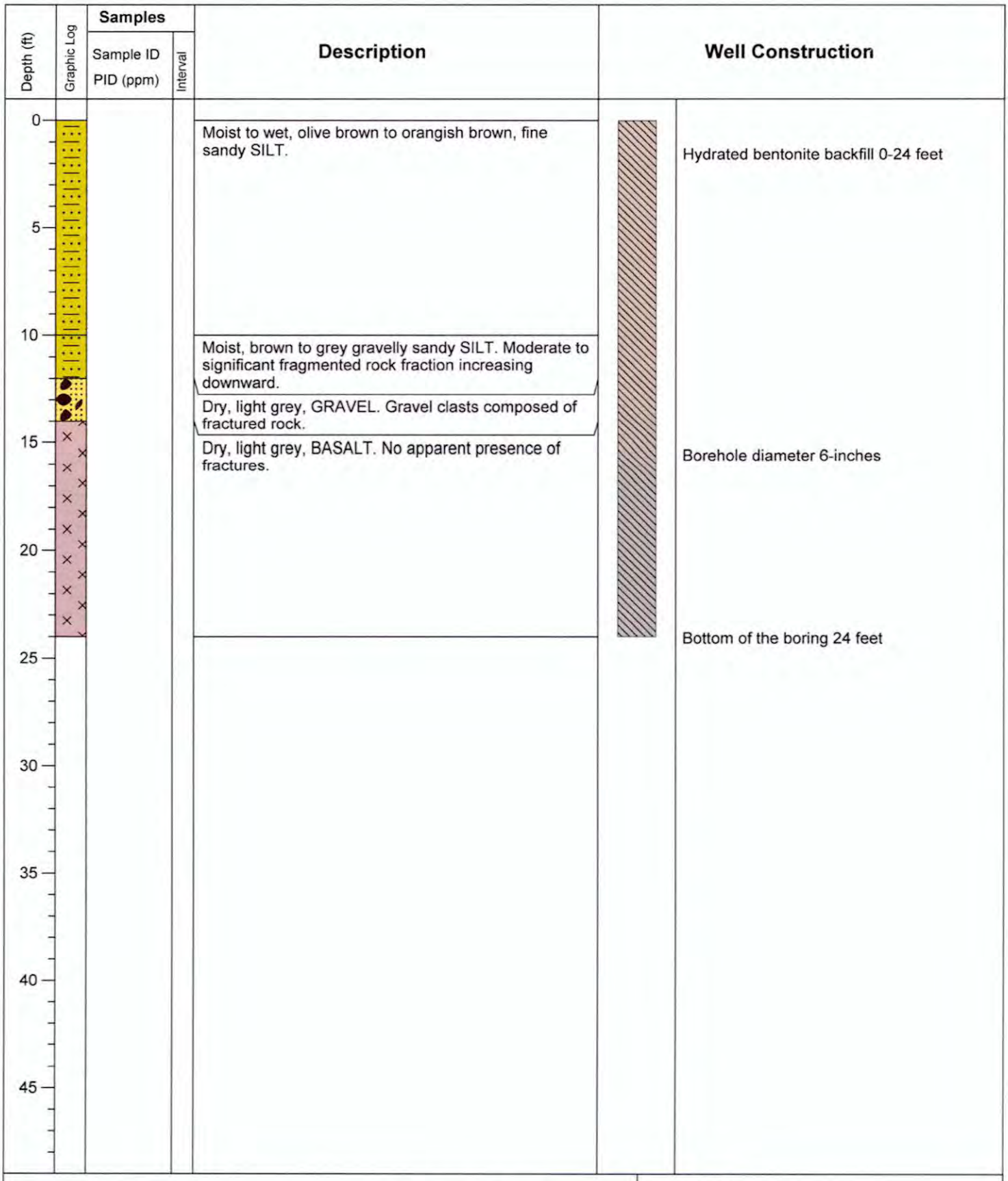
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 6.23 ft
MP Elevation: 762.89 ft
V. Datum: NAD88

YC-MW-33
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R23-09
Northing/Easting: N 375350.1 ft, E 1779900.9 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 1/19/2018
Ecology ID: N/A

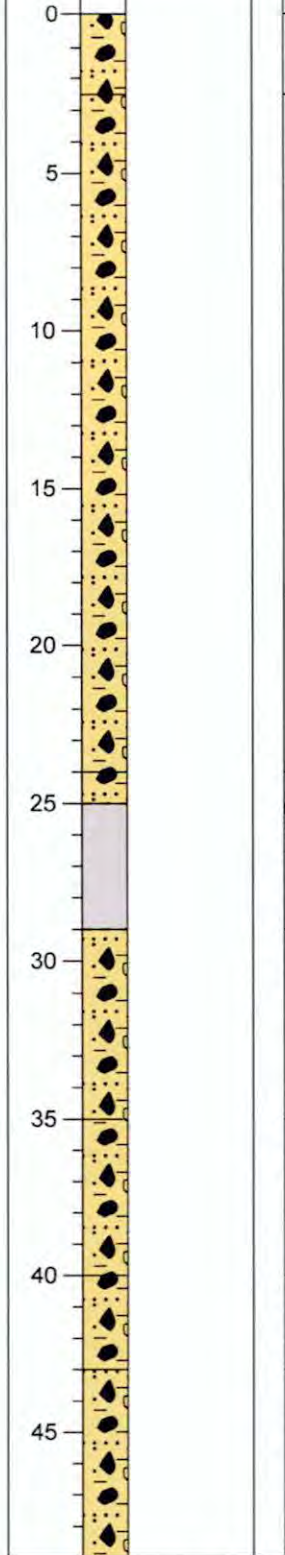
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: N/A
MP Elevation: N/A
V. Datum: NAD88

YC-MW-35
Boring Log

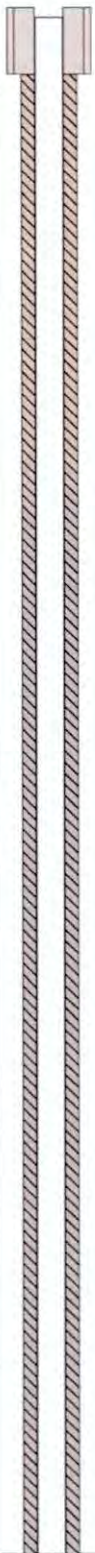
Yakima GWMA

JE1803

PgG



Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Moist, brown, fine sandy medium to very coarse GRAVEL.
5				Dry to moist, grey, fine sandy medium to very coarse GRAVEL. Moderate presence of CaCO3 accumulation. Increased medium gravel fraction from 2.5 to 5 feet.
10				
15				
20				
25				Dry to moist, grey to brown, fine sandy medium to very coarse GRAVEL. Significant presence of CaCO3 accumulation. Trace presence of oxidization.
				Dry to moist, grey to dark brown, fine sandy medium to very coarse GRAVEL.
30				Dry to moist, grey to dark brown, fine sandy medium to very coarse GRAVEL. Moderate presence of CaCO3 accumulation.
35				Moist, dark brown, fine sandy medium to very coarse GRAVEL.
40				Dry to moist, light brown to dark brown, fine sandy medium to very coarse GRAVEL. Moderate presence of CaCO3 accumulation.
45				Dry to moist, brown, fine sandy medium to very coarse GRAVEL. Trace to moderate presence of CaCO3 accumulation. Trace to moderate presence of oxidization.



Well Construction

Flush mount monument with concrete pad
Top of PVC is 0.22 feet below top of steel monument

Hydrated bentonite annular seal 2-116 feet

Borehole diameter 6-inches

2-inch schedule 40 flush thread PVC blank well casing 0.22-135.2 feet

Location (TRS): T9R23-36
Northing/Easting: N 324605 ft, E 1794427.1 ft
Logged by: David Wampler, PGG
Completion Date: 1/17/2019
Ecology ID: BKB-758

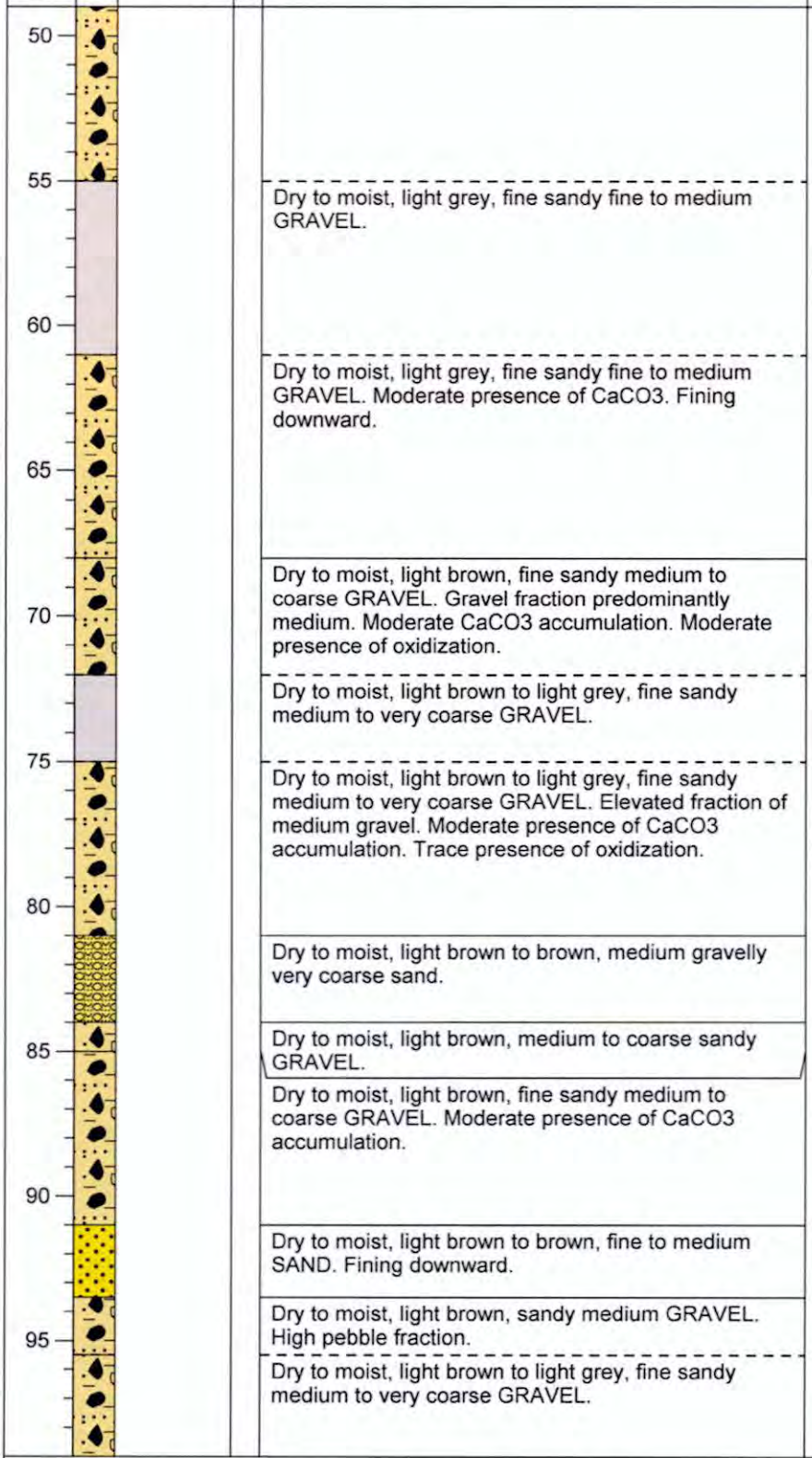
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 120.39 ft
MP Elevation: 766.75 ft
V. Datum: NAD88

YC-MW-38
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T9R23-36
Northing/Easting: N 324605 ft, E 1794427.1 ft
Logged by: David Wampler, PGG
Completion Date: 1/17/2019
Ecology ID: BKB-758

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 120.39 ft
MP Elevation: 766.75 ft
V. Datum: NAD88

YC-MW-38
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
100				Dry to moist, light brown to brown, fine to medium SAND.	
105				Dry to moist, light brown, medium sandy medium GRAVEL. High pebble fraction.	
				Dry to moist, light brown to light grey, fine sandy medium to coarse GRAVEL.	
110				Dry to moist, light grey, medium gravelly SAND. Bed of sandy gravel with high pebble fraction from 113.5 to 114 feet.	
115				Dry, dark grey, basalt BOULDER.	
				Moist, light brown to dark brown, gravelly fine to medium SAND. Light tan to orangish brown gravelly sand from 123.5 to 124 feet.	12-20 silica sand pack 116-137 feet
120					2-inch 10 slot PVC screen 120-135 feet with a flush thread tail pipe
125				Wet, grey, coarse to very coarse sandy fine to medium GRAVEL. Slightly higher silt fraction from 129 feet to 140 feet.	
130					
135					Bottom of the well 135.2 feet
140					Bottom of the boring 140 feet
145					

Location (TRS): T9R23-36
Northing/Easting: N 324605 ft, E 1794427.1 ft
Logged by: David Wampler, PGG
Completion Date: 1/17/2019
Ecology ID: BKB-758

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 120.39 ft
MP Elevation: 766.75 ft
V. Datum: NAD88

YC-MW-38
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
0				Moist, brown, silty fine SAND. Moderately well sorted.	Flush mount monument with concrete pad Top of PVC is 0.29 feet below top of steel monument
5				Moist, brown, silty fine SAND.	Hydrated bentonite annular seal 2-99 feet
10				Moist, brown, silty fine SAND. Slight presence of thin beds with higher silt content.	
				Moist, brown, medium SAND. Well sorted.	
15				Moist, light brown, coarse sandy coarse GRAVEL. Trace presence of oxidization.	Borehole diameter 6-inches
				Moist, light brown, silty fine SAND.	2-inch schedule 40 flush thread PVC blank well casing 0.29-115.2 feet
20				Moist, light brown, silty fine SAND. Fining downward.	
				Moist, light brown to brown, fine sandy SILT. Fining downward and hardening downward.	
25					
30					
35					
40					
45				Moist, brown, fine sandy SILT. Dense to very dense. Moderate presence of very thin bands of oxidization. Slight presence of clumps of dark brown to red to black oxidized silts.	

Location (TRS): T11R21-19
Northing/Easting: N 395749.6 ft, E 1703378.8 ft
Logged by: David Wampler, PGG
Completion Date: 1/13/2019
Ecology ID: BKB-753

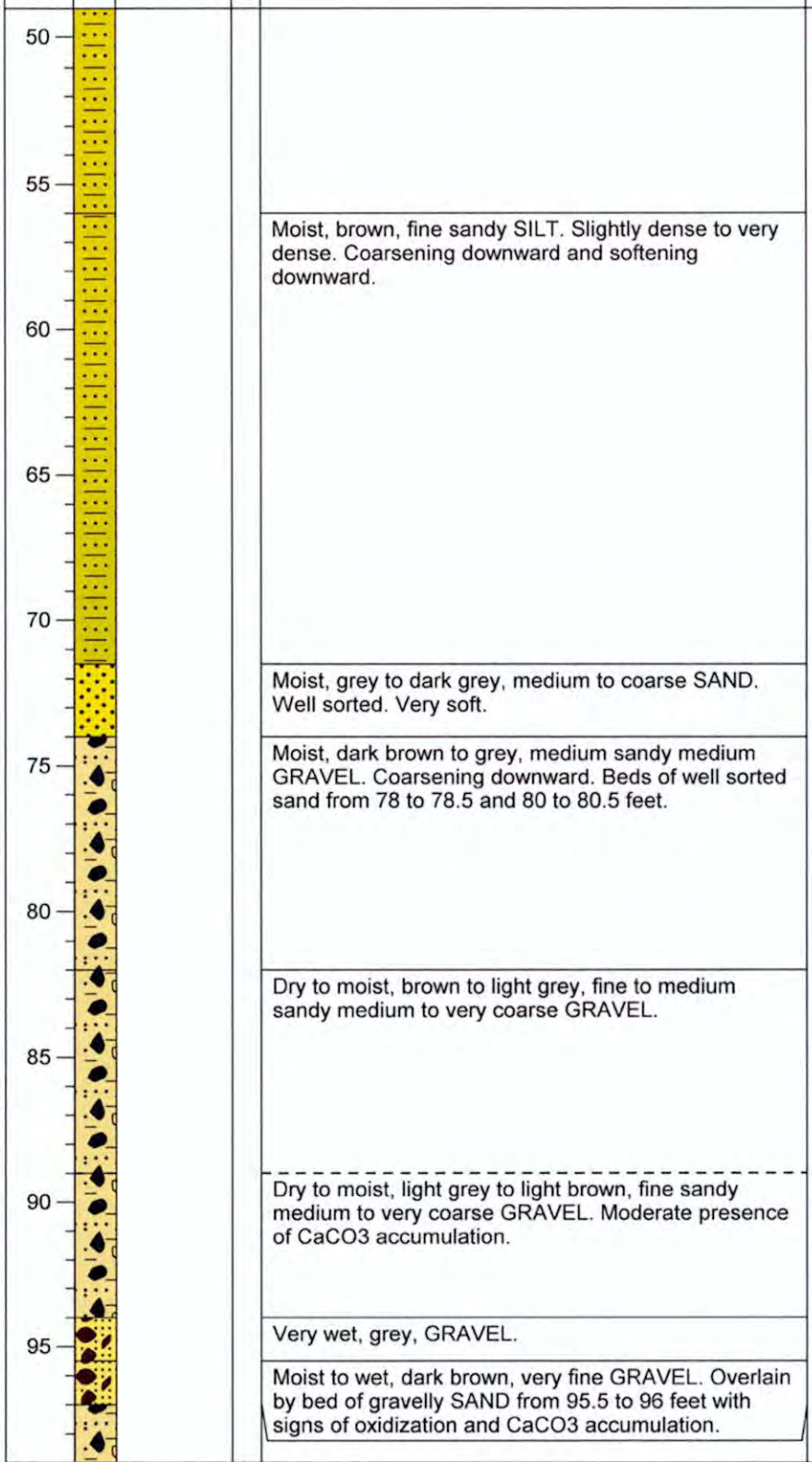
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 107.11 ft
MP Elevation: 880.63 ft
V. Datum: NAD88

YC-MW-39
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T11R21-19
Northing/Easting: N 395749.6 ft, E 1703378.8 ft
Logged by: David Wampler, PGG
Completion Date: 1/13/2019
Ecology ID: BKB-753

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 107.11 ft
MP Elevation: 880.63 ft
V. Datum: NAD88

YC-MW-39
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
100				Dry to moist, dark brown to light brown to grey, sandy medium to very coarse GRAVEL.	12-20 silica sand pack 99-116 feet
				Moist to wet, dark grey to light brown, sandy medium to very coarse GRAVEL. Small fines fraction. Signs of oxidization from 104 to 106 feet.	2-inch 10 slot PVC screen 100-115 feet with a flush thread tail pipe
105					
				Wet, dark grey, medium sandy medium to coarse GRAVEL. Slight fining downward.	
110					
				Wet, dark grey, silty medium to coarse GRAVEL.	
115				Wet, dark grey, sandy medium to coarse GRAVEL. Well sorted sand fraction.	Bottom of the well 115.2 feet
					Bottom of the boring 116 feet
120					
125					
130					
135					
140					
145					

Location (TRS): T11R21-19
Northing/Easting: N 395749.6 ft, E 1703378.8 ft
Logged by: David Wampler, PGG
Completion Date: 1/13/2019
Ecology ID: BKB-753

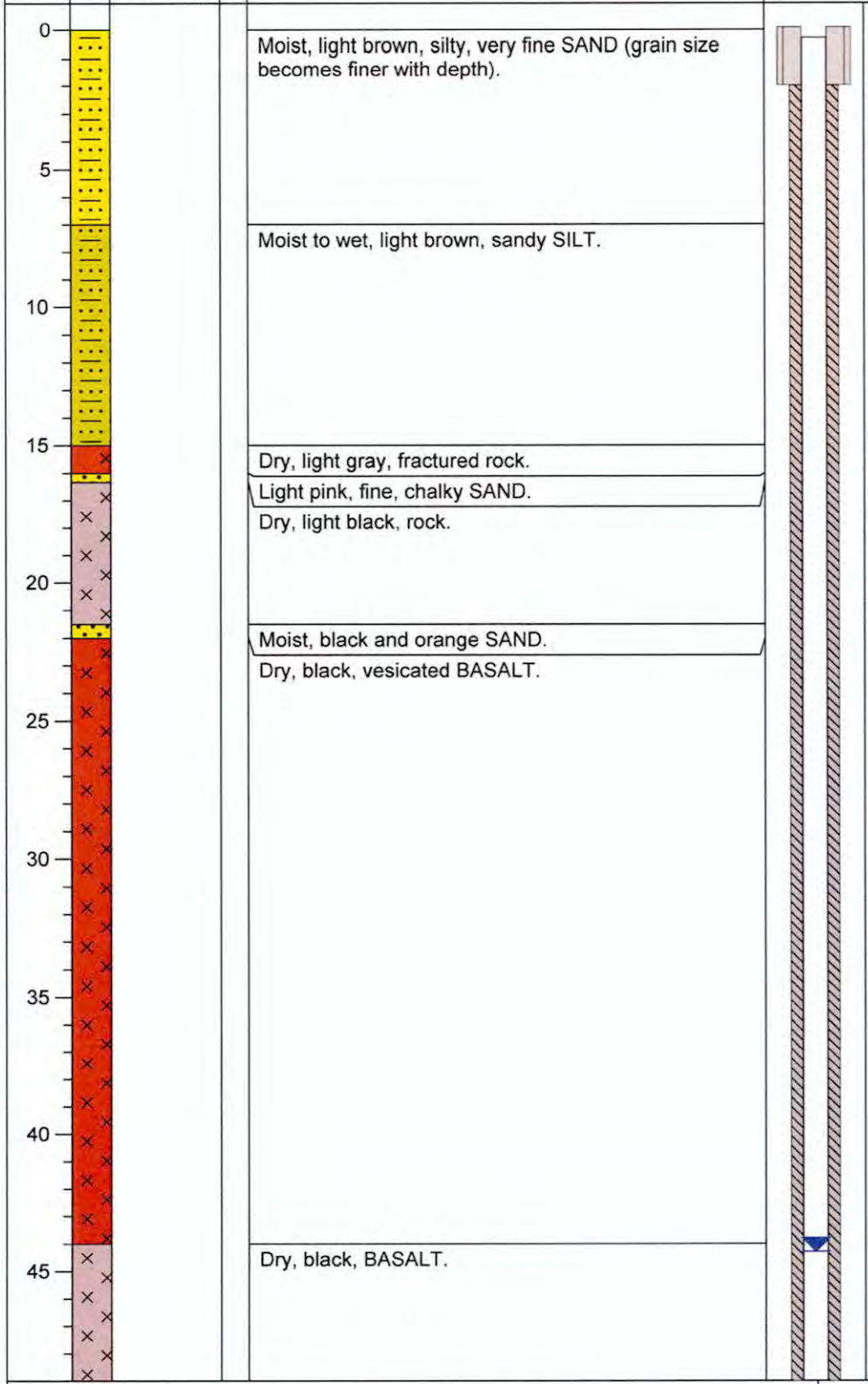
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 107.11 ft
MP Elevation: 880.63 ft
V. Datum: NAD88

YC-MW-39
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R23-35
Northing/Easting: N 359037 ft, E 1789145.7 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/26/2018
Ecology ID: BKB-748

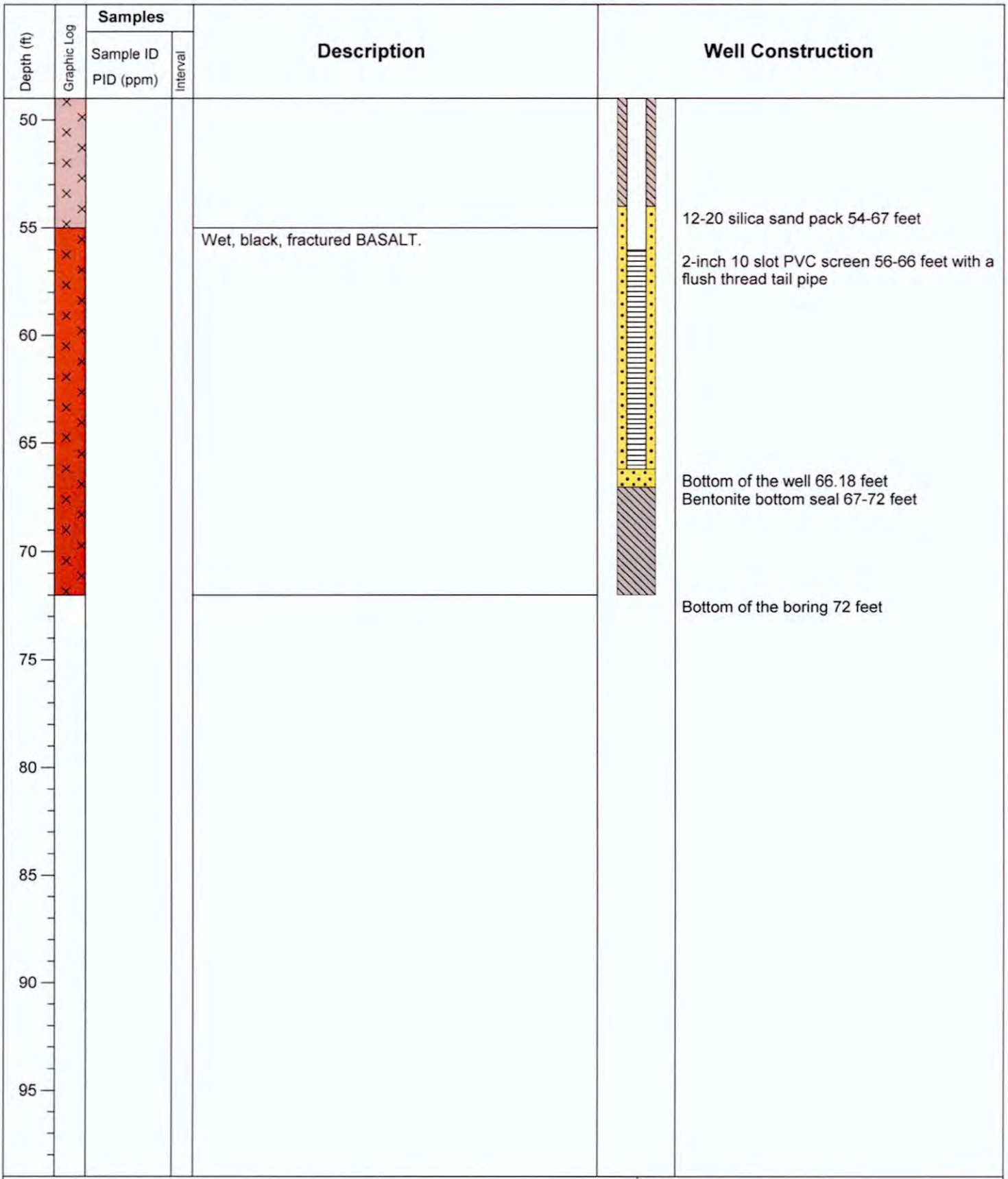
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 44.29 ft
MP Elevation: 965.66 ft
V. Datum: NAD88

YC-MW-41
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R23-35
Northing/Easting: N 359037 ft, E 1789145.7 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/26/2018
Ecology ID: BKB-748

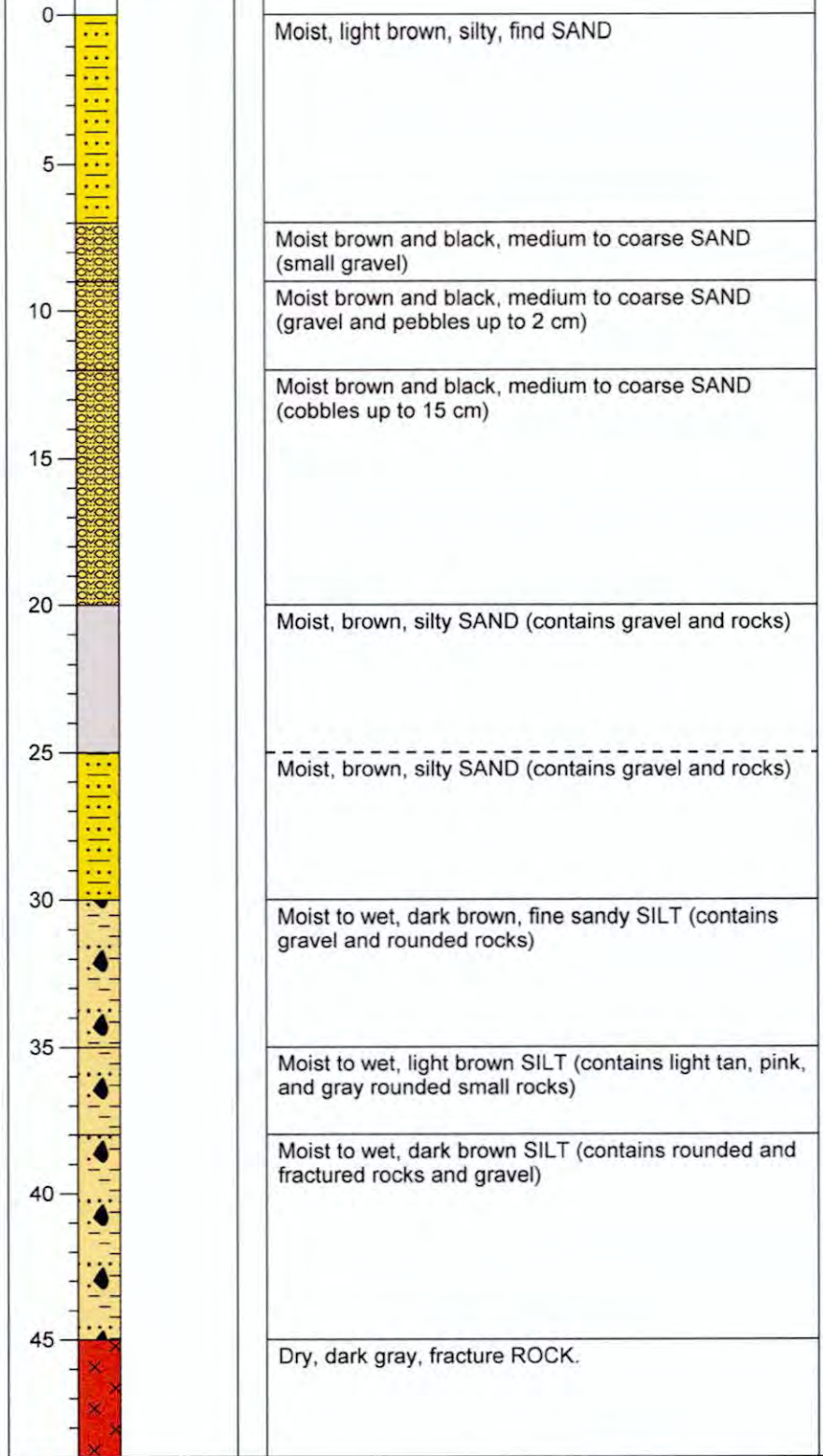
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 44.29 ft
MP Elevation: 965.66 ft
V. Datum: NAD88

YC-MW-41
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T8R23-05
Northing/Easting: N 321854 ft, E 1778078.4 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/26/2018
Ecology ID: BKB-746

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 33.39 ft
MP Elevation: 699.42 ft
V. Datum: NAD88

YC-MW-42
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description	Well Construction
50					Bottom of the boring 50 feet
55					
60					
65					
70					
75					
80					
85					
90					
95					

Location (TRS): T8R23-05
Northing/Easting: N 321854 ft, E 1778078.4 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 11/26/2018
Ecology ID: BKB-746

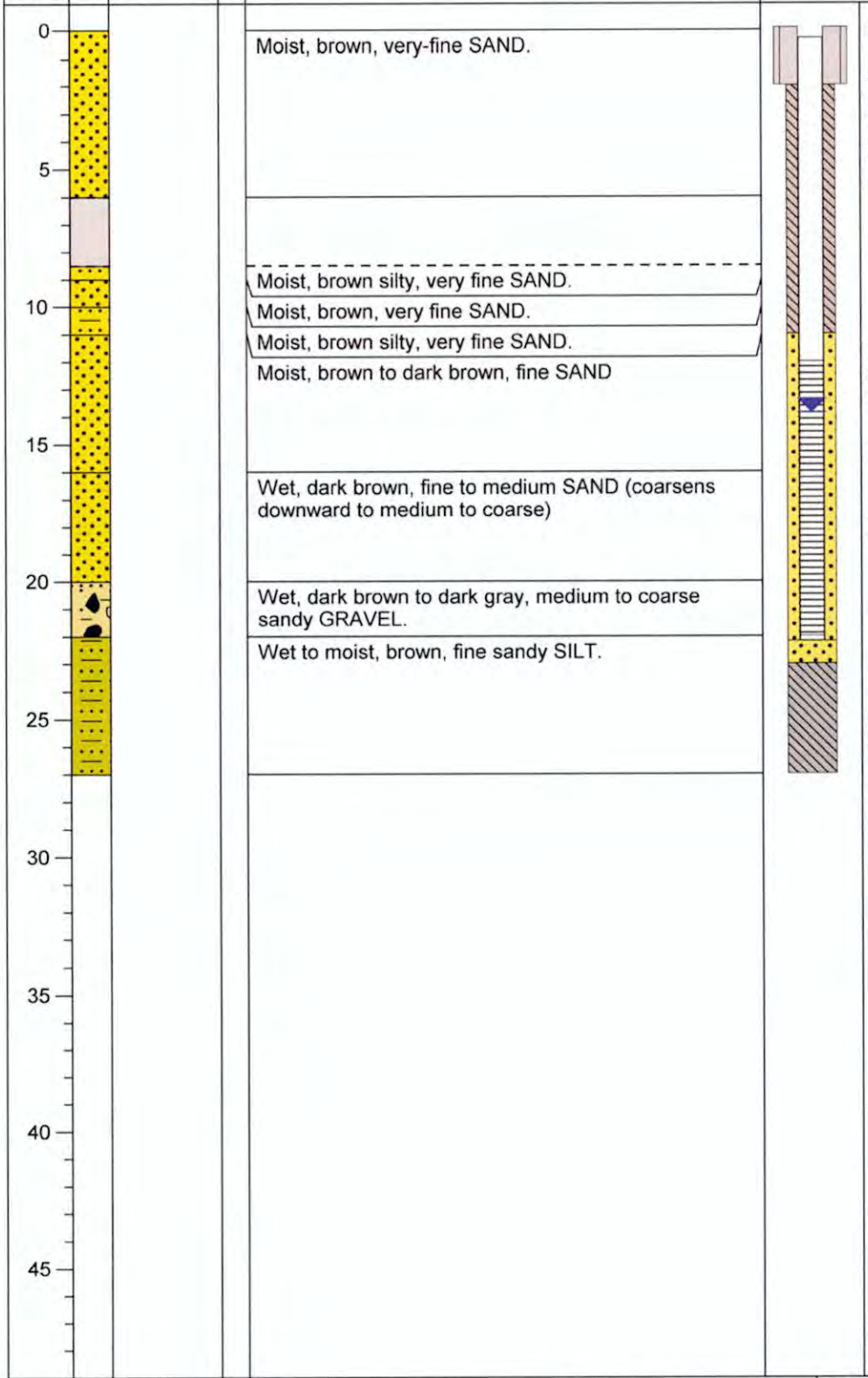
Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 33.39 ft
MP Elevation: 699.42 ft
V. Datum: NAD88

YC-MW-42
Boring Log and As-Built

Yakima GWMA

JE1803

PgG



Location (TRS): T10R23-33
Northing/Easting: N 356483.9 ft, E 1777956 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 1/15/2019
Ecology ID: BKB-755

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 13.85 ft
MP Elevation: 754.41 ft
V. Datum: NAD88

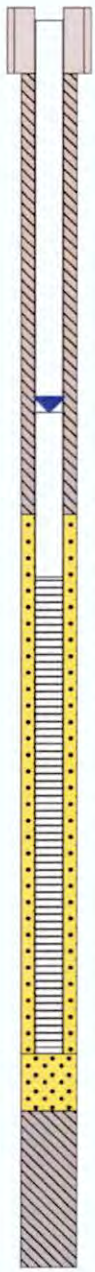
YC-MW-44
Boring Log and As-Built

Yakima GWMA

JE1803

PGG

Depth (ft)	Graphic Log	Samples: Sample ID / PID (ppm)	Samples: Interval	Description
0				Moist, dark brown, silty medium SAND.
5				
10				
15				Moist to wet, silty, medium SAND.
				Wet, dark brown, medium SAND.
20				Wet, dark brown, silty, fine medium SAND (finer with depth).
25				
30				
35				Wet, dark, brown, silty fine SAND.
				Wet, light brown, very fine sandy SILT.
40				
45				



Well Construction

- Flush mount monument with concrete pad
- Top of PVC is 0.3 feet below top of steel monument
- Hydrated bentonite annular seal 2-16 feet
- Borehole diameter 6-inches
- 12-20 silica sand pack 16-35 feet
- 2-inch schedule 40 flush thread PVC blank well casing 0.3-33.18 feet
- 2-inch 10 slot PVC screen 18-33 feet with a flush thread tail pipe
- Bottom of the well 33.18 feet
- Bentonite bottom seal 35-40 feet
- Bottom of the boring 40 feet

Location (TRS): T10R22-16
Northing/Easting: N 372869.7 ft, E 1748379.6 ft
Logged by: Koshlan Mayer-Blackwell, PGG
Completion Date: 1/18/2019
Ecology ID: BKB-757

Drilling Firm: Yellow Jacket
Drilling Method: Sonic
DTW: 12.78 ft
TOM Elevation: 824.48
V. Datum: NAD88

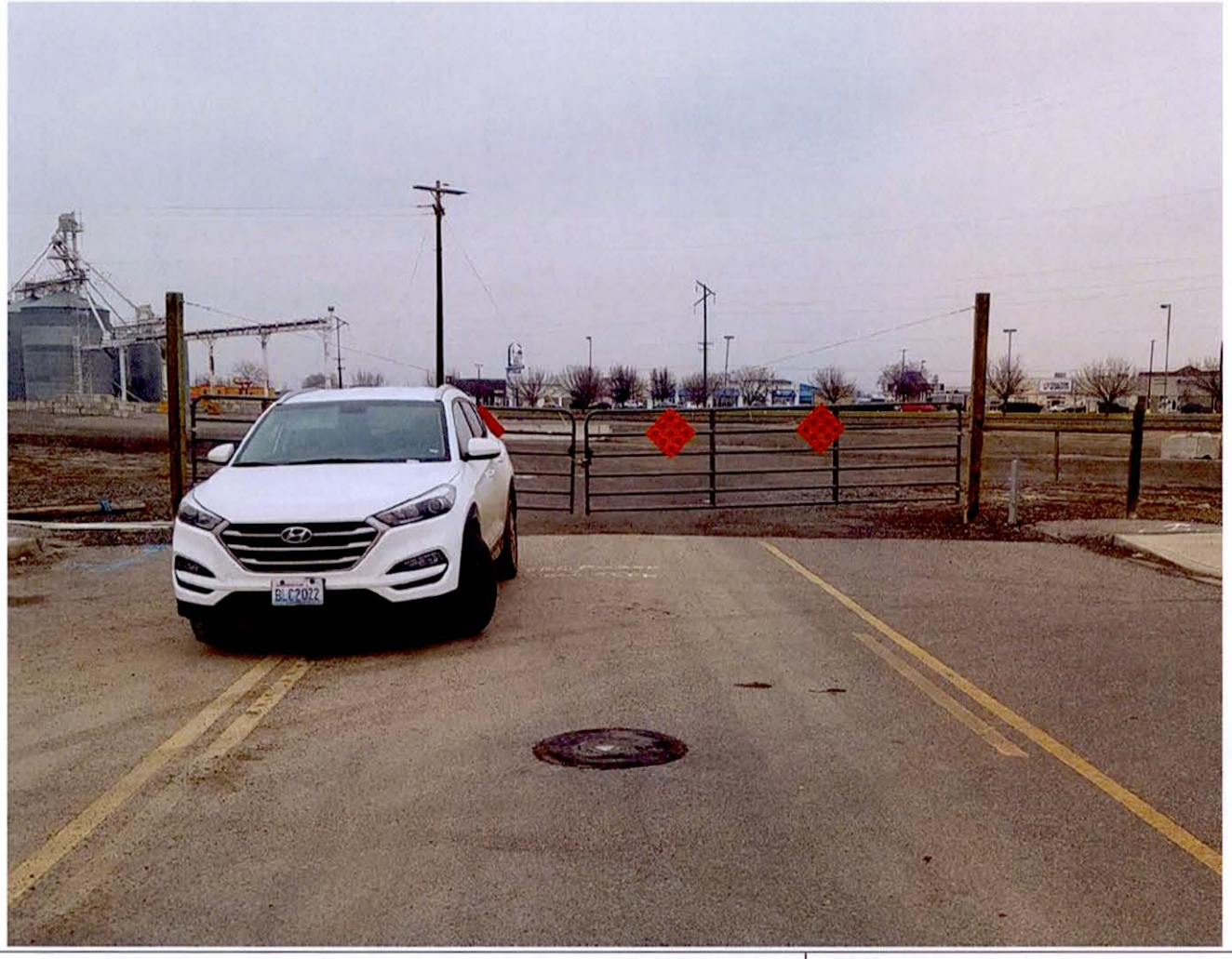
YC-MW-46
Boring Log and As-Built

Yakima GWMA

JE1803

PgG

APPENDIX C
Wellhead Completion Photos



YC-MW-01
Wellhead Completion Photo

PgG



YC-MW-02
Wellhead Completion Photo

PgG



YC-MW-05
Wellhead Completion Photo

PgG



YC-MW-06
Wellhead Completion Photo

PgG



YC-MW-07
Wellhead Completion Photo

PgG



YC-MW-08
Wellhead Completion Photo

PgG



YC-MW-09
Wellhead Completion Photo

PgG



YC-MW-10
Wellhead Completion Photo

PgG



YC-MW-11
Wellhead Completion Photo

PgG



YC-MW-12
Wellhead Completion Photo

PgG



YC-MW-14
Wellhead Completion Photo

PgG



YC-MW-15
Wellhead Completion Photo

PgG



YC-MW-16
Wellhead Completion Photo

PgG



YC-MW-17
Wellhead Completion Photo

PgG



YC-MW-19
Wellhead Completion Photo

PgG



YC-MW-21
Wellhead Completion Photo

PgG



YC-MW-23
Wellhead Completion Photo

PgG



YC-MW-24
Wellhead Completion Photo

PgG



YC-MW-25
Wellhead Completion Photo

PgG



YC-MW-26
Wellhead Completion Photo

PgG



YC-MW-27
Wellhead Completion Photo

PgG



YC-MW-28
Wellhead Completion Photo

PgG



YC-MW-31
Wellhead Completion Photo

PgG



YC-MW-33
Wellhead Completion Photo

PgG



YC-MW-38

Wellhead Completion Photo

PgG



YC-MW-39
Wellhead Completion Photo

PgG



YC-MW-41

Wellhead Completion Photo

PgG



YC-MW-42

Wellhead Completion Photo

PgG



YC-MW-44
Wellhead Completion Photo

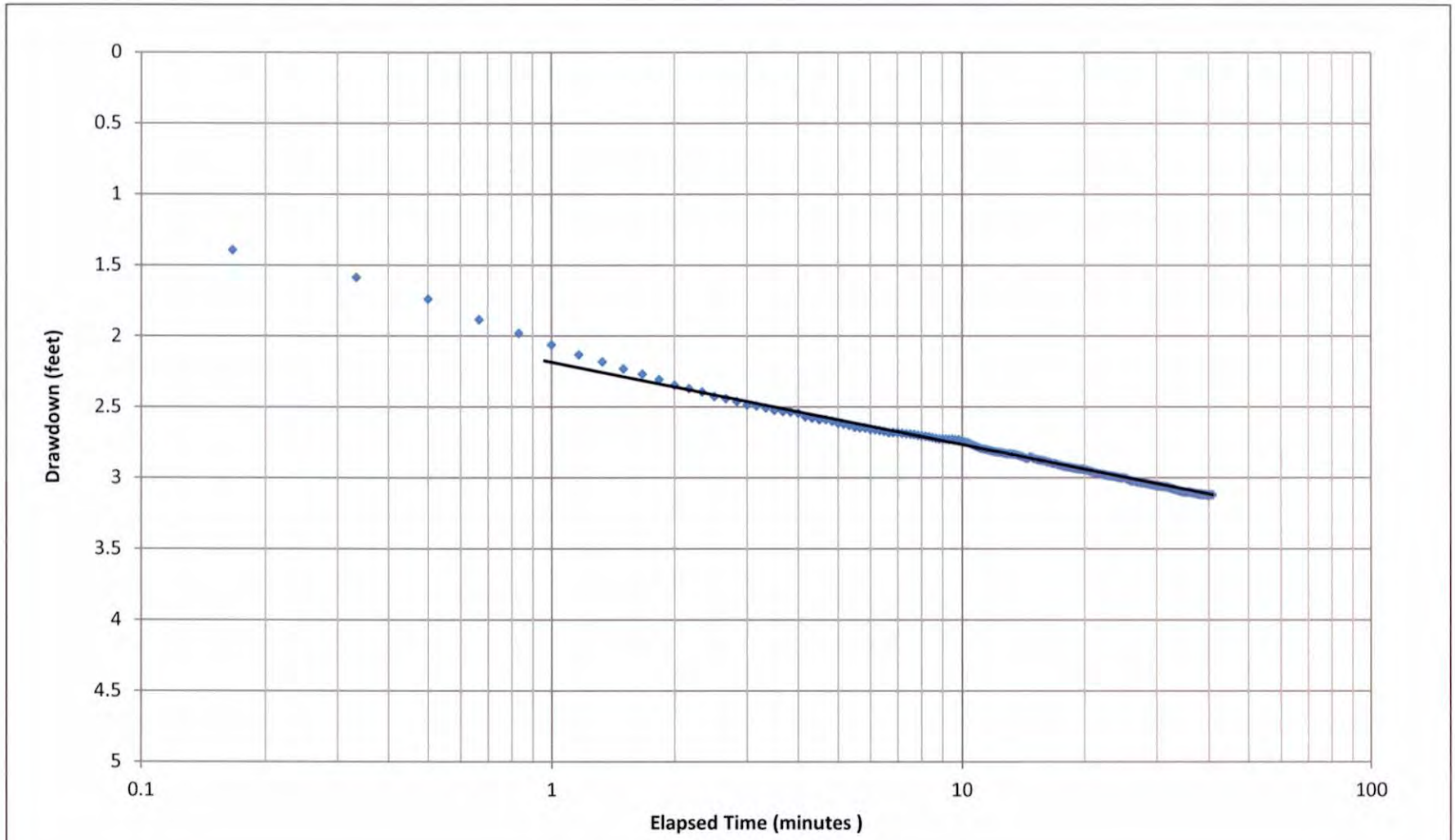
PgG



YC-MW-46
Wellhead Completion Photo

PgG

APPENDIX D
PUMPING TEST DATA



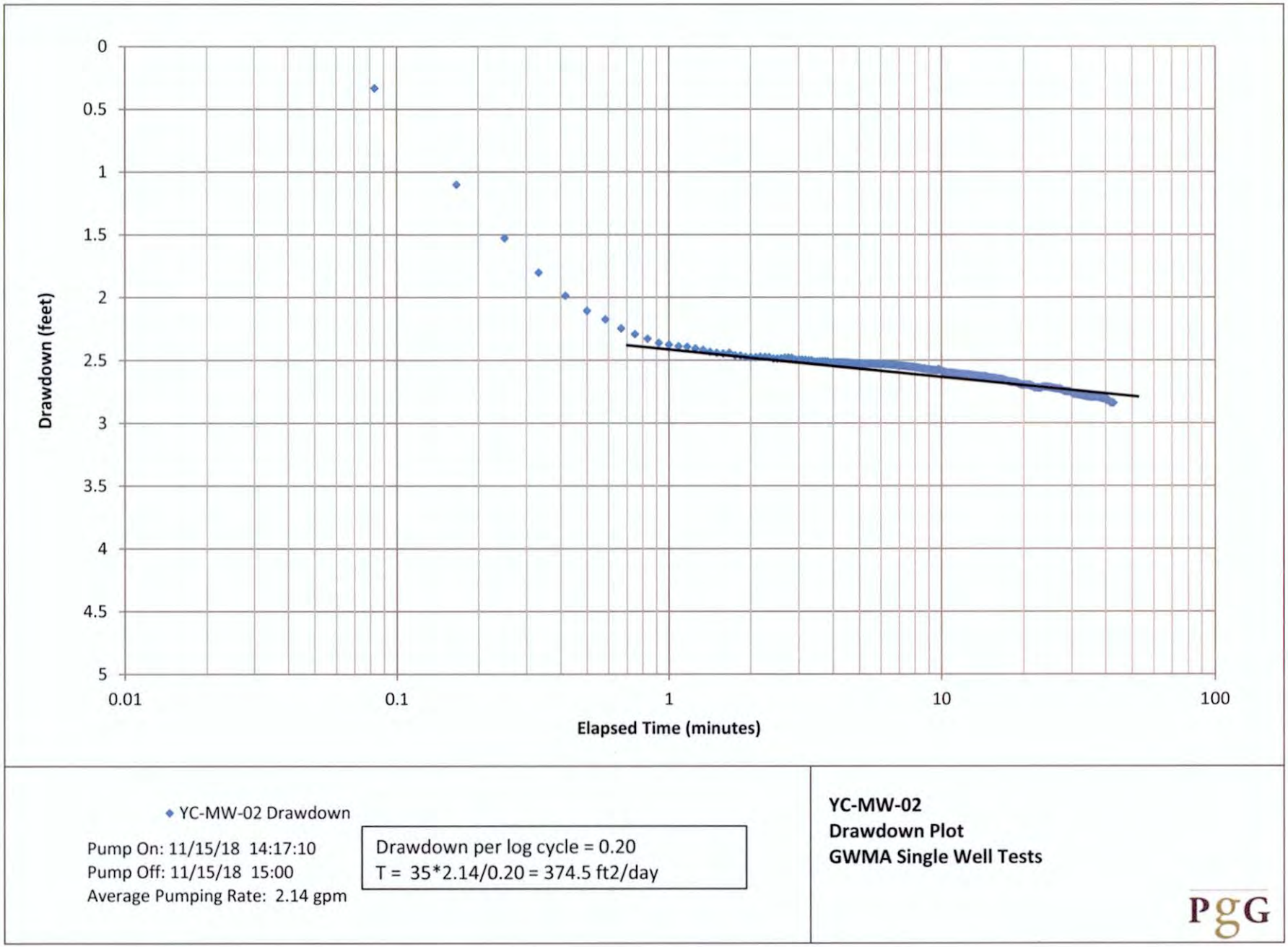
◆ YC-MW-01 Drawdown

Pump On: 12/04/18 13:58:10
Pump Off: 12/04/18 14:39
Average Pumping Rate: 1.17 gpm

Drawdown per log cycle = 0.60
T = 35*1.17/0.60 = 68.3 ft2/day

YC-MW-01
Drawdown Plot
GWMA Single Well Tests

PgG



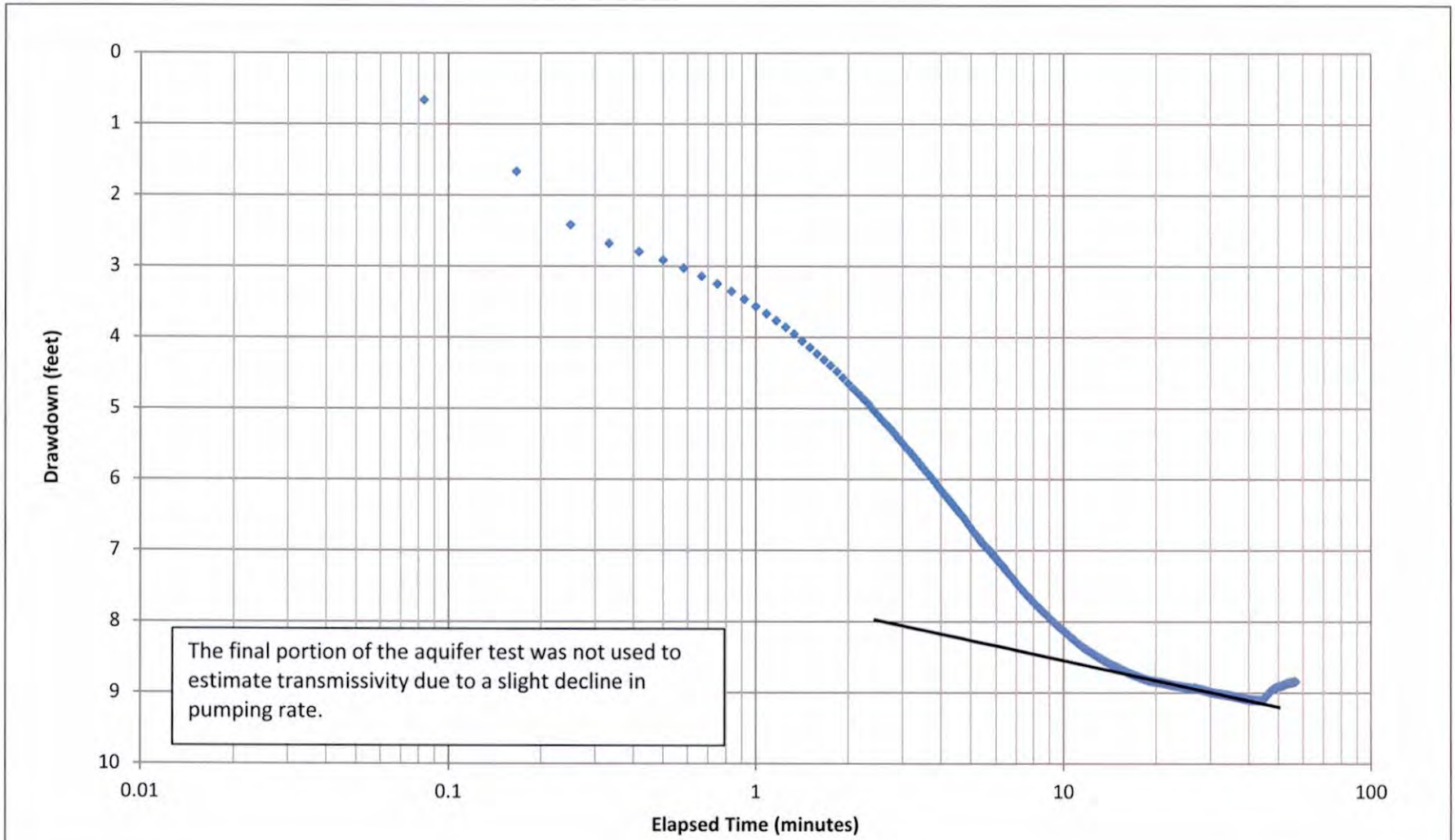
◆ YC-MW-02 Drawdown

Pump On: 11/15/18 14:17:10
Pump Off: 11/15/18 15:00
Average Pumping Rate: 2.14 gpm

Drawdown per log cycle = 0.20
T = 35*2.14/0.20 = 374.5 ft2/day

YC-MW-02
Drawdown Plot
GWMA Single Well Tests

PgG



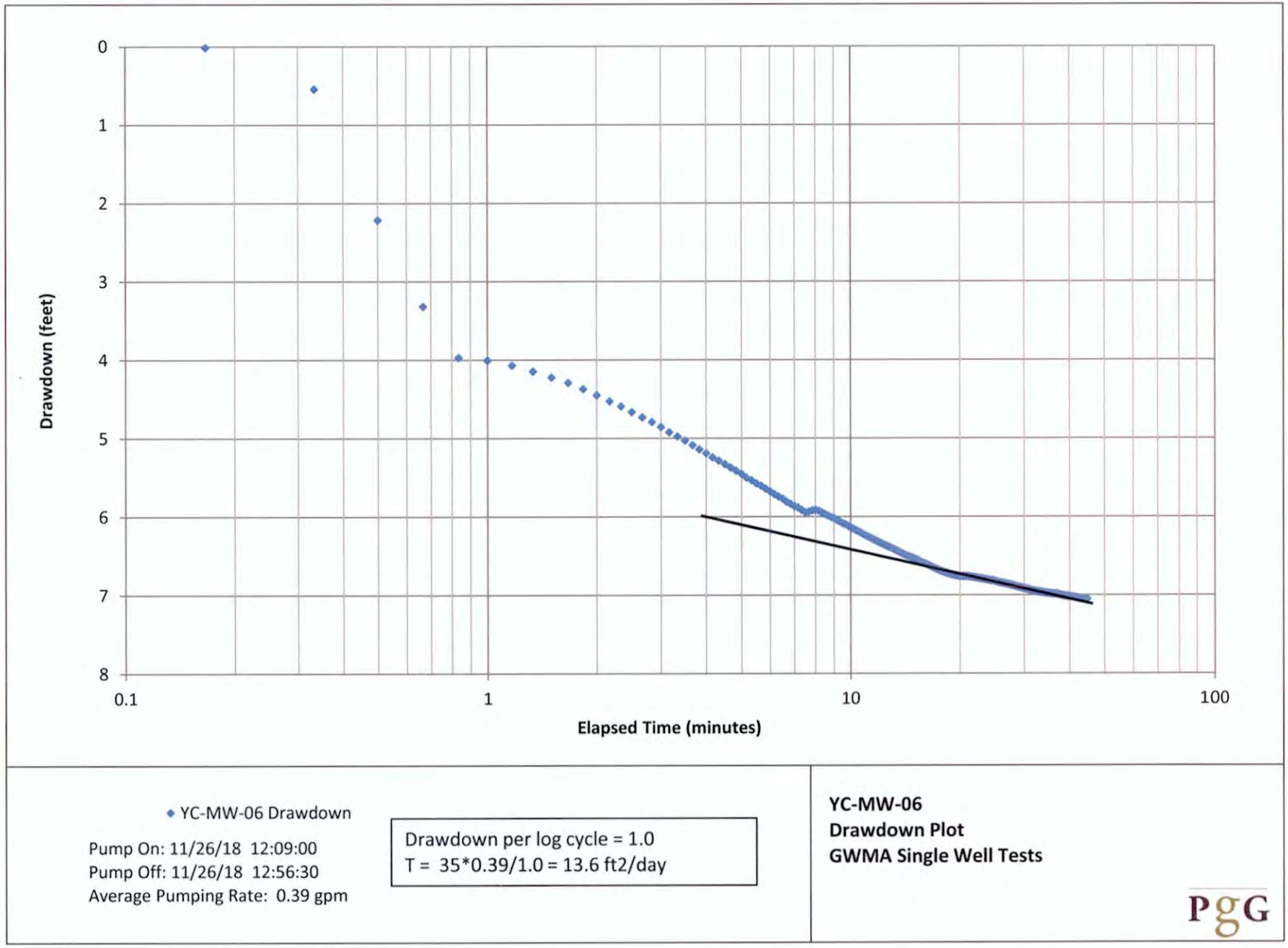
◆ YC-MW-05 Drawdown

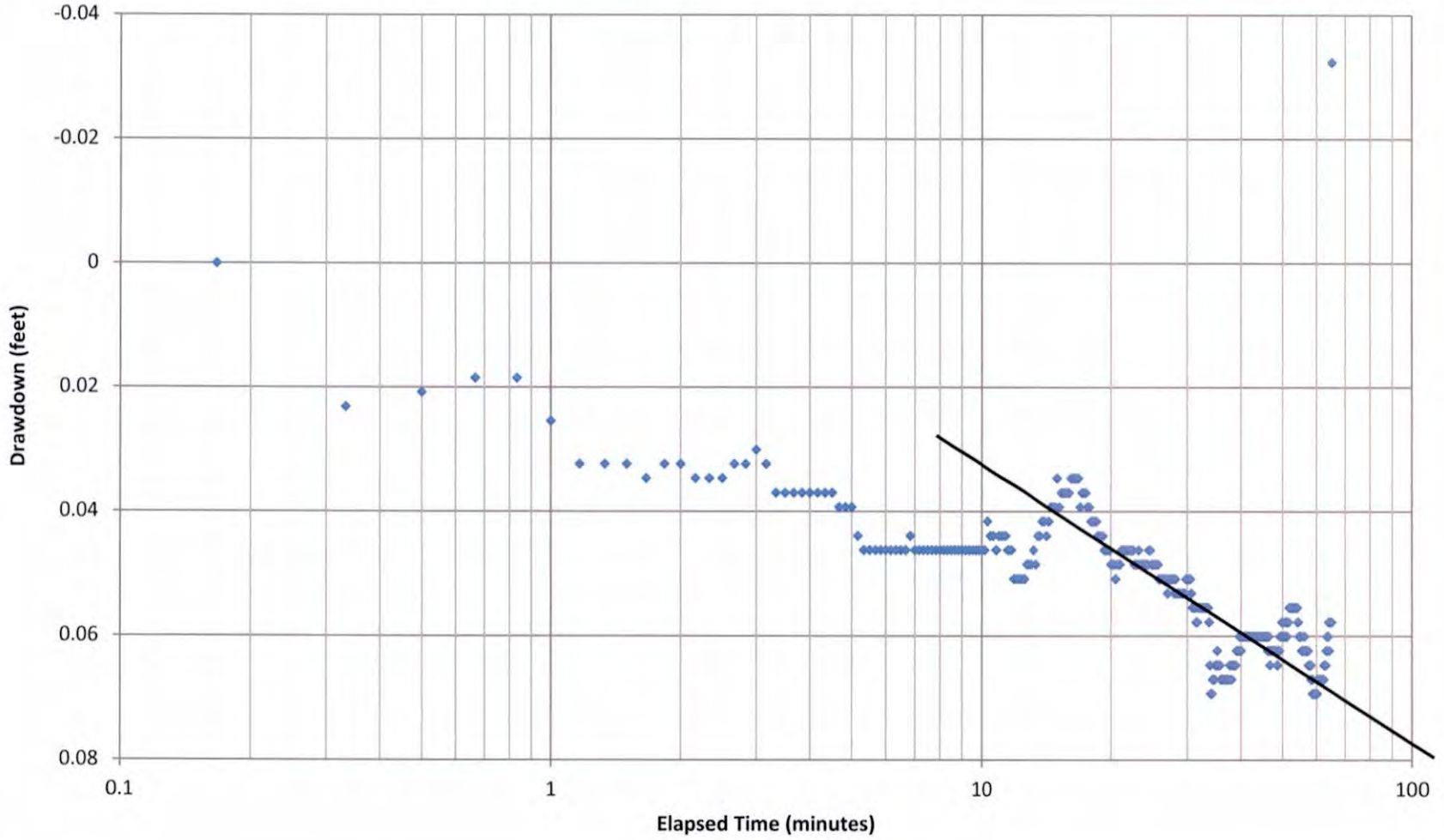
Pump On: 11/15/18 12:15:10
Pump Off: 11/15/18 13:12
Average Pumping Rate: 0.43 gpm

Drawdown per log cycle = 0.9
T = 35*0.43/0.9 = 16.7 ft2/day

YC-MW-05
Drawdown Plot
GWMA Single Well Tests

PgG


Drawdown (feet)
0
1
2
3
4
5
6
7
8
0.1
1
10
100
Elapsed Time (minutes)
YC-MW-06 Drawdown
Pump On: 11/26/18 12:09:00
Pump Off: 11/26/18 12:56:30
Average Pumping Rate: 0.39 gpm
Drawdown per log cycle = 1.0
T = 35*0.39/1.0 = 13.6 ft2/day
YC-MW-06
Drawdown Plot
GWMA Single Well Tests
PgG



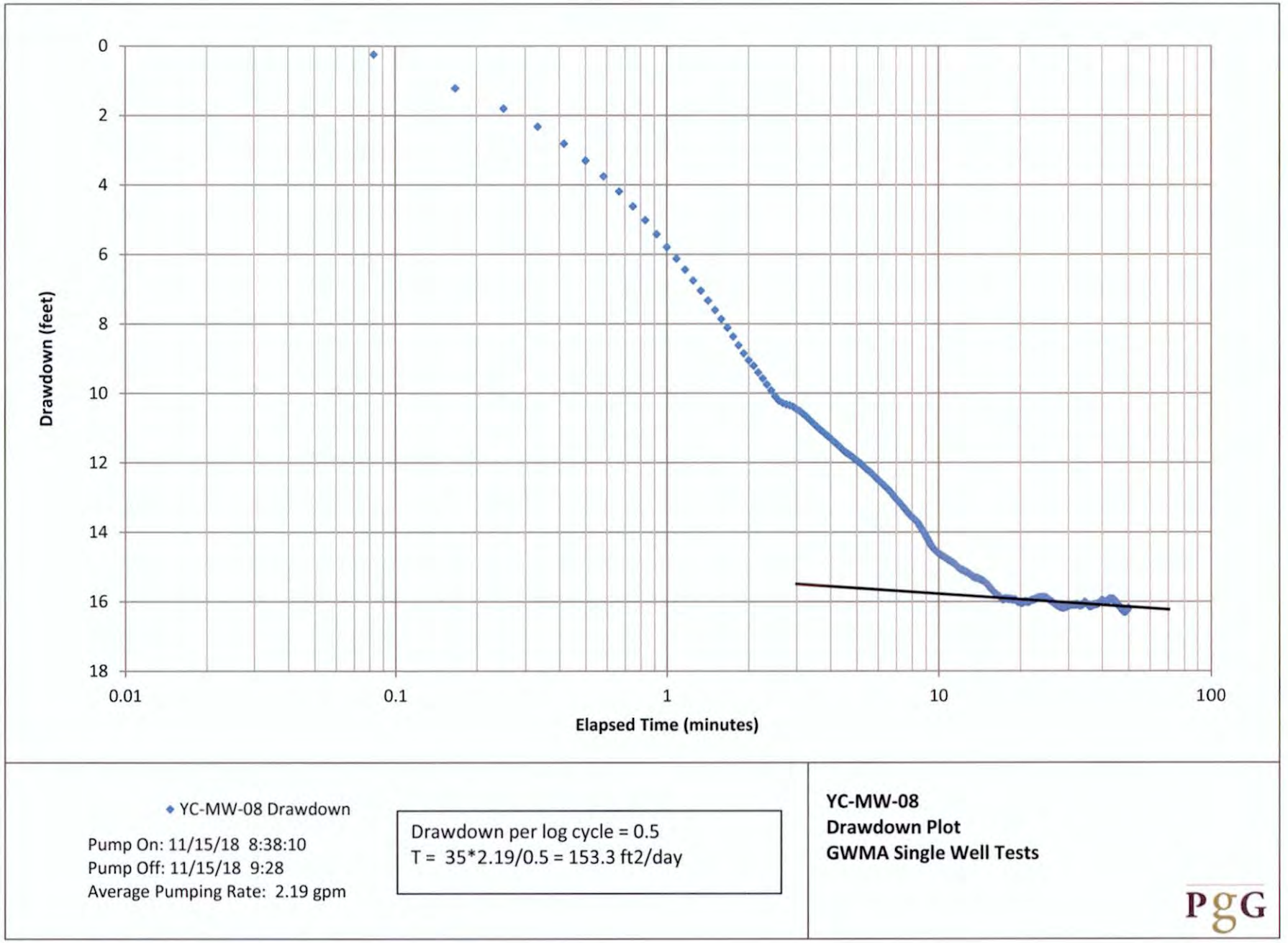
◆ YC-MW-07 Drawdown

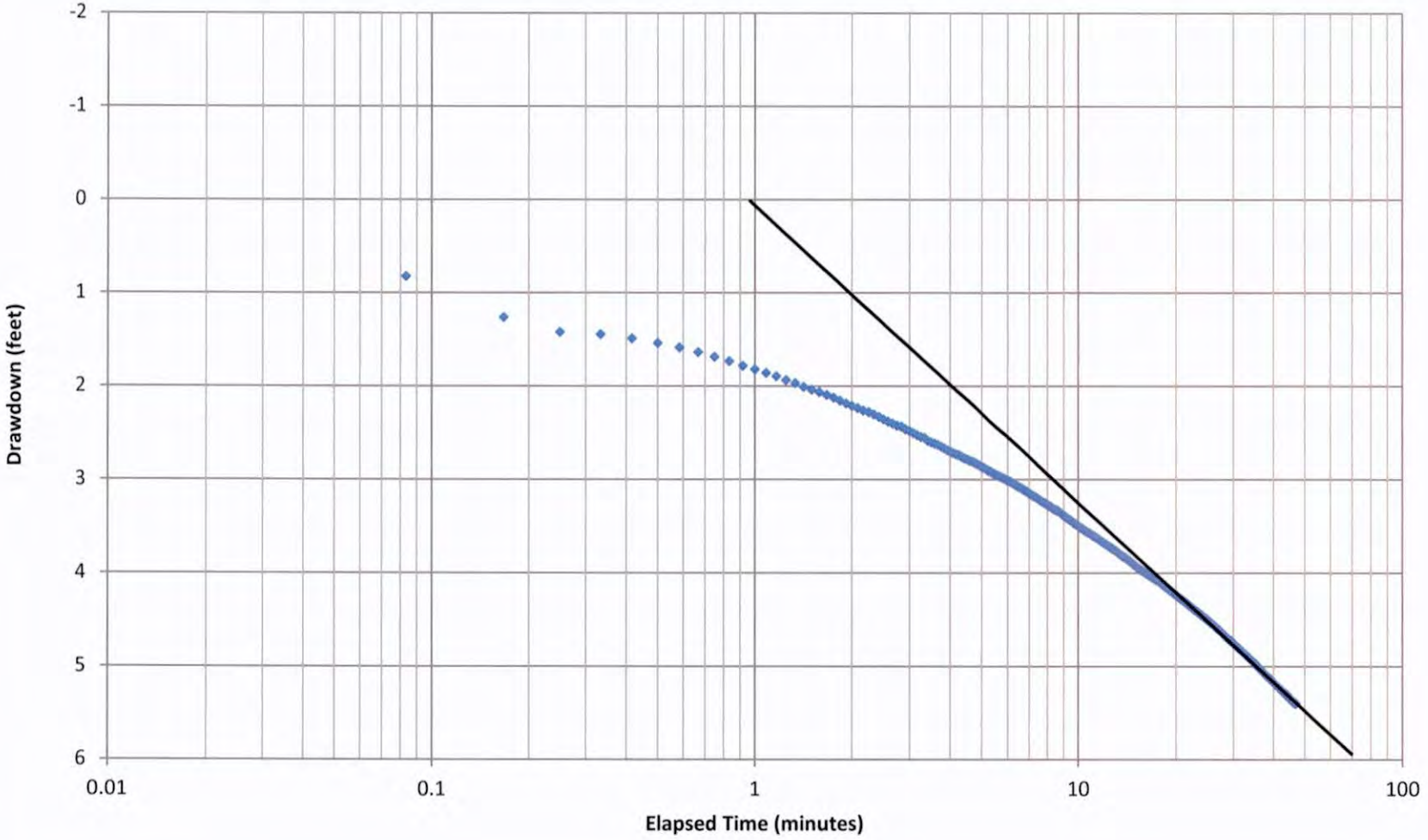
Pump On: 11/26/18 13:45:00
Pump Off: 11/26/18 14:50:00
Average Pumping Rate: 0.55 gpm

Drawdown per log cycle = 0.05
T = 35*0.55/0.05 = 385 ft2/day

YC-MW-07
Drawdown Plot
GWMA Single Well Tests

PgG


Drawdown (feet)
0
2
4
6
8
10
12
14
16
18
0.01
0.1
1
10
100
Elapsed Time (minutes)
YC-MW-08 Drawdown
Pump On: 11/15/18 8:38:10
Pump Off: 11/15/18 9:28
Average Pumping Rate: 2.19 gpm
Drawdown per log cycle = 0.5
T = 35*2.19/0.5 = 153.3 ft2/day
YC-MW-08
Drawdown Plot
GWMA Single Well Tests
PgG



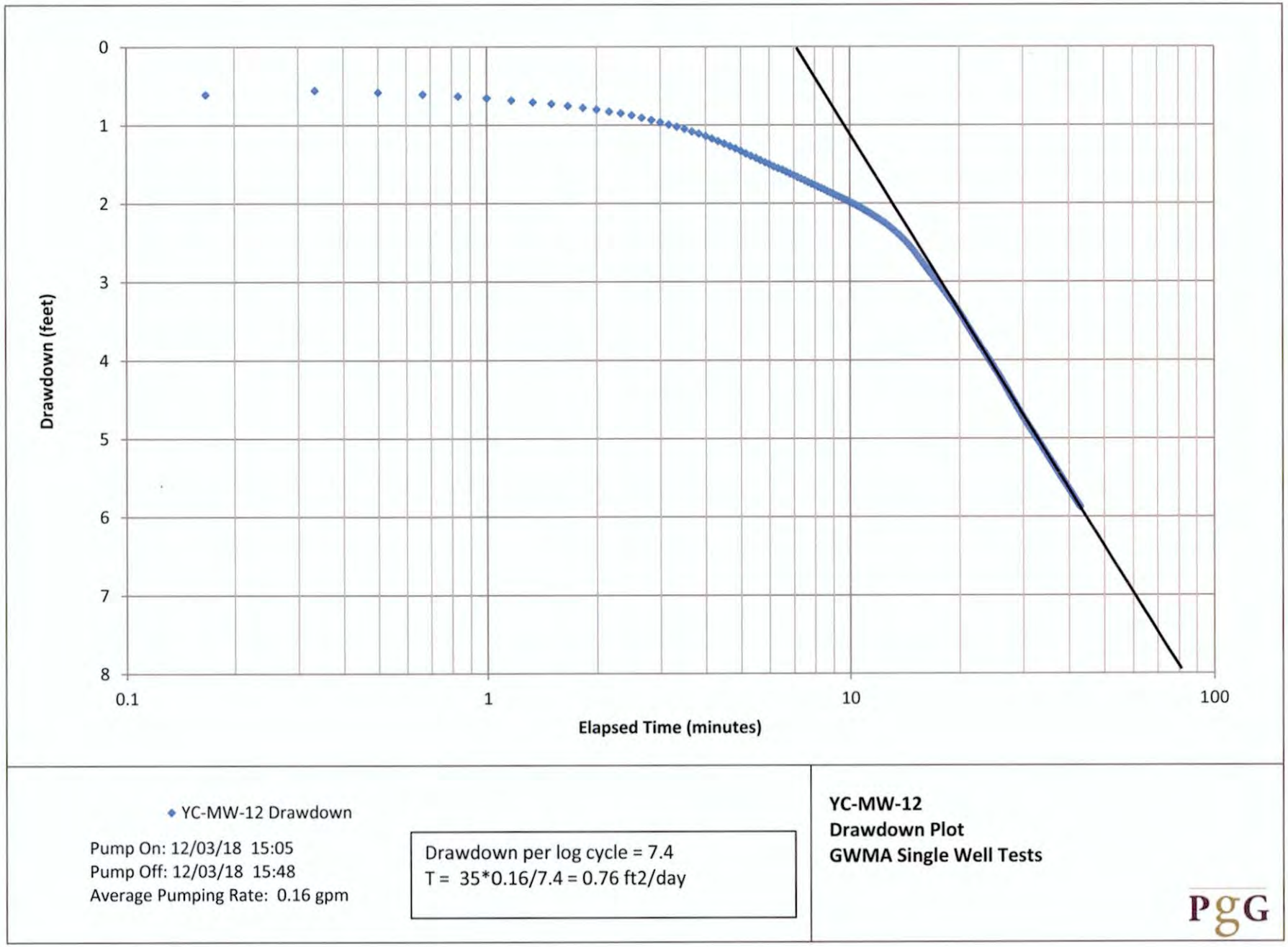
◆ YC-MW-10 Drawdown

Pump On: 11/13/18 13:16:10
Pump Off: 11/13/18 14:03
Average Pumping Rate: 1.11 gpm

Drawdown per log cycle = 3.2
T = 35*1.11/3.2 = 12.1 ft2/day

YC-MW-10
Drawdown Plot
GWMA Single Well Tests

PgG

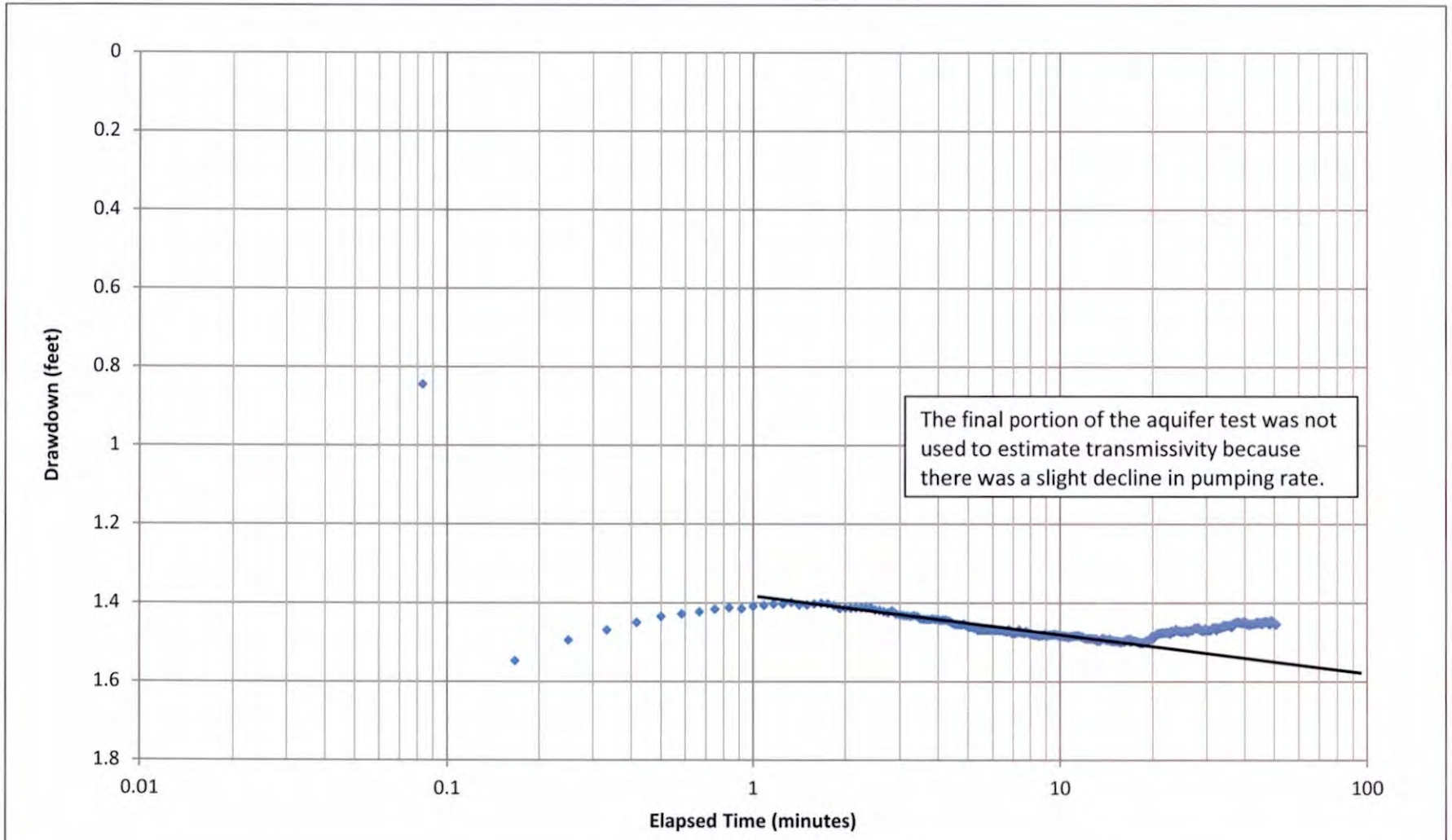


Pump On: 12/03/18 15:05
Pump Off: 12/03/18 15:48
Average Pumping Rate: 0.16 gpm

Drawdown per log cycle = 7.4
T = 35*0.16/7.4 = 0.76 ft2/day

YC-MW-12
Drawdown Plot
GWMA Single Well Tests

PgG



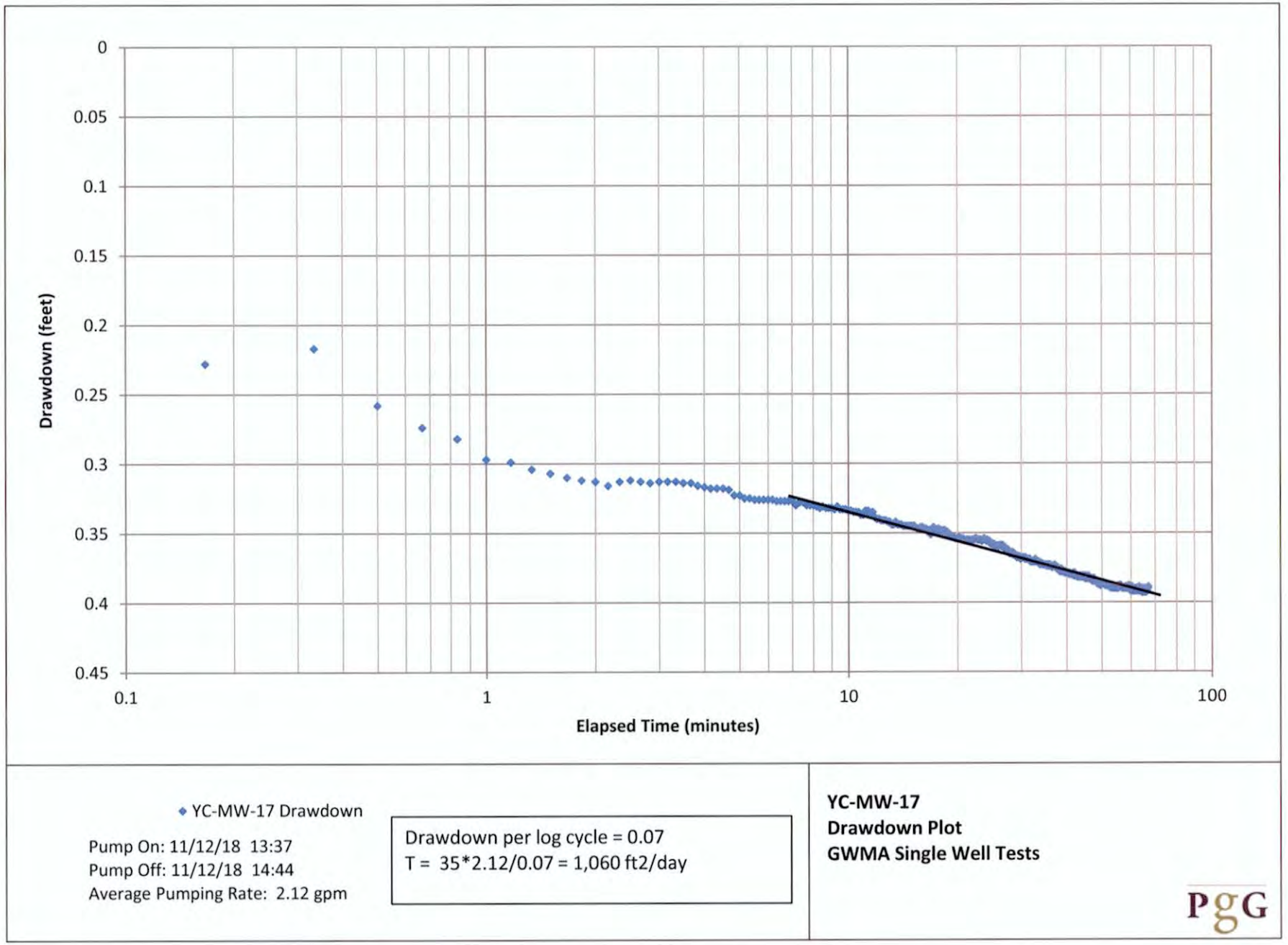
◆ YC-MW-16 Drawdown

Pump On: 11/14/18 14:21:10
Pump Off: 11/14/18 15:12
Average Pumping Rate: 0.7 gpm

Drawdown per log cycle = 0.2
T = 35*0.7/0.2 = 122.5 ft2/day

YC-MW-16
Drawdown Plot
GWMA Single Well Tests

PgG

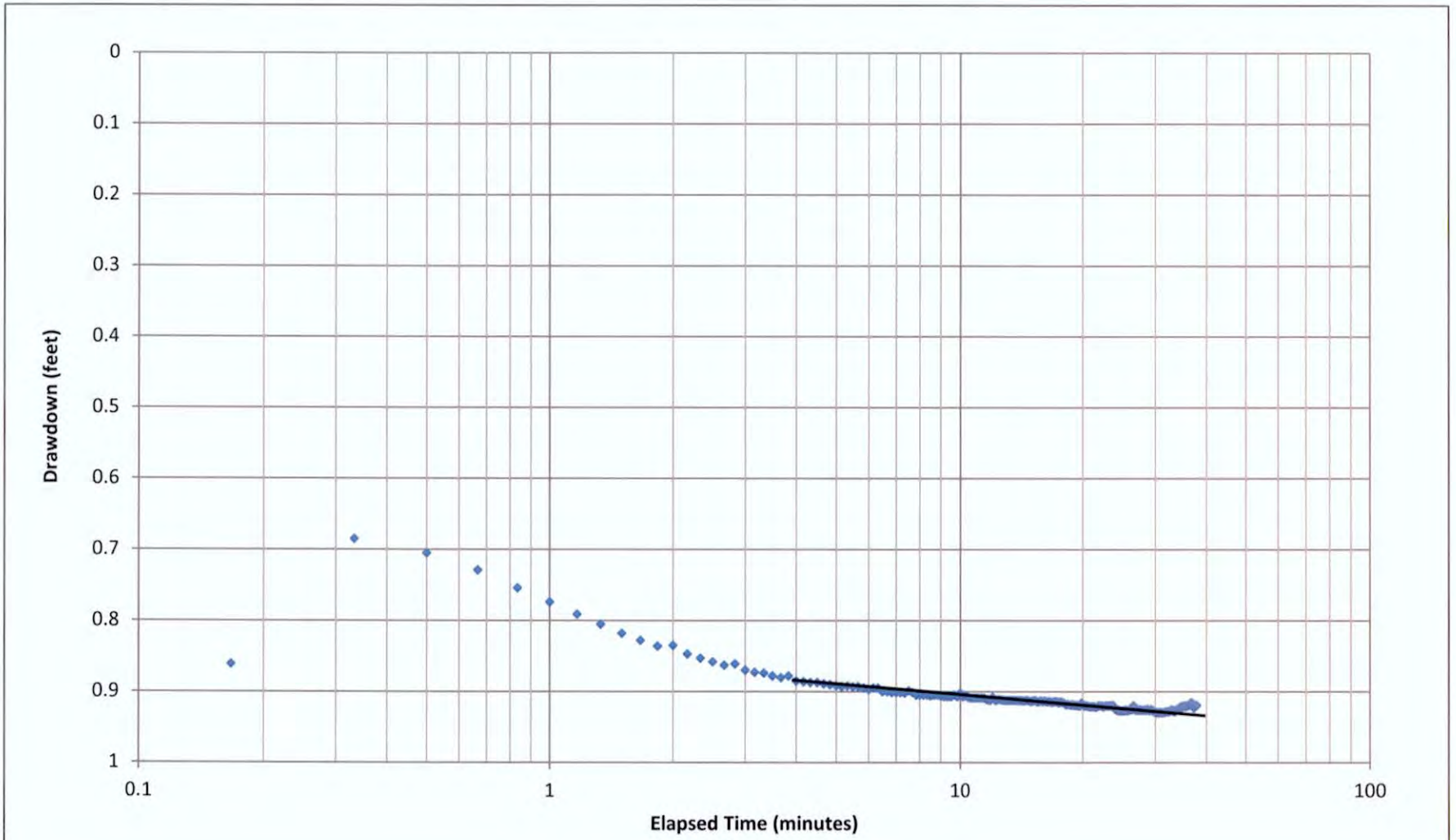


Pump On: 11/12/18 13:37
Pump Off: 11/12/18 14:44
Average Pumping Rate: 2.12 gpm

Drawdown per log cycle = 0.07
T = 35*2.12/0.07 = 1,060 ft2/day

YC-MW-17
Drawdown Plot
GWMA Single Well Tests

PgG



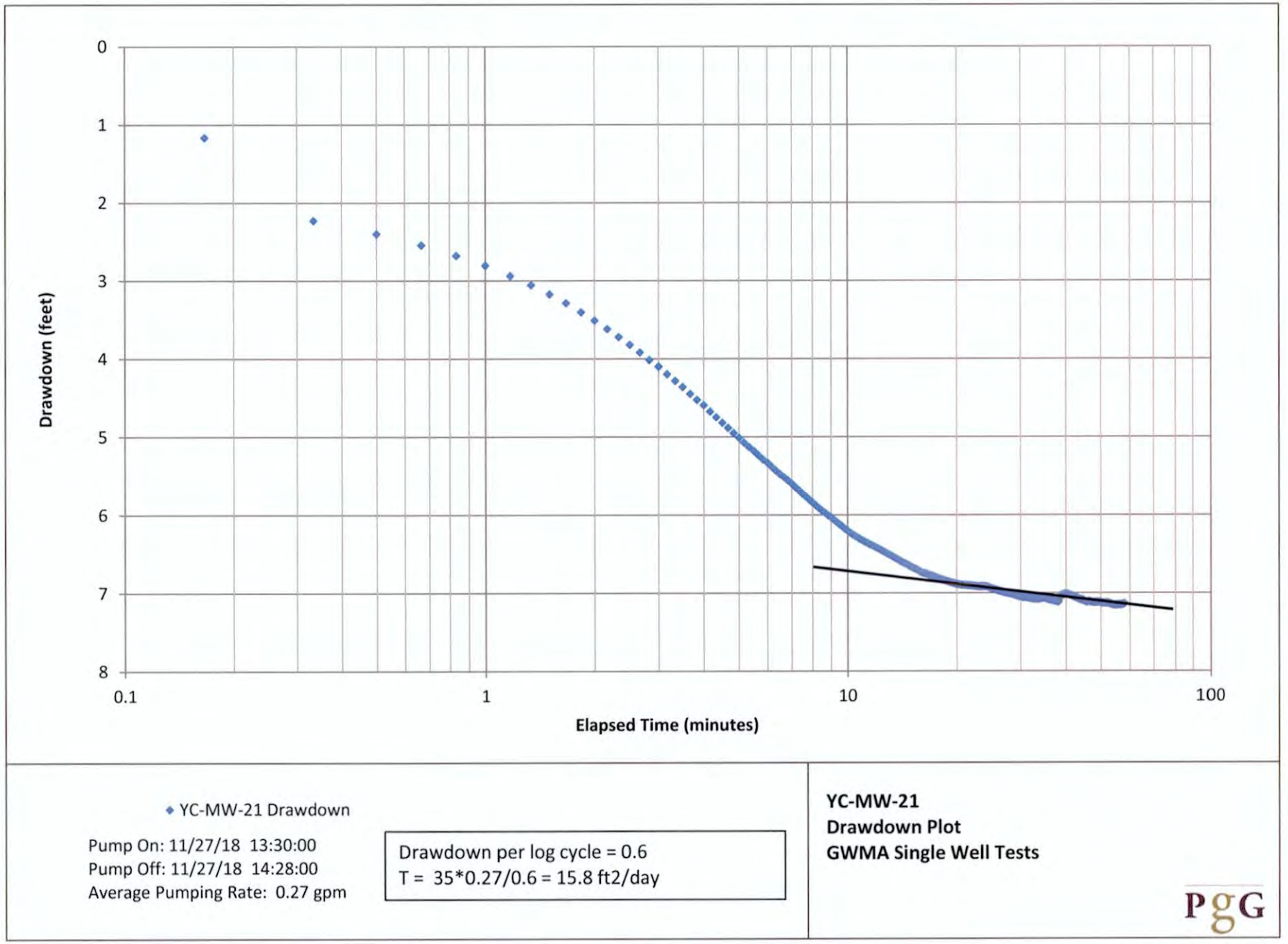
◆ YC-MW-19 Drawdown

Pump On: 11/13/18 10:20:10
Pump Off: 11/13/18 10:58
Average Pumping Rate: 0.94 gpm

Drawdown per log cycle = 0.04
T = 35*0.94/0.04 = 822.5 ft2/day

YC-MW-19
Drawdown Plot
GWMA Single Well Tests

PgG

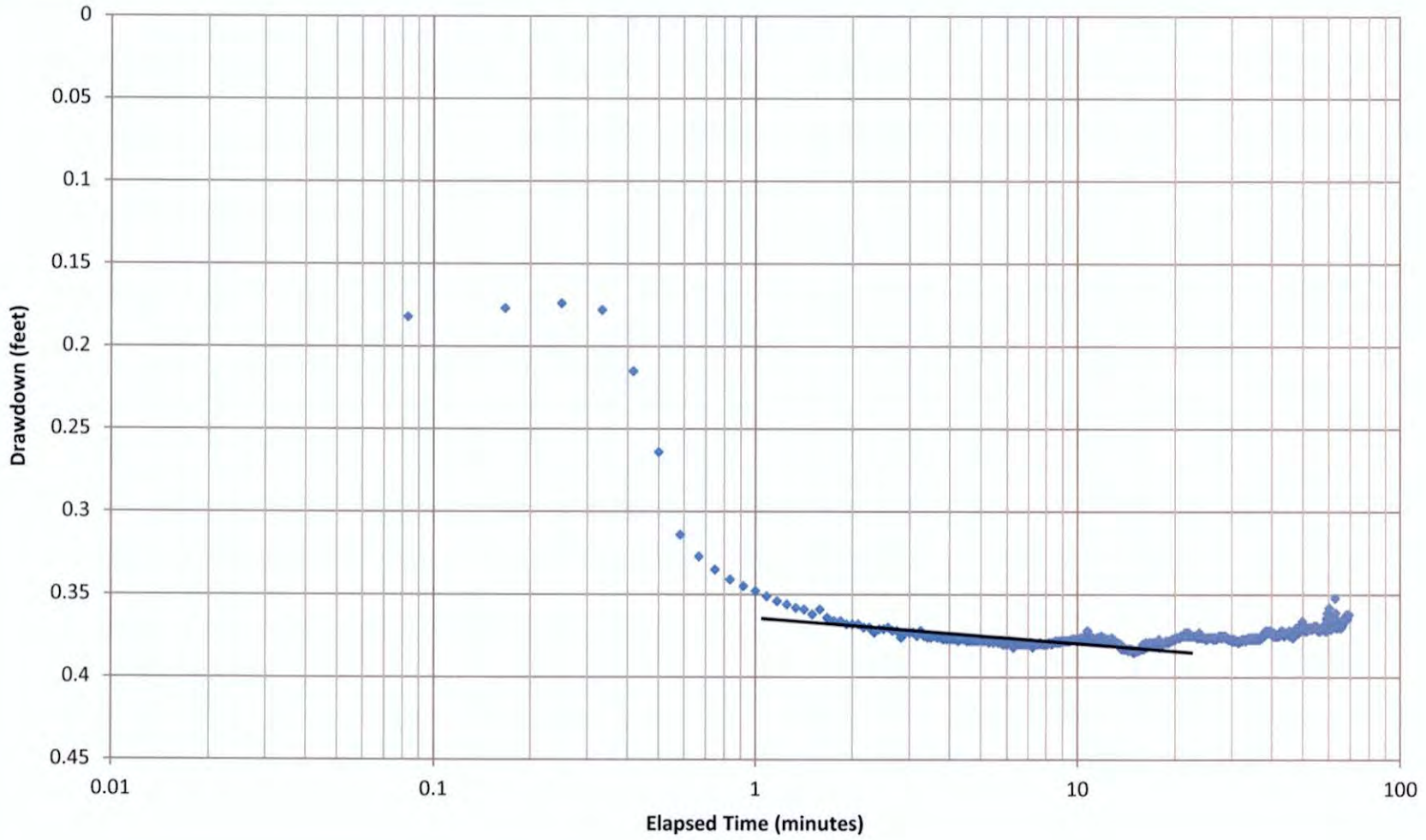


Pump On: 11/27/18 13:30:00
Pump Off: 11/27/18 14:28:00
Average Pumping Rate: 0.27 gpm

Drawdown per log cycle = 0.6
T = 35*0.27/0.6 = 15.8 ft2/day

YC-MW-21
Drawdown Plot
GWMA Single Well Tests

PgG



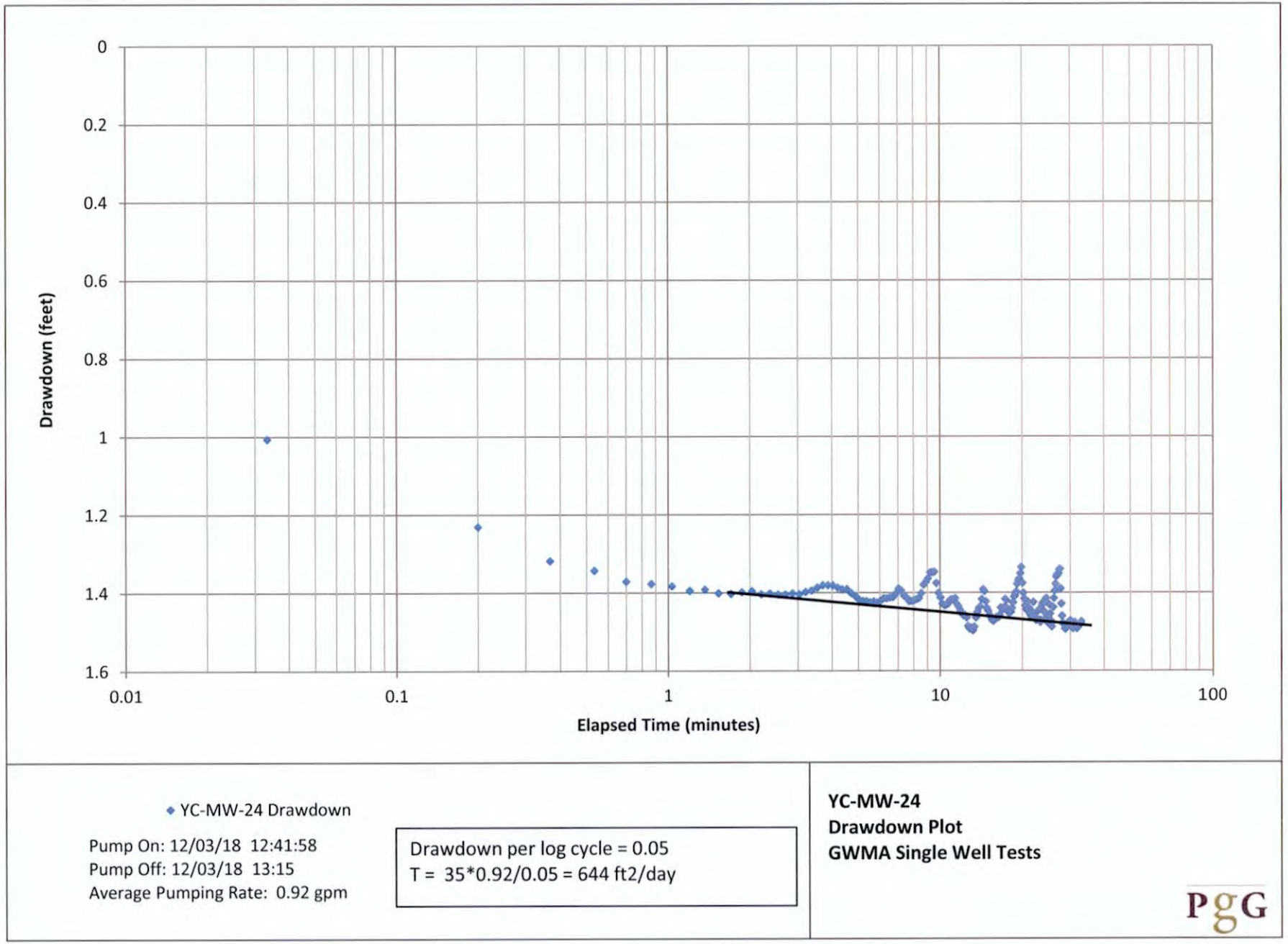
◆ YC-MW-23 Drawdown

Pump On: 11/14/18 10:22:50
Pump Off: 11/14/18 11:32
Average Pumping Rate: 1.97 gpm

Drawdown per log cycle = 0.03
T = 35*1.97/0.03 = 2,298 ft2/day

YC-MW-23
Drawdown Plot
GWMA Single Well Tests

PgG

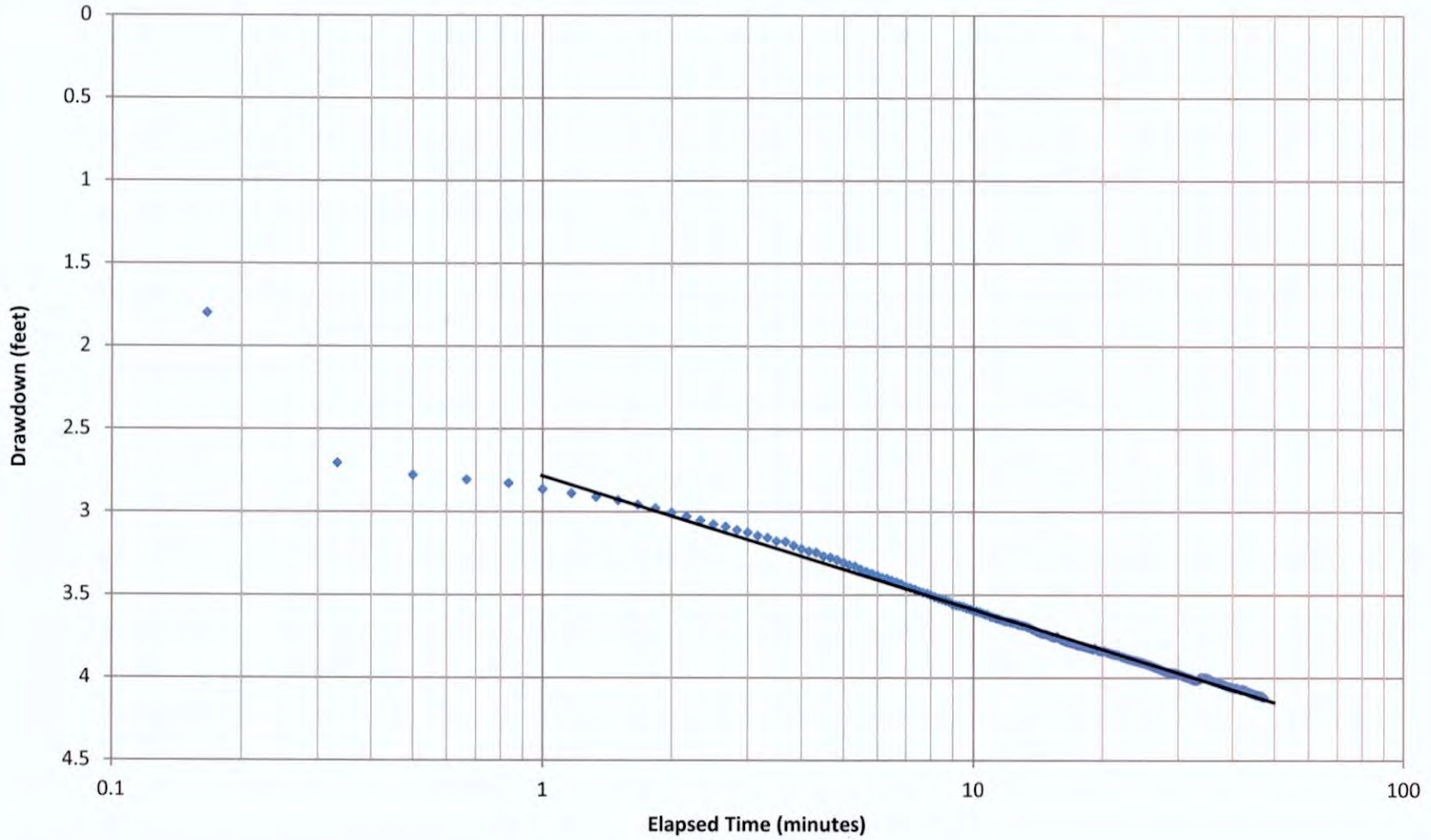


Pump On: 12/03/18 12:41:58
Pump Off: 12/03/18 13:15
Average Pumping Rate: 0.92 gpm

Drawdown per log cycle = 0.05
T = 35*0.92/0.05 = 644 ft2/day

YC-MW-24
Drawdown Plot
GWMA Single Well Tests

PgG



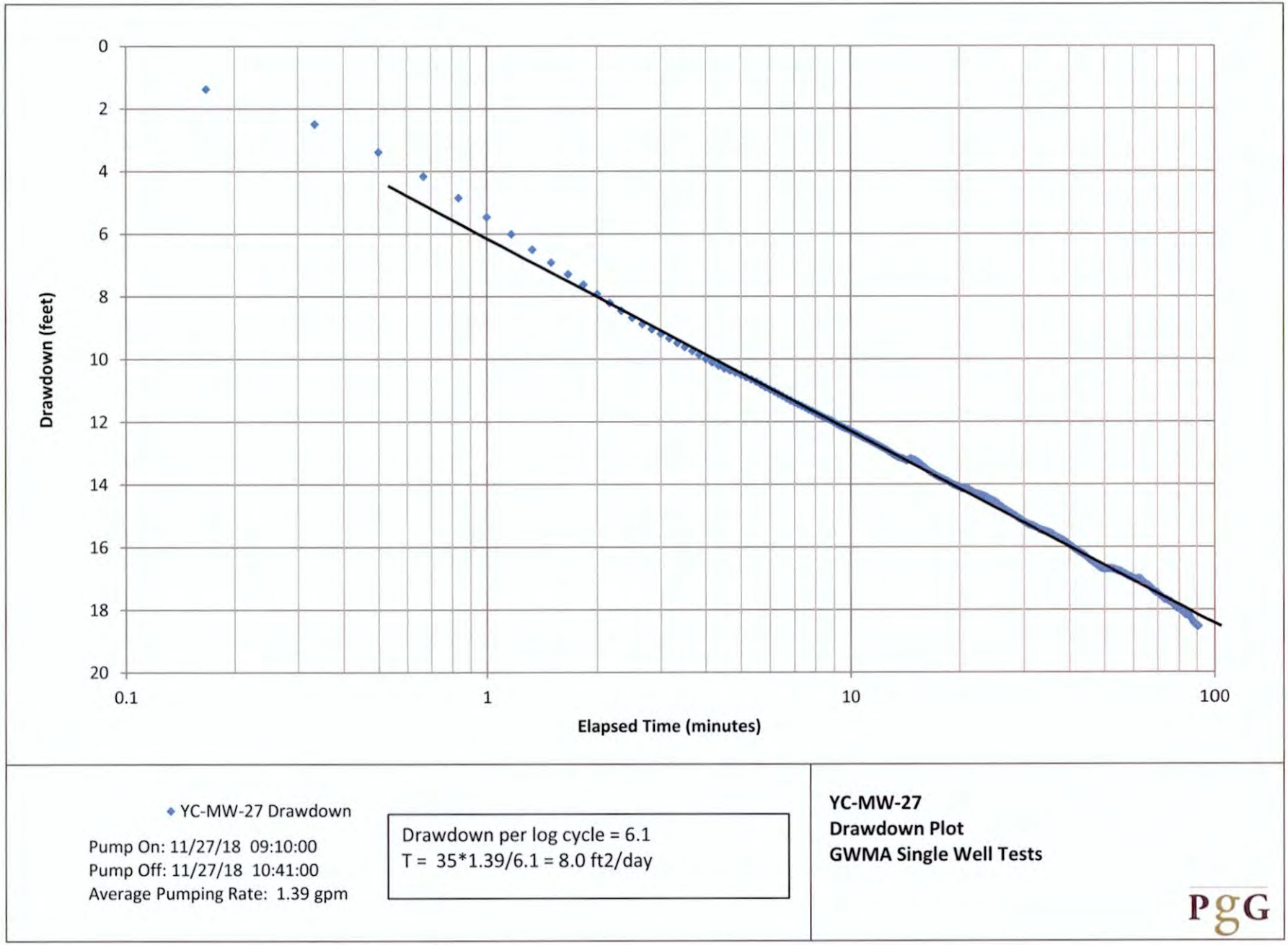
◆ YC-MW-26 Drawdown

Pump On: 11/13/18 7:46:10
Pump Off: 11/13/18 8:33:30
Average Pumping Rate: 0.22 gpm

Drawdown per log cycle = 0.79
T = 35*0.22/0.79 = 10.3 ft2/day

YC-MW-26
Drawdown Plot
GWMA Single Well Tests

PgG



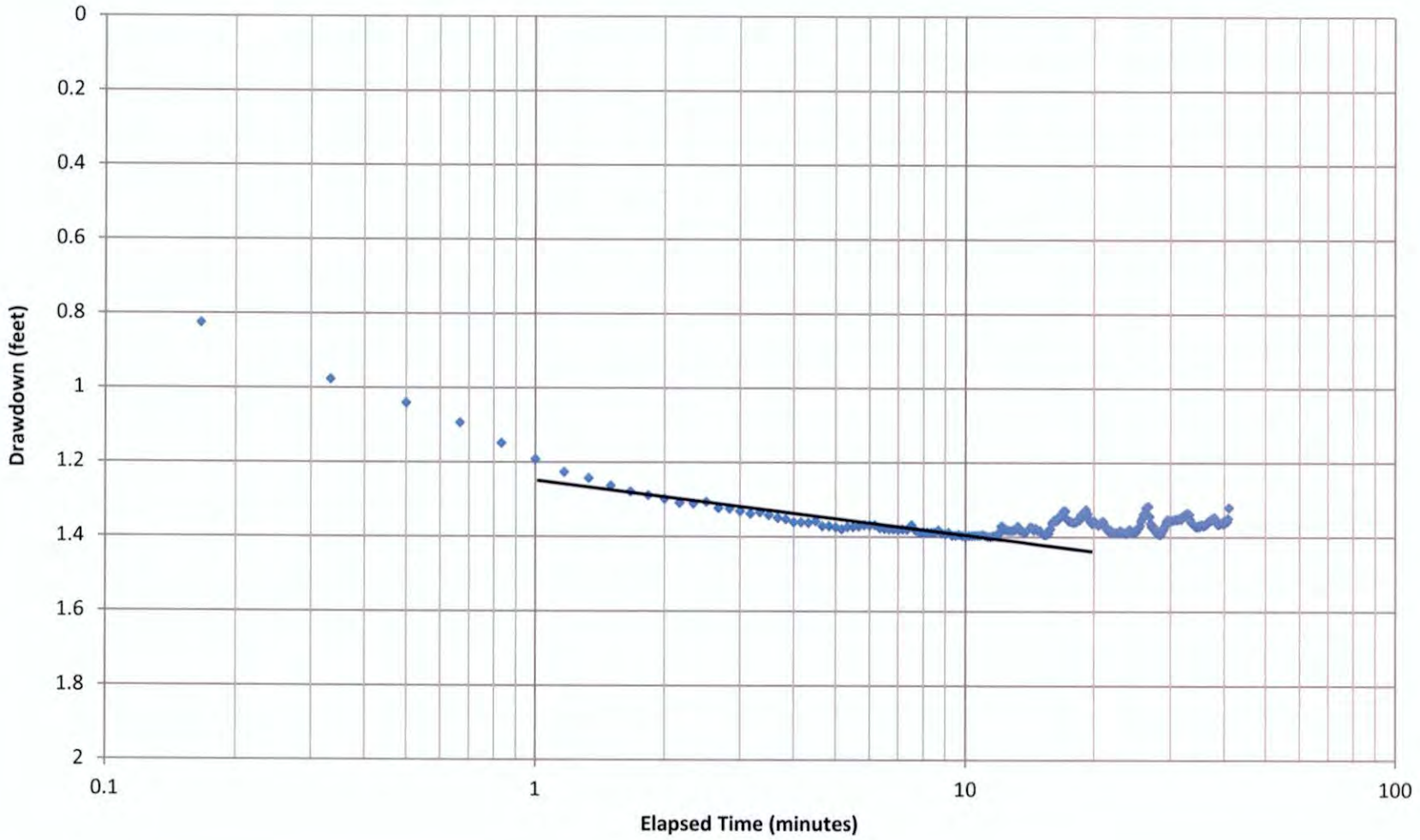
◆ YC-MW-27 Drawdown

Pump On: 11/27/18 09:10:00
Pump Off: 11/27/18 10:41:00
Average Pumping Rate: 1.39 gpm

Drawdown per log cycle = 6.1
T = 35*1.39/6.1 = 8.0 ft2/day

YC-MW-27
Drawdown Plot
GWMA Single Well Tests

PgG



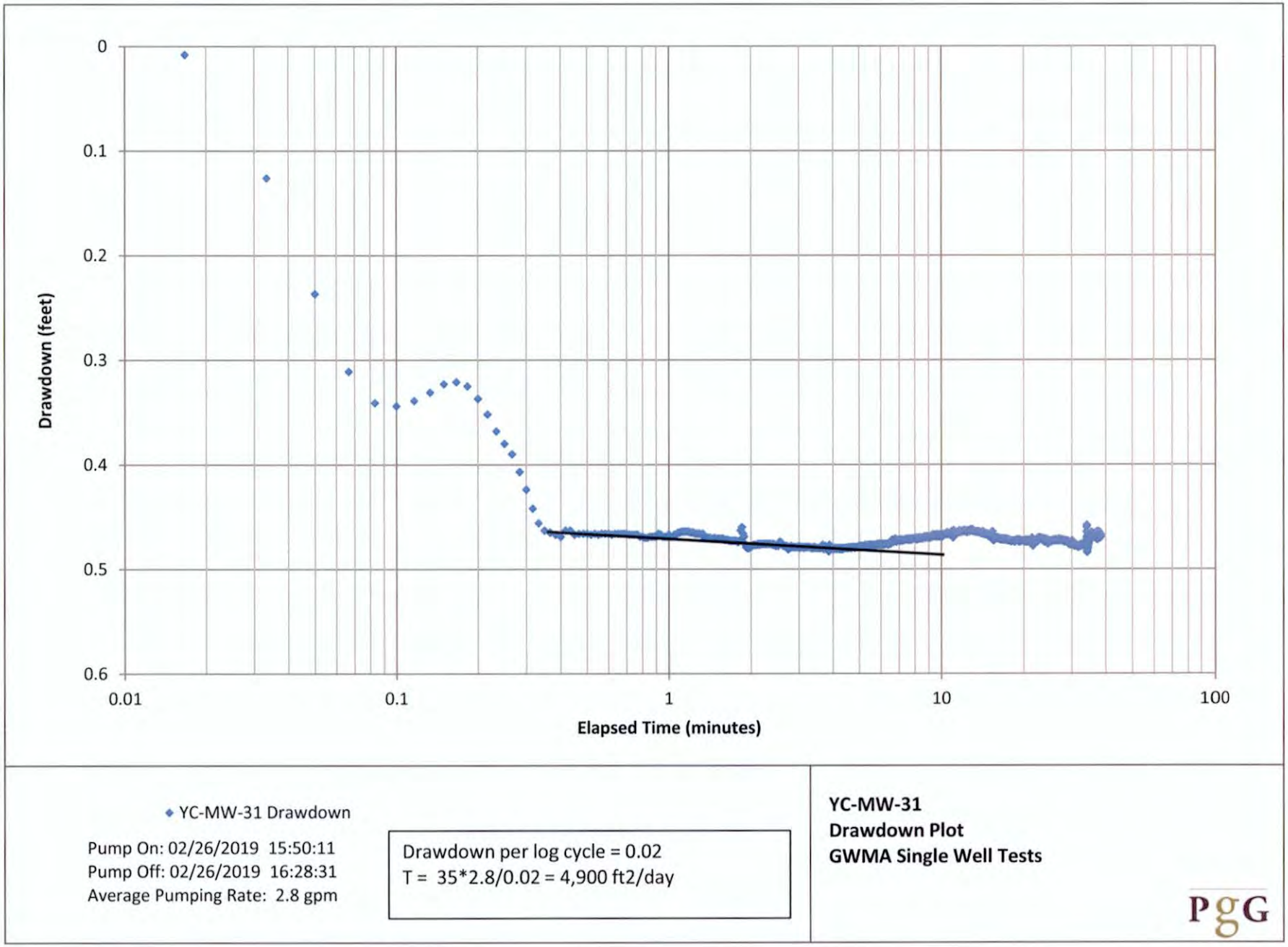
◆ YC-MW-28 Drawdown

Pump On: 12/04/18 9:38
Pump Off: 12/04/18 10:19
Average Pumping Rate: 1.4 gpm

Drawdown per log cycle = 0.075
T = 35*1.4/0.075= 653 ft2/day

YC-MW-28
Drawdown Plot
GWMA Single Well Tests

PgG



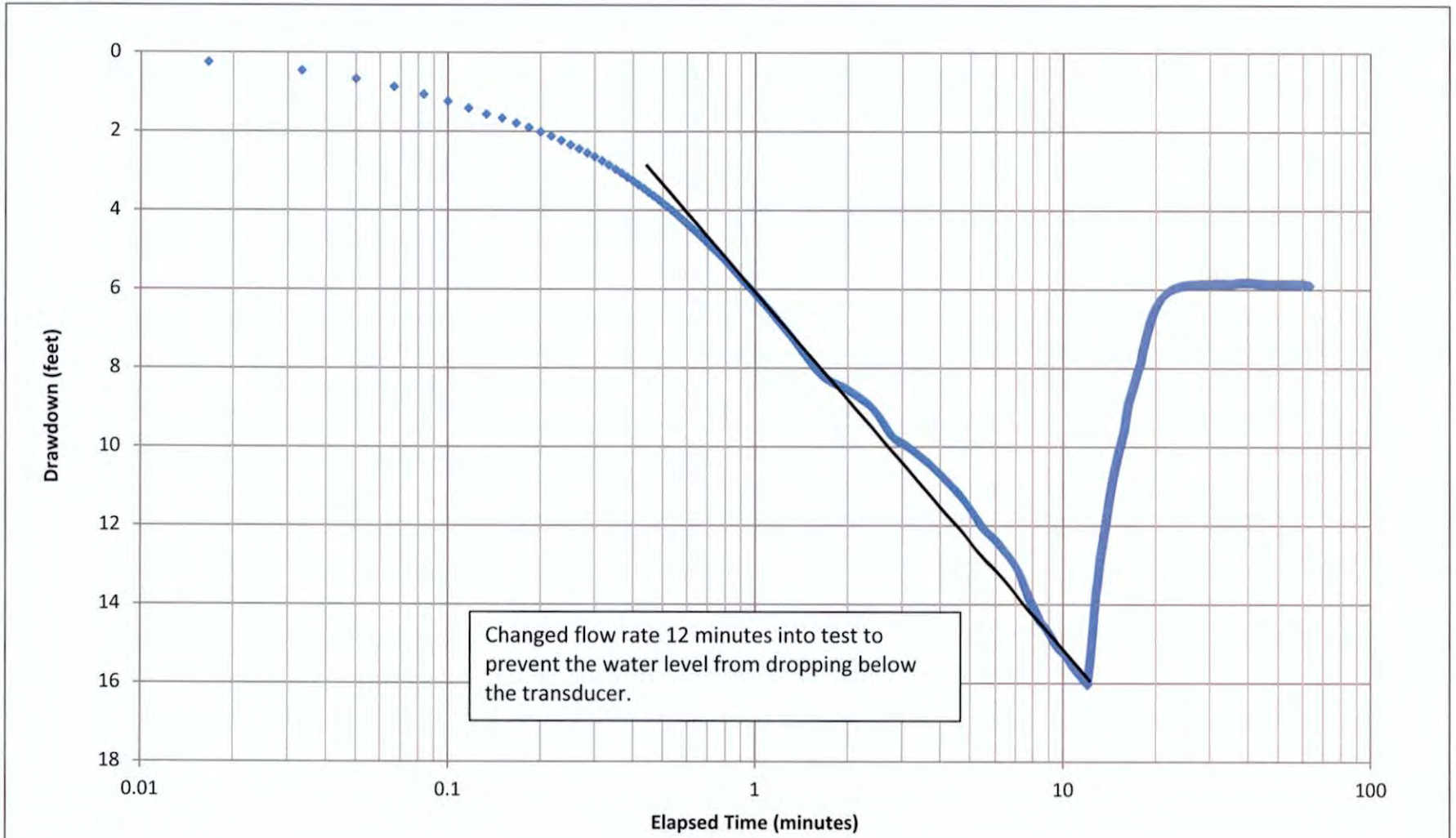
◆ YC-MW-31 Drawdown

Pump On: 02/26/2019 15:50:11
Pump Off: 02/26/2019 16:28:31
Average Pumping Rate: 2.8 gpm

Drawdown per log cycle = 0.02
T = 35*2.8/0.02 = 4,900 ft2/day

YC-MW-31
Drawdown Plot
GWMA Single Well Tests

PgG



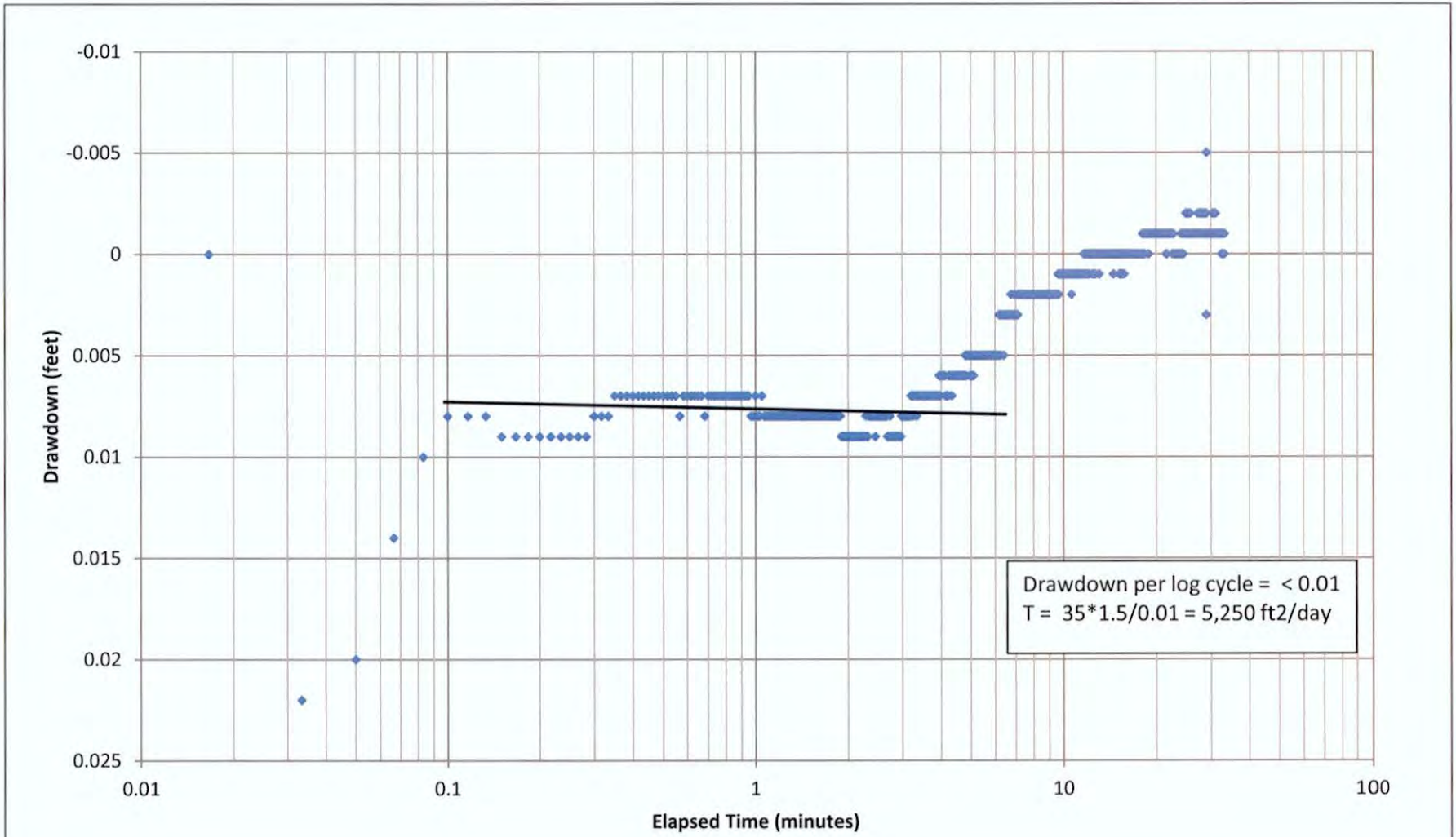
◆ YC-MW-33 Drawdown

Pump On: 2/27/2019 11:04
Pump Off: 2/27/2019 12:07:40
Average Pumping Rate: 0.68 gpm

Drawdown per log cycle = 9.2
T = 35*0.68/9.2 = 2.6 ft2/day

YC-MW-33
Drawdown Plot
GWMA Single Well Tests

PgG



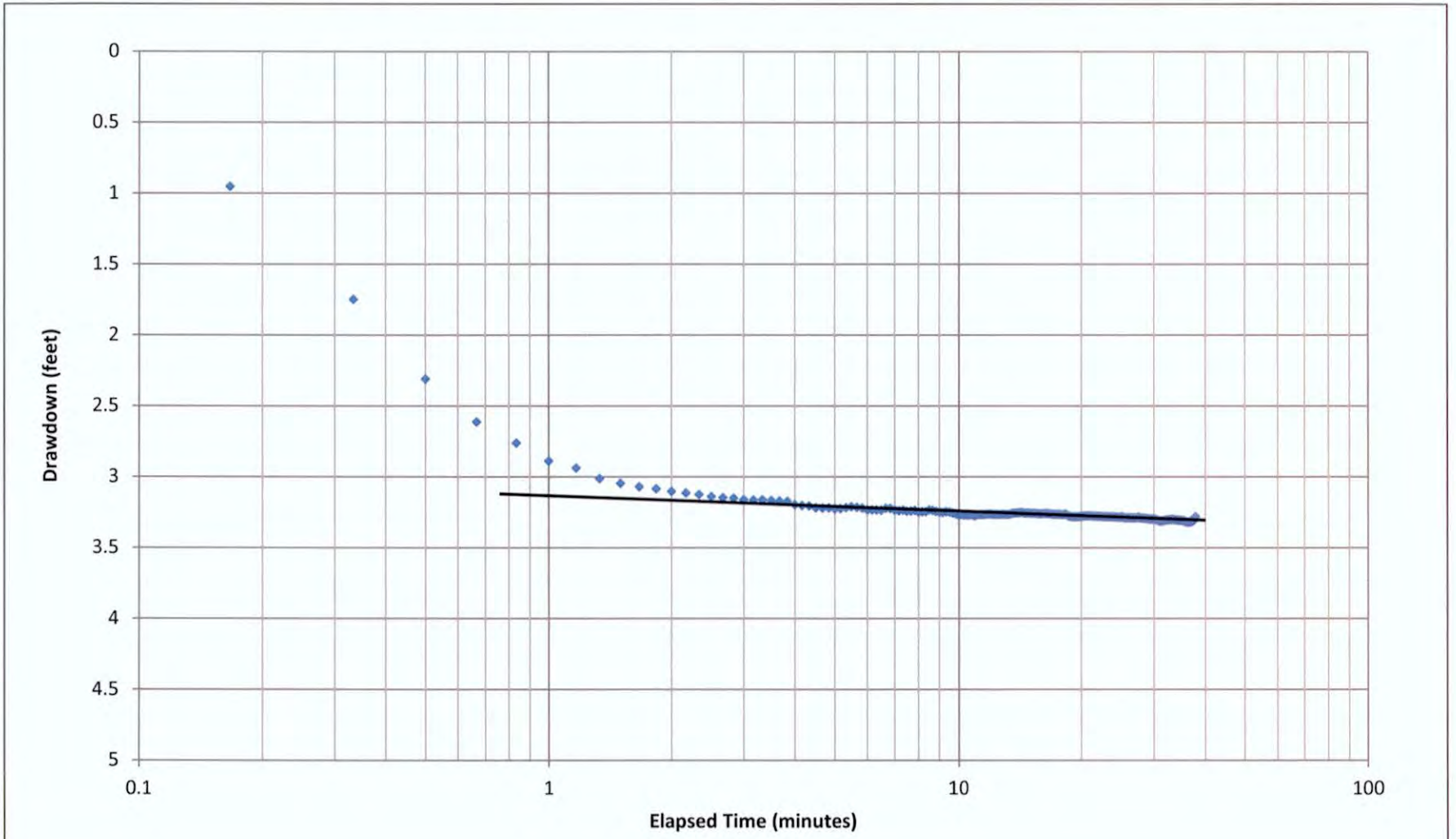
◆ YC-MW-38 Drawdown

Pump On: 2/26/19 11:23:00
Pump Off: 2/26/19 11:56:30
Average Pumping Rate: 1.5 gpm

Note: well could not be pumped hard enough to produce adequate drawdown for analysis, transducer drift is apparent in plotted data. Therefore the estimated hydraulic conductivity should be considered a lower-end value.

YC-MW-38
Drawdown Plot
GWMA Single Well Tests

PgG



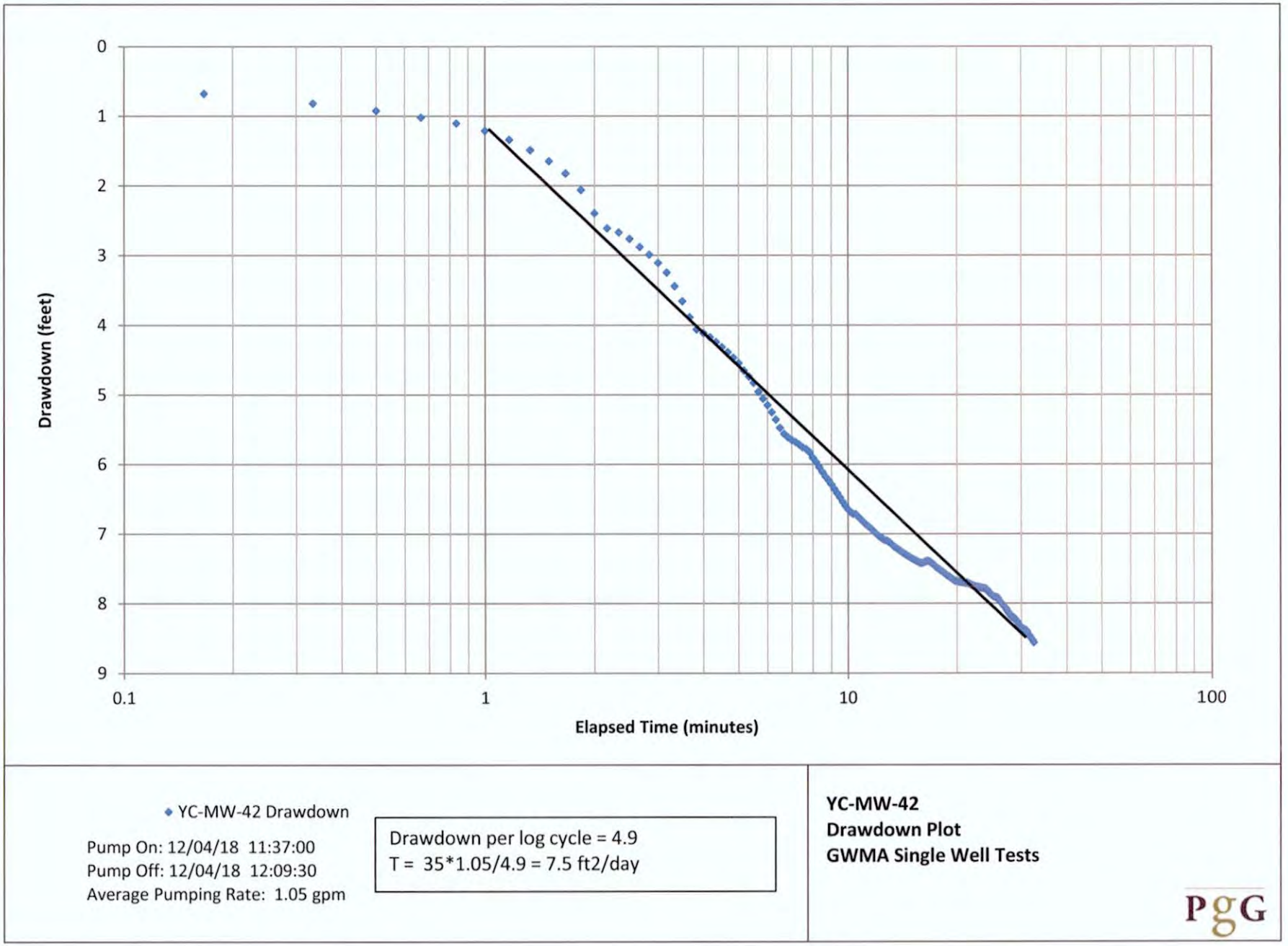
◆ YC-MW-41 Drawdown

Pump On: 12/05/18 9:03:10
Pump Off: 12/04/18 9:41:00
Average Pumping Rate: 2.64 gpm

Drawdown per log cycle = 0.1
T = 35*2.64/0.1 = 924 ft2/day

YC-MW-41
Drawdown Plot
GWMA Single Well Tests

PgG



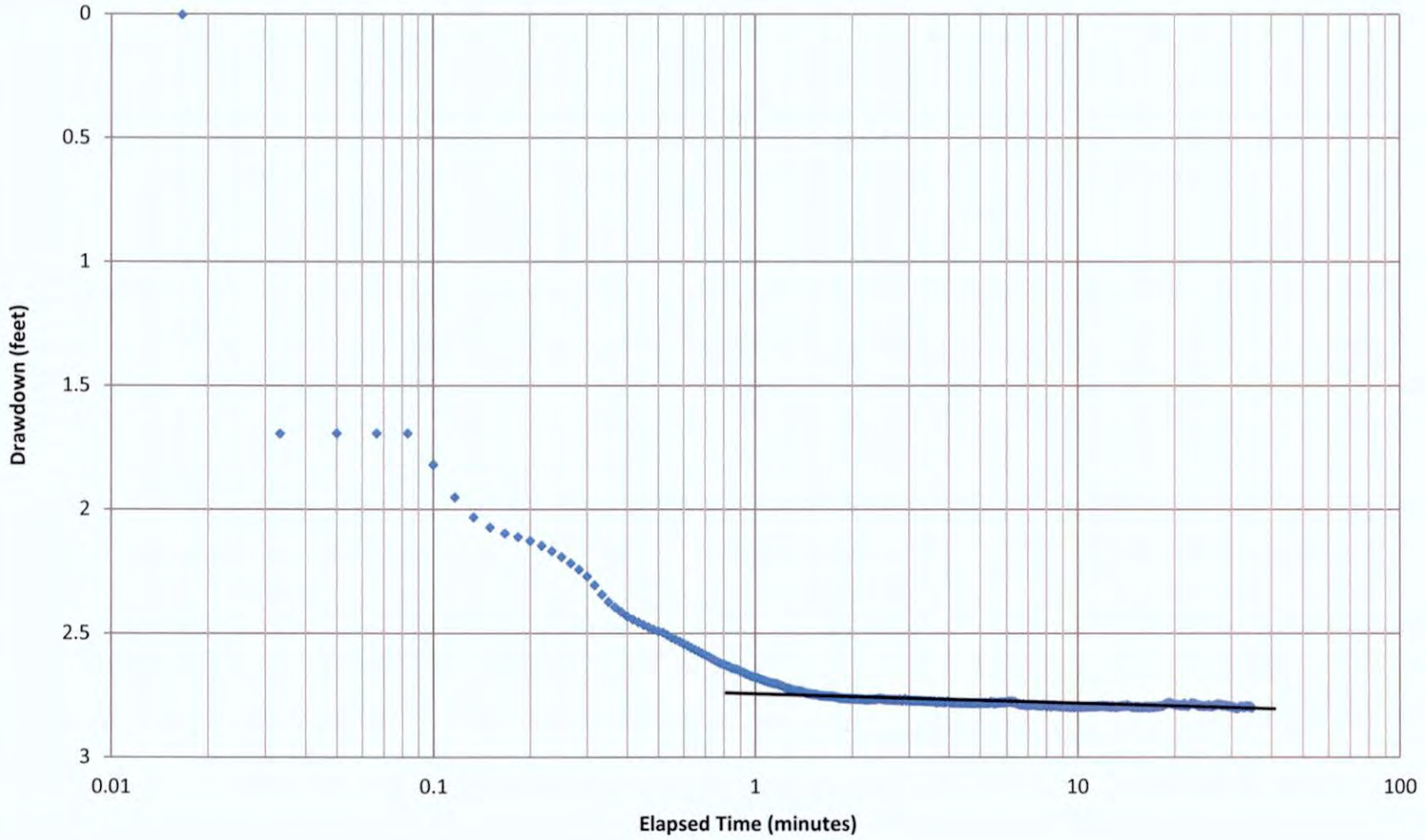
◆ YC-MW-42 Drawdown

Pump On: 12/04/18 11:37:00
Pump Off: 12/04/18 12:09:30
Average Pumping Rate: 1.05 gpm

Drawdown per log cycle = 4.9
T = 35*1.05/4.9 = 7.5 ft2/day

YC-MW-42
Drawdown Plot
GWMA Single Well Tests

PgG



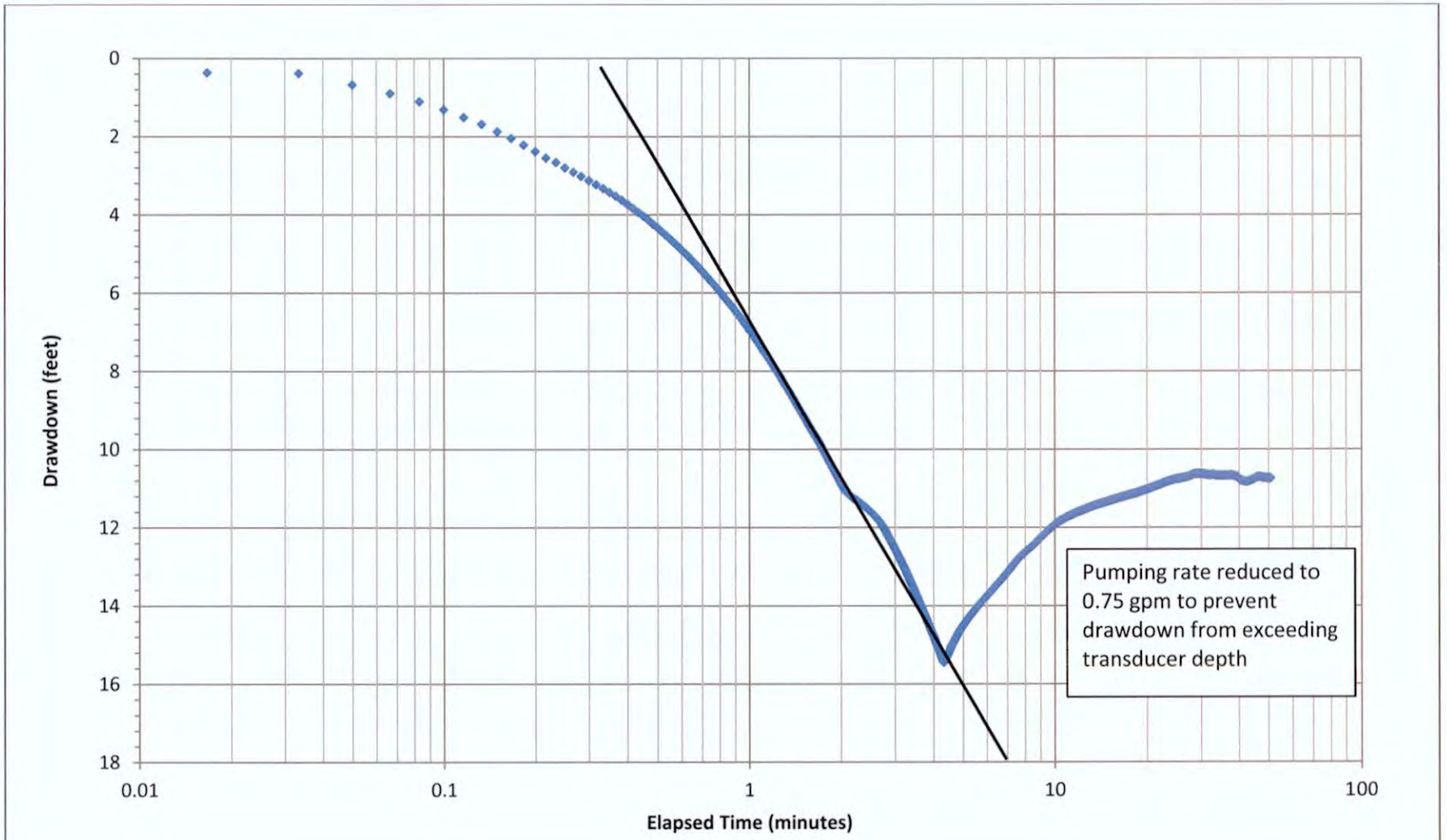
◆ YC-MW-44 Drawdown

Pump On: 2/26/19 14:02:08
Pump Off: 2/26/19 14:37:00
Average Pumping Rate: 3.44 gpm

Drawdown per log cycle = 0.1
T = 35*3.44/0.1 = 1,204 ft2/day

YC-MW-44
Drawdown Plot
GWMA Single Well Tests

PgG



◆ YC-MW-46 Drawdown

Pump On: 2/27/2019 08:52
Pump Off: 2/27/2019 09:43
Initial Pumping Rate: 1.5 gpm
Pumping rate reduced to 0.75 gpm at 08:56:30

Drawdown per log cycle = 13.5
T = 35*1.5/13.5 = 3.9 ft2/day

YC-MW-46
Drawdown Plot
GWMA Single Well Tests

PgG

APPENDIX E
GROUNDWATER SAMPLING SHEETS AND CHAIN-OF-CUSTODY SHEETS

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd
Union Gap, WA 98903

Batch: 883978
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis Klaas
PO Number:

--- Water Analytical Report ---

Report Date: 11/21/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E036107
Sample Identification: YC MW-2

Date Received: 11/15/18
Date Sampled: 11/15/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	17.2	mg/L	0.25	EPA 300.0	11/16/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd
Union Gap, WA 98903

Batch: 883978
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis Klaas
PO Number:

--- Water Analytical Report ---

Report Date: 11/21/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E036108
Sample Identification: YC MW-8

Date Received: 11/15/18
Date Sampled: 11/15/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	15.4	mg/L	0.25	EPA 300.0	11/16/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 883978
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis Klaas
PO Number:

--- Water Analytical Report ---

Report Date: 11/21/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E036109
Sample Identification: YC MW-5

Date Received: 11/15/18
Date Sampled: 11/15/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	3.14	mg/L	0.1	EPA 300.0	11/16/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

WATER ANALYSIS ORDER FORM

CASCADE ANALYTICAL, INC.

3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

Batch# 883978

	SAMPLE # 1	2	3	4	5
SEND RESULTS TO 1) Client 2) Billing 3) Both	X				
SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other			X		
SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other	X				

New Acct. #

CLIENT NAME/ADDRESS
Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102
SAMPLER'S NAME
Travis Klaas

BILLING NAME/ADDRESS

PHONE

E-mail

E-mail

RELINQUISHED BY (Signature) 1	DATE	RELINQUISHED BY (Signature) 2	DATE	RELINQUISHED BY (Signature) 3	DATE
	11/15/18				
(Printed) Travis Klaas	TIME 16:05	(Printed)	TIME	(Printed)	TIME
RECEIVED BY (Signature) DSemott	DATE 11/15/18	RECEIVED BY (Signature)	DATE	RECEIVED FOR LAB BY (Signature)	DATE
(Printed) DSemott	TIME 16:25	(Printed)	TIME	(Printed)	TIME

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

36107	1 YC-MW-2	11/15/2018 15:00	Sample Date / Sample Time
36108	2 YC-MW-8	11/15/18 9:20	Sample Date / Sample Time
36109	3 YC-MW-5	11/15/18 13:10	Sample Date / Sample Time
	4		Sample Date / Sample Time
	5		Sample Date / Sample Time

*METALS - circle type of analysis - T=total or D=dissolved
Total N package = TKN, NO_3, NO_2, NH_3
Sample container received by client was sealed Yes ✓ No____
Sample container received by laboratory was sealed Yes ✓ No____

(see legend on back)

		SAMPLE # 1	2	3	4	5
IRRIGATION WATER						
	Standard					
GENERAL CHEMISTRY						
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	Kjeldahl Nitrogen (TKN)					
1170	Nitrate+Nitrite					
1265	NO_3 (As N)	X	X	X		
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
MICROBIOLOGY						
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
METALS - TOTAL OR DISSOLVED						
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1081	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
MINERALS						
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

Disclaimer:
Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability from the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a sum equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date 11/15/2018

This form also serves as "Chain of Custody."

CAICOF - 03

REV. 04/26/2013

CASCADE ANALYTICAL

Sample Receipt Form

Date Received: 11/15/18 Time Received: 16'05 Initials: DS

Client Name: Pacific Groundwater Project Name: _____

Temperature of cooler upon receipt: 7 °C Thermometer ID: _____

Custody seals: (Intact) Broken None N/A

Chain of Custody Completed:

Client name, address, and phone number;	(Yes)	No
Date and time of sampling;	(Yes)	No
Test requests clear;	(Yes)	No
Completed in ink;	(Yes)	No
Signed by client;	(Yes)	No
All samples received:	(Yes)	No
All samples intact:	(Yes)	No
Sample ID's match COC form:	(Yes)	No
Appropriate containers used:	(Yes)	No
Sufficient amount of sample for analysis:	(Yes)	No
Correct preservative verified:	N/A (Yes)	No
Air bubbles in VOC, TTHM, or HAA5 samples:	(N/A) Yes	No
Sample(s) exceed hold time:	Yes	(No)

Type of coolant: Ice Blue Ice (None) Other Comment: _____

Shipping Method: FedEx UPS USPS Brett & Sons (Hand Delivered) CAI Sampled

Shipping Container: CAI Cooler CAI Cooler Box Client's Cooler (None) Other _____

Samples accepted for analysis: (Yes) No

Reason for Rejection: _____

Name of Person Contacted: _____ Date Contacted: _____

Comments: _____

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 883896
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis Klaas
PO Number:

--- Water Analytical Report ---

Report Date: 11/20/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E035905
Sample Identification: YC MW-23

Date Received: 11/14/18
Date Sampled: 11/14/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	6.00	mg/L	0.5	EPA 300.0	11/15/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd
Union Gap, WA 98903

Batch: 883896
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis Klaas
PO Number:

--- Water Analytical Report ---

Report Date: 11/20/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E035906
Sample Identification: YC MW-16

Date Received: 11/14/18
Date Sampled: 11/14/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	6.30	mg/L	0.5	EPA 300.0	11/15/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

2

CASCADE ANALYTICAL, INC.

3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

WATER ANALYSIS ORDER FORM

Batch# 883896

	SAMPLE # 1	2	3	4	5
SEND RESULTS TO 1) Client 2) Billing 3) Both	X				
SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other			X		
SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other	X				

New Acct. #

CLIENT NAME/ADDRESS
Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA

SAMPLER'S NAME
Travis Klaas

BILLING NAME/ADDRESS

PHONE

E-mail steve@pgwg.com

E-mail

RELINQUISHED BY: (Signature) 1	DATE	RELINQUISHED BY: (Signature) 2	DATE	RELINQUISHED BY: (Signature) 3	DATE
	11/14/18				
(Printed) Travis Klaas	TIME 16:10	(Printed)	TIME	(Printed)	TIME
RECEIVED BY: (Signature)	DATE 11/14/18	RECEIVED BY: (Signature)	DATE	RECEIVED FOR LAB BY: (Signature)	DATE
(Printed) DSemcit	TIME 16:12	(Printed)	TIME	(Printed)	TIME

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

35905	1	YC-MW-23 11/14/18	Sample Date
		11:30	Sample Time
35906	2	YC-MW-16 11/14/18	Sample Date
		15:05	Sample Time
	3		Sample Date
			Sample Time
	4		Sample Date
			Sample Time
	5		Sample Date
			Sample Time

***METALS - circle type of analysis - T=total or D=dissolved**

Total N package = TKN, NO_3, NO_2, NH_3

Sample container received by client was sealed Yes ✓ No ____

Sample container received by laboratory was sealed Yes ____ No ____

Disclaimer:

Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability from the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a sum equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date 11/14/18

This form also serves as "Chain of Custody."

CAICOF - 03

REV. 04/26/2013

(see legend on back)

	IRRIGATION WATER	SAMPLE # 1	2	3	4	5
	Standard					
	GENERAL CHEMISTRY					
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	~~Kjeldahl~~ Nitrogen (TKN)					
1170	Nitrate+Nitrite					
1265	NO_3 (As N)	X	X			
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO_4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
	Nitrate	X	X			
	MICROBIOLOGY					
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
	METALS - TOTAL OR DISSOLVED					
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1081	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
	MINERALS					
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

Sample Receipt Form

Date Received: 11/14/18 Time Received: 16:12 Initials: DS

Client Name: Pac Groundwater Group Project Name: _____

Temperature of cooler upon receipt: 2 °C Thermometer ID: OR2

Custody seals: (Intact) Broken None N/A

Chain of Custody Completed:

Client name, address, and phone number;		(Yes)	No
Date and time of sampling;		(Yes)	No
Test requests clear;		(Yes)	No
Completed in ink;		(Yes)	No
Signed by client;		(Yes)	No
All samples received:		(Yes)	No
All samples intact:		(Yes)	No
Sample ID's match COC form:		(Yes)	No
Appropriate containers used:		(Yes)	No
Sufficient amount of sample for analysis:		(Yes)	No
Correct preservative verified:	N/A	(Yes)	No
Air bubbles in VOC, TTHM, or HAA5 samples:	(N/A)	Yes	No
Sample(s) exceed hold time:		Yes	(No)

Type of coolant: Ice (Blue Ice) None Other Comment: _____

Shipping Method: FedEx UPS USPS Brett & Sons (Hand Delivered) CAI Sampled

Shipping Container: CAI Cooler CAI Cooler Box (Client's Cooler) None Other _____

Samples accepted for analysis: (Yes) No

Reason for Rejection: _____

Name of Person Contacted: _____ Date Contacted: _____

Comments: _____

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 883796
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 11/16/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

~~Laboratory Number: 18-E035699~~
Sample Identification: YC MW-17

~~Date Received: 11/13/18~~
Date Sampled: 11/12/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	6.85	mg/L	0.25	EPA 300.0	11/14/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 883796
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 11/16/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E035700 Date Received: 11/13/18
Sample Identification: YC MW-26 Date Sampled: 11/13/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	3.26	mg/L	0.1	EPA 300.0	11/14/18	

Approved By Name: Andy Schut Signature:
Function: Lab Manager/Yakima

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 883796
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 11/16/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E035701
Sample Identification: YC MW-19

Date Received: 11/13/18
Date Sampled: 11/13/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	15.1	mg/L	0.5	EPA 300.0	11/14/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 883796
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 11/16/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E035702
Sample Identification: YC MW-10

Date Received: 11/13/18
Date Sampled: 11/13/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	11.5	mg/L	0.1	EPA 300.0	11/14/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.

3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

WATER ANALYSIS ORDER FORM

Batch# 883796

SEND RESULTS TO 1) Client 2) Billing 3) Both steve@pgwg.com

SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other

SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other

SAMPLE #	1	2	3	4	5
	X	X	X	X	
	X	X	X	X	

New Acct. #

CLIENT NAME/ADDRESS
Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102
SAMPLER'S NAME Travis

BILLING NAME/ADDRESS
same
PHONE

E-mail steve@pgwg.com

E-mail

RELINQUISHED BY (Signature) 1	DATE	RELINQUISHED BY (Signature) 2	DATE	RELINQUISHED BY (Signature) 3	DATE
(Printed) Travis Klaas	TIME 14'55	(Printed)	TIME	(Printed)	TIME
RECEIVED BY (Signature) Kristin Erickson	DATE 11/13/18	RECEIVED BY (Signature)	DATE	RECEIVED FOR LAB BY (Signature)	DATE
(Printed) Kristin Erickson	TIME 2:55	(Printed)	TIME	(Printed)	TIME

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

35699	1	YC-mw-17 11/12/2018	Sample Date
		14:40	Sample Time
35700	2	YC-mw-26 11/13/2018	Sample Date
		8:30	Sample Time
35701	3	YC-mw-19 11/13/2018	Sample Date
		11:00	Sample Time
35702	4	YC-mw-10 11/13/2018	Sample Date
		14:00	Sample Time
	5		Sample Date
			Sample Time

***METALS - circle type of analysis - T=total or D=dissolved**

Total N package = TKN, NO_3, NO_2, NH_3

Sample container received by client was sealed Yes ✓ No____

Sample container received by laboratory was sealed Yes ✓ No____

Disclaimer:
Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability from the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a sum equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date_____

This form also serves as "Chain of Custody."

CAICOF - 03

REV. 04/26/2013

(see legend on back)

IRRIGATION WATER		SAMPLE # 1	2	3	4	5
	Standard					
GENERAL CHEMISTRY						
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	Kjeldahl Nitrogen (TKN)					
1170	Nitrate+Nitrite					
1265	NO_3 (As N)					
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
	Nitrate	X	X	X	X	
MICROBIOLOGY						
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
METALS - TOTAL OR DISSOLVED						
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1081	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
MINERALS						
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

Sample Receipt Form

Date Received: 11.13.18 Time Received: 2:55 Initials: KE

Client Name: Pacific Groundwater Group Project Name: _____

Temperature of cooler upon receipt: 1.2 °C Thermometer ID: OR2

Custody seals: (Intact) Broken None N/A

Chain of Custody Completed:

Client name, address, and phone number;	(Yes)	No
Date and time of sampling;	(Yes)	No
Test requests clear;	(Yes)	No
Completed in ink;	(Yes)	No
Signed by client;	(Yes)	No

All samples received:		(Yes)	No
All samples intact:		(Yes)	No
Sample ID's match COC form:		(Yes)	No
Appropriate containers used:		(Yes)	No
Sufficient amount of sample for analysis:		(Yes)	No
Correct preservative verified:	(N/A)	Yes	No
Air bubbles in VOC, TTHM, or HAA5 samples:	(N/A)	Yes	No
Sample(s) exceed hold time:		Yes	(No)

Type of coolant: (Ice) Blue Ice None Other Comment: _____

Shipping Method: FedEx UPS USPS Brett & Sons (Hand Delivered) CAI Sampled

Shipping Container: CAI Cooler CAI Cooler Box (Client's Cooler) None Other _____

Samples accepted for analysis: (Yes) No

Reason for Rejection: _____

Name of Person Contacted: _____ Date Contacted: _____

Comments: _____

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884253
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Theo
PO Number:

--- Water Analytical Report ---

Report Date: 11/29/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E036675 Date Received: 11/27/18
Sample Identification: YC MW 21 11/27/18 Date Sampled: 11/27/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	0.66	mg/L	0.1	EPA 300.0	11/29/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd
Union Gap, WA 98903

Batch: 884253
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Theo
PO Number:

--- Water Analytical Report ---

Report Date: 11/29/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E036676
Sample Identification: YC MW 27 11/27/18

Date Received: 11/27/18
Date Sampled: 11/27/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	24.6	mg/L	0.5	EPA 300.0	11/29/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884253
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Theo
PO Number:

--- Water Analytical Report ---

Report Date: 11/29/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E036677 Date Received: 11/27/18
Sample Identification: YC MW 7 11/26/18 Date Sampled: 11/26/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	4.34	mg/L	0.1	EPA 300.0	11/29/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

WATER ANALYSIS ORDER FORM

Batch# 884253

	SAMPLE # 1	2	3	4	5
SEND RESULTS TO 1) Client 2) Billing 3) Both	X				
SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other			X		
SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other	X				

New Acct. #

CLIENT NAME/ADDRESS: Pacific Groundwater Group

BILLING NAME/ADDRESS: 2377 Eastlake Ave E, Seattle, WA 98102

SAMPLER'S NAME: Travis Theo

PHONE: 206-329-0141

E-mail: steve@pgwg.com

E-mail:

RELINQUISHED BY (Signature) 1	DATE	RELINQUISHED BY (Signature) 2	DATE	RELINQUISHED BY (Signature) 3	DATE
	11/27/18				
(Printed) Travis	TIME 15:45	(Printed)	TIME	(Printed)	TIME
RECEIVED BY (Signature)	DATE 11/27/18	RECEIVED BY (Signature)	DATE	RECEIVED FOR LAB BY (Signature)	DATE
(Printed) DSchmidt	TIME 15:45	(Printed)	TIME	(Printed)	TIME

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

			Sample Date / Sample Time
366075	1	YC-MW-21 11272018 14:30	11/27/18
366076	2	YC-MW-27 11272018 10:30	11/27/18
366077	3	YC-MW-7 11202018 14:50	11/20/18
	4		
	5		

*METALS - circle type of analysis - T=total or D=dissolved

Total N package = TKN, NO_3, NO_2, NH_3

Sample container received by client was sealed Yes ✓ No

Sample container received by laboratory was sealed Yes ✓ No

Disclaimer:

Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a sum equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date 11/27/18

This form also serves as "Chain of Custody."

CAICOF - 03

REV. 04/26/2013

(see legend on back)

		SAMPLE # 1	2	3	4	5
	IRRIGATION WATER Standard					
	GENERAL CHEMISTRY					
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	Kjeldahl Nitrogen (TKN)					
1170	Nitrate+Nitrite					
1265	NO_3 (As N)	X	X	X		
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
	MICROBIOLOGY					
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
	METALS - TOTAL OR DISSOLVED					
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1081	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
	MINERALS					
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

CASCADE ANALYTICAL INC

Sample Receipt Form

Date Received: 11/27/18 Time Received: 15:45 Initials: DS

Client Name: Pacific Groundwater Project Name: _____

Temperature of cooler upon receipt: 8 °C Thermometer ID: OR2

Custody seals: (Intact) Broken None N/A

Chain of Custody Completed:

Client name, address, and phone number;	(Yes)	No
Date and time of sampling;	(Yes)	No
Test requests clear;	(Yes)	No
Completed in ink;	(Yes)	No
Signed by client;	(Yes)	No

All samples received:		(Yes)	No
All samples intact:		(Yes)	No
Sample ID's match COC form:		(Yes)	No
Appropriate containers used:		(Yes)	No
Sufficient amount of sample for analysis:		(Yes)	No
Correct preservative verified:	N/A	(Yes)	No
Air bubbles in VOC, TTHM, or HAA5 samples:	(N/A)	Yes	No
Sample(s) exceed hold time:		Yes	(No)

Type of coolant: (Ice) Blue Ice None Other Comment: _____

Shipping Method: FedEx UPS USPS Brett & Sons (Hand Delivered) CAI Sampled

Shipping Container: CAI Cooler (CAI Cooler Box) Client's Cooler None Other _____

Samples accepted for analysis: (Yes) No

Reason for Rejection: _____

Name of Person Contacted: _____ Date Contacted: _____

Comments: _____

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884521
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Inger
PO Number:

--- Water Analytical Report ---

Report Date: 12/10/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

received 12.17.18.

Laboratory Number: 18-E037284
Sample Identification: YC-MW-11

Date Received: 12/ 3/18
Date Sampled: 12/ 2/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	1.74	mg/L	0.1	EPA 300.0	12/ 5/18	

Approved By Name: Andy Schul
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884521
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Inger
PO Number:

--- Water Analytical Report ---

Report Date: 12/10/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E037285
Sample Identification: YC-MW-9

Date Received: 12/ 3/18
Date Sampled: 12/ 3/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	1.70	mg/L	0.1	EPA 300.0	12/ 5/18	

Approved By Name: Andy Schul
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884521
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Inger
PO Number:

--- Water Analytical Report ---

Report Date: 12/10/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E037286
Sample Identification: YC-MW-24

Date Received: 12/ 3/18
Date Sampled: 12/ 3/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	6.32	mg/L	0.1	EPA 300.0	12/ 5/18	

Approved By Name: Andy Schul
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.

3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

WATER ANALYSIS ORDER FORM

Batch# 884521

	SAMPLE # 1	2	3	4	5
SEND RESULTS TO 1) Client 2) Billing 3) Both	X				
SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other			X		
SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other	X				

New Acct. #

CLIENT NAME/ADDRESS	BILLING NAME/ADDRESS
Pacific Groundwater Group	Chris Keener
2377 Eastlake Ave E	2377 Eastlake Ave E
Seattle, WA 98102	Seattle, WA 98102
SAMPLER'S NAME: Travis & Inger	PHONE: 206-329-0141
E-mail steve@pgwg.com	E-mail chris@pgwg.com

RELINQUISHED BY (Signature) 1	DATE	RELINQUISHED BY (Signature) 2	DATE	RELINQUISHED BY (Signature) 3	DATE
	12/3/18				
(Printed) Travis	TIME 15:25	(Printed)	TIME	(Printed)	TIME
RECEIVED BY (Signature)	DATE 12/3	RECEIVED BY (Signature)	DATE	RECEIVED FOR LAB BY (Signature)	DATE 12/3/18
(Printed)	TIME 4:06	(Printed)	TIME	(Printed) Andy Schut	TIME 1606

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

37284	1	YC-MW-11	Sample Date 12/2/18
		"	Sample Time 17:00
37285	2	YC-MW-9	Sample Date 12/3/18
			Sample Time 11:05
37286	3	YC-MW-24	Sample Date 12/3/18
			Sample Time 13:15
	4		Sample Date
			Sample Time
	5		Sample Date
			Sample Time

***METALS - circle type of analysis - T=total or D=dissolved**

Total N package = TKN, NO_3, NO_2, NH_3

Sample container received by client was sealed Yes ✓ No ____

Sample container received by laboratory was sealed Yes ____ No ____

Disclaimer:

Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability from the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a sum equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date 12/3/2018

This form also serves as "Chain of Custody."

CAICOF - 03

REV. 04/26/2013

(see legend on back)

	IRRIGATION WATER	SAMPLE # 1	2	3	4	5
	Standard					
	GENERAL CHEMISTRY					
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	Kjeldahl Nitrogen (TKN)					
1170	Nitrate+Nitrite					
1265	NO_3 (As N)	X	X	X		
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO_4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
	MICROBIOLOGY					
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
	METALS - TOTAL OR DISSOLVED					
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1081	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
	MINERALS					
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

CASCADE ANALYTICAL INC

Sample Receipt Form

Date Received: 12/3/18 Time Received: 1606 Initials: AS

Client Name: Pacific Groundwater Project Name: _____

Temperature of cooler upon receipt: 0.2 °C Thermometer ID: 082

Custody seals: (Intact) Broken None N/A

Chain of Custody Completed:

Client name, address, and phone number;	(Yes)	No
Date and time of sampling;	(Yes)	No
Test requests clear;	(Yes)	No
Completed in ink;	(Yes)	No
Signed by client;	(Yes)	No

All samples received:		(Yes)	No
All samples intact:		(Yes)	No
Sample ID's match COC form:		(Yes)	No
Appropriate containers used:		(Yes)	No
Sufficient amount of sample for analysis:		(Yes)	No
Correct preservative verified:	N/A	(Yes)	No
Air bubbles in VOC, TTHM, or HAA5 samples:	(N/A)	Yes	No
Sample(s) exceed hold time:		Yes	(No)

Type of coolant: (Ice) Blue Ice None Other Comment: _____

Shipping Method: FedEx UPS USPS Brett & Sons (Hand Delivered) CAI Sampled

Shipping Container: CAI Cooler (CAI Cooler Box) Client's Cooler None Other _____

Samples accepted for analysis: (Yes) No

Reason for Rejection: _____

Name of Person Contacted: _____ Date Contacted: _____

Comments: _____

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884609
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 12/10/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E037452
Sample Identification: YC-MW 28

Date Received: 12/ 4/18
Date Sampled: 12/ 4/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	3.10	mg/L	0.1	EPA 300.0	12/ 6/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884609
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 12/10/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E037453
Sample Identification: YC-MW 42

Date Received: 12/ 4/18
Date Sampled: 12/ 4/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	7.04	mg/L	0.1	EPA 300.0	12/ 6/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884609
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 12/10/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E037454
Sample Identification: YC-MW 1

Date Received: 12/ 4/18
Date Sampled: 12/ 4/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	22.2	mg/L	0.5	EPA 300.0	12/ 6/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884609
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 12/10/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E037455
Sample Identification: YC-MW 12

Date Received: 12/ 4/18
Date Sampled: 12/ 4/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	0.38	mg/L	0.1	EPA 300.0	12/ 6/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.

3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

WATER ANALYSIS ORDER FORM

Batch# 884609

	SAMPLE # 1	2	3	4	5
SEND RESULTS TO 1) Client 2) Billing 3) Both	X				
SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other			X		
SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other	X				

New Acct. #

CLIENT NAME/ADDRESS	BILLING NAME/ADDRESS
Pacific Groundwater Group	Chris Keerner
2377 Eastlake Ave E	2377 Eastlake Ave E
Seattle, WA 98102	Seattle, WA 98102
SAMPLER'S NAME: Travis	PHONE: 206 329-0141

E-mail steve@pgwg.com E-mail chris@pgwg.com

RELINQUISHED BY (Signature) 1	DATE	RELINQUISHED BY (Signature) 2	DATE	RELINQUISHED BY (Signature) 3	DATE
	12/4/18				
(Printed) Travis	TIME 15:35	(Printed)	TIME	(Printed)	TIME
RECEIVED BY (Signature)	DATE 12/4/18	RECEIVED BY (Signature)	DATE	RECEIVED FOR LAB BY (Signature)	DATE
(Printed)	TIME 15:35	(Printed)	TIME	(Printed)	TIME

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

37452	1	Yc - mw - 28	Sample Date 12/4/18; Sample Time 10:15
37453	2	Yc - mw - 42	Sample Date 12/4/18; Sample Time 12:00
37454	3	Yc - mw - 1	Sample Date 12/4/18; Sample Time 14:35
37455	4	Yc - mw - 12	Sample Date 12/3/18; Sample Time 15:45
	5		Sample Date; Sample Time

***METALS - circle type of analysis - T=total or D=dissolved**

Total N package = TKN, NO_3, NO_2, NH_3

Sample container received by client was sealed Yes ✓ No

Sample container received by laboratory was sealed Yes No ✓

Disclaimer:

Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability from the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a sum equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date 12/4/18

This form also serves as "Chain of Custody."

CAICOF - 03

REV. 04/26/2013

(see legend on back)

		SAMPLE # 1	2	3	4	5
	IRRIGATION WATER					
	Standard					
	GENERAL CHEMISTRY					
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	Kjeldahl Nitrogen (TKN)					
1170	Nitrate+Nitrite					
1265	NO_3 (As N)	X	X	X	X	
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO_4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
	MICROBIOLOGY					
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
	METALS - TOTAL OR DISSOLVED					
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1081	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
	MINERALS					
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

CASCADE ANALYTICAL INC

Sample Receipt Form

Date Received: 12/4/18 Time Received: 15:35 Initials: DF

Client Name: Pacific GW Group Project Name: _____

Temperature of cooler upon receipt: 13 °C Thermometer ID: OR2

Custody seals: Intact Broken (None) N/A

Chain of Custody Completed:

Client name, address, and phone number;	(Yes)	No
Date and time of sampling;	(Yes)	No
Test requests clear;	(Yes)	No
Completed in ink;	(Yes)	No
Signed by client;	(Yes)	No

All samples received:		(Yes)	No
All samples intact:		(Yes)	No
Sample ID's match COC form:		(Yes)	No
Appropriate containers used:		(Yes)	No
Sufficient amount of sample for analysis:		(Yes)	No
Correct preservative verified:	N/A	(Yes)	No
Air bubbles in VOC, TTHM, or HAA5 samples:	(N/A)	Yes	No
Sample(s) exceed hold time:		Yes	(No)

Type of coolant: Ice Blue Ice (None) Other Comment: _____

Shipping Method: FedEx UPS USPS Brett & Sons (Hand Delivered) CAI Sampled

Shipping Container: CAI Cooler CAI Cooler Box Client's Cooler (None) Other _____

Samples accepted for analysis: (Yes) No

Reason for Rejection: _____

Name of Person Contacted: _____ Date Contacted: _____

Comments: _____

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884746
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 12/13/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 18-E037731 Date Received: 12/ 6/18
Sample Identification: YC MW-41 Date Sampled: 12/ 5/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	26.9	mg/L	0.5	EPA 300.0	12/12/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884746
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 12/13/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

~~Laboratory Number: 18-E037732~~ ~~Date Received: 12/ 6/18~~
Sample Identification: YC MW-25 Date Sampled: 12/ 6/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	3.58	mg/L	0.1	EPA 300.0	12/11/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884746
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 12/13/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

~~Laboratory Number: 18-E037733~~
Sample Identification: YC MW-15

~~Date Received: 12/ 6/18~~
Date Sampled: 12/ 5/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	1.02	mg/L	0.1	EPA 300.0	12/11/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 884746
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis
PO Number:

--- Water Analytical Report ---

Report Date: 12/13/18

Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

~~Laboratory Number: 18-E037734~~
Sample Identification: YC MW-6

~~Date Received: 12/ 6/18~~
Date Sampled: 12/ 5/18

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	58.4	mg/L	1	EPA 300.0	12/12/18	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.

3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

WATER ANALYSIS ORDER FORM

Batch# 884746

	SAMPLE # 1	2	3	4	5
SEND RESULTS TO 1) Client 2) Billing 3) Both	X				
SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other			X		
SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other	X				

New Acct. #

CLIENT NAME/ADDRESS	BILLING NAME/ADDRESS
Pacific Groundwater Group	Chris Keenan
2377 Eastlake Ave E	2377 Eastlake Ave E
Seattle, WA 98102	Seattle, WA 98102
SAMPLER'S NAME: Travis	PHONE: 206 329-0141

E-mail steve@pgwg.com E-mail Chris@pgwg.com

RELINQUISHED BY (Signature) [1]	DATE	RELINQUISHED BY (Signature) [2]	DATE	RELINQUISHED BY (Signature) [3]	DATE
	12/6/18				
(Printed) Travis	TIME 13:30	(Printed)	TIME	(Printed)	TIME
RECEIVED BY (Signature)	DATE 12/6/18	RECEIVED BY (Signature)	DATE	RECEIVED FOR LAB BY (Signature)	DATE
(Printed) DSchmidt	TIME 13:30	(Printed)	TIME	(Printed)	TIME

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

37731	1	YC-MW-41	Sample Date 12/5/18; Sample Time 9:35
37732	2	YC-MW-25	Sample Date 12/6/18; Sample Time 12:10
37733	3	YC-MW-15	Sample Date 12/5/18; Sample Time 17:00
37734	4	YC-MW-6	Sample Date 12/5/18; Sample Time 12:55
	5		Sample Date; Sample Time

*METALS - circle type of analysis - T=total or D=dissolved

Total N package = TKN, NO_3, NO_2, NH_3

Sample container received by client was sealed Yes ✓ No____

Sample container received by laboratory was sealed Yes____ No ✓

Disclaimer:

Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability from the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a sum equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date 12/6/18

This form also serves as "Chain of Custody."

CAICOF - 03

REV. 04/26/2013

(see legend on back)

	IRRIGATION WATER	SAMPLE # 1	2	3	4	5
	Standard					
	GENERAL CHEMISTRY					
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	Kjeldahl Nitrogen (TKN)					
1170	Nitrate+Nitrite					
1265	NO_3 (As N)	X	X	X	X	
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
	MICROBIOLOGY					
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
	METALS - TOTAL OR DISSOLVED					
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1081	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
	MINERALS					
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

CASCADE ANALYTICAL INC

Sample Receipt Form

Date Received: 12/6/18 Time Received: 13:30 Initials: DS

Client Name: Pacific Groundwater Project Name: _____

Temperature of cooler upon receipt: 3 °C Thermometer ID: OR2

Custody seals: Intact Broken (None) N/A

Chain of Custody Completed:

Client name, address, and phone number;		(Yes)	No
Date and time of sampling;		(Yes)	No
Test requests clear;		(Yes)	No
Completed in ink;		(Yes)	No
Signed by client;		(Yes)	No
All samples received:		(Yes)	No
All samples intact:		(Yes)	No
Sample ID's match COC form:		(Yes)	No
Appropriate containers used:		(Yes)	No
Sufficient amount of sample for analysis:		(Yes)	No
Correct preservative verified:	N/A	(Yes)	No
Air bubbles in VOC, TTHM, or HAA5 samples:	(N/A)	Yes	No
Sample(s) exceed hold time:		Yes	(No)

Type of coolant: Ice Blue Ice (None) Other Comment: _____

Shipping Method: FedEx UPS USPS Brett & Sons (Hand Delivered) CAI Sampled

Shipping Container: CAI Cooler CAI Cooler Box Client's Cooler (None) Other _____

Samples accepted for analysis: (Yes) No

Reason for Rejection: _____

Name of Person Contacted: _____ Date Contacted: _____

Comments: _____

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 987601
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Glenn
PO Number:

--- Water Analytical Report ---

Report Date: 3/ 4/19

Pacific Groundwater Group
Travis Klaas
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 19-E004574
Sample Identification: YC-MW-39

Date Received: 2/27/19
Date Sampled: 2/27/19

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	18.1	mg/L	0.5	EPA 300.0	2/28/19	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 987601
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Glenn
PO Number:

--- Water Analytical Report ---

Report Date: 3/ 4/19

Pacific Groundwater Group
Travis Klaas
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 19-E004575 Date Received: 2/27/19
Sample Identification: YC-MW-33 Date Sampled: 2/27/19

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	24.2	mg/L	0.5	EPA 300.0	2/28/19	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 987601
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Glenn
PO Number:

--- Water Analytical Report ---

Report Date: 3/ 4/19

Pacific Groundwater Group
Travis Klaas
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 19-E004576 Date Received: 2/27/19
Sample Identification: YC-MW-44 Date Sampled: 2/26/19

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	30.2	mg/L	0.5	EPA 300.0	3/ 1/19	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 987601
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Glenn
PO Number:

--- Water Analytical Report ---

Report Date: 3/ 4/19

Pacific Groundwater Group
Travis Klaas
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 19-E004577
Sample Identification: YC-MW-38

Date Received: 2/27/19
Date Sampled: 2/26/19

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	10.3	mg/L	0.1	EPA 300.0	2/28/19	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima
Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 987601
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Glenn
PO Number:

--- Water Analytical Report ---

Report Date: 3/ 4/19

Pacific Groundwater Group
Travis Klaas
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 19-E004578
Sample Identification: YC-MW-31

Date Received: 2/27/19
Date Sampled: 2/26/19

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	5.94	mg/L	0.1	EPA 300.0	3/ 1/19	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.
1-800-545-4206

(509) 662-1888
Fax: (509) 662-8183
3019 G. S. Center Road
Wenatchee, WA 98801

(509) 452-7707
Fax: (509) 452-7773
1008 W. Ahtanum Rd.
Union Gap, WA 98903

Batch: 987601
Client: Pacific Groundwater Group
Account: 03558
Sampler: Travis/Glenn
PO Number:

--- Water Analytical Report ---

Report Date: 3/ 4/19

Pacific Groundwater Group
Travis Klaas
2377 Eastlake Ave E
Seattle, WA 98102

Laboratory Number: 19-E004579
Sample Identification: YC-MW-46

Date Received: 2/27/19
Date Sampled: 2/27/19

Test Requested	Results	Units	RL	Method	Date Analyzed	Flags
Nitrate-N	18.1	mg/L	0.5	EPA 300.0	2/28/19	

Approved By Name: Andy Schut
Function: Lab Manager/Yakima

Signature:

Cascade Analytical uses procedures established by EPA, AOAC, APHA, ASTM, and FDA/BAM. Cascade Analytical makes no warranty of any kind the client assumes all risk and liability from the use of these results. Cascade Analytical, Inc.'s liability to the client as a result of use of Cascade's test results shall be limited to a sum equal to the fees paid by the client to Cascade Analytical, Inc. for analysis. PLEASE REVIEW YOUR DATA IN A TIMELY MANNER. DATA GAPS OR ERRORS AFTER THREE MONTHS WILL NOT BE OUR RESPONSIBILITY. THOUGH WE DO KEEP ALL ANALYTICAL DATA FOR SEVERAL YEARS, SAMPLES ARE DISPOSED OF AFTER SIX WEEKS.

CASCADE ANALYTICAL, INC.

3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

WATER ANALYSIS ORDER FORM

	SAMPLE # 1	2	3	4	5
Batch# 987601					
SEND RESULTS TO 1) Client 2) Billing 3) Both	1	1	1	1	1
SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other	3	3	3	3	3
SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other	1	1	1	1	1

New Acct #

CLIENT NAME/ADDRESS
Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102
SAMPLER'S NAME
Travis Klaas, Glenn Mutti-Driscoll

BILLING NAME/ADDRESS
← same

PHONE
206-329-0141

E-mail travis@pgwg.com

E-mail

RELINQUISHED BY (Signature) 1	DATE	RELINQUISHED BY (Signature) 2	DATE	RELINQUISHED BY (Signature) 3	DATE
	2/27/19				
(Printed) Travis Klaas	TIME 15:35	(Printed)	TIME	(Printed)	TIME
RECEIVED BY (Signature) DSchmidt	DATE 2/27/19	RECEIVED BY (Signature)	DATE	RECEIVED FOR LAB BY (Signature)	DATE
(Printed) DSchmidt	TIME 15:35	(Printed)	TIME	(Printed)	TIME

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

4574	1	YC-MW-39	Sample Date 2-27-19
			Sample Time 1445
4575	2	YC-MW-33	Sample Date 2-27-19
			Sample Time 1145
4576	3	YC-MW-44	Sample Date 2-26-19
			Sample Time 14:30
4577	4	YC-MW-38	Sample Date 2-26-19
			Sample Time 11:50
4578	5	YC-MW-31	Sample Date 2-26-19
			Sample Time 1620

(see legend on back)

	IRRIGATION WATER	SAMPLE # 1	2	3	4	5
	Standard					
	GENERAL CHEMISTRY					
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	Kjeldahl Nitrogen (TKN)					
1170	Nitrate+Nitrite					
1265	NO_3 (As N)	X	X	X	X	X
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO_4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
	MICROBIOLOGY					
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
	METALS - TOTAL OR DISSOLVED					
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1061	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
	MINERALS					
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

***METALS - circle type of analysis - T=total or D=dissolved**

Total N package = TKN, NO_3, NO_2, NH_3

Sample container received by client was sealed Yes____ No____

Sample container received by laboratory was sealed Yes____ No____

Disclaimer:

Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability from the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a sum equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date 2/27/19

This form also serves as "Chain of Custody."

CASCADE ANALYTICAL, INC.

3019 G. S. Center Rd.
Wenatchee, WA 98801
(509) 662-1888
Fax: (509) 662-8183
1-800-545-4206

1008 W. Ahtanum Rd.
Union Gap, WA 98903
(509) 452-7707
Fax: (509) 452-7773

WATER ANALYSIS ORDER FORM

Batch# 98'1601

	SAMPLE # 1	2	3	4	5
SEND RESULTS TO 1) Client 2) Billing 3) Both	1				
SAMPLE REPRESENTS 1) Irrigation 2) Waste Water 3) Other	3				
SAMPLE BY 1) Client 2) Quality Control 3) Cascade 4) Other	1				

New Acct. #

CLIENT NAME/ADDRESS
Pacific Groundwater Group
2377 Eastlake Ave E
Seattle, WA 98102

SAMPLER'S NAME
Travis Klaas, Glenn Mutti-Driscoll

BILLING NAME/ADDRESS
← same

PHONE

E-mail travis@pgwg.com

E-mail

RELINQUISHED BY (Signature) 1	DATE	RELINQUISHED BY (Signature) 2	DATE	RELINQUISHED BY (Signature) 3	DATE
	2/27/19				
(Printed) Travis K	TIME 15:35	(Printed)	TIME	(Printed)	TIME
RECEIVED BY (Signature) DSchmidt	DATE 2/27/19	RECEIVED BY (Signature)	DATE	RECEIVED FOR LAB BY: (Signature)	DATE
(Printed) DSchmidt	TIME 15:35	(Printed)	TIME	(Printed)	TIME

FORM MUST BE COMPLETED BEFORE ANALYSIS WILL BE PERFORMED.

4579	1	XC-MW-46	Sample Date 2/27/19
			Sample Time 930
	2		Sample Date
			Sample Time
	3		Sample Date
			Sample Time
	4		Sample Date
			Sample Time
	5		Sample Date
			Sample Time

(see legend on back)

	IRRIGATION WATER	SAMPLE # 1	2	3	4	5
	Standard					
	GENERAL CHEMISTRY					
1135	pH					
1140	Conductivity					
1200	Solids-Dis. (TDS)					
1230	Solids-Susp. (TSS)					
1240	Tot. Phosphorus					
1250	Orthophosphate					
1260	Kjeldahl Nitrogen (TKN)					
1170	Nitrate+Nitrite	3				
1265	NO_3 (As N)	X				
1280	Ammonia					
1300	Biol. Oxy. Demand					
1310	Chem. Oxy. Demand					
1190	Sulfate (SO_4)					
1180	Chloride (Cl)					
1150	Turbidity					
1320	Hexane Ext. Mat.					
1340	Alkalinity					
217	Total N Pkg					
	MICROBIOLOGY					
10040	Total Coliform MF					
10010	Fecal Coliform MF					
10041	Total Coliform MPN					
10011	Fecal Coliform MPN					
	METALS - TOTAL OR DISSOLVED					
1391	Antimony (Sb)					
1011	Arsenic (As)					
1025	Barium (Ba)					
1405	Beryllium (Be)					
1031	Cadmium (Cd)					
1045	Chromium (Cr)					
1215	Copper (Cu)					
1065	Iron (Fe)					
1075	Manganese (Mn)					
1081	Mercury (Hg)					
1435	Molybdenum (Mo)					
1051	Lead (Pb)					
1335	Nickel (Ni)					
1091	Selenium (Se)					
1105	Silver (Ag)					
1381	Thallium (Tl)					
1225	Zinc (Zn)					
	MINERALS					
1120	Calcium (Ca)					
1130	Magnesium (Mg)					
1115	Potassium (K)					
1110	Sodium (Na)					

***METALS - circle type of analysis - T=total or D=dissolved**

Total N package = TKN, NO_3, NO_2, NH_3

Sample container received by client was sealed Yes____ No____

Sample container received by laboratory was sealed Yes____ No____

Disclaimer:

Cascade Analytical, Inc., makes no warranty of any kind, expressed or implied, and customer assumes all risk and liability om the use of Cascade's test results. Cascade neither assumes nor authorizes any person to assume for Cascade any other liability in connection with the testing done by Cascade Analytical, Inc., and there are no other oral agreements or warranties collateral to or affecting this agreement.

Cascade Analytical Inc.'s liability to customer as a result of customers use of Cascade's test results shall be limited to a um equal to the fees paid by customer to Cascade Analytical, Inc. for the testing work.

Customer Signature: _____ Date 2/27/19

his form also serves as "Chain of Custody."

CASCADE ANALYTICAL, INC.

Sample Receipt Form

Date Received: 2/27/19 Time Received: 15:35 Initials: DK

Client Name: Pacific Groundwater Project Name: _____

Temperature of cooler upon receipt: 1.7 °C Thermometer ID: OR2

Custody seals: Intact Broken (None) N/A

Chain of Custody Completed:

Client name, address, and phone number;		(Yes)	No
Date and time of sampling;		(Yes)	No
Test requests clear;		(Yes)	No
Completed in ink;		(Yes)	No
Signed by client;		(Yes)	No
All samples received:		(Yes)	No
All samples intact:		(Yes)	No
Sample ID's match COC form:		(Yes)	No
Appropriate containers used:		(Yes)	No
Sufficient amount of sample for analysis:		(Yes)	No
Correct preservative verified:	N/A	(Yes)	No
Air bubbles in VOC, TTHM, or HAA5 samples:	(N/A)	Yes	No
Sample(s) exceed hold time:		Yes	(No)

Type of coolant: (Ice) Blue Ice None Other Comment: _____

Shipping Method: FedEx UPS USPS Brett & Sons (Hand Delivered) CAI Sampled

Shipping Container: (CAI Cooler) CAI Cooler Box Client's Cooler None Other _____

Samples accepted for analysis: (Yes) No

Reason for Rejection: _____

Name of Person Contacted: _____ Date Contacted: _____

Comments: _____