CHAPTER 3.
PREVIOUS STUDIES

Several hydrologic and hydraulic investigations have been conducted in Yakima County over the last 40 years, mostly within the CFHMP study area. Many of the studies were directed toward developing and revising floodplain maps. Flood elevations and floodplain boundaries have long been disputed within the study area and are still being investigated. Other studies reviewed flood reduction alternatives. For example, a 1978 comprehensive flood study proposed a flood reduction plan from which a few recommendations were implemented by the County.

A summary of studies since 1970 provides an overview of historical flood control work and identifies flooding issues that remain a concern. Recommendations made in previous studies are summarized in Table 3-1, along with the status of their implementation.

REVISED PRELIMINARY YAKIMA COUNTY FLOOD INSURANCE STUDY

The revised preliminary Yakima County Flood Insurance Study (FIS), which modifies the original FIS published in 1985 by FEMA, addresses the contention that floodplain boundaries were inaccurate because the original study did not properly take into account hydraulic conditions such as the geometry of the river channel and levees. The final revised FIS and floodplain maps are expected to be published in late 1997.

Flood risk data developed in the FIS are used by the National Flood Insurance Program (NFIP) to determine flood insurance ratings. The NFIP, a federal program established in 1968 and administered by FEMA, allows property owners to purchase federally backed flood insurance. In return for insurance protection, participating communities are required to implement floodplain management measures to reduce flood risks in new developments.

Yakima County and the incorporated cities in the study area currently participate in the NFIP. Table 3-2 summarizes city and County coverage, insurance premiums, and claims from 1978 to 1994. The number of policies indicates only the number of structures insured, not the total number of structures at risk of flood damage.

Estimated Flood Flows

The revised preliminary FIS made estimates of Yakima and Naches River flood flows based on statistical analysis of flow records, Ahtanum and Wide Hollow Creek flood flows based on synthetic frequency curves developed by the COE, and Spring Creek flood flows based on Yakima River discharges (FEMA 1994). Table 3-3 summarizes the 100-year flood flow estimates, which determine the extent of the 100-year floodplain.

To compute the magnitude of the 100-year flood, the revised preliminary FIS used updated flow records accounting for the effects of upper basin storage reservoirs, which have been informally operated for flood control since the 1933 flood. The use of these records reduced the estimates of 100-year flood flow from the original FIS.

TABLE 3-1.
SUMMARY OF RECOMMENDATIONS MADE IN PREVIOUS STUDIES

Study (Source)	Description of Recommendations or Problems Identified	Status
Yakima County Flood Insurance Study (FEMA 1994)	Update floodplain maps upon completing the KOA levee upgrade.	Being completed
	Upgrade the right bank Naches River levee located near the river's mouth to contain the 100-year flood.	Awaiting funding
	Upgrade and tie the right bank Yakima River levee into I-82.	No action
	Modify floodplain maps to reflect the elimination of Spring Creek backwater flooding.	Being completed
Yakima River Flood Evaluation for Yakima County Diking District No. 1 (Irrigation & Hydraulics 1991)	Incorporate changed hydrologic conditions and 100-year protection provided by the federal levee system into floodplain boundary maps.	Being completed
	Raise the KOA levee and levee near Moxee-Hubbard diversion to provide 100-year protection.	Completed
	Modify East Valley flood hazard zones to reflect historical and existing hydraulic conditions.	Being completed
Yakima-Union Gap Flood Control Project (COE 1986)	Update floodplain maps to reflect existing hydraulic conditions.	Being completed
Yakima-Union Gap Flood Damage Reduction (COE 1977)	Control development in unprotected floodway lands.	Regulated
	Raise existing levee system upstream of the old Moxee Bridge.	Completed
	Construct a 2.5-mile right bank and 1.1-mile left bank levee extending downstream from the old Moxee Bridge.	Proposed
	Install control gates on two culverts which pass Spring Creek beneath I-82.	Completed
	Place additional riprap along I-82 embankment near Union Gap.	Completed
Floodplain Information - City of Selah & Vicinity (COE 1973)	No recommendations presented.	—
Floodplain Information - Yakima and Naches Rivers (COE 1970)	The KOA levee provide less than 100-year protection.	Levee upgraded
	Culvert openings in I-82 cause backwater flooding.	Corrected
	Near the mouth of the Naches River, the underpass through the Burlington Northern Railroad allows downstream floodwater inundation.	Considering upgrading Naches levee
	Dikes around borrow pits (gravel extraction pits) are obstructing flood flows and may cause channel migration during flood events.	Migration alternatives being examined

TABLE 3-2.
NATIONAL FLOOD INSURANCE PROGRAM PARTICIPANTS IN THE CFHMP STUDY AREA

Community	Date of Coverage	No. of Policies	Annual Premium	Coverage (x1,000)	Total Claims Since 1978	Dollars Paid Since 1978
Yakima County (unincorporated)	June 5, 1985	442	$163,816	$36,811	148	$716,806
City of Yakima	Dec. 15, 1981	25	$6,944	$2,222	8	$10,212
City of Selah	May 2, 1982	4	$11,237	$616	38	$517,237
City of Union Gap	May 2, 1983	6	$1,633	$324	1	$3,291

SOURCE: FEMA 1997.

TABLE 3-3.
FLOOD INSURANCE STUDY 100-YEAR FLOOD FLOWS

Stream and Location	Drainage Area (sq. mi.)	100-Year Discharge (cfs)
Yakima River at Parker	3,660	56,300
Yakima River Upstream of Naches River	2,135	35,500
Naches River at Mouth	1,125	27,100
Ahtanum Creek at Union Gap	173	2,850
Wide Hollow Creek at Burlington Northern Railroad Bridge	65.7	640
Spring Creek at confluence with Wide Hollow Creek	Data not Available	285

SOURCE: FEMA 1994.

Hydraulic Computer Modeling

Yakima River flood elevations from Wapato Dam to Selah were estimated using the COE's HEC-2 computer program. The program calculates flood elevations based on flood flows and the physical characteristics of the floodplain and river channel. Floodplain topographic information was taken from hydraulic analysis performed in an unpublished 1986 flood reduction study. River channel geometry was surveyed in 1984 and overbank elevations were determined in 1985 from topographic maps using photogrammetrical methods.

The HEC-2 computer model was calibrated by reproducing the water surface elevations measured during the November 1990 flood. To verify the computer model, the 1933 flood was simulated by modifying the topographic cross-sections to reflect 1933 conditions. The 1990 calibration and 1933 verification reproduced floodwater elevations to within 0.5 feet of measured elevations.

Key differences between the 1994 and 1985 computer modeling efforts include the following:

- The new model used improved flood flow estimates as described above.
- The new model accounted for recent upgrades to federal levees that provide 100-year flood protection.

- The new model confined flood flows between COE-certified levees. The 1985 model extended floodplain boundaries beyond federal levees because portions of the levees did not meet FEMA standards. The 1985 flood elevations were computed by confining the flood flow within the levees and extending the water surface elevations beyond the substandard levees. This technique exaggerated the extent of overbank floodplain boundaries.
- I-82 elevations were inspected for the 1994 study and determined to contain the 100-year flood. Levees that fail to meet FEMA elevation requirements between the river and the highway are predicted to overtop but floodwaters are prevented from spreading by I-82.
- Floodplain boundaries estimated in the 1994 study incorporated a private levee near the KOA campground. The levee did not meet FEMA elevation requirements; however, Diking District No. 1 has since raised the levee to federal standards.

Flood Insurance Rate Maps, Floodway Maps, and Flood Boundary Maps

FEMA uses the results of the FIS to prepare Flood Insurance Rate Maps (FIRMs) identifying special flood hazard areas—areas subject to inundation by the 100-year flood. The FIRMs show different types of flood hazard areas, or zones, based on the location of the 100-year floodplain and the type of analysis used to predict water surface elevations. Flood hazard zones are used to determine insurance rates. FEMA delineated the following zones within the study area:

- **Zone A**—Areas subject to inundation by the 100-year flood where base (100-year) flood elevations and flood hazard factors were not determined. Mandatory flood insurance purchase requirements apply in this zone.
- **Zones AE and A1, A4, A7, A8, and A9**—Areas subject to inundation by the 100-year flood determined by the FIS using detailed methods; base flood elevations shown. Mandatory flood insurance purchase requirements apply.
- **Zone B, C, and X**—Areas with moderate or minimal flood hazard from the principal source of flooding in the area. These areas may experience flooding from severe storm events or inadequate local drainage. Flood insurance is available but not required in these zones. Zone X is used on new and revised maps in place of Zones B and C.

Floodway and flood boundary maps, like FIRMs, show 100-year flood boundaries, as well as the floodway as determined by FEMA. A floodway includes the channel of the stream and the adjacent floodplain that must be reserved in an unobstructed condition in order to discharge the 100-year flood without increasing flood levels by more than one foot (less if specified in local ordinances). FEMA requires communities to designate the floodway to avoid significantly increasing upstream flood elevations. To maintain insurance coverage, communities must prohibit development within the designated floodway that would cause any increase in the 100-year flood elevation. Appendix A shows the revised preliminary 100-year floodplain as currently defined in the County's GIS system. The GIS floodplain is based on the most recent information; however, modifications are expected when the final maps are completed and the FIS is adopted.

Expected Revisions

The revised preliminary FIS removes portions of the study area from the 100-year floodplain. FEMA issued preliminary maps in December 1995 for Yakima County and the cities of Yakima, Selah, and Union Gap. Final maps, to be published, may include further modifications to flood hazard zones and base flood elevations based on information collected from the February 9, 1996, flood. Currently, the final maps will include the following modifications:

Yakima County FIRM panel 530217 0740C—The flood hazard zone near Harrison Road, east of the Yakima River, will be reduced from Zone B to Zone C, indicating a minimal flood hazard in this area. Mislabeled base flood elevations of 1,100 and 1,102 feet between I-82 and West Selah Highway will be corrected to 1,102 and 1,104 feet, respectively. The previous base flood elevation, also 1,104 feet will be eliminated.

Yakima County FIRM panel 530217 0720C—Zone B will be extended along Burlington Northern Railroad track, indicating a reduced flood hazard.

Yakima County FIRM panel 530217 1055C—The base flood elevation of 1,005 feet north of West Birchfield Road and west of Keys Road will be eliminated. The area will remain in the floodplain, but specific flood elevations are not listed.

Yakima County FIRM panel 530217 1061C—Zone A1 along Spring Creek will be changed to Zone B. This is due to the elimination of Yakima River backwater flooding following installation of floodgates along Spring Creek. Flood insurance will no longer be required in this area.

City of Union Gap FIRM panel 53029 001C—Zone AE will be change to Zone B along Spring Creek near I-82 due to the elimination of Yakima River backwater flooding following installation of floodgates along Spring Creek. Flood insurance will no longer be required in this area.

City of Union Gap FIRM panel 530229 0002C—The flood hazard zone north of the confluence of Spring Creek and Hollow Creek will be changed from Zone AE to Zones B and C due to the elimination of Yakima River backwater flooding following installation of floodgates along Spring Creek. Flood insurance will no longer be required in this area.

1970 FLOODPLAIN INFORMATION; YAKIMA AND NACHES RIVERS

This report was prepared to help identify flood hazard areas; it did not address flood reduction measures. The report contains maps, flood profiles, and river cross-sections indicating the extent of past and probable future flooding. The following flood issues identified in the report are still being discussed today:

- The left bank levee upstream of SR 24 bridge (KOA levee) does not provide adequate protection (recently upgraded)
- Backwater flooding occurs due to culvert openings in I-82 (box culvert near Union Gap recently upgraded)
- Near the mouth of the Naches River, an underpass through the Burlington Northern Railway needs additional stop-log bulkheads to protect the area

downstream from inundation (not currently necessary due to upgrade of US Highway 12).

- Dikes surrounding borrow pits (locations of former gravel extraction operations) obstruct flood flows and could cause channel shifting during extreme floods.

This was the first study to define the 100-year floodplain in the CFHMP study area. The original 1985 FIS used this information to produce floodplain maps. However, the unpublished 1986 COE study found significant differences in the 100-year flood levels and flood magnitudes. These discrepancies prompted the January 6, 1989, floodplain map revision and subsequent revisions made in the 1994 FIS.

1973 FLOODPLAIN INFORMATION; CITY OF SELAH AND VICINITY

This study identified areas subject to flooding near Selah by examining historical floods and mapping inundation areas for specific flood flows. The study area included the Yakima River from Yakima Canyon to Selah Gap. The work did not present solutions to flood problems, but it did provide information on land use controls to limit future flood damage.

The flooded areas identified in the study are similar to those seen today. East Selah is hit hardest by flooding. Accounts of historical floods describe several homes being evacuated in East Selah, farmlands being lost as the river cut new channels, and the golf course being entirely inundated and covered with silt. The largest recorded flood, 41,000 cfs at Umtanum in 1906, caused extensive agricultural damage. During the 1933 flood, the river flow exceeded the bank-full flow of 10,000 cfs at Umtanum for nine consecutive days and rose at a maximum rate of 4 feet per day.

Flood hazards were also identified by mapping flood inundation areas for the 100-year flood event. The Yakima River 100-year flood flow was estimated at 39,000 cfs at Selah Gap, slightly higher than current estimates (35,500 cfs). Identified flooded areas are similar to those determined in the 1994 FIS; as the Yakima River leaves Yakima Canyon the floodplain is narrow and confined between the Burlington Northern Railroad grade to the east and high ground to the west. Flooded areas widen significantly after Harrison Road bridge as floodwater spreads out over the Selah Valley. Flood boundaries extend east from the Burlington Northern Railroad grade into East Selah. Downstream, floodwaters again become constricted as they approach the golf course and Selah Gap.

1978 YAKIMA-UNION GAP FLOOD DAMAGE REDUCTION REPORT

This flood damage reduction report, prepared by the COE, was a comprehensive examination of floodplain management in the Yakima-Union Gap area. An interim report was issued in May 1977 and a draft environmental impact statement (EIS) was completed in 1978.

The plan developed in this report was intended to reduce flood damage potential and threats to public welfare within existing economic constraints. The report assessed levels of protection provided by existing flood control facilities, determined current and future potential for flood damage, and examined alternative flood reduction measures with regard to engineering and economic feasibility and associated environmental impact. The costs and benefits of the seven alternatives evaluated are summarized in Table 3-4.

TABLE 3-4.
SUMMARY OF ALTERNATIVES EVALUATED IN THE 1977 FLOOD REDUCTION STUDY

Alternative	Average Annual Flood Damage	Average Annual Benefits	Average Annual Costs	Benefit-to-Cost Ratio
1. No Action	$825,100[a]	$0	$0	Not Applicable
2. Floodplain Management Alone	$825,100[a]	$428,700[b]	$245,300[c]	1.7
3. Floodplain Management with Additional Upstream Storage	Not Evaluated			
4. Floodplain Management with Levees	$583,400	$508,700[d]	$261,500	1.9
5. Floodplain Management with Channel Modification	$583,400	$635,900[e]	$1,280,000	-0.5
6. Purchase Development Rights	$583,400	$0	$9,000	0
7. Purchase Floodway	$583,400	$0	$34,200	0

a. Assumes no restriction on future development
b. Includes damages prevented ($241,700) and flood insurance payments ($187,000)
c. Includes flood insurance premium ($208,000), cost of administering floodplain management ($22,000), and floodproofing costs ($15,300)
d. Includes damages prevented ($419,700), area redevelopment ($70,000), elimination of future floodproofing ($15,300), and intensification benefits ($3,600)
e. Includes area redevelopment benefits ($110,000)
SOURCE: COE 1977

Alternative 1—No Action

This alternative called for maintaining the status quo of minimal floodplain management, which would allow the continued encroachment of development into the floodplain and result in greater flood damage. No structural or nonstructural measures would be implemented. Alternative 1 was evaluated as a baseline for comparison with other alternatives. Under this alternative, no flood reduction benefits would be realized and estimated annual flood damages were expected to grow from $465,900 in 1976 to $1,758,000 by the year 2032.

Alternative 2—Floodplain Management Alone

Alternative 2 would maintain existing flood management conditions, with the addition of land use restrictions, an early warning system, and floodproofing for new construction. This alternative would provide no protection for current floodplain residents, but would reduce future increases in flood damage. Estimated annual flood damages would be $765,200 by the year 2032, a 56 percent reduction from Alternative 1. Annual average benefits were estimated at $428,700, annual costs at $245,000, and continued flood damages estimated at $583,400 over the life of the project. This alternative has a positive benefit-to-cost ratio, but would not eliminate the flood threat to current floodplain residents.

Alternative 3—Floodplain Management with Additional Flood Control Storage

A preliminary review was conducted to examine the feasibility of constructing additional reservoirs in the upper Yakima basin. Twelve potential reservoir sites, proposed by the Bureau of Reclamation and shown in Figure 3-1, were examined. It was concluded that such projects were economically unjustified, environmentally unsound, or not technically feasible, except for the Bumping Lake Enlargement Project. The Bumping Lake project, proposed by the Bureau of Reclamation and the U.S. Fish and Wildlife Service, would be used to enhance in-stream flows for fisheries. Additional storage projects would negate Bumping Lake enhancements, require excessive development costs, and produce significant adverse environmental impact. Alternative 3 was dropped from further development based on this preliminary evaluation. The Bumping Lake proposal has remained in the planning stage.

Alternative 4—Floodplain Management with Levees

Alternative 4 incorporated structural alternatives along with the floodplain management measures proposed in Alternative 2. The structural measures included improvements to existing levees above Moxee Bridge, construction of two levees below Moxee Bridge, application of riprap along I-82, and installation of control structures at the Spring Creek culvert crossings under I-82. The levees upstream of the Moxee bridge would be upgraded from a 25-year to a 200-year level of flood protection. The levees downstream of Moxee bridge would be upgraded from 2-year to 100-year flood protection.

An additional 3,300 acres of suburban and agricultural lands would be protected under this alternative. Average annual flood damages in the year 2032 would be $253,700, a 77 percent reduction from Alternative 2. Estimated average annual benefits would be $508,700, with average annual costs estimated at $261,500.

Alternative 5—Floodplain Management with Channel Modification

This alternative included dredging the Yakima River to increase conveyance capacity and reduce flood levels. An evaluation was made for straightening and dredging the channel between Moxee Bridge and Ahtanum Creek to convey the 100-year flood. The analysis assumed that upstream levees would be upgraded.

Under this alternative, estimated average annual benefits would be $635,900. Estimated average annual costs, which include extensive riprap, were computed at $1,280,000. Cost, maintenance requirements associated with additional sediment removal, and environmental impacts made this alternative infeasible.

Alternative 6—Purchase of Development Rights

This alternative called for the purchase by public agencies of development rights on 850 undeveloped acres in the Yakima River floodway downstream of Moxee Bridge at a price equal to the loss of market value associated with further land use restrictions. Only pasture, open space, general recreation, and wildlife habitat would be allowed in the floodway. This alternative offered no additional benefits; existing floodplain regulations already limit floodway development.

Alternative 7—Purchase of Floodway

This alternative considered purchasing the floodway downstream of Moxee bridge for conversion to a regional park. Cost of land acquisition was estimated at $548,000. This alternative, like Alternative 6, would provide minimal additional benefits because existing floodplain regulations already limit floodway development.

Recommended Plan

The seven alternatives were compared for benefits and adverse effects in reducing potential flood damage. Alternative 4 was selected as the recommended plan based on its ability to maximize national economic benefits and limit environmental impact while meeting the planning objective. The recommended plan consisted of the following:

- Control the development of 2,300 acres of unprotected floodway lands
- Raise the existing levee system above Moxee Bridge for 200-year flood protection and provide additional riprap protection. Left bank improvements include upgrading the Moxee Bridge-to-Roza Wasteway levee, the Burlington Northern Railroad embankment levee, and the cross levee extending from the railroad embankment. Right bank improvements include upgrading levees from Moxee Bridge to the Burlington Northern Railroad bridge crossing the Naches River
- Construct two levees extending from the Moxee Bridge to a 100-year flood capacity; a 2.5-mile right bank levee and 1.1-mile right bank levee to protect the City of Yakima's regional sewage treatment facility
- Install drainage control gates on the two culverts that conduct Spring Creek under I-82 (completed by Yakima County and WSDOT).
- Protect I-82 by placing additional riprap on the highway embankment near Union Gap (completed by WSDOT).

The recommended project had a benefit-to-cost ratio of 1.9 to 1, but was not constructed as a federal project due to lack of local support. However, since the issuance of this report, Diking Improvement District #1 has made improvements to the KOA levee upstream of Moxee Bridge to provide 100-year protection, Yakima County and WSDOT installed control structures on the Spring Creek culverts, and WSDOT placed additional riprap on the I-82 embankment (Simonson, R., 15 March 1995, personal communication).

1986 YAKIMA-UNION GAP FLOOD CONTROL PROJECT

This unpublished report COE, completed in 1986, examined floodplain boundaries and found significant differences from an earlier flood study conducted in May 1970, triggering an official request to modify the existing floodplain boundary maps. The modification, called a Letter of Map Revision (LOMR), was issued on January 6, 1989, making this the official FIS. However, this study estimated floodplain boundaries by modeling the flood flow confined within the levee system and, because some levees did not meet FEMA standards, extending the levee-confined water surface elevations into the floodplain. This technique exaggerated the extent of the overbank floodplain boundaries. No adjustments were made to account for levee failures or for levee sections with elevations exceeding FEMA requirements. These problems

led to the release of an additional LOMR dated May 16, 1994. The revised preliminary FIS incorporated the 1994 LOMR to reflect current levee conditions.

1991 YAKIMA RIVER FLOOD EVALUATION FOR YAKIMA COUNTY DIKING DISTRICT NO. 1

The 1991 Yakima River Flood Evaluation, conducted by Irrigation & Hydraulics Unlimited for Yakima County Diking District No. 1, sought to determine whether East Valley base flood elevations and flood hazard zones were overestimated in previous studies. Analysis included review of flood frequencies, historical floods, flood risks, and previous flood studies, focusing on the East Valley area, the Diking District's primary service area. Recommendations were made for protection of properties in the East Valley and potential problems with previous flood studies were identified. The study objectives were as follows:

- Estimate flood flows using data that account for Bureau of Reclamation reservoir management
- Analyze the data used to develop previous FIRMs and compare those data to historical water surface elevations
- Calculate the Yakima River flow that would overtop SR 24 and the Moxee-Hubbard diversion
- Analyze the impact of the SR 24 bridge on flood elevations
- Evaluate the flooding impact of gravel bar and vegetation growth upstream of the SR 24 bridge on flooding.

Estimated Flood Flows

Following the 1933 flood, the Bureau of Reclamation began informal operation of upper basin reservoirs to reduce flood flow. To assess the impact of reservoir management on flood flows, a flood frequency analysis of winter floods was performed for the entire 1909-1990 period, as well as for 1933 to 1990, omitting the years prior to the use of the reservoirs.

Results of the flood frequency analysis for the Yakima River at Parker, completed by Irrigation & Hydraulics Unlimited and shown in Table 3-5, indicate that flood flows are reduced by reservoir management for all floods except the two-year flood. This demonstrates the capacity of the reservoirs to reduce flow during extreme events and increase it during low-flow events. Recent floodplain mapping takes the effect of the reservoirs into account. FEMA still uses the flows shown in Figure 3-3.

Review of Historical Floods

The 1933, 1948, and 1990 flood events were reviewed to assess historical flood damages in the East Valley. East Valley flood damage was described as generally minor for these flood events (see Chapter 4).

During the 1933 flood, the largest flood of record, moderate flooding was experienced in East Valley. West Birchfield Road had water extending over the road for 800 feet. The depth of flow was computed to be 9 inches, resulting in a calculated flow of approximately 2,000 cubic feet per second (cfs). The flow originated from the north and was not a result of downstream

backwater. During the 1948 flood, floodwaters entered East Valley through a small levee failure south of Terrace Heights Boulevard. Damage was minimal as floodwaters were primarily confined to fringes of the Yakima River. During the 1990 flood, floodwaters did not enter the East Valley. Some water seeped through the levees, causing only minor damage.

TABLE 3-5.
RESULTS OF FLOOD FREQUENCY ANALYSIS

Flood Frequency (years)	1909 - 1990 Flood Flows (cfs)	1933 - 1990 Flood Flows (cfs)
200	70,536	66,515
100	57,542	51,809
50	46,248	44,472
25	36,804	35,204
10	24,697	24,519
2	8,633	9,122

SOURCE: Irrigation & Hydraulics 1991

Issues Identified as Affecting Flood Risks

Three issues were identified as affecting flood risks in the East Valley: federal levee construction, informal reservoir management for flood control, and construction of SR 24 across the Yakima River.

The federal levee system, completed in 1948, greatly reduced flood risks (see Chapter 5). Right and left bank levee segments extend from the Naches River confluence to the old Moxee bridge. The system was constructed to contain floods equal to the 1933 flood, and provides protection for many floodplain residents.

Flood risks also decreased when the Bureau of Reclamation began informal operation of upper basin storage reservoirs for flood control following the 1933 flood. The reservoirs store floodwaters, thereby reducing flood flows and flood risk. Reservoir flood flow reduction is a function of available storage capacity, the duration of the flood, and the amount of runoff during the flood.

Construction of the new SR 24 bridge was identified as increasing flood risk by constricting the Yakima River and raising floodwater elevations. A left bank levee directly upstream of the bridge (the KOA levee) faces increased flood risk as a result. This levee is not high enough to contain the 100-year flood; floodwaters would overtop the levee and cause additional damage. Recommendations were made to raise the levee or increase the size of a downstream culvert to convey overtopping flow back into the Yakima River main channel.

Assessment of Previous Studies

The Diking District's flood evaluation included review of FEMA's 1985 Flood Insurance Study and the unpublished 1986 COE study to assess the accuracy of their predictions for East Valley floodplain boundaries and base flood elevations. The review identified the following concerns about the previous studies:

- Flooding conditions may have been overestimated through the use of a one-dimensional steady-state computer model to predict floodplain boundaries
- Improper computer model cross-sections were used near the SR 24 bridge, causing the computer model to be unstable
- An entire left bank levee was modeled to fail even though only a portion of the levee was below FEMA standards
- The flood studies should have integrated historical flood data
- It is improper to compute floodplain boundaries by confining the flood flow within the levees and extending the confined water surface elevations beyond substandard levees.

Key Results

The Diking District's study highlighted the following findings and recommendations as the key results of the evaluation; many of the recommendations were incorporated into the 1994 FIS:

- Flood magnitudes estimated in the evaluation were consistent with previous work performed by FEMA and COE
- FEMA-estimated floodway elevations are consistent with historical floods
- FEMA estimates of flood elevations north of SR 24 are low due to the poor cross-sections used in FEMA's computer model
- One-dimensional computer modeling should not have been used to determine overbank flood elevations in previous studies
- The 1985 FEMA FIS should have incorporated historical flood elevation data
- It was improper for previous studies to have defined floodplain boundaries by extending floodway elevations beyond the levees and into the floodplain
- FEMA's floodplain boundary maps should take into account the protection provided by the levee north of West Birchfield Road. The FIS incorrectly represented the levee north of SR 24 to Terrace Heights Boulevard as one levee system. The levee north of West Birchfield Road should have been represented as providing 100-year flood protection, and the levee south of West Birchfield Road should have been represented as a separate system that would fail during the 100-year flood
- The levee south of West Birchfield Road (KOA levee) should be raised by 5 feet to provide 100-year flood protection and the dike's river slope should be modified from 2:1 to 3:1
- The levee near Moxee-Hubbard diversion should be raised to provide 100-year flood protection
- The levee north of SR 24 (KOA campground levee) should be raised to provide 100-year flood protection
- East Valley flood hazard zones should be modified to reflect historical and existing conditions
- Gravel deposition near the SR 24 bridge does not significantly affect flood depths.