Upper Yakima River
Comprehensive Flood Hazard
Management Plan
--2018 Cowiche Addendum--

YAKIMA COUNTY

CITY OF YAKIMA
INCORPORATED 1886

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

Mid-Columbia
FISHERIES
ENHANCEMENT
GROUP

CONFEDERATED TRIBES AND BANDS
YAKAMA NATION
TREATY OF 1855

ACKNOWLEDGEMENTS

This Upper Yakima Comprehensive Flood Hazard Management Plan, 2018 Cowiche Addendum was prepared by Yakima County Public Services Water Resources Division with the assistance of citizens, stakeholder groups, landowners and agency representatives listed below. We thank them for the time and effort they spent improving the final product.

UPPER YAKIMA RIVER CFHMP ADVISORY COMMITTEE (2017-2018)	
Voting Members	Affiliation
Mr. Scott Anfinson	Washington State Department of Transportation
Mr. Eric Bartrand	Washington State Department of Fish and Wildlife
Mr. David Brown	City of Yakima Water/Irrigation
Mr. Joseph Calhoun	City of Yakima Planning
Mr. Bruce Dekker	Lake Aspen Homeowner's Association
Mr. Jeff Emmons	Yakima County Office of Emergency Management
Mr. Joel Freudenthal	Yakima County Flood Control Zone District
Mr. David Garretson	Private Landowner
Mr. Bob Ingham	Private Landowner
Mr. John Marvin	Yakama Nation
Ms. Keelan McPhee	Yakima County Planning Division
Mr. Mike Price	City of Yakima Wastewater/Stormwater
Mr. Bill Sauriol	Washington State Department of Transportation
Mr. Brett Sheffield	City of Yakima Chief Engineer
Ms. Katrina Strathman	Mid-Columbia Fisheries Enhancement Group
Alternates and Non-Voting Members	
Mr. Jason Clapp	Yakima County Office of Emergency Management
Mr. Mark Cleaver	Yakima County Roads Maintenance
Ms. Joan Davenport	City of Yakima Community Development
Mr. Glenn Denman	Lake Aspen Homeowner
Mr. Donald Gatchalian	Yakima County Environmental Services Director
Ms. Michelle Gilbert	Washington Department of Ecology
Mr. Byron Gumz	Yakima County Planning Division
Mr. Perry Harvester	Washington State Department of Fish and Wildlife
Mr. David Haws	Yakima County Flood Control Zone District
Mr. Terry Keenhan	Yakima County Flood Control Zone District
Mr. Dale Meck	Yakima County Flood Control Zone District
Ms. Margaret Neuman	Mid-Columbia Fisheries Enhancement Group
Mr. Connor Parrish	Mid-Columbia Fisheries Enhancement Group
Mr. Matt Pietrusiewicz	Yakima County Engineer
Mr. Scott Schafer	City of Yakima Public Works
Mr. Horace Ward	Yakima County Office of Emergency Management

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AV—Assessed Value
BFE—Base Flood Elevation
BOR—Bureau of Reclamation
CAN—Community Alert Network
CAO—Critical Areas Ordinance
CFHMP—Comprehensive Flood Hazard Management Plan
cfs—Cubic feet per second
CIP—Capital Improvement Program
COE—U.S. Army Corps of Engineers
CRS—Community Rating System
CTED—Washington Department of Community, Trade and Economic Development
DNR—Washington State Department of Natural Resources
Ecology—Washington State Department of Ecology
EIS—Environmental Impact Statement
EOC—Emergency Operations Center
EPA—U.S. Environmental Protection Agency
EHSB—Engrossed House Substitute Bill
ESSB—Engrossed Senate Substitute Bill
FCAAP—Flood Control Assistance Account Program
FEMA—Federal Emergency Management Agency
FHO—Flood Hazard Ordinance
FHWA—Federal Highway Administration
FIRM—Flood Insurance Rate Map
FIS—Flood Insurance Study
Foundation—Yakima Greenway Foundation
FOZ—Floodplain Overlay Zone
FSA—Farm Services Agency
GIS—Geographical Information System
GMA—Growth Management Act
GO—General Obligation (bond)
HPA—Hydraulic Project Approval
HRCA—Hydrologically Related Critical Area
IDB—Industrial development bond
LID—Local Improvement District
LOMR—Letter of Map Revision
MDNS—Mitigated determination of non-significance
MOA—Memorandum of agreement
NAWQA—National Water Quality Assessment
NFIP—National Flood Insurance Program
NRCS—National Resource Conservation Service
O&M—Operations and Maintenance
OEM—Office of Emergency Management
OHWM—Ordinary high-water mark
PEO—Public education officer
PL—Public Law
RAP—Rural Arterial Program
RCW—Revised Code of Washington
ROW—Right-of-way
SCS—U.S. Department of Agriculture Soil Conservation Service
SEPA—State Environmental Policy Act
SFHA—Special Flood Hazard Area
SMP—Shoreline Master Plan
SR—State Route
TMDL—Total Maximum Daily Load
UGA—Urban Growth Area
USDA—U.S. Department of Agriculture
USGS—U.S. Geological Survey
WAC—Washington Administrative Code
WDFW—Washington State Department of Fish and Wildlife
WSDOT—Washington State Department of Transportation
YUA—Yakima Urban Area

UPPER YAKIMA CFHMP
2018 COWICHE ADDENDUM

EXECUTIVE SUMMARY

This addendum to the 2007 Upper Yakima River Comprehensive Flood Hazard Management Plan (CFHMP) addresses the flood risks posed by Lower Cowiche Creek and its confluence with the Naches River, located within the original CFHMP study area. These risks were not previously addressed in the earlier CFHMP due to a lack of available information.

Recent studies and flood events have demonstrated the current risks posed by failing or undersized infrastructure in this area towards the residents of the City of Yakima and emphasized the need to plan into the future for revised flood hazard response, protective actions, and flood hazard management for this focused study area.

CFHMP REQUIREMENTS

As in the case of the 1998 and 2007 Upper Yakima CFHMP, this addendum follows the Ecology process for flood hazard management plans redefined by the 1991 Ecology guidelines. This flood hazard management process uses a balanced approach to flood damage protection, resource protection, environmental enhancement, and land development.

The CFHMP must identify the flood issues, flood management goals, and rank appropriate structural and nonstructural measures to reduce flood damage. The study area may include the entire watershed or, at a minimum, the 100-year floodplain within a reach of the watershed, and the reach must be of sufficient length that a comprehensive evaluation can be made of its flood problems. The completed CFHMP and its recommendations provides the technical foundation for future flood management measures.

The CFHMP must be adapted by the local jurisdictions within the established study area prior to submission to Ecology for approval. An approved local and state CFHMP facilitates grant funding for the plan's recommendations. To ensure that fishery resources are maintained, the WDFW has review authority for the CFHMP regarding recommended flood projects. Ecology is required to consult with WDFW before approving any CFHMP.

ADVISORY COMMITTEE

Public and agency involvement was achieved by forming an Advisory Committee whose members—representatives of public and private organizations and agency representatives—provided input through eleven meetings and document review. The committee had 15 voting and 16 non-voting members, met 11 times and provided plan goals and objectives, developed alternatives and recommended actions.

The public provides input for the CFHMP through the SEPA process and any hearings required by the local jurisdictions prior to adoption. Additional agency representatives were contacted as

needed throughout the plan preparation, and contact was maintained with Ecology to ensure compliance with Ecology requirements.

HYDRAULIC ANALYSES

Identification of flood vulnerabilities and issues and the development of mitigation alternatives was based on flood data and the hydraulic analyses provided in Section 6.0. The analyses were developed at a planning level from the existing limited information, the CFHMP timeframe and funding. Fortunately, recent LiDAR data at high resolutions was available from a November 2017 flight, in addition to findings from the FEMA FIS study. The analysis of past events and hydraulic modeling has highlighted vulnerabilities and opportunities for flood response actions with substantive benefits.

The committee identified and ranked the flood issues in Table ES-1 below.

TABLE ES-1
2018 ADVISORY COMMITTEE RANKING OF FLOODING ISSUES

ID	Flooding Issue	Rank
LC1	Inadequate facilities in floodplain, and hydraulic capacity of Lower Cowiche Creek to prevent flood overflows to City	1
LC2	Floodplain and Flood Risk Mapping not reflective of risk	2
LC3	Improve Public Awareness and Flood Insurance knowledge	2
LC4	Improve Formal Interagency coordination	2
LC5	Revision and Consistency of Flood Hazard, Critical Areas & Shoreline Ordinances for this location	2
LC6	Inadequate flood forecasting system	2 or 3
LC7	Define Clear Action Points to Initiate Emergency Response Activities for Cowiche Creek overflows	3
LC8	Funding for Flood Control Works and Restoration Project elements.	3
LC9	Extensive Flood Routing in (and outside of) the City of Yakima	4
LC10	Stability of berms on Lake Aspen/Myron/Willow & Aspen drainage	4
LC11	Risk to US12 during major flood events	5
LC12	Threat of flooding to State, County, and City Roads	5
LC13	Lack of Space for Cowiche Creek Channel Migration	6
LC14	Availability of Centralized GIS Data & Modeling Impacts in planning and inventory	6

TABLE ES-1 2018 ADVISORY COMMITTEE RANKING OF FLOODING ISSUES		
ID	**Flooding Issue**	**Rank**
LC15	Ownership and Standards for new/upgraded Flood Control Facilities	6
LC16	Development pressures in affected areas promoting additional harm	6
LC17	Lack of space for Cowiche Creek low flow Channel Migration	6 or 7
LC18	Operation and Maintenance of Flood Control Facilities	7
LC19	Acquisition/Preservation of Floodplain Open Space	8
LC20	Loss of Channel Capacity due to sediment accumulation and lateral confinement	9
LC21	Sediment accumulates in reach, reducing flood capacity	9
LC22	Nelson Dam and Fruitvale infrastructure reducing hydraulic capacity downstream of US12	9
LC23	Erosion/Loss of Agricultural Land	

The advisory committee were unable to rank some issues before others so such situations are given the same rank.

RECOMMENDED ACTIONS

The current risk and urgency for risk mitigation within the Cowiche Creek study area led to the need to develop near, short and long-term recommendations that match the risk with the agencies' ability to provide the required concurrent infrastructure modifications that reduce current flood hazard.

Near-term mitigation actions would precede the next flood season and incorporate more flood warning and response measures pending more structural actions, long-term actions would provide the significant infrastructure changes with long lead times, while short-term actions must bridge the intervening period by planning and aligning ongoing infrastructure changes with the long-term plan developed here. As several agencies will be involved in this effort, the plan must provide enough detail to develop individual capital improvement plans (CIPs).

The near-term priorities with respect to potential flood events are: flood warning, minimizing overflows toward the city while notifying the public, including evacuation and preparedness, lessening exposure of existing development through redirection of flows while intercepting flood overflows from vulnerable areas as far upstream as practical. Near term actions were put in place for the upcoming 2017/2018 flood season prior to this plan and are contained in Appendix A. The

most beneficial of these near-term actions is to reroute any Cowiche overflows back into the Naches below reaching the Fruitvale and 40th interchange. In this regard a Memorandum of Understanding is being formed between the City, WSDOT and the FCZD, which will extend beyond the first flood season.

It is evident from the hydraulic capacity computations that the following long-term replacements in Table ES-2 will be required and that the short-term actions are required to reduce risk in the interim. They are listed in order of priority. The recommendations' explanatory text is abridged below. The full recommendations with explanatory text and costs are contained in the recommendations section. The first long-term structural action will be S2 which must lower the channel by 3 feet to allow sufficient upstream capacity for the 100-year flood overflows to be contained**.** Leads are provided in the table, the first in each item is considered responsible for ensuring implementation.

TABLE ES-2 STRUCTURAL RECOMMENDATIONS – LONG-TERM

ID	Recommendation	Lead Entities
S1	**Design and Implementation of all structural recommendations in PL1 will be coordinated with the overall design in Recommendation PL8 and updated during implementation of each structural element.**	City, FCZD, WSDOT
S2	**Replace Cowiche channel between US12 and the Naches confluence with capacity to pass 100-yr flood and remove Cowiche overflows into City from 100-yr flood maps.**	FCZD
S3	**Coordinate removal of Fruitvale infrastructure at Cowiche-Naches confluence with downstream channel design.**	City, FCZD
S4	**Replace Cowiche channel between Powerhouse Road and US12 with capacity to pass 100-yr flood and remove Cowiche overflows into City from 100-yr flood maps.**	City
S5	**Provide levees in the reach between Powerhouse Road and US12 that prevent Cowiche overflows into the City and allow for enrollment in PL84-99 program, certification and accreditation, as well as connection to a new US12 bridge.**	City
S6	**Replace US12 bridge capacity to pass 100-yr flood and remove Cowiche overflows into City from 100-yr flood maps**	WSDOT
S7	**Remove city storage pond to increase hydraulic capacity for Recommendations S4, S5 & S6.**	City
S8	**Improve Naches Trail Bridge downstream of US12 as necessary to pass 100-yr flood with planned wider channel.**	County, FCZD
S9	**Interim structural elements will be required east of 40th Avenue based on the Cowiche overflow drainage study.**	City, WSDOT
S10	**Spillway and drainage improvements for Myron and Willow dams.**	Landowners

TABLE ES-2 STRUCTURAL RECOMMENDATIONS – LONG-TERM		
ID	**Recommendation**	**Lead Entities**
S11	**City culvert improvements to route City overflows from Cowiche Creek**	City
S12	**Replace Powerhouse bridge with capacity to pass 100-yr flood and remove Cowiche overflows into City from 100-yr flood maps.**	City

The short-term recommendations are provided below by category: planning, flood preparedness and public awareness and listed within each by priority.

TABLE ES-3 PLANNING RECOMMENDATIONS – SHORT-TERM		
ID	**Recommendation**	**Lead Entities**
PL1	**Provide a new Cowiche Creek riverine infrastructure corridor between Powerhouse Road and the Naches River to eliminate Cowiche overflows into the City.**	City, WSDOT, FCZD
PL2	**Maintain interagency coordination, necessary flood fight ILAs and information exchange until existing Lower Cowiche corridor replaced.**	City, FCZD, YVOEM, WSDOT
PL3	**Adopt the new Cowiche Creek FEMA preliminary maps for new development and use overflow scenario map as guidance.**	City, County
PL4	**Appoint a Planning Task Force to minimize Community risk from Cowiche Creek overflows to ensure planning and building measures are in step with structural measures over all phases of exposure.**	City, County
PL5	**Incorporate the 2017 flood extent map during the interim period for flood protection on development for drainage, stormwater, building design, siting, and layout.**	City
PL6	**Provide Contingency Planning across jurisdictions & agencies as a living document for the following overflow scenarios: current day, the intervening period when individual corridor elements are replaced, and upon completion of rehabilitated corridor.**	City, YVOEM, FCZD
PL7	**Provide an ILA to locate funding sources (local, state and federal) and secure funding to replace the Lower Cowiche stream and stream crossing corridor and increase reliability of flood warning.**	City, County, WSDOT
PL8	**Provide a rehabilitation design that is hydraulically coordinated to replace the existing channel and crossings between Powerhouse Road and the confluence with the Naches River (Lower Cowiche)**.	City, FCZD, WSDOT

TABLE ES-3 PLANNING RECOMMENDATIONS – SHORT-TERM		
ID	**Recommendation**	**Lead Entities**
PL9	**Incorporate multi benefit considerations with the coordinated corridor design such as trails, open space, agricultural and habitat.**	City, County
PL10	**Acquire required land to increase the current Lower Cowiche corridor in accordance with goals and design standards (noted in Recommendation PL8).**	City, FCZD
PL11	**Assess Cowiche basin need for new snow, precipitation and stream gages to reduce risk and seek partners for regional small basin needs on the west slopes of Naches and Upper Yakima region (Cowiche, Wide Hollow and Ahtanum). Partners should include basin data collection agencies: USGS, Ecology and BOR**	FCZD, City
PL12	**Organize community-level funding districts of local funding that construct and maintain approved protective risk-reduction features.**	City
PL13	**Install the coordinated Cowiche corridor channel elements from downstream to upstream order to maximize upstream function, minimize cost and reduce transitory impacts.**	FCZD, City
PL14	**Provide a Cowiche Creek overflow drainage study through the City**.	City, Landowners
PL15	**Review safety and drainage of Myron and Willow lake dams in response to Cowiche Creek overflow drainage for current day, interim and rehabilitated condition.** The dam owners need to assess dam safety issues related to Cowiche Creek overflows due to consequences of low-lying development and limited drainage	Landowners
PL16	**Ensure all owners of critical infrastructure (defined by consequences of failure) develop operational plans and funding to sustain structure integrity.**	City, WSDOT
PL17	**Provide during SEPA or Shorelines comment period comment to City on development proposals in the overflow area regarding facility siting and layout based on mapping, inundation areas.**	FCZD, City
PL18	**Coordinate existing ordinances to establish ability to provide interim and long-term protection from Cowiche creek overflows and/or dam failures.**	City
PL19	**Allow within the planning and design process of structural elements for the insertion of trails and future Greenway overlay to connect Naches and Cowiche trails.**	WSDOT, City, County, Greenway, WO Douglas
PL20	**Establish a gravel management plan in the Lower Cowiche corridor to reduce flood and habitat risk over the short and long-term.**	City, FCZD
PL21	**Emphasize more natural riverine processes downstream of US12 to maximize habitat enhancement for current and future species.**	FCZD

TABLE ES-3 PLANNING RECOMMENDATIONS – SHORT-TERM		
ID	**Recommendation**	**Lead Entities**
PL22	**Identify location for sediment removal and monitoring, and removal of identified sediment, especially upstream of US12.** As per recommendation 20 to limit disturbances	City, FCZD
PL23	**Provide a future Cowiche Upper Basin CFHMP from the siphon upstream to South and North Cascade branches including hydrological effects including sediment releases or pulses on the reach**	FCZD

TABLE ES-4 FLOOD PREPAREDNESS RECOMMENDATIONS – SHORT-TERM		
ID	**Recommendation**	**Lead Entities**
FP1	**Form ILAs to allow cross coordinated flood response measures.**	City, FCZD, County, WSDOT
FP2	**Provide a Cowiche Creek Overflows Flood Response Plan that includes a public Notification Plan.**	City, FCZD, YVOEM
FP3	**Provide flood fight locations on Cowiche Creek levee to minimize overflows.**	City, Landowners
FP4	**Provide emergency flood fight facilities to intercept overflows and reroute west of 40th interchange.**	City, WSDOT, YVOEM
FP5	**Emphasize short-term flood routes, maximizing Cowiche Creek overflows returns back to the Naches as far east as practical and identified in City Drainage study.**	City
FP6	**Increase the gaging stations in the upper watershed to increase flood response time at Lower Cowiche levee.**	City, FCZD, Ecology, USGS, USBOR
FP7	**Provide timely public notice of flood threat status to allow for timely private mitigation response.**	YVOEM
FP8	**Design emergency facilities to minimize fish stranding.**	City, WDFW

TABLE ES-5 PUBLIC AWARENESS RECOMMENDATIONS – SHORT-TERM		
ID	**Recommendation**	**Lead Entities**
PA1	**Increase general Public Awareness of current risk and measures.**	City, FCZD
PA2	**Advise landowners on interim and long-term potential for flooding.**	City
PA3	**Share Action Plans.**	City, FCZD, OEM
PA4	**Encourage local protections for individual infrastructure such as ring dikes around homes, barns, shops.**	City
PA5	**Awareness of new FEMA Maps and limitations.**	City, FCZD
PA6	**Engage upper management and politicians in plan for flood hazard mitigation.**	City, FCZD
PA7	**Garner public support for capital measures to remove flood risk areas through capital expenditures.**	City, FCZD
PA8	**Locate best Web sites(s) for public notification and use YVOEM response abilities as emergency declared.**	FCZD, YVOEM
PA9	**Notify public of flood threat status to allow private mitigation response.**	City, YVOEM

Implementation of the short-term recommendations above would be concurrent across the categories: planning, flood preparedness and public awareness. Implementation, if limited by funding, should reflect the suggested priority within each table, and can be concurrent. Many short-term recommendations will diminish or cease with completion of the long-term recommendations.

UPPER YAKIMA CFHMP
2018 COWICHE ADDENDUM

1.0 INTRODUCTION

This addendum to the 2007 Upper Yakima River Comprehensive Flood Hazard Management Plan (CFHMP) addresses the flood risks posed by Lower Cowiche Creek and its confluence with the Naches River, located within the original CFHMP study area. These risks were not previously addressed in the earlier CFHMP due to a lack of available information. The original CFHMP study area is presented in Figures 1-1 and 1-2. The amendment study area is shown in Figure 1-3.

Recent studies and flood events, shown in Figure 1-4, have highlighted the current risks posed by failing or undersized infrastructure in this area towards the residents of the City of Yakima, and emphasized the need to plan into the future for revised flood hazard response, protective actions, and flood hazard management for this focused study area.

CFHMP REQUIREMENTS

The CFHMP must identify and rank appropriate structural and nonstructural measures to reduce flood damage. The study area may include the entire watershed or, at a minimum, the 100-year floodplain within a reach of the watershed. The reach must be of sufficient length that a comprehensive evaluation can be made of its flood problems. The completed CFHMP provides the technical foundation for future nonstructural and structural flood hazard management measures.

State law requires that a CFHMP describe the area where any proposed project is located and the types and locations of existing flood problems. A complete description of the information that a CFHMP must include is contained in WAC 173-145-040. Among the required information is certification from the Washington Department of Commerce that the local emergency management organization is administering an acceptable comprehensive emergency operations plan. The law allows up to three years for local authorities to complete and adopt a CFHMP. Applications for project funding under FCAAP require the county engineer to certify that a CFHMP plan has been completed and adopted or is in preparation. Ecology must approve the final CFHMP, and the municipality must subsequently adopt the plan.

Required Consultation with Other Agencies

A variety of state and federal agencies are involved in key river issues such as fishery resources, wildlife habitat, and public use. The presence of fishery resources, primarily salmon and steelhead, is a key consideration in performing any flood hazard management activities in and around the waters of the State of Washington. The potential loss of fish habitat resulting from construction in and next to rivers has been a major concern of fisheries agencies, sports fishermen, and Native American groups.

To ensure that fishery resources are maintained, the WDFW has review authority for most phases of FCAAP. Ecology is required to consult with WDFW before approving any CFHMP.

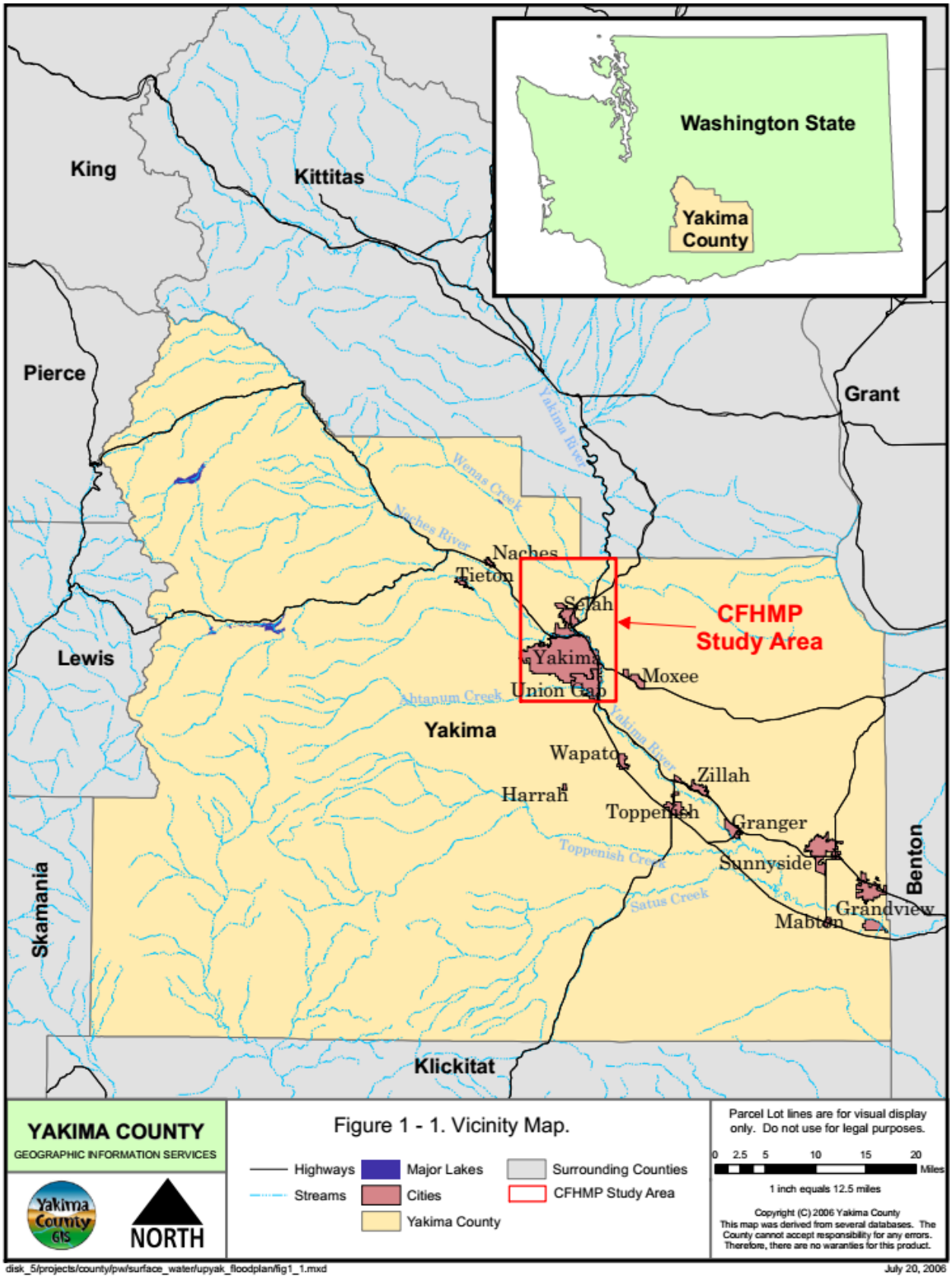
To obtain funds for flood control maintenance through FCAAP, jurisdictions must prepare a CFHMP that, as discussed in RCW 86.26.105, accomplishes the following:

- Identifies the river's meander belt or floodway
- Establishes the need for flood control work
- Considers alternatives to in-stream flood control work
- Identifies and considers potential impacts of in-stream flood control work on the state's in-stream resources.

Applicants for FCAAP project funds must review their proposals with WDFW, DNR, and affected Native American tribes. Construction work to be performed in or adjacent to navigable waters of the United States, including wetlands, must be approved by the COE. The COE permit process ensures that all federal, state, and local regulatory agencies with jurisdiction over the project are properly notified and have approved the project. The COE will not approve a project that has been rejected by another permitting agency.

As in the case of the 1998 Upper Yakima CFHMP, this addendum follows the Ecology process for flood hazard management plans redefined by the 1991 Ecology guidelines. The Ecology process, as presented within the 1998 Upper Yakima CFHMP, delivered in a two-year period for a larger area, is presented below in Figure 1-5.

This flood hazard management process uses a balanced approach to flood damage protection, resource protection, environmental enhancement, and land development, as discussed below.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King
Kittitas
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Benton
Yakima River
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Naches River
Ahtanum Creek
Toppenish Creek
Satus Creek
Naches
Tieton
Selah
Yakima
Union Gap
Moxee
Wapato
Harrah
Toppenish
Zillah
Granger
Sunnyside
Grandview
Mabton
CFHMP Study Area
YAKIMA COUNTY
GEOGRAPHIC INFORMATION SERVICES
Yakima County GIS
NORTH
Figure 1 - 1. Vicinity Map.
Highways
Streams
Major Lakes
Cities
Yakima County
Surrounding Counties
CFHMP Study Area
Parcel Lot lines are for visual display only. Do not use for legal purposes.
0 2.5 5 10 15 20
Miles
1 inch equals 12.5 miles
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This map was derived from several databases. The County cannot accept responsibility for any errors. Therefore, there are no waranties for this product.
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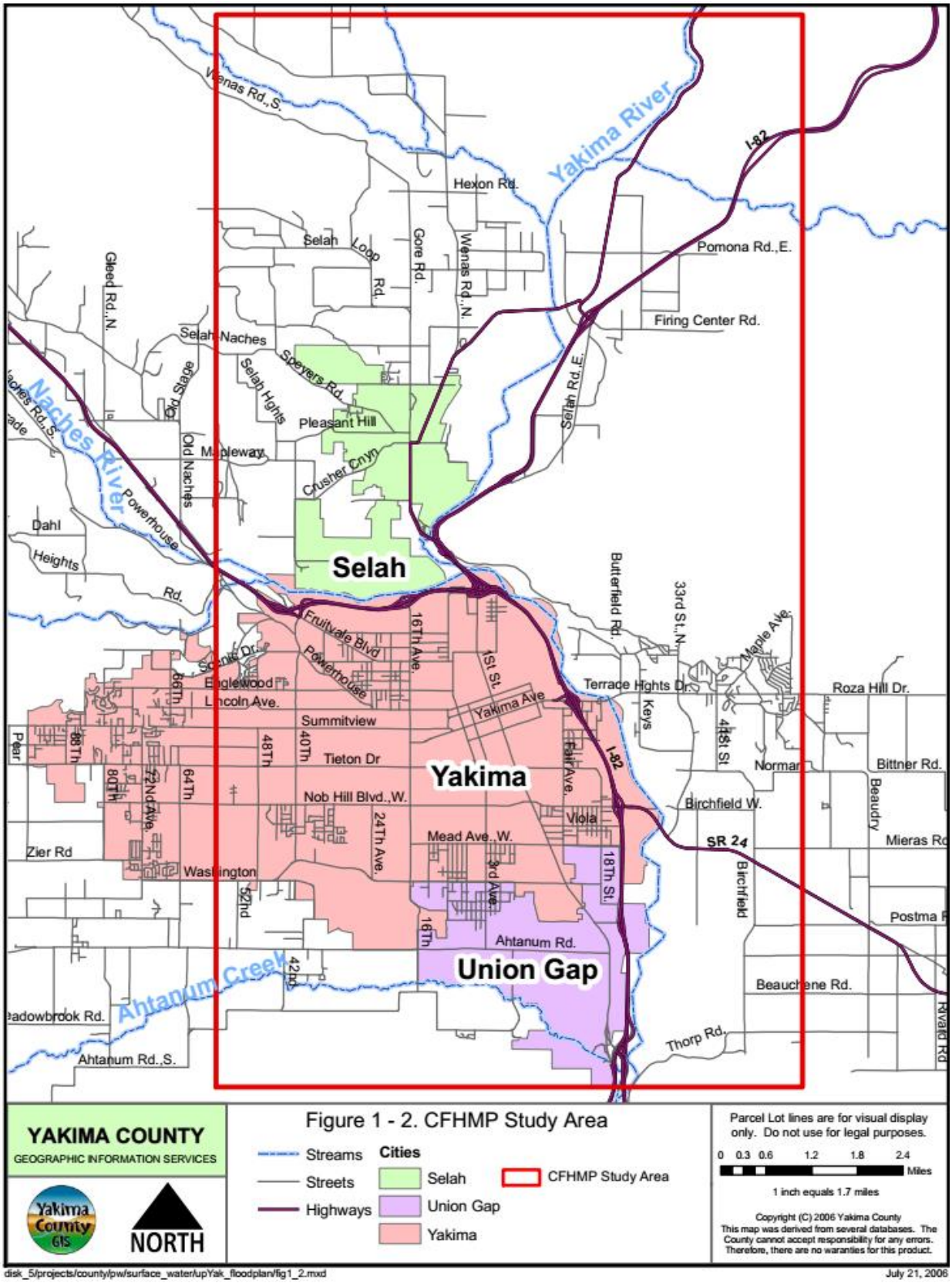
July 20, 2006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I-82
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Gore Rd.
Wenas Rd.,N.
Pomona Rd.,E.
Gleed Rd.,N.
Firing Center Rd.
Selah Naches
Speyers Rd.
Selah Hghts
Selah Rd.,E.
Naches River
Old Stage
Pleasant Hill
Old Naches
Mapleway
Crusher Cnyn
Naches Rd.,S.
Powerhouse
Dahl
Heights
Rd.
Selah
Butterfield Rd.
33rd St.,N.
Maple Ave.
Fruitvale Blvd
16Th Ave.
1St St.
Scenic Dr.
Powerhouse
Terrace Hghts Dr.
Roza Hill Dr.
Eaglewood
Lincoln Ave.
Yakima Ave
Keys
Summitview
Pear
88Th
86Th
48Th
40Th
Tieton Dr
Yakima
Fair Ave.
I-82
48th St.
Normar
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72Nd Ave.
64Th
Nob Hill Blvd.,W.
Viola
Beaudry
Birchfield W.
24Th Ave.
Mead Ave.,W.
SR 24
Mieras Rd
Zier Rd
Washington
3rd Ave.
18Th St.
Birchfield
52nd
16Th
Ahtanum Rd.
Postma R
Union Gap
42nd
Ahtanum Creek
Beauchene Rd.
adowbrook Rd.
Thorp Rd.
Rivalto Rd
Ahtanum Rd.,S.
YAKIMA COUNTY
GEOGRAPHIC INFORMATION SERVICES
Yakima County GIS
NORTH
Figure 1 - 2. CFHMP Study Area
Streams
Streets
Highways
Cities
Selah
Union Gap
Yakima
CFHMP Study Area
Parcel Lot lines are for visual display only. Do not use for legal purposes.
0 0.3 0.6 1.2 1.8 2.4
Miles
1 inch equals 1.7 miles
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This map was derived from several databases. The County cannot accept responsibility for any errors. Therefore, there are no waranties for this product.
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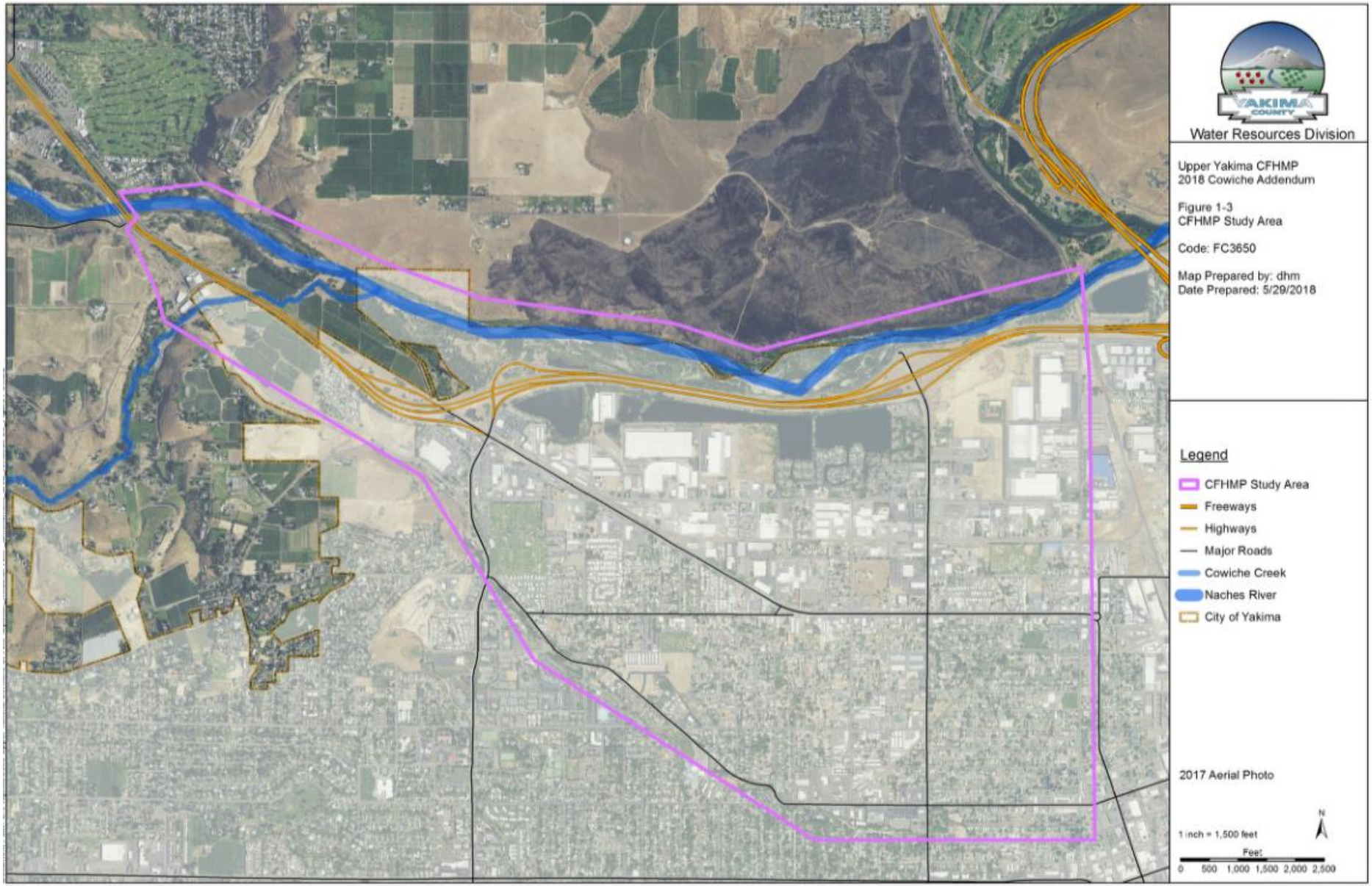
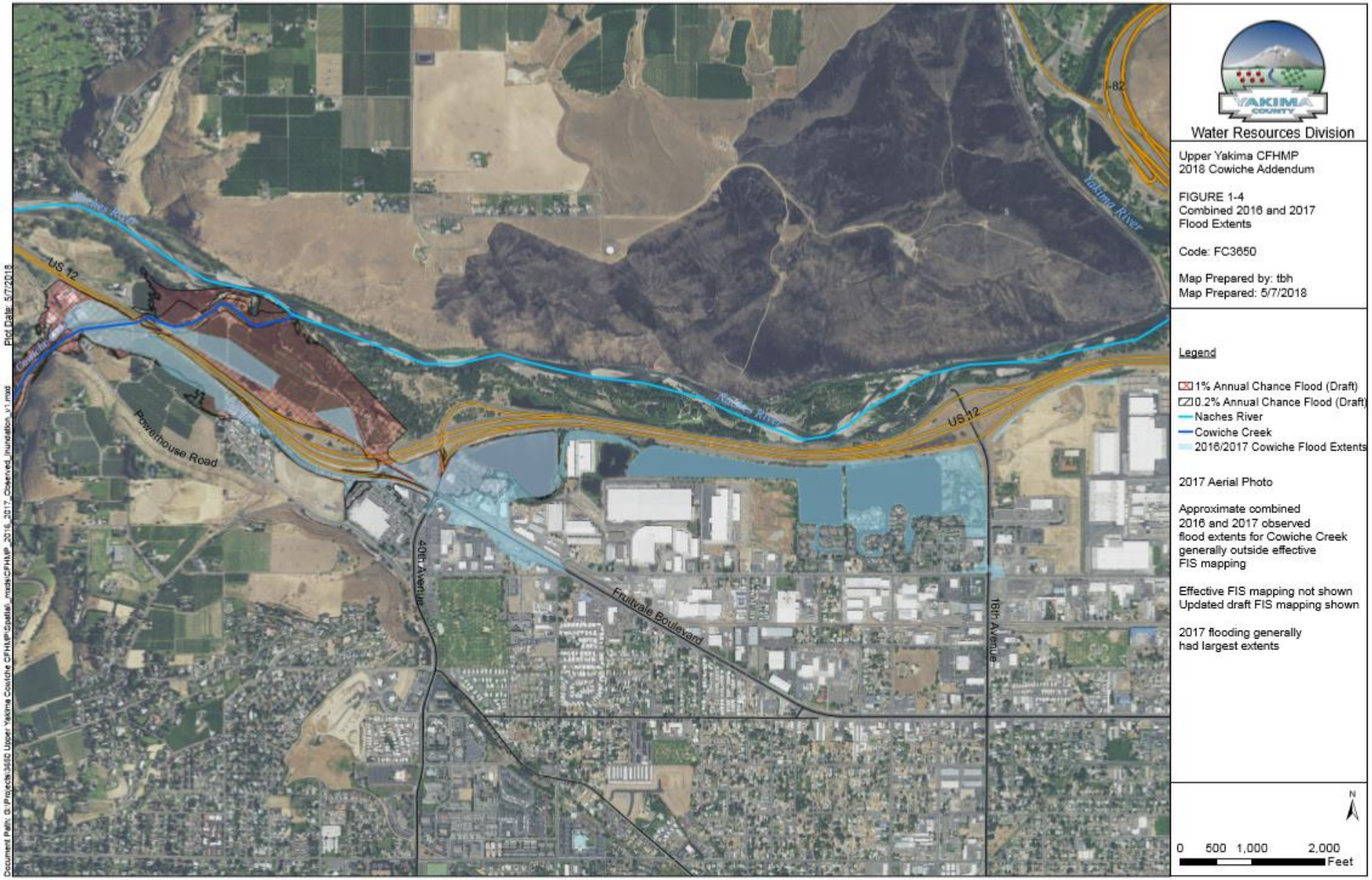
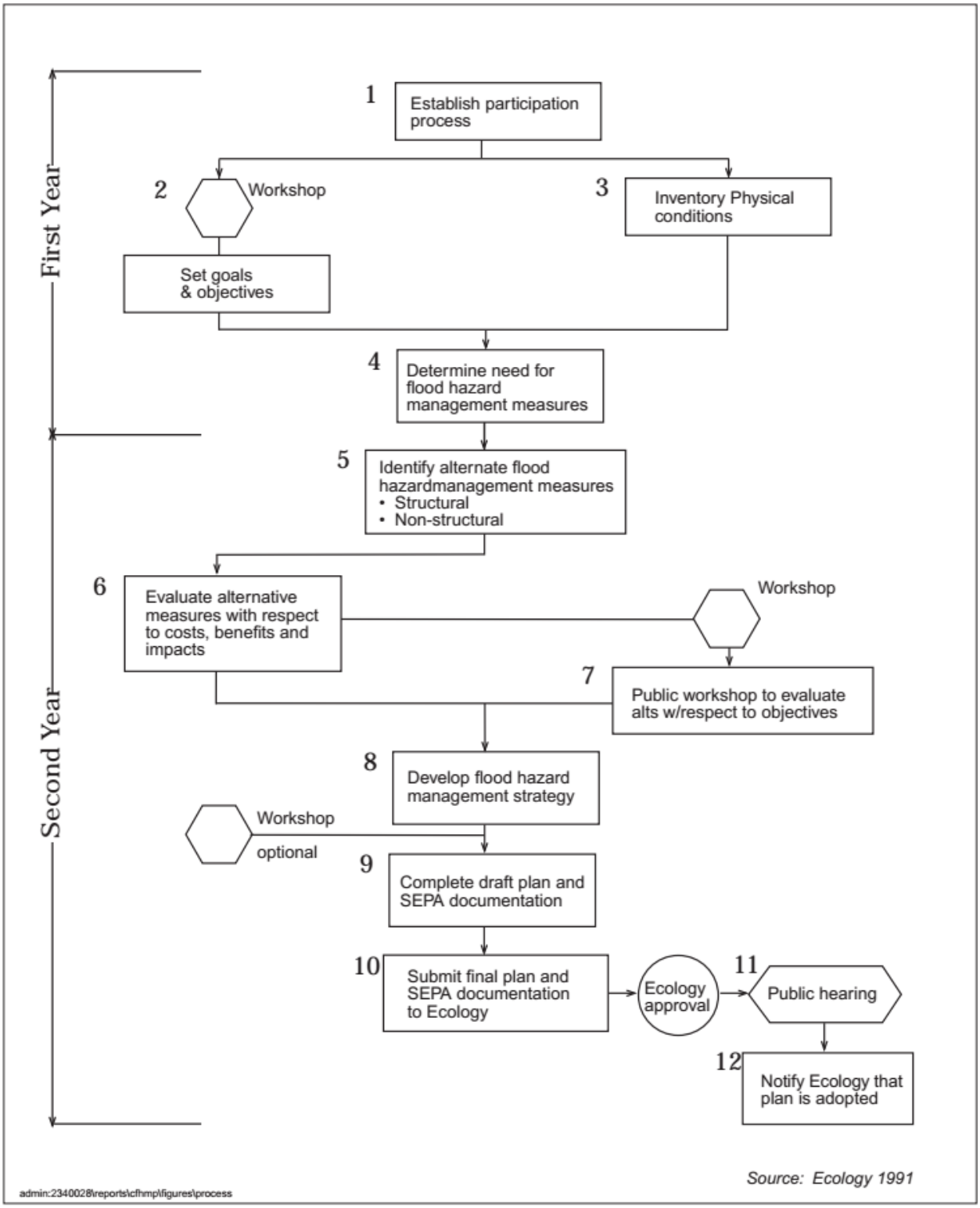
July 21, 2006


Water Resources Division
Upper Yakima CFHMP
2018 Cowiche Addendum
Figure 1-3
CFHMP Study Area
Code: FC3650
Map Prepared by: dhm
Date Prepared: 5/29/2018
Legend
CFHMP Study Area
Freeways
Highways
Major Roads
Cowiche Creek
Naches River
City of Yakima
2017 Aerial Photo
N
1 inch = 1,500 feet
Feet
0 500 1,000 1,500 2,000 2,500


Water Resources Division
Upper Yakima CFHMP
2018 Cowiche Addendum
FIGURE 1-4
Combined 2016 and 2017
Flood Extents
Code: FC3650
Map Prepared by: tbh
Map Prepared: 5/7/2018
Legend
1% Annual Chance Flood (Draft)
0.2% Annual Chance Flood (Draft)
Naches River
Cowiche Creek
2016/2017 Cowiche Flood Extents
2017 Aerial Photo
Approximate combined 2016 and 2017 observed flood extents for Cowiche Creek generally outside effective FIS mapping
Effective FIS mapping not shown
Updated draft FIS mapping shown
2017 flooding generally had largest extents
N
0 500 1,000 2,000
Feet
US 12
Powerhouse Road
40th Avenue
Fruitvale Boulevard
16th Avenue
Naches River
Yakima River
Plot Date: 5/7/2018



KCM 1917 First Avenue Seattle, Washington 98101	Yakima County UPPER YAKIMA RIVER CFHMP	Figure 1-5. CFHMP PLANNING PROCESS

Flood Hazard Management

To increase the chances of success, this plan is based on flood hazard management. *Flood hazard management* encompasses flood control management and floodplain management techniques, including structural and nonstructural approaches affecting the river, the floodplain, and the watershed beyond. Actions include flood warning and flood response measures as well as maintenance of flood control/protection facilities.

Flood hazard management, to be successful, must take into account the entire river system. Any activity in a river or its watershed can change the nature of the river's flooding. Human intervention can either exacerbate or reduce the extent of flooding and its effects on human health, property, and the environment. The anthropogenic effects incorporated in the original goals and objectives must be fully identified and understood before any flood control actions are established and successfully taken. This focused study area has significant infrastructure that has modified flood risk and available solutions.

The current risk within the Cowiche Creek study area and urgency for risk mitigation has led to the need to develop near-term, short and long-term actions that match the ability of the agencies to meet needed concurrent infrastructure modifications to reduce current flood hazard. Near-term mitigation actions would precede the next flood season and incorporate more flood warning and response measures pending more structural actions, long-term actions would necessitate significant infrastructure changes with long lead times, while short-term actions must bridge the intervening period and align any infrastructure changes with the long-term plan developed here. As several agencies are involved in this effort the plan must provide enough detail to develop their individual capital improvement plans (CIPs).

Advisory Committee

Public and agency involvement was achieved by forming an Advisory Committee whose members—representatives of public and private organizations and agency representatives—provided input through meetings and document review. The CFHMP is also provided with public input through the SEPA process and any hearings required by the local jurisdictions prior to adoption. Additional agency representatives were contacted as needed throughout the plan preparation, and contact was maintained with Ecology to ensure compliance with FCAAP requirements, and this process will be again followed for this amendment.

An Advisory Committee of local agencies, landowners and jurisdictions was formed within this addendum to refine issues, provide goals and objectives, develop alternatives and develop recommend actions. Members are listed below in Table 1-1, and the meeting agendas for the 11 meetings are presented in Table 1-2:

TABLE 1-1.
YAKIMA COUNTY CFHMP ADVISORY COMMITTEE

Voting Members	Affiliation
Mr. Scott Anfinson	Washington State Department of Transportation
Mr. Eric Bartrand	Washington State Department of Fish and Wildlife
Mr. David Brown	City of Yakima Water/Irrigation
Mr. Joseph Calhoun	City of Yakima Planning
Mr. Bruce Dekker	Lake Aspen Homeowner's Association
Mr. Jeff Emmons	Yakima County Office of Emergency Management
Mr. Joel Freudenthal	Yakima County Flood Control Zone District
Mr. David Garretson	Private Landowner
Mr. Bob Ingham	Private Landowner
Mr. John Marvin	Yakama Nation
Mr. Keelan McPhee	Yakima County Planning Division
Mr. Mike Price	City of Yakima Wastewater/Stormwater
Mr. Bill Sauriol	Washington State Department of Transportation
Mr. Brett Sheffield	City of Yakima Chief Engineer
Ms. Katrina Strathman	Mid-Columbia Fisheries Enhancement Group
Alternates and Non-Voting Members	
Mr. Jason Clapp	Yakima County Office of Emergency Management
Mr. Mark Cleaver	Yakima County Roads Maintenance
Ms. Joan Davenport	City of Yakima Community Development
Mr. Glenn Denman	Lake Aspen Homeowner
Mr. Donald Gatchalian	Yakima County Environmental Services Director
Ms. Michelle Gilbert	Washington Department of Ecology
Mr. Byron Gumz	Yakima County Planning Division
Mr. Perry Harvester	Washington State Department of Fish and Wildlife
Mr. David Haws	Yakima County Flood Control Zone District
Mr. Terry Keenhan	Yakima County Flood Control Zone District
Mr. Dale Meck	Yakima County Flood Control Zone District
Ms. Margaret Neuman	Mid-Columbia Fisheries Enhancement Group
Mr. Connor Parrish	Mid-Columbia Fisheries Enhancement Group
Mr. Matt Pietrusiewicz	Yakima County Engineer
Mr. Scott Schafer	City of Yakima Public Works
Mr. Horace Ward	Yakima County Office of Emergency Management

TABLE 1-2. SUMMARY OF ADVISORY COMMITTEE MEETINGS	
Meeting Date	Topic
October 30, 2017	**Overview** of CFHMP planning process, goals and objectives & review of flooding issues.
November 7, 2017	**Prior studies** and Existing Conditions report review, including near-term action plan and emergency responsiveness.
December 5, 2017	**Establish overall risk and restraints**. Review CFHMP goals and objectives in order to add any that apply to the study area. **Add, Refine and Rank** identified flooding **issues.** Discuss risk in floodplain (100-year) and review land use and regulatory flood hazard reduction alternatives and strategies. Begin **Floodplain Hazard Management 101**.
December 19, 2017	**Amend goals and objectives and flood issues.** Continue Floodplain Hazard Management 101. **Generate and Review** land use, regulatory, emergency and structural flood hazard reduction **alternatives for the City to match identified flood issues.** Review flooding issues arising from 2016 and 2017 flood in light of 100-year flooding.
January 9, 2018	**Continue prior meeting agenda**. **Discuss** alternatives analysis values prior to voting.
January 16, 2018	**Vote on** flood hazard reduction **alternatives** according to criteria, flood issues, residual risk and goals and objectives. Discuss priorities for recommended actions**. Complete** Floodplain Hazard Management 101.
February 6, 2018	**Generate and Review** land use, regulatory, emergency and structural flood hazard reduction **alternatives for the City to match identified flood issues.** Amend goals and objectives and flood issues**. Discuss** alternatives analysis values prior to voting. **Vote on** flood hazard reduction **alternatives** according to criteria, flood issues, residual risk. goals and objectives. Discuss priorities for recommended actions**.**
February 20, 2018	**Continue February 6, 2018 agenda.**
March 6, 2018	**Continue February 6, 2018 agenda.**
March 26, 2018	**Address tabled alternatives from prior meeting and complete voting on alternatives Finalize** alternatives and goals and objectives. Discuss city drainage. Identify **leads and partners** for various alternatives.
April 16, 2018	**Committee presented with Recommendations and priorities generated from recommended alternatives**. **Discuss** which items to prioritize. Set **leads and partners**. Committee requested for input on items, leads.

Goals and Objectives

The goals and objectives defined in the 1998 CFHMP were updated by the Committee in the above meetings in order to match the Lower Cowiche flood issues. The short-term and long-term goals are presented in Tables 1-3a and 1-3b. Recommended actions for this amendment area are evaluated with respect to their conformance with to the goals and objectives.

TABLE 1-3a.
SHORT-TERM GOALS AND OBJECTIVES FOR YAKIMA COUNTY CFHMP

Goals	Objectives
Identify flood hazards, propose alternatives, and select appropriate flood hazard management measures and funding plans.	Prepare a comprehensive flood hazard management plan to address flooding problems in study area: • At a minimum, propose permanent management measures for the principal flood problems • Review existing O&M plan. • Select flood hazard management measures based on the following criteria: — Severity of problem — Effectiveness, with emphasis on solving regional problems — Cost — Public acceptance — Impact • Prepare a Capital Improvement Program (CIP) from selected alternatives • Secure County, City and Ecology approval of the CFHMP.
Implement short-term actions to help alleviate current flooding problems.	Identify maintenance actions and other changes to existing City and County programs that can be achieved with existing resources.
Ensure that pending and near-term development proposals are consistent with goals and objectives of the CFHMP.	Communicate with private developers to convey the results of interim CFHMP analyses affecting proposed development parcels. Review development proposals to ensure consistency with flood hazard management alternatives that are likely to be developed in the CFHMP.
Lessen flood impacts to City and related infrastructure in the next few years while planning and implementing long-term solutions.	
Maintain fish passage, habitat through the action reach and reduce the potential for fish stranding.	Ensure that any channel scour is moderated so as to avoid formations of headcut barriers and habitat simplification. Create adequate fish returns for overland flow back to into streams or plan for fish rescue operations upon receding flood.
Ensure that emergency response plans and procedures reflect known or suspected changes in flood impact from recent flood event**.**	Ensure action points are established for emergency response activities. Review emergency response actions after large flood events for timeliness and effectiveness. After a large event, compare actual flood impact to historical impacts to identify changes.

TABLE 1-3b

LONG-TERM GOALS AND OBJECTIVES FOR YAKIMA COUNTY CFHMP

Goals	Objectives
Remove City from 100-year flood mapping, where possible & desirable, certainly east of 40th Ave, and south of US 12.	Design level-standard 100-year protection with appropriate freeboard. Reduce risk of a 100-year flood by limiting the impact to residents, businesses, and the economy. Provide infrastructure to route all floodwaters under/through US 12 without overflows toward the City. Remove or relocate diversions, control structures, canals, and fishways which artificially reduce the overall gradient of Lower Cowiche Creek and increase backwatering effects.
Prevent the loss of life and the creation of public health or safety problems.	Implement flood hazard management measures as identified and recommended in the CFHMP. Ensure integrity of dams between Myron, Aspen and Willow Lakes by long-term inspection, maintenance and management.
Reduce disruptions to local businesses and the economy. Reduce damages to public and private property.	Maintain regulations to prevent new development from causing flood damage or from being susceptible to damage by floods. Encourage development that does not increase protection structures in stream environment. Limit development North of US 12. Retrofit or remove existing infrastructure where feasible to improve resiliency.
Maintain the varied uses of existing drainage pathways and floodplains within the County.	Preserve opportunities for floodplain uses that are compatible with periodic flooding. Discourage land uses in the floodplain that are incompatible with periodic flooding. Adopt flood control measures that preserve or enhance existing fisheries and wildlife habitats. Ensure that changes in land use restore natural character and function wherever possible. Incorporate considerations for extending and enhancing trails and recreational corridors in the design of flood risk reduction and habitat restoration measures.
Enhance functioning aquatic and floodplain habitats compatible with flood-risk reduction and maintenance actions.	Restore existing degraded aquatic and floodplain habitats with functional riparian buffers, floodplains and channels, recognizing that these efforts are also beneficial to flood hazard management and risk reduction efforts. Ensure that flood risk reduction measures are designed to restore, enhance and preserve aquatic and terrestrial habitat complexity, minimize maintenance needs, and minimize aquatic and terrestrial habitat disruptions in emergency or planned maintenance.
Achieve channel functions and habitat conditions that approach natural conditions. Conditions will be consistent with the slope of the landscape and the quantity and	Design channel and floodplain systems which promote self-building and self-maintaining habitat functions, including riparian habitat development and maintenance, recruitment of large woody debris, and other processes that promote natural plant community succession.

TABLE 1-3b

LONG-TERM GOALS AND OBJECTIVES FOR YAKIMA COUNTY CFHMP

composition of sediment being transported and deposited. Target conditions will also account for the geometry of the prospective Cowiche floodplain, the necessity to route flows through two bridges, the presence of the active Naches floodplain, and the need to meet fish lifecycle needs through gravel renewal.	Allow irregular channel banks that provide cover and fish refuge habitat. Minimize gravel removal required, and select removal locations to reduce impacts on channel and riparian habitat. Gravel removals are planned to meet fish lifecycle needs through gravel renewal. Minimize need for ongoing large woody material management through channel and floodplain geometry. Minimize bank armoring. Design floodplain and flood control features that so that flow velocities during 10-yr events, and more frequent floods, are able to support stable riparian communities.
Prevent the degradation of surface and groundwater.	Minimize the impact of contaminants and sediment in stormwater runoff on receiving waters (Cowiche Creek, Naches River, and the Yakima River) and groundwater aquifers. Integrate water quality needs with flood control needs to provide consistency in flood hazard management.
Establish and adopt a systematic and comprehensive approach to flood hazard management in the short-term, and with an eye to minimizing the expenditure of public funds in the future.	Pursue strategies for flood hazard management that balance engineering, economic, environmental, and social factors. Evaluate goals and objectives every five years to maintain consistency with current policy, comprehensive plans, the Growth Management Act, and to anticipate and adapt to changes in climate and watershed hydrology. Coordinate flood hazard planning with all interested and affected parties in both public and private sectors to solve mutual flooding problems. Improve community awareness of flood hazard management through public outreach efforts. Provide for public input and the opportunity to comment on flood hazard management decisions. Establish additional methods for acquiring, analyzing, and distributing locally-specific hydrologic data. Develop structural and nonstructural measures that increase resiliency and decrease maintenance costs and the likelihood of costly emergency actions. Give preference to nonstructural flood control measures such as regulations and preservation of existing flowpaths in the urban area.
Establish a stable, adequate, and publicly acceptable long-term source of financing.	Determine flood hazard management funding needs and alternatives including both capital improvements and maintenance costs.

TABLE 1-3b LONG-TERM GOALS AND OBJECTIVES FOR YAKIMA COUNTY CFHMP	
	Establish responsible parties for infrastructure and flood response along with sustainable funding source. Establish funding mechanisms and partnership agreements to help implement the structural and non-structural recommendations of the CFHMP.
Plan for future flood reduction in Cowiche watershed above Powerhouse Road.	Plan to provide a future CFHMP to address flooding issues along Cowiche Creek from Powerhouse Road to the upper watershed.
Improve empirical Cowiche flow data & forecasting.	Establish stream and snowpack stations monitoring basin hydrology to reduce uncertainty and improve designs.
Remove City from 100-year flood mapping, where possible & desirable, certainly east of 40th Ave, and south of US 12.	Design level-standard 100-year protection with appropriate freeboard. Reduce risk of a 100-year flood by limiting the impact to residents, businesses, and the economy. Provide infrastructure to route all floodwaters under/through US 12 without overflows toward the City. Remove or relocate diversions, control structures, canals, and fishways which artificially reduce the overall gradient of Lower Cowiche Creek and increase backwatering effects.

Table 1-4 contains 2007 CFHMP Update recommendations relevant to the Cowiche Creek amendment area. These recommendations and subsequent intervening actions were considered in the generation of flooding issues for the amendment area in section 6.

TABLE 1-4 SUMMARY OF PRIOR PERTINENT CFHMP RECOMMENDED ACTIONS	Issues Addressed
Structural Actions	
Retirement of the Fruitvale Diversion and Consolidation with the Current Nelson Dam Diversion	NA1
The County should implement bank protection projects following established guidelines (e.g., King County 1993 or ISPG, 2003), modified for Yakima County.	RW3, LR1, UR1
The following are recommended to address operations and maintenance issues: Consolidate maintenance requirements into one document. (COE documents) Adopt a policy requiring all new flood-control projects to define maintenance responsibilities and a funding source for operations, maintenance, and repairs before acceptance by the County Continually update and maintain a flood control facility inventory database to document the current condition of each flood control facility (GIS).	RW16
Based on the county-wide road closure database, prioritize roads requiring flood damage mitigation.	RW12
Study	
Request that FEMA produce a digital floodplain map that combines all jurisdictions and reflects recent data for use in the County's GIS.	RW1
Given the long-term nature of this type of flood hazard (channel migration, sediment accumulation, erosion), a study to determine these values and to monitor sediment transport and energy should be implemented.	RW20

TABLE 1-4 SUMMARY OF PRIOR PERTINENT CFHMP RECOMMENDED ACTIONS	Issues Addressed
Obtain flood damage GIS coverages for recent and historical floods as they become available from FEMA	RW15
Non-Structural Actions (Flood Fight)	
During flood events posing risk, formalize procedures for dispatching field teams and volunteers to critical locations along rivers and creeks to manually collect real-time river information. (Complete) Compile time delays from the BOR in flood peaks between locations along the Yakima and Naches Rivers for various flood magnitudes (Completed) Continue reviewing and compiling information on past flood events to create a database that correlates road closures with river stage and discharge (Ongoing) Develop and communicate to the public a policy on sandbag distribution during flood events (use periodic public outreach methods to reiterate this policy) (Ongoing). Develop a flood inundation map for distribution to the public (FEMA maps Completed) Establish real-time, automatic gauging stations within the upper watershed of tributary creeks (Pending) Create a Community Alert Network for use at the EOC (Ongoing)	RW19
Non-Structural (Funding)	
Actively pursue state and federal grant programs to supplement funding provided by flood control district.	RW13
Investigate the value and need for sub-zones within the FCZD.	RW13
Provide direction and support to secure funding for large scale actions which involve cooperation across jurisdictions and agencies	RW13, RW17
County should provide guidance in designing private bank protection projects (Completed with Planning).	RW3, LR1, UR1
Pursue funding through state and federal programs to purchase high-hazard floodplain properties or development rights for open space use.	RW10
Non-Structural (Regulatory)	
City jurisdictions should integrate flood hazard items included in the County's CAO.	RW4, RW5
Obtain from FEMA the best available digital flood hazard map that meets the objectives listed below: *Accuracy:* Establish definitive and accurate representations of the floodway, 100-year floodplain, Special Flood Hazard Areas (SFHAs), and Base Flood Elevations (BFEs) *Completeness:* Ensure that all of the items listed above are present in the GIS database and that the database includes all jurisdictions within Yakima County *Accessibility:* Enhance the County's ability to perform floodplain determinations, measure areas of SFHAs, determine BFEs of specific locations, and realize time savings in the permit process *Community Review:* Ensure that sufficient local review of flood hazard information has occurred prior to release of that data for public use.	RW15
	RW7

The 2007 Update briefly addressed concerns and opportunities on the Naches River, including pending replacement of Nelson dam and subsequent retirement of related irrigation infrastructure at the confluence of Cowiche Creek and Naches River.

Since 2007 the need for maintenance of Cowiche Creek levees and for management of flood risk to the City has been identified by levee failures in 2016 and 2017.

2.0 GROWTH MANAGEMENT ACT

The Growth Management Act is a state statute pertaining to urban growth, which requires certain cities and counties to develop community Comprehensive Plans with public input procedures to direct and manage community development and growth. GMA growth requirements will cover the entire County or jurisdiction are separate from CFHMP related statutes and produce separate types of plans. GMA Comprehensive Plans provide policy for growth which directs local planning and building ordinances.

The CFHMPs are functional plans, that are adopted into state and federal hazard mitigation plans, and directly influence the natural hazards element within the GMA Comprehensive Plans. The two types of plans coincide in the consideration of growth in flood hazard areas, defined by federal and state procedures. Guidance for GMA Hazard Reduction Goals for incorporation into the Comprehensive Plan elements is provided within "Optional Comprehensive Plan Element for Natural Hazard Reduction", Washington State CTED, June 1999.

This CFHMP identifies the community vulnerabilities and hazard issues in a developable area and develops hazard-related goals (see table 1-3a and 1-3b) specific to the CFHMP area and also provides recommendations to address them that can be incorporated into the Comprehensive Plans as policies. Yakima County's Horizon 2040 has adopted the following flood related goals that concern development of hazardous areas and potential modification of ordinances:

TABLE 2-1.
HORIZON 2040 COMPREHENSIVE PLAN – FLOODING (Prevent the loss of life or property and minimize public and private costs associated with repairing or preventing flood damages from development in frequently flooded areas.)

	Policies
NH 1.1	Support comprehensive flood control planning.
NH 1.2	Conduct additional analysis and mapping of frequently flooded areas in cases where the 100-year floodplain maps prepared by the Federal Emergency Management Agency do not adequately reflect the levels of risk or the geographic extent of flooding.
NH 1.3	Direct new critical facility development away from areas subject to catastrophic, life-threatening flood hazards where the hazards cannot be mitigated.
NH 1.4	Where the effects of flood hazards can be mitigated, require appropriate standards for subdivisions, parcel reconfigurations, site developments and for the design of structures.
NH 1.5	Plan for and facilitate returning rivers to more natural hydrological conditions, and recognize that seasonal flooding is an essential natural process.

TABLE 2-1. HORIZON 2040 COMPREHENSIVE PLAN – FLOODING (Prevent the loss of life or property and minimize public and private costs associated with repairing or preventing flood damages from development in frequently flooded areas.)	
Policies	
NH 1.6	When evaluating alternate flood control measures on rivers: • Consider the removal or relocation of structures in the FEMA 100-year floodplain; • Where feasible, give preference to nonstructural flood hazard reduction measures over structural measures; • Structural flood hazard reductions measures should be consistent with the County's comprehensive flood hazard management plan.
NH 1.7	New development or new uses, including the subdivision of land, should not be established when it would be reasonably foreseeable that the development or use would require structural flood hazard reduction measures within the channel migration zone or floodway.
NH 1.8	Restrict subdivisions in areas subject to flooding.

TABLE 2-2. HORIZON 2040 COMPREHENSIVE PLAN – MULTI-HAZARD (Protect property, life, and health from impacts of multiple and cumulative natural hazards.)	
Policies	
NH 7.1	Ensure proposed subdivisions, other development, and associated infrastructure are designed at a density, level of site coverage, and occupancy to preserve the structure, values, and functions of the natural environment or to safeguard the public from hazards to health and safety.
NH 7.2	Encourage mechanisms to restrict or minimize development in high-risk hazard areas to protect public health and safety.
NH 7.3	Maintain existing infrastructure to reduce the risk of infrastructure fail during a natural disaster.
NH 7.4	Locate critical facilities and infrastructure outside of high-risk hazard areas.
NH 7.5	Ensure new developments in high-risk hazard areas include secondary egress.
NH 7.6	Develop processes and procedures for streamlining projects intended to mitigate for natural hazards.

TABLE 2-3. HORIZON 2040 COMPREHENSIVE PLAN – DISASTER RECOVERY (Be prepared to recover from a major natural disaster.)	
Policies	
NH 8.1	Implement Recovery Plan to guide the redevelopment, public participation process, and long-term recovery after a natural disaster.
NH 8.2	Provide a process and procedure to streamline projects intended to provide relief and recovery from a natural disaster.

With a clearer understanding of the level of hazard avoidance necessary for the local study area, as identified in this CFHMP, cities and counties can define actions or strategies to minimize public risk and achieve the above GMA goals. These actions and strategies are applied in the implementation of vulnerable area mapping, regulatory codes and standards, and capital investments. Strategies which can satisfy multiple objectives are important for overall success.

Coordination between jurisdictions, as watersheds and flood risks cross basin boundaries is a critical tool for implementing watershed-wide planning. It is also an important means to ensure that transportation evacuation route redundancy is achieved, and that infrastructure incursions into the floodplain and exposure can be minimized, while appropriate resource utilization practices are applied in the upper watersheds.

3.0 BACKGROUND DATA, STUDIES AND PROGRAMS

Background information for the CFHMP was compiled from sources including the County, state and federal agencies, and the original Advisory Committee members. Data collected to define the study areas physical, social, and historical characteristics included the following:

- Land use and topographic information from County Geographic Information System (GIS) maps
- Information describing the physical setting, including climate, soil, vegetation, hydrology, water quality, fisheries, and wildlife
- Population data
- The findings of past flood-related studies performed by the U.S. Army Corps of Engineers (COE) and the Federal Emergency Management Agency (FEMA)
- Yakima Authorized Federal Levee Operation and Maintenance Manual, COE, 1955
- County Comprehensive Plan background documents
- Records of historical flood events and control activities including permanent records, personal accounts and newspaper accounts
- County and City observations of the March 2016 and March 2017 Cowiche flooding in the City of Yakima
- Yakima County – hydraulic modeling and supporting data for the updated Flood Insurance Study on the lower Naches River and Cowiche Creek,
- Cowiche Creek Hydrologic Analysis, WEST Consultants for Yakima County and FEMA, 2017
- Cowiche Creek FIRM analysis, WEST consultants for Yakima County, 2017 preliminary.

Other sources of data were historical documents, newspaper articles, and interviews with local officials and citizens.

RELATED STUDIES

Preceding the preparation of this amendment, there were a number of recommended programs underway in Yakima County which directly affected this area in addition to the recent County's revised Cowiche flood insurance study. The recommended actions are listed in Table 3-1 below.

TABLE 3-1.
SUMMARY OF RECOMMENDATIONS FROM RELATED STUDIES 2000-2007

Study (Source)	Description of General Recommendations or Problems Identified	Status
The Reaches Project (2002)	All five (Yakima River mainstem) reaches have significant potential for restoration. However, the restoration potential is highest in the Union Gap reach.	Recommended in 2007 CFHMP, applicable to Lower Naches

TABLE 3-1.
SUMMARY OF RECOMMENDATIONS FROM RELATED STUDIES 2000-2007

Study (Source)	Description of General Recommendations or Problems Identified	Status
	The Union Gap reach depends on sediment from the Naches reach. Sediment from the Selah reach is limited due to the gravel mining and Roza Dam has stopped upstream bedload sediment. Sediment transport out of the Naches should be improved and maintained.	Recommended in Lower Naches River Coord. Partnership
	Another risk is the avulsion capture of bedload by the existing gravel pits. Pit capture of the river by some of the very deep gravel pits (~15 m or 50 ft) could disconnect groundwater-surface water interaction across the floodplain for periods of several decades.	Recommended in 2007 CFHMP, n/a for Naches
	The acquisition of floodplain habitat in all reaches should be a priority, particularly those areas that yet maintain some degree of habitat complexity. The general pattern is for the lower end of each of the various reaches to maintain higher complexity.	In progress through YRBWEP, YBIP & FbD, including Lower Naches & Lower Cowiche
SR 24 Project Floodplain Consistency Report (2003)	Levees and bridge abutments in danger of erosion, New SR 24 bridge should be substantially longer.	Constructed 2006
	Floodplain function compromised for habitat, sediment transport, and riverine processes.	Corps section 1135 & Ramblers Park setbacks/ Nelson Dam 2018
Lower Naches River Coordination Project (2005)	Remove Fruitvale Diversion, restore connection of Cowiche Creek with Lower Naches River, combine diversions at Nelson Dam.	After Nelson Dam-2019
	Remove Old Union Diversion, combine diversions at Nelson Dam	2019 2017
	Acquire floodplain properties in Lower Naches River to allow habitat restoration and flood hazard reduction projects to occur while minimizing impact on private properties.	2019
	Remove Ranney Collector dike and associated levee to improve floodplain function and reduce flood hazard.	Complete 2010
	Implement large scale bioengineering and structural repairs to US Highway 12 in the vicinity of 16th Avenue to reduce flood hazard to the City of Yakima and US Highway 12, and improve habitat.	Design studies complete-construct 2019
	Improve sediment transport in this reach – lengthen current Powerhouse/Twin Bridges/Nelson Dam constriction point, redesign Nelson Dam to allow for better sediment transport.	

TABLE 3-1.
SUMMARY OF RECOMMENDATIONS FROM RELATED STUDIES 2000-2007

Study (Source)	Description of General Recommendations or Problems Identified	Status
Lower Cowiche Channel Relocation	Relocate and restore Cowiche Creek channel downstream of US Highway 12 following reworking of Nelson Dam infrastructure Nelson Dam.	Completed Design (2014) & acquisition (2017), construct (2019) after Nelson Dam reconstruction

The upstream extent of the CFHMP amendment area is US Highway 12, just downstream of Nelson Dam, so that the dam is located within the Naches CFHMP study area. However, actions and changes now proposed at Nelson Dam, starting in 2019, will greatly modify current channels and infrastructure around the Naches-Cowiche confluence in this study area. Accordingly, the following recent relevant studies are noted below:

1. Naches River Reach Analysis and Management Plan, Lower Naches River (RM 0 – 3.75), GeoEngineers, 2003
2. Geomorphic processes analysis in the Naches reach since the 1920s, Golder, 2003
3. Surveyed cross sections within the reach Aggett, 2003
4. Naches River Channel Migration Study. Prepared for Yakima County Public Services, Tetra Tech/KCM, Inc. 2004
5. Naches River Comprehensive Flood Hazard Management Plan (River Mile 3.7 To River Mile 17.5). Prepared for Yakima County Public Services. Yakima, WA, Tetra Tech/KCM, Inc. 2005.
6. Yakima County (2006 and interim studies) hydraulic modeling and supporting data for the updated Flood Insurance Study on the lower Naches River,
7. Lower Naches Flood Insurance Study and Maps, FEMA, 2009,
8. Geomorphic Assessment of the Water Gaps of the Yakima Basin, prepared for Yakima County Public Services, Surface Water Management Division, Entrix Inc., 2009a
9. An annotated Bibliography of Water Gaps in the Yakima Basin, Washington, prepared for Yakima County Public Services, Surface Water Management Division, Entrix Inc., 2009b
10. 65% Draft: Appraisal Design Report, Naches River at Nelson Dam Fish Screen and Diversion Design, USBR, 2010.
11. Evaluation of Hydraulics and Sediment Transport for Proposed Fish Bypass Alternatives at Nelson Dam, USBR, 2011
12. Nelson Dam Project/Power House Bridge Project, DHI, 2011 reports

- Task 1: Initial Model Review and Update: Baseline Conditions Model
- Task 2: Evaluation of Infrastructure and Sediment Removal, Scenarios 1 and 2
- Task 2: Evaluation of Infrastructure and Sediment Removal, Scenario 3

- Task 3: Evaluation of Nelson Dam Reinsertion
- Task 4: Evaluation of Nelson Dam Reinsertion– Final Report

13. Discovery Report, Naches Watershed, FEMA, 2012
14. Ramblers' Park Conveyance Projects, including levee setback, Phases I, II and III, County of Yakima, 2012-2016
15. Preliminary Assessment of the Nelson Dam Surface Water Intake, Technical HDR, 2013
16. Lower Naches Sediment Study, Planning Assistance to the State, USCOE, 2015
17. Lower Naches River Geomorphic Atlas, NHC 2015
18. Review of Morphological Effects from Naches River Levee Setbacks, NHC 2015
19. Nelson ByPass Channel Design Project, Physical Modeling and Preliminary Design, NHC 2017
20. Nelson Dam Consolidation and Reconfiguration Preliminary Design, HDR, 2017
21. Nelson Dam Environmental Memorandum, Yakima County, 2017

Many of the above studies are summarized in relation to Nelson Dam, in the 2013 HDR report above.

YAKIMA COUNTY REVISED FLOOD INSURANCE STUDY (2017)

The NFIP implements a comprehensive set of regulations for mitigating flood damage. Yakima County and the City of Yakima participates in the NFIP by adopting zoning restrictions and enforcing building standards to limit flood damage in the 100-year floodplain. In 2008 the county contracted with FEMA to revise the Cowiche Creek Flood Insurance Study defined 100-year floodplain to reflect updates in Cowiche hydrologic and hydraulic information, through inclusion of 2005 high resolution LiDAR in the basin.

FEMA's consultant provided a detailed hydrologic analysis for the Cowiche Creek basin. There are no long-term flow records for the Cowiche Creek watershed. Although the Washington State Department of Ecology installed several gauges on Cowiche Creek, these gauges are no longer active, and they collected flow for only 2-4 years. A much longer flow record is available for upper North Fork Cowiche Creek measured through an inline weir just upstream of French Canyon Dam. It represents the total natural inflow to the French Canyon reservoir and was used in the study.

The recommended discharges for the Cowiche Creek basin mapping study are shown below.

Table 3-2. FEMA adopted discharges for Cowiche Creek basin.

Flooding Source and Location	Drainage Area	Peak Discharges (Cubic Feet per Second)				
	(Square Miles)	10-Percent Annual Chance	4-Percent Annual Chance	2-Percent Annual Chance	1-Percent Annual Chance	0.2-Percent Annua-Chance
Cowiche Creek						
At mouth	119.5	1,519	2,001	2,396	2,818	3,903
North Fork Cowiche Creek						
At mouth	38.8	627	833	1,003	1,187	1,661
Above confluence with Tributary 1	23.5	422	564	680	807	1,135
Above confluence with Tributary 2	19.0	357	478	577	685	965
South Fork Cowiche Creek						
At mouth	71.5	1,014	1,341	1,610	1,899	2,643

The above values were determined from the current U.S. Geological Survey (USGS) flood peak discharges regional regression equations that were evaluated and found to be most applicable to the Cowiche Creek basin. The USGS regional equations were used to calculate the 10-, 4-, 2-, and 1-percent-annual-chance flood peak discharges, while the 0.2-percent-annual-chance flood discharges were estimated by extrapolating the 10-, 4-, 2-, and 1-percent-annual-chance flood discharges.

Flooding in the study area normally occurs in winter or spring from January through April. Spring floods occur when warm weather and rainstorms accelerate snow melt and runoff. Winter floods, which are more frequent and of larger magnitude, occur when rainfall on accumulated snow and warm winds produce large volumes of runoff from snowmelt and rain.

Flood discharges are distributed along the Cowiche reaches in accordance with the above table and any flow splits caused by the localized topography. A flow split is shown in the amendment area on Figure 3-1 due to overflows from the channel over the private berm or levee on the south

bank of the Creek, and towards the City of Yakima prior to passing under US Highway 12. This flow split discharge to the City of Yakima was caused by the lack of capacity in the channel/levee/bridge infrastructure from Powerhouse Road to US Highway 12.

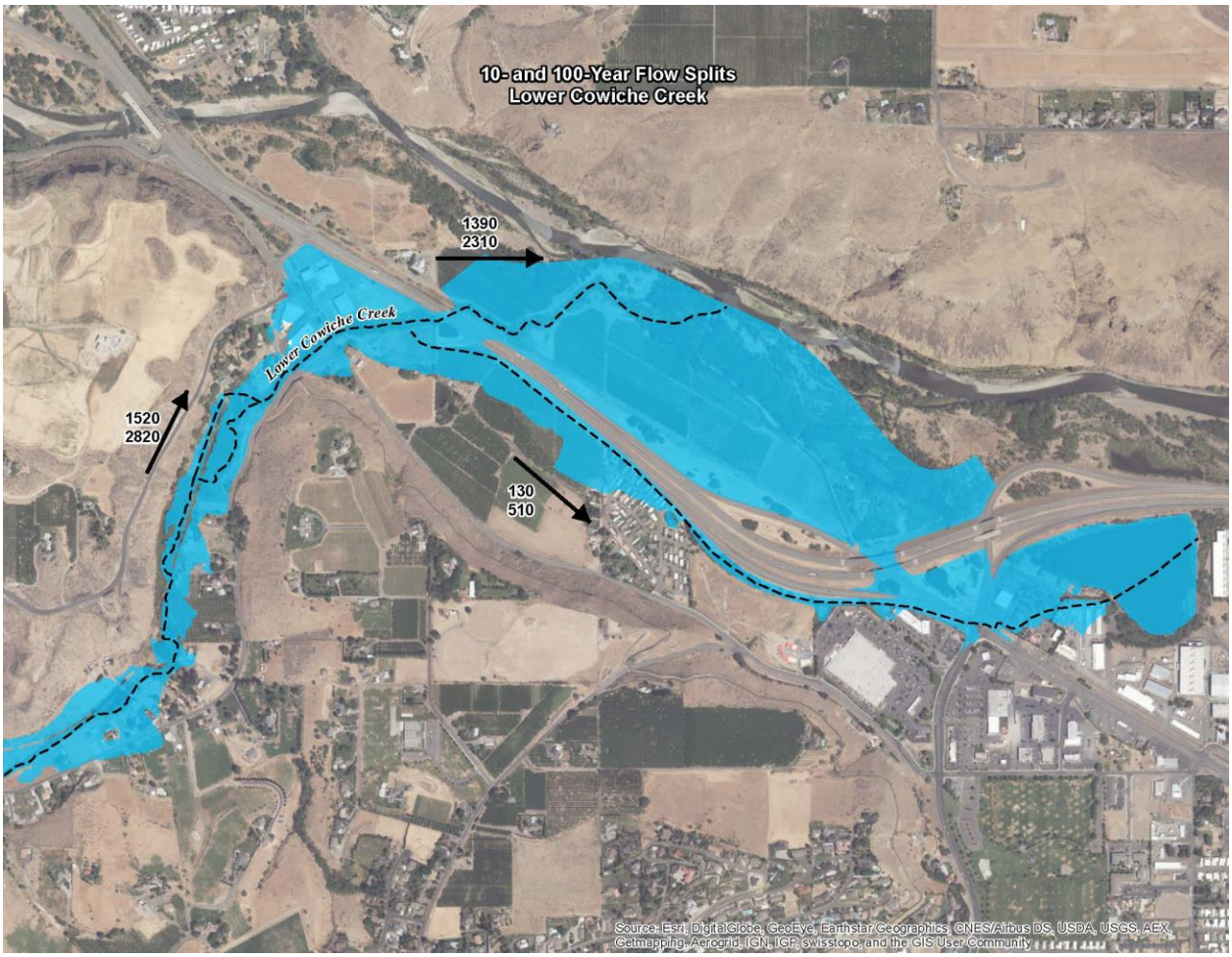


Figure 3-1. 10-and-100-year Flow Splits: Lower Cowiche Creek

The revised preliminary 100-yr flood mapping for Cowiche Creek FIS is scheduled for release in December 2017. FEMA mapping work maps for this reach are shown on Figures 3-2 and 3-3 below. The analysis shows the lack of protection afforded to the City of Yakima for flows exceeding the 10-year flood.

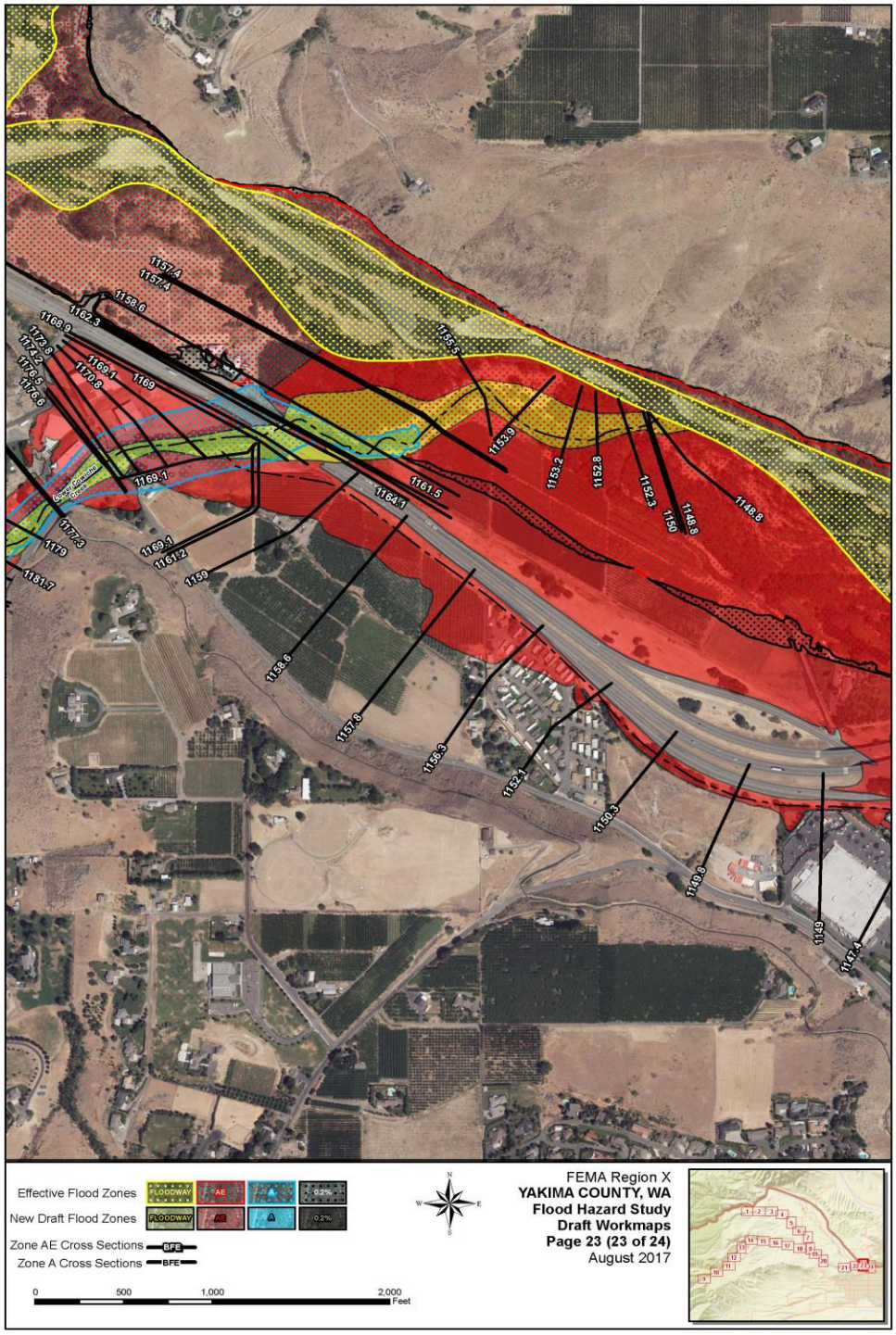


Figure 3-2. Effective Flood Zone: Cowiche to N. 40th Ave

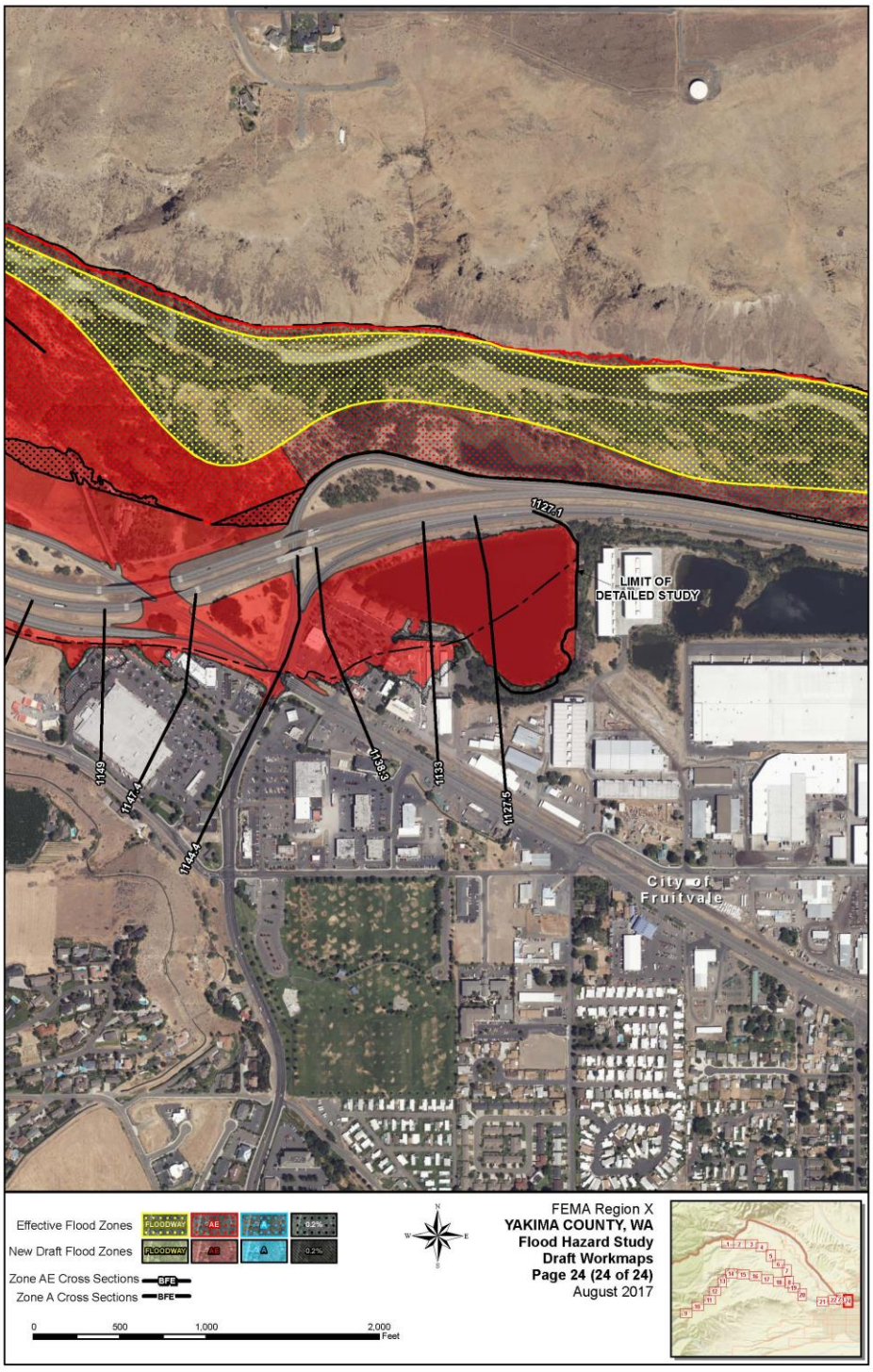


Figure 3-3. Effective Flood Zone: N 40th Ave to Myron Ave

RELATED PROGRAMS AND PROJECTS

Lower Naches River Partnership Projects (2005)

This is a cooperative project between the Washington State Department of Transportation, Yakima County, and the City of Yakima. The project area (Figure 3-2) is from the area of Nelson Dam/Twin Bridge to the confluence with the Yakima River. The cooperative partners all anticipate that they will undertake infrastructure projects (some 20 at last count) within the project area over the next several years, and each project will have common design constraints and goals for improvement in infrastructure efficiency (transportation, irrigation), fish habitat and habitat enhancement, and in most cases, flood hazard reduction. The objectives of the Lower Naches River Coordination Partnership are to "make better decisions collectively, share and accumulate data and information to complete planned projects, work together whenever possible to complete partnership actions, and to help protect the environment for all to enjoy."

Actions recommended for anticipated infrastructure projects will be based on an understanding of the physical and biological conditions in the reach.

These conditions have been documented and described in the recent studies listed above, specifically studies 1 through 8, 10 through 11, 148 through 18, 20 and 22.

Recommended actions that effect reduction of flood hazard include the following:

- Purchase of the majority of privately owned parcels in this reach – given the number of projects scheduled for this reach in the future, action will maximize floodplain function, maximize flood hazard reduction and save project costs.
- Decommission the City of Yakima's Fruitvale diversion and associated structure, decommission the Old Union diversion and associated structure, and remove dikes associated with City of Yakima's Ranney Well system. The Fruitvale diversion and associated structures are a chronic flood hazard problem at the diversion dam in lower Cowiche Creek, which is heavily modified to serve as irrigation conveyance for a short distance. Removal of these structures will have water quantity, flood hazard reduction and major fish habitat and fish passage benefits. Removal of the Ranney well associated diking and other infrastructure that currently limit Naches and Cowiche Creek sediment transport in this reach.
- Cowiche Creek Flow and Habitat Enhancement – This was proposed by YHTAP and WDFW with potential partnering with the City of Yakima and the Yakima County Flood Control Zone District. The County has undertaken design studies and easement purchase for the portion within the County (see Lower Cowiche Channel Relocation below). The City has not been engaged to date.

Lower Cowiche Channel Relocation Project (2013)

Relocate and restore Cowiche Creek channel downstream of US Highway 12 following reworking of Nelson Dam infrastructure Nelson Dam. This is a cooperative project between Yakima County, and the City of Yakima. The County has developed the new channel design and acquired the

relocation easement. Construction between US 12 and the Naches confluence requires removal of existing Naches River infrastructure for Fruitvale Diversion following intake incorporation into Nelson Dam.

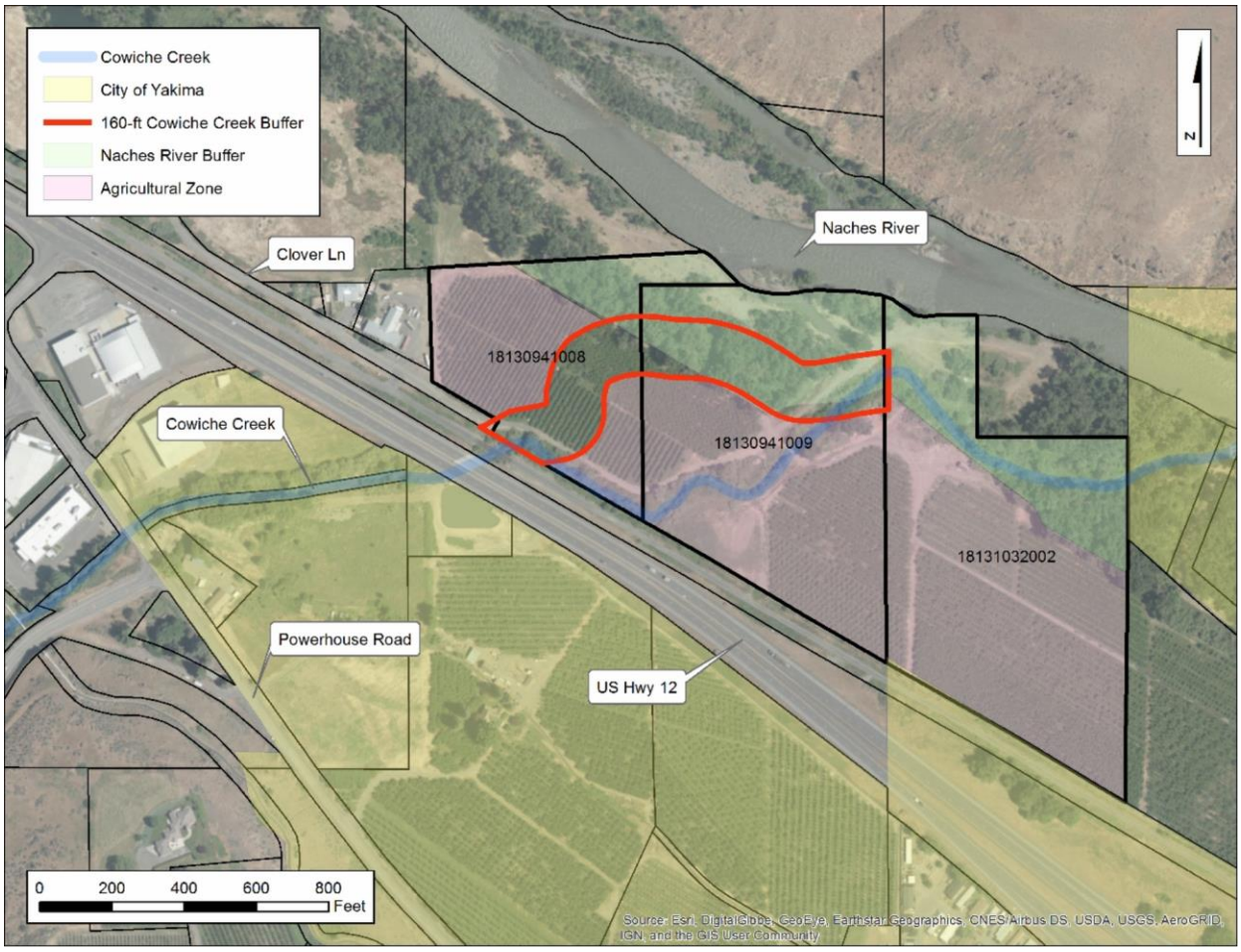


Figure 3-4. Lower Cowiche Easement

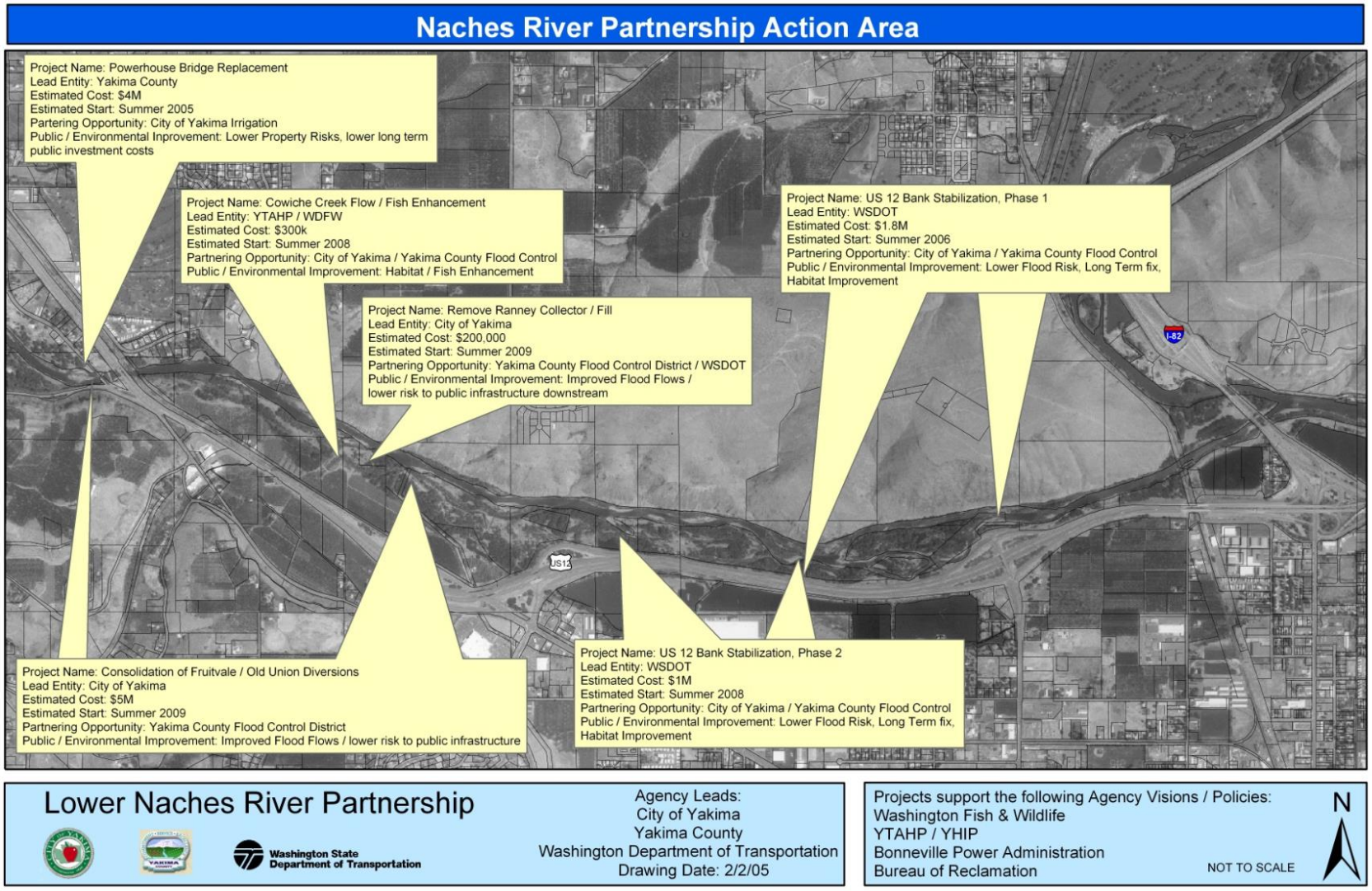


Figure 3-5. Naches River Partnership Action Area

4.0 FLOOD HISTORY

UPSTREAM DRAINAGE AND REGULATION

The headwaters of Cowiche Creek are located in the foothills of the Cascade Mountains. The total drainage area of the Cowiche Creek basin is 119.5 square miles. As shown in 4-1, the Cowiche Creek basin is separated by a high and long mountain ridge on the west and on the north, by the Cowiche Mountains on the south, and by the Naches Heights on the east. The basin elevation is relatively high with maximum and minimum basin elevations of 6,660 and 1,150 feet, respectively, and mean basin elevation of 3,110 feet. Based on 1930-1957 precipitation data the mean basin annual precipitation is about 27 inches.

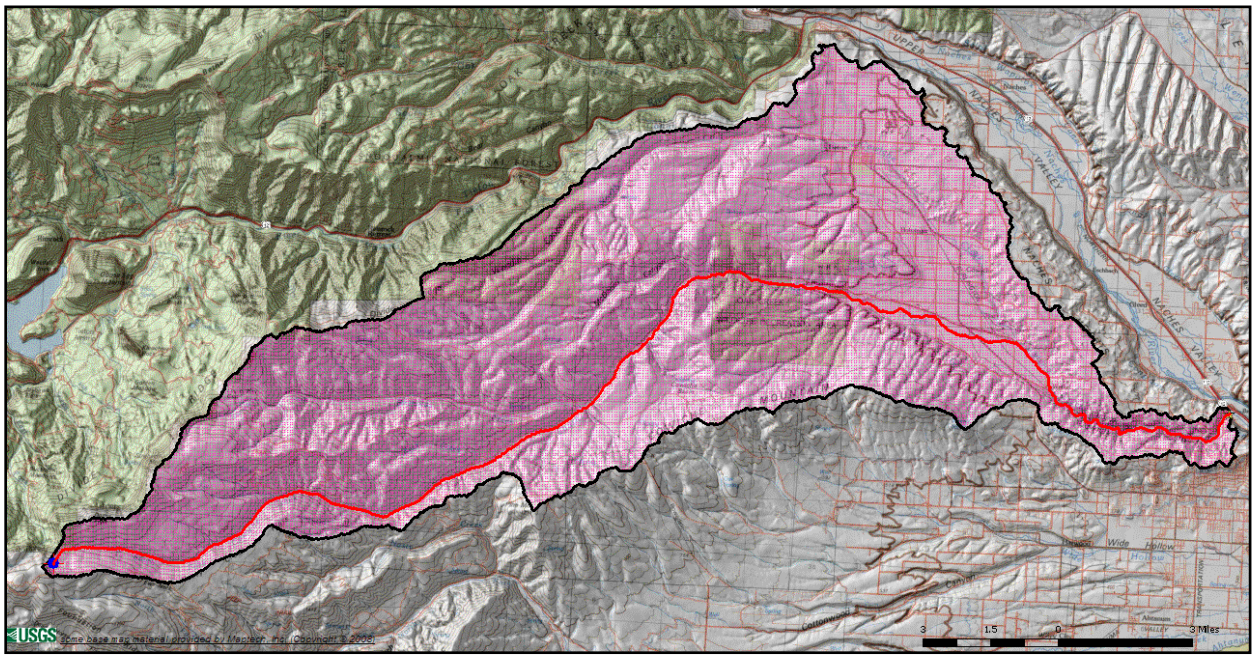


Figure 4-1. Cowiche Basin Map

The main channel from the headwaters of South Fork Cowiche Creek to the mouth of Cowiche Creek, as shown in red on figure 4-1, is approximately 33.6 miles long with an average slope of 137 feet per mile. The north and south forks of Cowiche Creek join together approximately 2 miles southeast of the town of Cowiche and form the mainstem of Cowiche Creek. Cowiche Creek then runs for about 7.2 miles before it joins the Naches River.

The French Canyon Dam located on North Fork Cowiche Creek, is approximately 1.7 miles west of the City of Tieton (see). The dam is owned by the Bureau of Reclamation and operated by the Yakima-Tieton Irrigation District. During the FEMA flood study, a sensitivity evaluation of the effect of French Canyon Dam starting levels (available flood storage) versus 10-yr through 100-yr return period floods indicate no ability of the dam to reduce the 100-yr peak flood and minimal ability to reduce the 10-yr flood.

The study area includes the lower 2.0 miles of the Cowiche Creek before it joins the Naches River.

SIGNIFICANT COWICHE CREEK FLOODS

Recent flooding in the study area occurred from rain on lower elevation snow in February 2016 and March 2017 with extensive damage that is not yet fully compiled. Prior reported events and damages on Cowiche Creek tended to be coincident with larger snow melt events across the Yakima basin, included the 1933, 1974 and 1996 floods.

The Yakima River basin, including the Naches River, typically produces winter and spring floods. Spring floods are caused by snowmelt aggravated by periods of unusually warm weather and rainstorms and their magnitude is generally moderate, but they can last 10 or more weeks, resulting in very large total volumes of runoff and river erosion. The more frequent winter floods are caused by rain on snow and warm winds that produce runoff from snowmelt and rain. They typically follow precipitation periods that have saturated the soil and replenished groundwater reserves, or extended periods of below freezing temperatures, which freezes the soil surface and causes even minor amounts of snowmelt to generate high rates of runoff. Historically, winter floods are the largest in magnitude, but their durations are typically less than one week, so the total volume of runoff is not as high as that of spring floods. The largest Yakima flood of record, the flood of December 1933, was the result of a winter rain-on-snow event. Upper basin reservoir storage typically reduces the magnitude of winter floods, which occur after the irrigation season when reservoir storage is available.

Major Yakima basin floods have been recorded in 1894, 1906, 1909, 1917, 1919, 1921, 1933, 1948, 1952, 1956, 1959, 1974, 1975, 1980, 1990, 1995, 1996 and 1997. Before the Cowiche flooding of the last two years the worst reported Cowiche floods damages were 1933, 1974, 1995 and 1996, coincident with basin-wide damages.

Mid Yakima Valley creeks draining from the Cascade Range, like Cowiche basin are susceptible to flooding during winter Chinook weather (snow accumulation followed by a period of warming temperatures, high winds, and heavy rainfall) due to their snow prone location and the limited number of trees in their drainage areas. Flood damage from such events is frequent along the Wenas, Cowiche, Wide Hollow, Ahtanum, Toppenish, and Satus creeks.

TABLE 4-1.
DOCUMENTED FLOOD DAMAGE IN YAKIMA COUNTY

Flood Event	Damage Type	Total Damage	Year of Estimate	Source
February 9, 1996	Private Public COE levees State Roads Emergency Shelters **Total**	$5,000,000 $5,349,861 $376,000 $6,845,000 $150,000 **$17,720,861**	1996	Lacey 1996 p.c. Lacey 1996 p.c. COE 1996 WSDOT 1996 Scofield 1996 p.c.
February 21, 1995	Debris Clearance Road Systems Pom Pom Bridge Emergency Response **Total**	$271,000 $230,000 $150,000 $54,000 **$705,000**	1995	Yakima County
November 26, 1990	Debris Clearance Protective Measures Road Systems Water Control Facilities Parks **Total**	$3,116 $2,000 $22,257 $21,855 $38,110 **$87,338**	1990	Yakima County
December 27, 1980	County roads and dikes	$50,000	1980	Yakima Herald-Republic
December 2, 1977	Private homes Dikes and Levees Local business Roads and Bridges Other **Total**	$1,300,000 $280,000 $147,500 $45,000 $90,000 **$1,862,500**	1977	Yakima Herald-Republic
December 4, 1975	Public facilities	$400,000	1975	FEMA (1994)
January 16, 1974	Homes in Yakima County Agricultural Damage State Highways Indian Res. Roads, Bridges County Roads **Total**	$5,400,000 $3,000,000 $2,000,000 $1,500,000 $1,000,000 **$12,900,000**	1974	Yakima Herald-Republic
January 31, 1965	County Roads in West and Upper Valleys	$30,000	1965	Yakima Daily Republic
December 23, 1933	Farmers Industries Utilities Non-Fed Irrig., Dikes Res/Bus Properties Homes Municipalities Counties Fed. Irrigation Works County Roads **Total**	$534,190 $112,000 $87,200 $50,350 $75,000 $19,675 $113,900 $187,500 $83,000 **$1,262,815**	1936	War Department, Office of the Chief of Engineers, January 20, 1936

TABLE 4-1.
DOCUMENTED FLOOD DAMAGE IN YAKIMA COUNTY

Flood Event	Damage Type	Total Damage	Year of Estimate	Source
November 17, 1906	Northern Pacific	$150,000	1906	Yakima Daily Republic
	North Yakima & Valley Rail	$60,000		
	Northwest Light & Water	$50,000		
	Cascade Lumber	$50,000		
	Yakima County Bridges	$15,000		
	Kittitas County Bridges	$15,000		
	Canal Companies	$30,000		
	Individuals	$30,000		
	Total	**$400,000**		

Impacts on Cowiche Creek were noted during the basin-wide 1933, 1974, 1995 and 1996 floods noted above, and are briefly described to allow a comparison between historical flooding conditions and recent flooding characteristics. All the flood events were winter floods involving rain on snow.

DECEMBER 23, 1933 FLOOD

The 1933 flood was a winter flood caused by rain on snow in the lower valley; it is the largest Yakima flood on record. Precipitation in the upper watershed was 500 percent above normal. Approximately 3 inches of rain per day fell in the upper watershed prior to peak flow. Over 16.5 inches of rain was reported at Keechelus Lake from December 17 through 22. Flow in the Yakima River at Parker peaked at 65,000 cfs and was estimated at approximately a 200-year flood event (see Table 4-1).

The flood caused extensive damage in the Yakima Valley, estimated as exceeding $1 million (1933 dollars). This amount is considered low in view of the community, state and federal response to Yakima flooding Newspaper accounts report water rushing over both approaches to the Terrace Heights Bridge, Naches Bridge being washed out, loss of the Union Gap bridge approach, and isolation of the City of Yakima due to loss of train and highway service for 36 hours. The Cowiche Creek overflowed and drained around the sediment pond. Any water not passing under the US 12 and railway bridges and not entering Fruitvale diversion was routed back to the river across US 12 near the current 40th Avenue intersection. The incident is reported to have resulted in the building of the flood fight levee north south adjacent to the storage pond, and may have resulted in some raising of the east west berm.

The high level of damage in 1933 resulted in Yakima County being incorporated in the federal Flood Act of 1935 and 1938 that authorized construction of the extensive federal levee system of approximately 25,000 feet of right bank levees protecting the City of Yakima, 10,700 feet of left bank levees protecting Terrace heights, and associated closure structures and culverts between Selah Gap and the Moxee bridge. Construction began in July 1947 and the primary system was completed in March 1948. The 1933 flood also resulted in Yakima County being identified and

incorporated in State Flood act of 1935 which created 18 flood zones across the State, including Yakima, which were administered by the State.

JANUARY 16, 1974 FLOOD

The January 16, 1974, flood was a significant winter flood event. Rain showers, rising temperatures, snowmelt, and ice debris in the river produced typical winter flood conditions. The January 1974 event resulted in ice jams near Selah allowing floodwaters to back up until ice debris dislodged. This produced a small flood wave and additional bank erosion along the Yakima River. Peak flow on the Yakima River at Parker reached 27,700 cfs. The Naches River peaked at 10,800 cfs. Aerial photographs indicate overtopping of the Cowiche east-west berm and not the north-south berm. Overtopping at the City storage pond into the City is apparent.

Excluding the 1933 flood, the January 1974 flood produced the greatest damage before the February 1996 flood. Yakima County was declared a federal disaster area. Six major bridges were damaged and two were completely washed out. Military helicopters were brought in to assist with evacuations and drop supplies. White Swan could not be reached by road. More than 500 people were forced to leave their homes.

An estimated $13 million of damage was reported, most of it outside the study area. Agricultural damage was estimated at $3 million, and $4 million of damage occurred to roads, highways, and other public facilities. Seventy-seven homes were destroyed and 383 others received major damage; 1,115 families were affected, and two fatalities were reported (FEMA 1994). Damage to private homes was estimated at about $5.4 million.

Flood damage was region-wide, with concentrations in the Lower Valley. Flooding affected properties along the Yakima River, in addition to smaller tributaries, as follows:

- Upper Valley—East Selah and the golf course were inundated. North Wenas Road was covered with floodwaters near Gibson Road.
- Mid-valley—Yakima Air Terminal was closed due to floodwaters covering half the runway. Citizens dug a drainage channel through South 47th Avenue to divert floodwaters away from homes.
- West Valley—All West Valley school districts were closed due to flooded roads. Many homes were flooded along Wide Hollow and Ahtanum Creeks. Lynch Road bridge on Ahtanum Creek washed out. Downed electrical poles caused a power outage near the North Fork of Ahtanum Creek. The entire Ahtanum Road was undercut.
- Lower Valley—White Swan was completely isolated by floodwaters from Toppenish Creek. Twenty-five homes were evacuated along Satus Creek. U.S. Highway 97 (Toppenish to Goldendale), SR 22 (Toppenish to Prosser and Toppenish to Buena), and SR 220 experienced flooding and structural damage. The U.S. Highway 97 bridge and dirt roads and bridges from Lateral A east were washed out along Toppenish Creek. Several families were stranded in Granger. Granger's sewage treatment plant was surrounded by floodwaters. Numerous roads

were closed, including Sunnyside-Mabton Road, all roads in the White Swan Area, roads along Satus Creek, and Mabton-Bickleton Road.

FEBRUARY 1995 FLOODS

January 1995 was the wettest January on record in the City of Yakima and the City's third wettest month on record, with a total precipitation of 3.67 inches; the wettest months on record were December 1964, with 4.19 inches, and December 1931, with 3.75 inches. These amounts are very high for an area with average annual precipitation of only 8 inches. Saturated soils, continued precipitation, and unseasonably warm temperatures produced typical winter flooding in February 1995.

The region's smaller tributary streams produced the primary flood damage. High water was experienced in Wenas, Cowiche, Ahtanum, Cottonwood, Wide Hollow, Satus, and Toppenish Creeks. The most extensive flooding was experienced in the West and Lower Valleys.

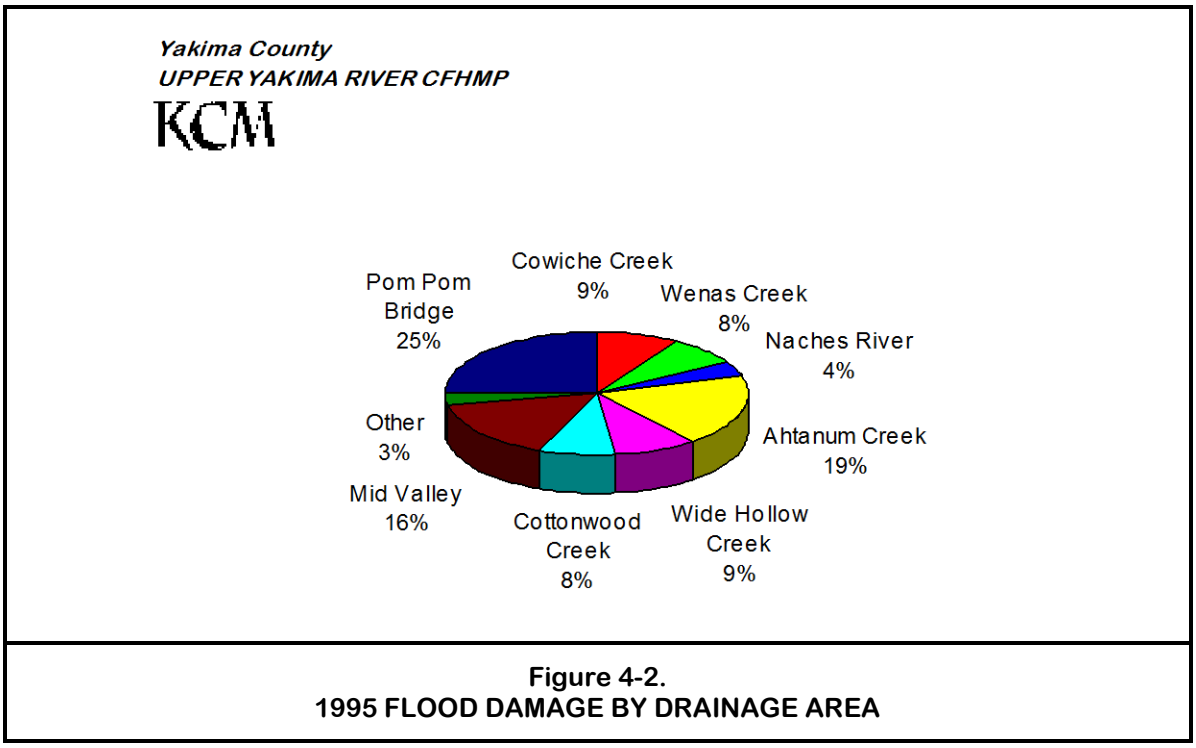


Figure 4-2.
1995 FLOOD DAMAGE BY DRAINAGE AREA

Figure 4-2 shows where County roads were damaged. Damage near Wide Hollow, Cottonwood, and Cowiche Creeks contributed approximately 26 percent of the total.

FEBRUARY 9, 1996 FLOOD

The February 9, 1996, flood was the second largest Yakima basin flood of record. Flow crested on the Yakima River at Parker at 57,500 cfs, which exceeded the then predicted 100-year event of

56,300 cfs. Water elevations exceeded flood stage by over 6 feet at Parker. This flood was a typical winter event caused by unseasonably warm weather and rainfall on a significant snow pack. Weather conditions produced flood flows from snowmelt combined with rainfall runoff. Keechelus Reservoir reported over 11 inches of precipitation within a three-day period; 5 inches of rain fell in 24 hours on Wednesday, February 7. Flooding conditions were aggravated by ice jams on the Yakima River near Selah Gap and along tributary creeks.

Flood damage was region-wide, occurring both along the Yakima mainstem and tributary creeks. Areas receiving the greatest damage included the Cowiche, Upper Naches, Selah, Ahtanum, Wapato, White Swan, and Toppenish Creeks. More details on the County-wide damages are contained in the CFHMP.

Yakima County was declared a federal disaster area. As of May 23, 1996, FEMA had received over 1,780 applications for disaster assistance. Requests for private assistance were estimated to exceed $5.0 million and requests for public assistance were estimated at over $92 million (Lacey, E., 1 March 1996, personal communication). As of May 23, 1996, FEMA had provided $5.3 million in assistance for public facilities. This figure does not include funding provided by other agencies such as COE and American Red Cross. Protective measures and road systems accounted for the largest portion of requested federal funding assistance (Figure 4-5).

According to personal anecdotes the north south levee was raised during this event to accommodate overflows from Cowiche Creek and the east-west levee along Cowiche Creek was raised post flood.

FEBRUARY 15, 2016 FLOOD

The February 15th, 2016 flood was caused by a persistent late-season snowpack in the lower elevation portions of the Cowiche Creek watershed (from 1500 feet to 3500 feet), coupled with a pronounced, multi-day warm-up event. Overnight low temperatures at the WSU Ag Station near the town of Cowiche went from generally near or below freezing before February 14th to over 43 °F on the night of February 14th. Daytime peak temperatures went from the low 40's on February 13th to nearly 60 °F on the afternoon of February 15th. From 10pm on the 14th, to 10pm on the 15th, the temperature did not drop below 50 °F. Flows peaked at around 12:15pm at the Ecology gage and around 4:45pm at the Bureau of Reclamation gage on Powerhouse Road. The peak stage recorded at the Ecology gage was 9.14 ft. The peak stage recorded at the BOR gage was 6.94 ft. The rating curve for the Ecology gage ends around 7.2 feet, but extrapolation of the rating curve suggests a peak flow of approximately 1,200 cubic feet per second. Snow Water Equivalent (SWE) records at the Green Lake SNOTEL site indicate that very little snowmelt-related runoff occurred at the higher elevations of the watershed. No significant precipitation occurred with this flood event.

Flood flows overtopped the east-west berm between Powerhouse Road and Highway 12. This overflow volume accumulated behind the north-south berm until it burst (the break caused a 25 foot, full-height opening in the 10-foot-high structure). There was some damage to the east-west berm from piping and overtopping as well as to the City's concrete irrigation reservoir due to the overflow heights and duration. This dam-break event (and continued overflow from the rising Creek) sent water through the adjoining orchard, along the south side of Highway 12, through the

northern end of the Riverview Manor mobile home park, and then east on along the south side of the Highway 12 off-ramp. Flows temporarily went northwards under Highway 12 to the Naches River via the Fruitvale canal (running backward). By early evening the peaking floodwaters had overwhelmed the canal and had reached the Fruitvale Blvd and 40th Avenue interchange. The intersection was shut-down to traffic. Floodwaters continued causing damage along the south side of Fruitvale Blvd as far eastward as Revolution Cycles and to a number of businesses along the primary overflow path between Fruitvale Blvd and Myron Lake. Flows receded overnight. By early morning on the 16th, the intersection was largely re-opened and flows were fully contained by the creek banks.

Post-flood debris was removed from the upstream face of the Highway 12 bridge and also from the channel and channel bank just upstream.

MARCH 6, 2016 FLOOD

An isolated thunderstorm event occurred in March of 2016 and dropped a substantial amount of rain in in the valleys and foothills west of Yakima. The WA-YK-8 CoCoRaHS weather station recorded 1.12 inches of rain on March 6th, 2016. The peak stage recorded at the Ecology gage on Cowiche Creek was 8.8 ft (~1100 cfs). This event did not overtop the banks of Cowiche Creek between Powerhouse Road and Highway 12 (possibly as result of emergency flood response efforts for the February event).

MARCH 14-16, 2017 FLOOD

The 2017 flood event on Cowiche Creek occurred with peak flows observed on both the evening of March 14th (approximately 1,200 cfs) and again the evening of March 15th/morning of March 16th (approximately 1,100 cfs). The event was largely caused by the rapid melt of a persistent (late-season), low-elevation snowpack, plus a moderate rain on snow event at the upper elevations. This yielded a more sustained high-water event, with a significantly larger total runoff volume than the 2016 event, with a bimodal or 'double-peak' hydrograph occurring over two days. Overnight low temperatures at the Green Lake SNOTEL site went from around 20°F on March 7th to above freezing on the evenings of March 13th and March 14th. Daytime temperatures at the Green Lake SNOTEL site went from below freezing on the 7th, to nearly 50°F on the 13th. Approximately 0.6 inches or rain was recorded at the site on March 14th. The recorded Snow Water Equivalent (SWE) dropped nearly 2 inches from March 14th to March 17th. Conditions were even warmer in the lower portion of the watershed. At the WSU Ag Station near Cowiche, the average temperature went from 31°F on March 7th, to 50°F on March 15th. Peak temperatures on the 15th reached 62°F.

In 2017, flood flows overwhelmed the south bank of the creek between Powerhouse Rd and US Highway 12, breached the east-west and north-south berms and flowed eastward toward the City of Yakima along the southern side of the highway. Flows did not pass over/through the City's irrigation reservoir as was observed in 2016, but breached the south bank of the creek approximately 230 feet upstream, immediately upstream of a significant woody debris jam. The initial breach occurred on the morning of the 15th and continued until City crews were able to locate and remove the debris jam on the 16th. The peak flow rate into town may have been as high as 300 cfs. The Fruitvale Canal (again) conveyed a portion of the flows back under Highway 12

and into the Naches River before it was overwhelmed allowing flood flows to head towards the 40th and Fruitvale intersection.

The extended duration of the hydrograph and the breached berm resulted in larger runoff volumes reaching Myron Lake which overflowed into Willow Lake and then Aspen Lake. The higher water level in the lakes caused considerable street and structure flooding in the surrounding commercial and residential area. A portion of the overland flood flows eventually crossed 16th Avenue. Urban stormwater drainage systems and infiltration into the ground diminished overland flows and prevented further damages to the east.

The 2016 and 2017 flood extents within the City are shown on Figure 1-4.

5.0 FLOODPLAIN INFRASTRUCTURE AND FLOOD CONTROL FACILITIES

This chapter describes flood control and flow conveyance facilities provided in the amendment study area, the infrastructure required as part of development that effect floods, and documents the historic channel realignments undertaken to enable this infrastructure. Examination of flood causes and former alignments can indicate potential solutions.

CREEK ALIGNMENTS

Examination of the 1901 USGS maps (see Figure 5-1) indicate the original Creek alignment, delta and confluence was to the north of its current alignment, passing several hundred feet east of the current Clover Lane interchange. The Naches Cowiche and Yakima Valley Canal (formerly Congdon Canal) alignments are also shown, which would have constrained the Cowiche Creek main channel alignment at their crossings.

North Pacific Railway (NPR) formed a subsidiary, North Yakima and Valley Railway (NYVR), in order to construct several Branch lines including the Naches (1906) and Cowiche (1913) branches. The Branches served fruit warehouses and a lumberyard in Naches. The Naches spur-crossed the original creek alignment, while the Cowiche Branch alignment constrained the rivers floodplain to the north. The Cowiche Branch Creek, as well as servicing the Fruit Packers in the upper basin also provided for transport of material to the Bureau dams in the Cowiche basin.

The Cowiche Branch alignment along Cowiche Creek and its tie in to Naches Branch near the Cowiche canyon mouth pushed the creek approximately 1000 feet southward, cut-off the channel path to its confluence, which was then north of its current location and narrowed the effective floodplain of Cowiche Creek. This was the initial displacement below the old Powerhouse Road of the Cowiche Creek off of its delta.

At that time Powerhouse Road alignment was west of the current alignment and warehouses that occupied the infilled floodplain were built on either side of Powerhouse Road and already confined the Creek.

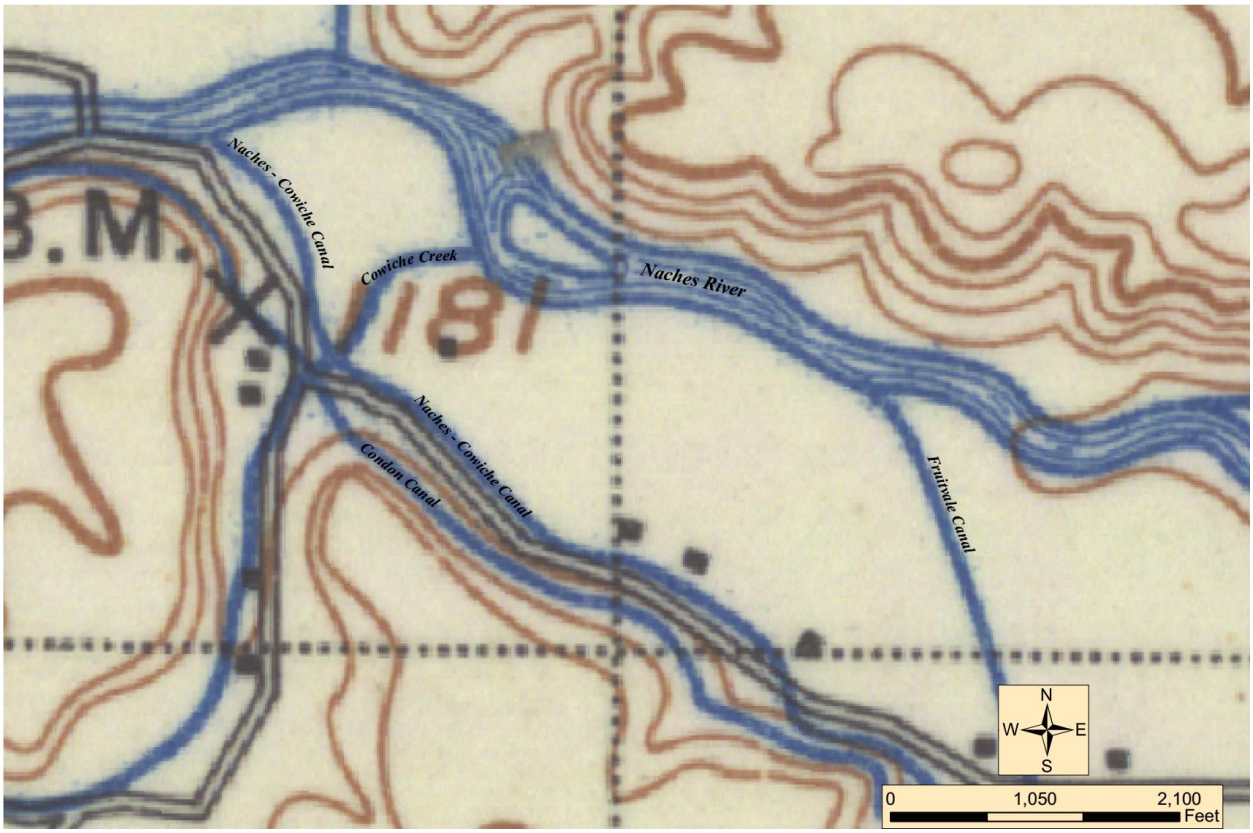


Figure 5-1. 1901 USGS Map of Lower Cowiche Creek.

The 1927 photo (see Figure 5-2) shows the Cowiche Creek realignment both upstream and downstream of the old Powerhouse Road. Downstream of the current Powerhouse Road the channel and floodplain were wholly confined by the Northern Pacific Railway Cowiche Branch and its connection to the Naches Branch until its Naches Branch bridge crossing further south of the 1901 alignment. The modified channel and floodplain is shown on the figure. In 1927 the channel is fully contained to the south on the current Holtzinger property (parcel 181309-42004), until it reached the junction of the Naches Branch. Despite this northern constraint the 1927 channel alignment was still entirely to the north of its current alignment.

Upstream of Powerhouse Road the channel was wider, occupying the Shooting Range parcel (parcel 181309-42402), and the Yakima Valley Canal Company parcel (parcel 181309-42017). All of these parcels have since been raised through filling. At the location of the current Powerhouse Road alignment Cowiche Creek extended more than 200 feet to the north of its current alignment, and covered a much larger area. Upon crossing Powerhouse Road, its alignment, initially pointed northeast before meandering southwesterly towards the City storage pond.

From the photo, ditches along the south side of NYPR Cowiche Branch reconnect to the Cowiche channel indicating the cutoff floodplain formerly lying to the north. Soil textures/moisture in the 1927 photo indicate cutoff of a large Cowiche Creek delta and confluence to Naches River north of NYR railway, in agreement with the 1901 USGS alignment.

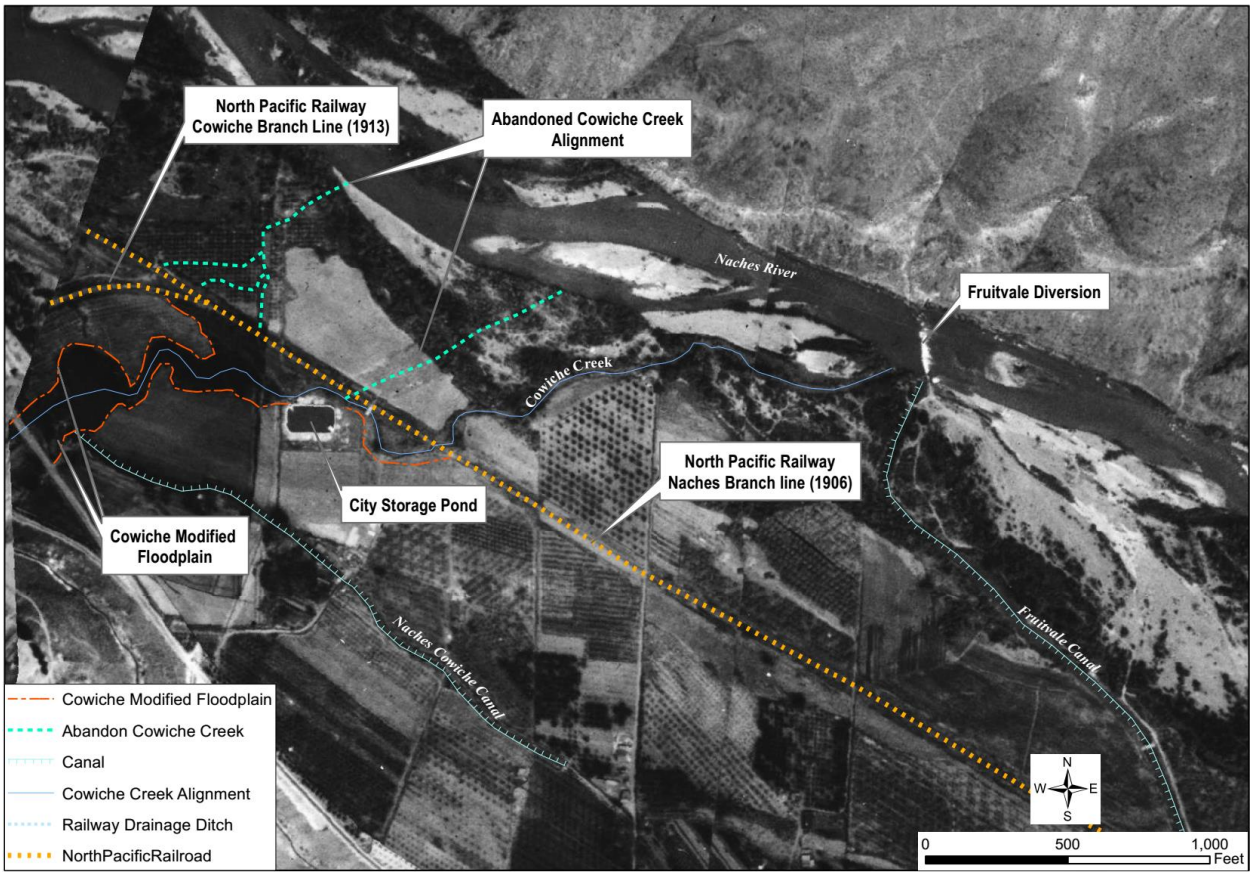


Figure 5-2. 1927 Aerial Photograph of Lower Cowiche Creek.

The storage pond, built around 1917, was built following the 1913 Cowiche channel railway induced realignment and ordinary high-water line, and forced the channel to go around the north side of the pond, hugging the pond along the pond's northern side until the channel runs against the railway crossing, deflecting the creek south before reaching the only railway bridge crossing to the southwest. The City took over the irrigation facilities at this location in 1926, including the storage pond. Also visible on the photos is a north south ditch adjacent to the storage pond, along the current alignment of the current north south berm and drainage line from the City's uphill reservoir. The 1927 photo shows the railway bridge location as much as 400 feet southwest of its current location towards Yakima. Any old pre-railway channel alignments to the east of the railway had been long filled in for farming by 1927.

Powerhouse Bridge was constructed in 1935 as part of State Route 5. State Route 5 to Naches and Yakima was moved and converted to Primary State Highway 5 in 1937 and its current alignment is shown on the 1947 photo (Figure 5-3). This second Cowiche Creek PSH5 bridge crossing was located immediately north and adjacent to the City storage pond, with the creek now aligned between PSH5, and the railway for 400 plus feet before passing under the railway.

Primary State Highway 5 was converted to US 12 with the reconstruction of US Highway 12 (formerly PS5) in the 1960's, with it's the provision of additional bridge span at the same location

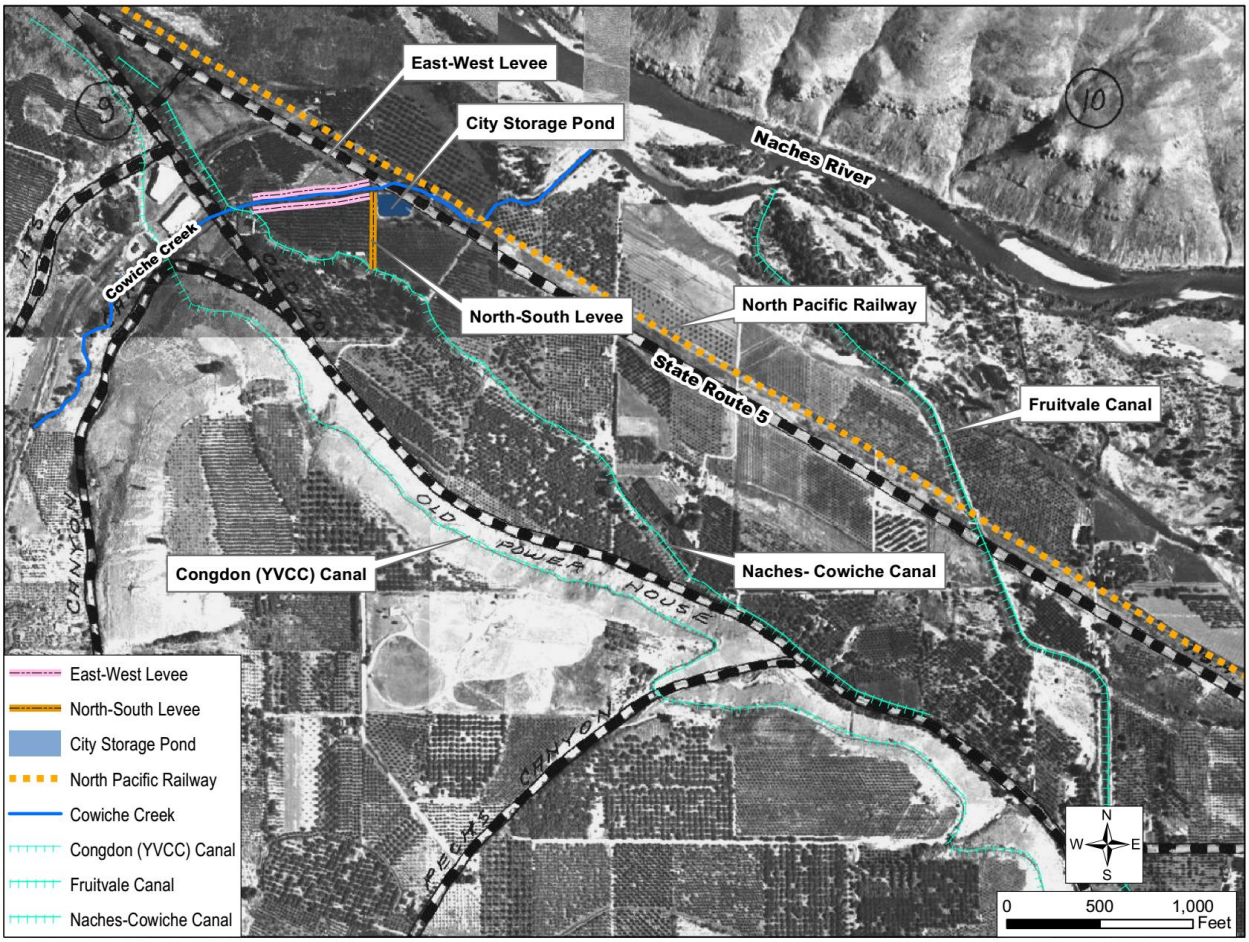


Figure 5-3. 1947 Aerial Photograph of Lower Cowiche Creek Overlaid with Existing Naches River Irrigation Diversion Schematic from Nelson Dam to the Old Union Diversion.

to accommodate the additional 2 lanes, starting in 1963, which resulted in abandonment of the railway bridge crossing located 430 feet southwest of the storage pond.

In summary, Cowiche Creek alignment has been greatly modified upstream of the Naches railway route to match railway, landowner, road, irrigation, storage pond and Highway configurations and reconfigurations, discussed further below.

LEVEES

Aerial photos indicate southward movement and straightening of Cowiche Creek between 1927 and 1947 into its current alignment upstream of the sediment storage pond. This straightening and channel excavation would have been required berms/levees. The constructed east-west creek containment levees (indicated on Figure 5-3), were most likely created by the landowners r to maximize the orchard space and contain flows. The channel is currently raised above the floodplain by several feet and the east-west containment levees would likely have been reinforced in response

to floods over time. The southern east-west levee was overtopped in 2016 and failed in the 2017 flood.

The 1955 Federal Authorized Project (Yakima Levee system) O&M manual page 11, Section 4.04, notes the existence of a separate private north-south levee protecting the City of Yakima from Cowiche flood overflows flows: "Cowiche Creek Levee – in addition to the main levee system described in the preceding paragraph, a privately-owned levee prevents Cowiche Creek flood waters from flowing into the City of Yakima. This levee is approximately 4 feet high and extends from the right (southwest) abutment of the current U.S Highway 12 bridge in a southerly direction approximately 400 feet to high ground". Plate I of that document shows the location of the north-south levee next to the existing City storage pond and the highway bridge. That bridge was incorporated and extended in the 1960's with the upgrade of U.S. Highway 410 to four divided lanes.

Discussions with local residents and operators of the Naches Cowiche irrigation system indicate that the north-south levee attached to the storage pond was built in response to the 1933 flood and then raised during the 1996 flood, when flood waters passed over the structure into the City. The north-south levee is located on top of the buried reservoir overflow line leading to the storage pond. The 1927 photos do not show the north south berm structure, but show instead a ditch where the city reservoir line was installed – likely this was the line under construction.

Examination of the lower 4 feet of the berm reveal it is composed largely of large rock indicating it was probably constructed as a flood fight levee built to withstand the conditions of flowing water. The 1955 O& M Corps manual verifies that the structure was not yet raised to its current height. The structure is now ten feet tall and has steep side slopes and is less than six feet wide at the top, indicating that it has an added-on vertical feature, without lateral extension for stability. The material in the upper six feet is fine sands and likely prone to piping due to the narrow section. This north-south levee failed in the 2016 flood.

HIGHWAY AND ROAD CROSSINGS

Within the study area there is a section of State/Federal Highway between 40th Avenue and the Naches Railroad bridge near 6th Street that acts as a levee to the Naches floods and provides 100-year level of protection for the City of Yakima to FEMA requirements, and displayed on the NFIP flood maps. The Cowiche crossing bridge was constructed in the 1930s well before the 1968 Act creating the National Flood Insurance Program. The two components as they effect the Naches and Cowiche floods are as follows:

US 12 – US 12 highway alignment along the Lower Naches River (historically aka SR5 and SR410) was constructed as two lanes in the 1930s and expanded to four lanes in between 1963 and 1971—Historically the Naches River floodplain extended beyond Fruitvale Avenue in the City of Yakima and in areas of Yakima County upstream to the current study area limit at the US 12 crossing of the Naches. Based on the FEMA 2009 remap the current four lane configuration of US 12 contains the Naches River 100 and 500-year floods to the north, protecting a large area of the City of Yakima from flooding by the Naches River. Failure of US 12 during a Naches River flood event would prove catastrophic to large areas of Yakima as there are currently no facilities

to let floodwaters exit the City and return to the Yakima or Naches rivers. Repeated damage to US 12 upstream of the 16th Avenue Exit, even during relatively minor flood events, presents high levels of flood hazard not only due to loss of transportation infrastructure, but also due to the key role that this portion of highway plays in providing a high level of flood protection to a large urbanized area.

US 12 Bridge – US 12 bridge crossing of the Lower Cowiche creek (historically aka SR5) was constructed in the 1930s as a two-lane span and expanded to four lanes between 1963 and 1971— The Cowiche Creek floodplain was modified by the City storage pond bridge alignment and thence by Highway 12. The Highway alignment in the 1930's cut of the northeast corner of the pond. In 1963, in preparation for the four lanes the WSDOT bridge was expanded initially for two lanes and the railway bridge moved 400 feet north. When the highway was expanded to four lanes in 1971 the two-lane bridge opening was extended upstream towards the storage pond creating a 110-foot bridge length along the channel. A retaining wall was built between the storage pond and the 1970 two-lane bridge extension. Modifications for piping to the pond were also accomplished at this time. The Recent FIS studies noted above establish that this portion of the highway does not provide 100-yr protection from Cowiche Creek as the bridge is undersized for this FEMA generated 100-yr flow. The bridge is still within its life span. This bridge without channel excavation does not pass the 10-year flow. Floodwaters overtop the southern river berm upstream side of the bridge and head toward town. The original two-lane bridge was built decades prior to current federal and state standards that use the 100-yr flood, since the National Flood Insurance Program was passed in 1968. Modeling has indicated that this span of bridge cannot pass the 100-yr flood even with excavation, so that a replacement or sister bridge would be required to pass the 100-yr flood. Review of 1963 WSDOT design drawings show the Cowiche Creek channel invert 3 feet lower than today, indicating a significant build-up of sediment in the channel over the last 54 years upstream of the US 12 bridge. However, investigation of the floodplains and LiDAR suggests this may have been a transcription error, as it would mean a significant trough in the stream gradient plus separation from the floodplain, as well as erosion of a downstream City water main. Replacement of this bridge is not currently on WSDOT's capital improvement plan.

City of Yakima Powerhouse Road Bridge – It is the original State Route #5 bridge built in 1930. This bridge is past its design life and barely passes the 10-year flow. It was designed according to standards at the time and all of the related infrastructure around it has already or will be modified this year. A new bridge would require more depth and width, but there is not much width upstream which would allow to gain upstream benefits as well. This bridge is located in what should be a 3-lane section and bike lane, so this bridge ideally would not only have a greater span but a much greater overall travelled lane width. Yakima County Roads provided a design for this bridge when it was in the County, before it was annexed by the City.

Squire-Ingham Orchard farm bridge – The orchard downstream of US 12 along Cowiche Creek currently uses a small 16-foot-wide bridge for both farming access and hauling freight out of both orchards toward US 12 on Clover Lane. Provision of alternative farm and haul routes for the orchard also needs to be considered as the widening of the bridges on US 12 may make construction of a relatively narrow bridge infeasible.

RAILWAYS AND TRAILS

Yakima County's Cowiche Creek Trail Bridge on the old Naches Spur line - This bridge is newly constructed and does pass the 100-year flow. However, if the US 12 replacement wider bridge alignment results in misalignment or we sister a new bridge span adjacent to the existing structure, the realignment will probably require another trail bridge. So, impacts and changes to the County bridge need to be considered within the study area.

IRRIGATION STRUCTURES AND CANALS

Four irrigation withdrawals are made from the Naches River in this reach, two at Nelson Dam (Naches-Cowiche and City of Yakima) and two just downstream of Cowiche Creek confluence (Fruitvale and Old Union). These intakes and canal systems were provided in the 19th century. They create a labyrinth of piping, siphons, fish passage structures and open canals in this area the complexity of which is depicted in Figure 5-1. Crossings with this infrastructure, particularly Naches Cowiche has confined potential channel alignments. The Fruitvale Canal diversion structure has also restrained the Cowiche alignment at its confluence with the Naches River.

These actions led to the subsequent development and in-filling of the Cowiche floodplain both upstream and downstream of the current Powerhouse Road alignment and the eventual relocation of the creek southward of its historic delta deposits.

FORMER US 12 GRAVEL PITS

During the construction of US Highway 12 as a four-lane divided highway in starting in 1963, three large gravel supply pits were created and built exterior to the river based on highway alignment. They are Myron, Willow and Aspen Lakes listed in upstream to downstream order along the Naches River. Due to the gradient along the Naches River the pits were separated to minimize constructed depths and construction pumpage. The lake elevations for the resultant pits determined by constructed drainage features are approximately 1125, 1109 and 1102 feet, for Myron, Willow and Aspen lakes respectively with corresponding surface areas of 14.6, 28.7 and 22.6 acres.

During highway construction the three pits were each provided with 18-inch outlet pipes and flap gates to the Naches River plus connecting overflow piping from upstream pond to downstream. Ownership of Willow and Aspen Lakes was transferred by WSDOT through a developer to Homeowner groups. Figure 5-4 shows their physical location and includes fish passage and other structures.

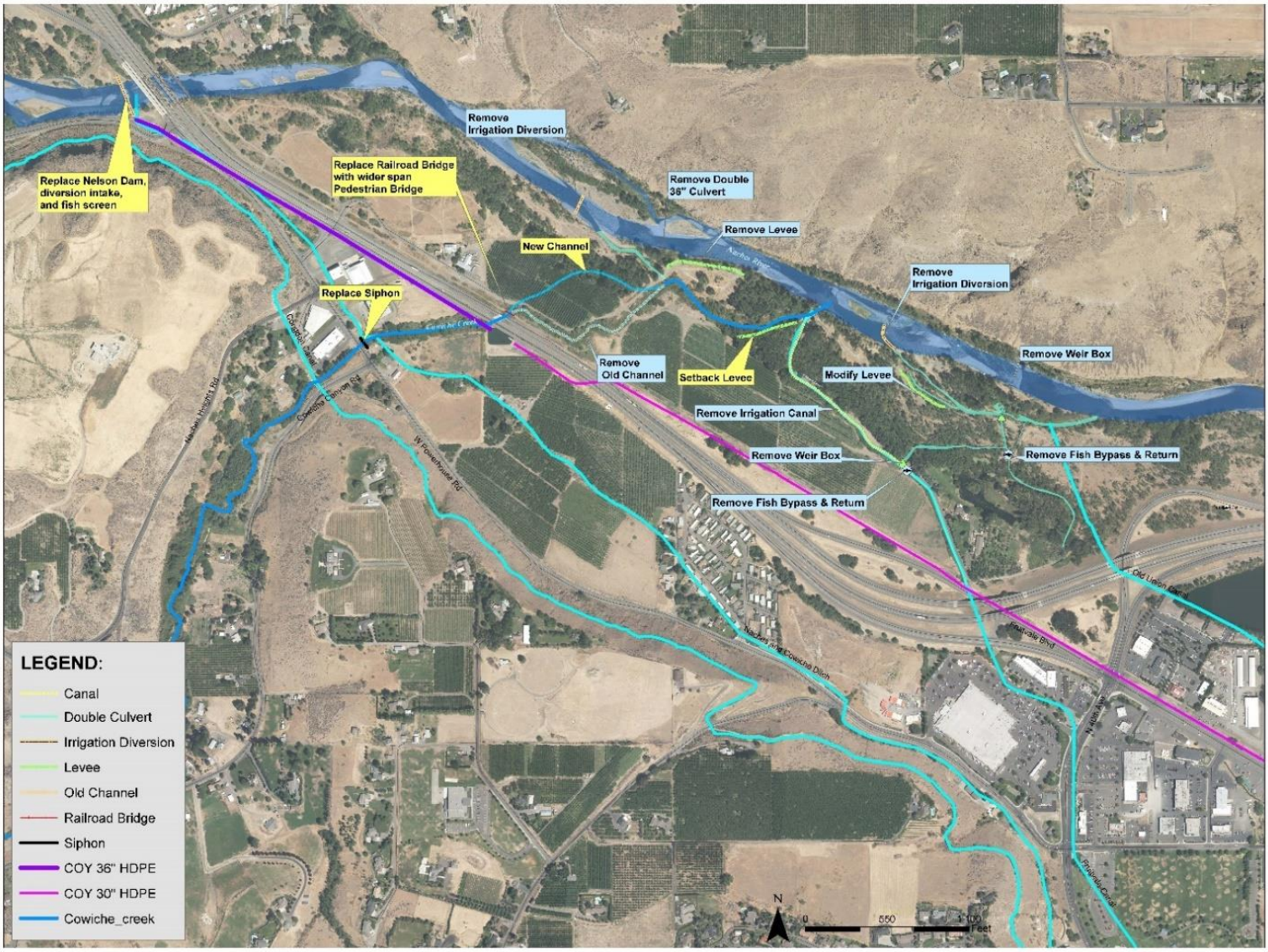


Figure 5-4. Location of Canals, Culverts, Diversions, Levees and Fish Passage

6.0 FLOOD ISSUES AND INFRASTRUCTURE

CAPACITY OF COWICHE CREEK INFRASTRUCTURE

During the recent FIS study flood restricting infrastructure in this reach was identified. The infrastructure providing restrictions to 100-yr floods are Powerhouse Road bridge, the channel capacity downstream of Powerhouse Road, the east west berm height on both sides of the channel, the storage pond height, Highway 12, the Yakima County trail bridge, the protective berm on Ingham's property and the channel capacity and grade downstream of the trail bridge. During this study, more detailed hydraulic investigations were provided below.

HYDRAULIC MODELING OF COWICHE CREEK INFRASTRUCTURE CAPACITIES

FCZD staff created and refined a hydraulic model of the Cowiche – Naches confluence as part of a coordinated technical response to the flood events of 2016 and 2017, and as part of the initial data gathering efforts associated with the preparation of this addendum to the CHFMP. The hydraulic model was originally developed as a linked 1D-2D HEC-RAS (version 5.0.3) simulation tool. It was aimed at re-creating the events of 2016 and 2017 with the goal of then estimating current channel capacities and to evaluate potential emergency actions that could be taken to reduce flood risk before the next flood season.

The model initially informed two maintenance actions in summer/fall 2017, performed by the City of Yakima (brush trimming, levee access improvements) and WSDOT/Yakima County (sediment removal under US Highway 12 and the trail bridge). The model was later expanded as additional information became available (survey, and new LiDAR) to include a number of different simulations, including fully 2D simulations and a range of small and large flood flow events (e.g. 2-yr, 10-yr, 100-yr, etc.). Estimated channel conveyance capacities are shown in Figure 6-1.

2016 / 2017 DISCHARGE HYDROGRAPHS

Flow estimates were required to simulate the 2016 and 2017 flood events. Ecology maintains a flow gage on Cowiche Creek just downstream of the confluence of the North Fork and the South Fork. The gage is largely targeted at informing reach water quality and provides good quality flow/temperature data for the predominant flow conditions. It is not intended as a flood flow gage for measuring peak flood discharges. The published rating curve for the 2017 WY was limited to flows of less than 540 cfs. At flows above this magnitude (both the 2016 and 2017 flood events), the station only reports the observed stage. To recreate the runoff hydrograph for the 2016 and 2017 events, the rating curve was extrapolated to flows around 1200 cfs as shown in Figure 6-2. Extrapolation of the rating curve assumes that the relationship between depth and flow area remains consistent even as flows rise above the upper limit of the published rating curve. Field observation of the gaging site suggests this may be a reasonable assumption up to about depths of 5 feet (corresponding to stage readings of about 9 ft) and flows around 1,200 cfs. Above that flow level, significant amounts of overbank/floodplain flow would occur and the rating curve would become increasingly inaccurate.

The Bureau of Reclamation maintains a stage-only gage on Cowiche Creek at the upstream side of the Powerhouse Road bridge. As a second check on the reasonableness of the extrapolation, this stage data was compared to the flows recorded at the Ecology gage upstream (see Figure 6-3). Peak flows at the Powerhouse bridge occurred about 5 to 8 hours after peak flows were observed at the Ecology gage upstream. Figure 6-4 shows the relatively close correlation between observed stage data on the upstream side of the Powerhouse Rd bridge, the time-shifted flow data recorded at the Ecology gage, and the rating curve for the Powerhouse Bridge section (from the HEC-RAS model). This reinforces the conclusion that the flow peak estimates yielded by the extrapolation of the rating curve are indeed reasonable and provides an estimate of the potential error (50 to 100 cfs).

Estimated hydrographs for both the 2016 and 2017 event are shown in Figure 6-5 along with the corresponding flows that were observed in the Naches River during the 2017 event. The analysis indicates that both flood peaks were very nearly 1200 cfs with the 2017 event exhibiting a second peak and persisting for a significantly longer duration.

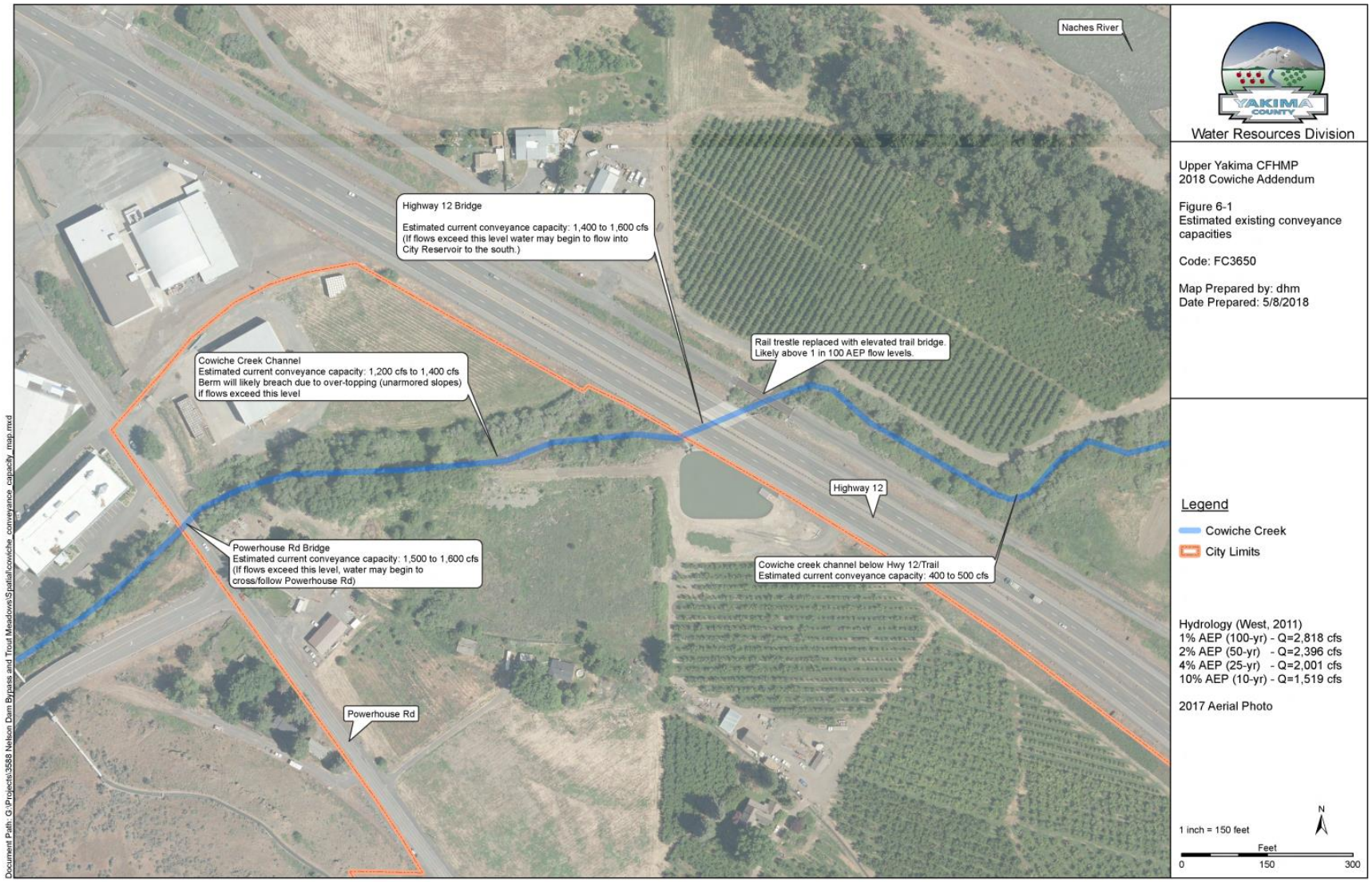


Figure 6-1. Estimated Existing Conveyance Capacities for Cowiche Creek

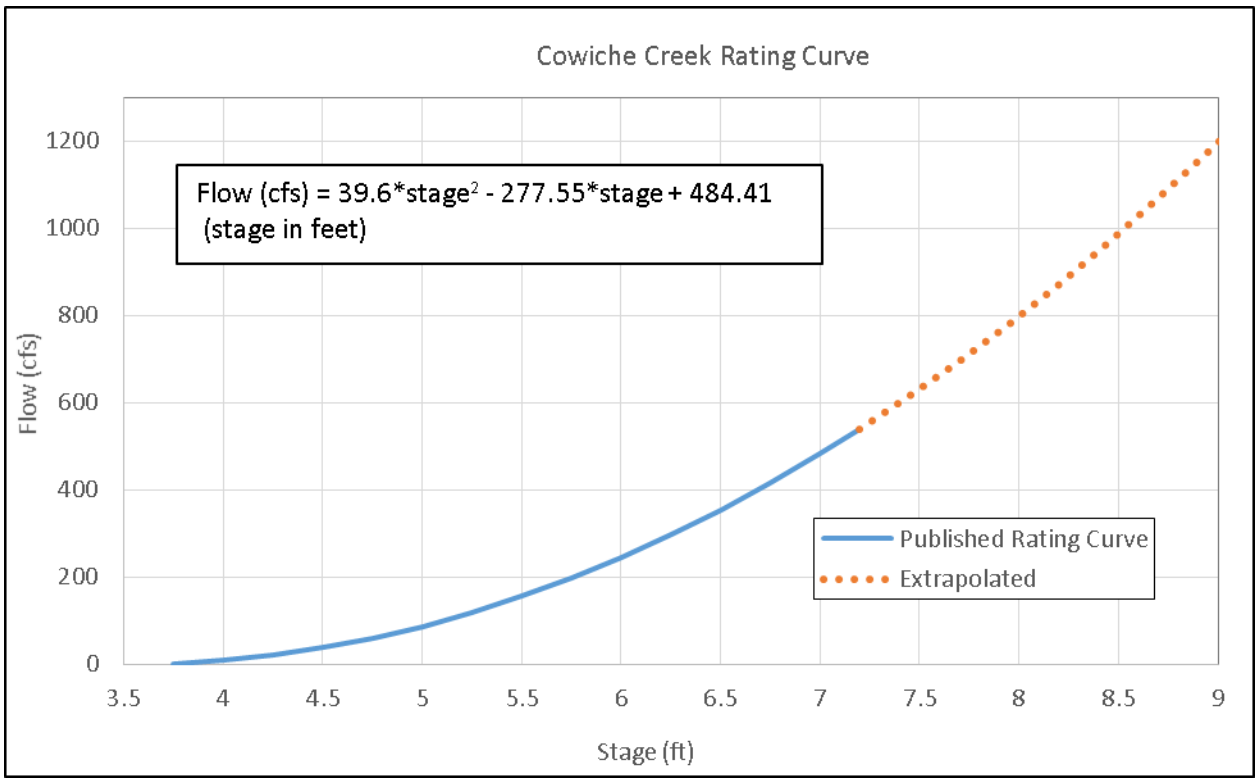


Figure 6-2. Extrapolated rating curve for Cowiche Creek at the Ecology gage (2017 WY)

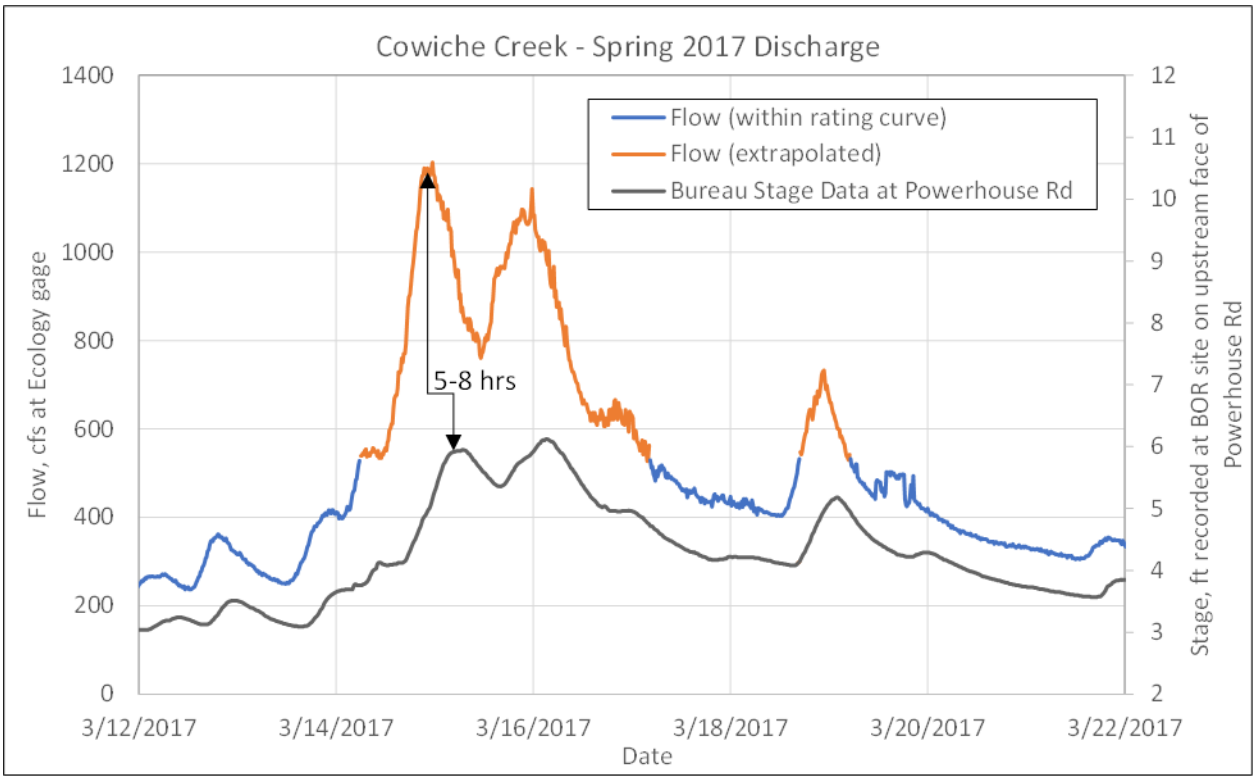


Figure 6-3. Reconstructed hydrograph versus recorded stage

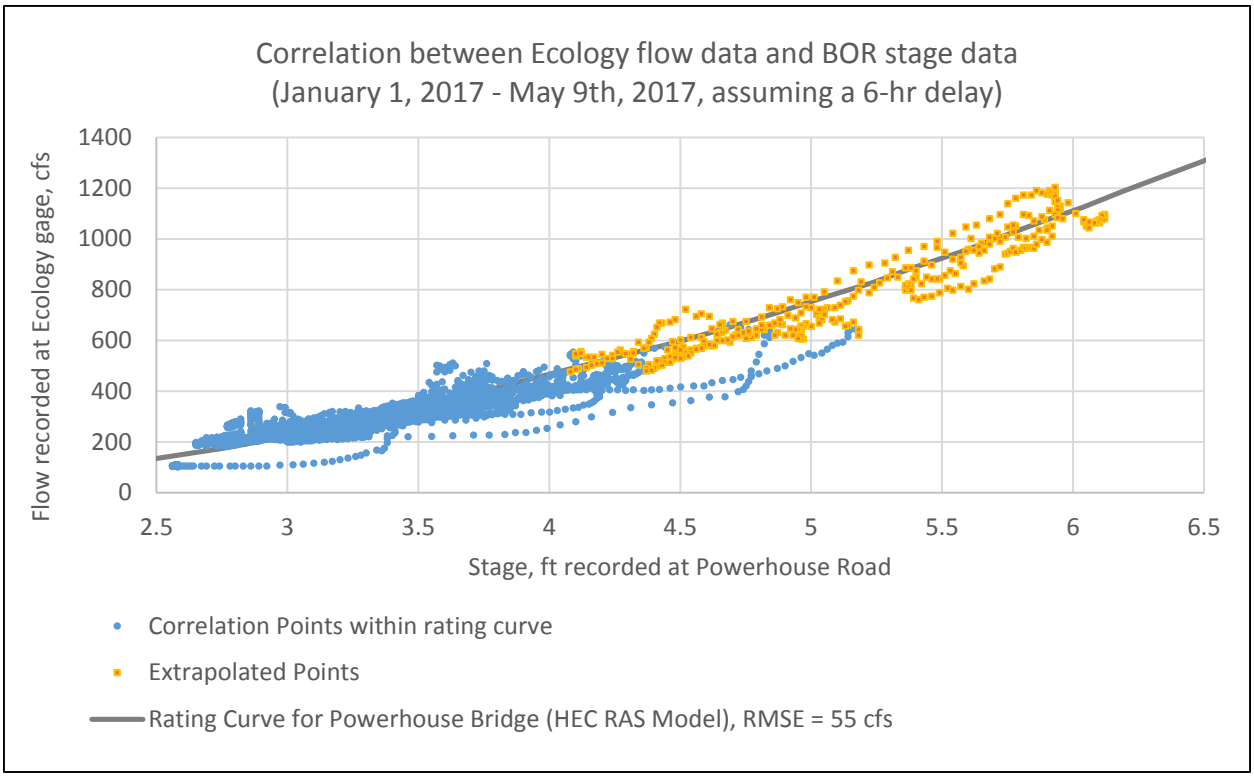


Figure 6-4. Correlation between Ecology flow data and BOR stage data

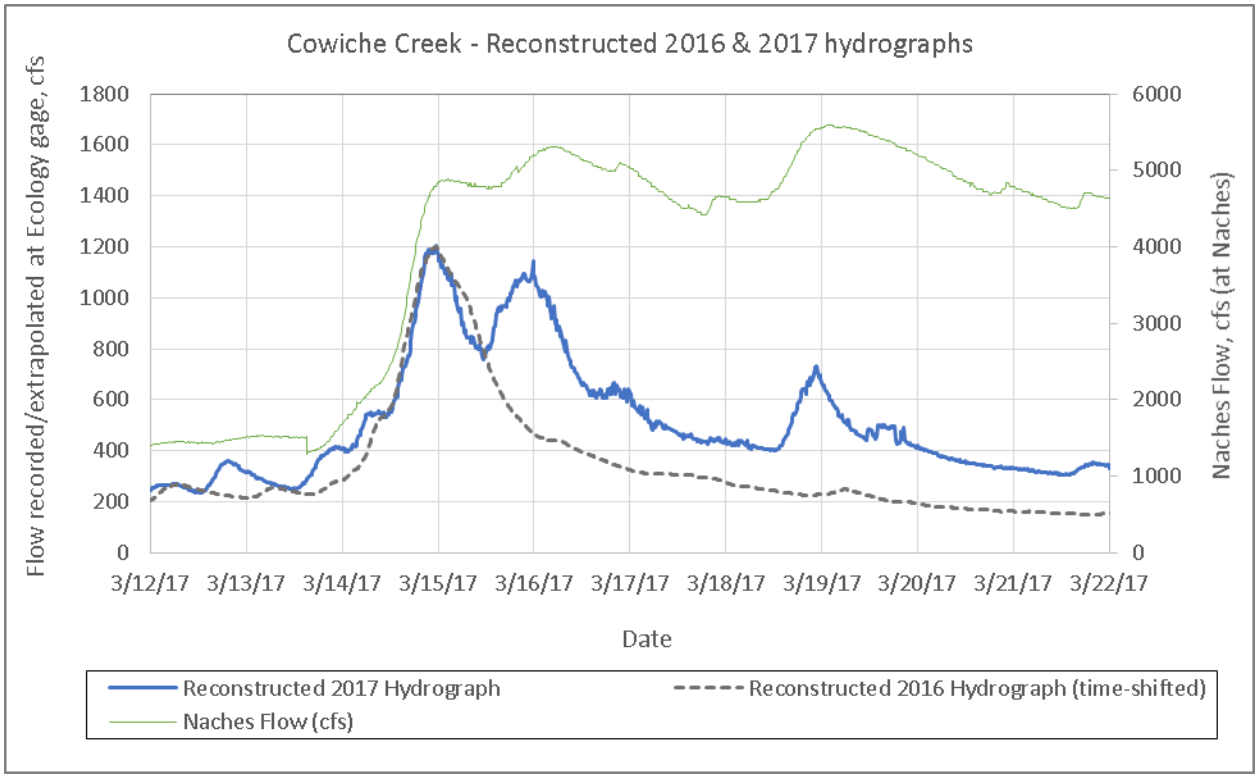


Figure 6-5. Reconstructed 2016/2017 hydrographs

HYDRAULIC SIMULATIONS

Hydraulic simulations were conducted using a 1D-2D model initially built from 2005 LiDAR topography and cross-sectional bridge survey data from the 1D RAS model that had been assembled as part of the 2011 Flood Insurance Study and flood map update for Cowiche Creek (West, 2011). Field observations of flood flows and local site conditions indicated the need for additional surveyed cross-sections and improved hydraulic structures to adequately model the Highway 12 bridge, the south berm of Cowiche creek, and overflow flood routing resulting from berm breaching. The model evolved into a 1D-2D linked simulation that used 1D sections for the main channel of Cowiche Creek connected to a 2D overbank floodplain domain via lateral structures (weirs) along the levee crests that could be breached during simulations. The spatial configuration of the model is illustrated in Figure 6-6 which shows the 1D sections, the break-lines and grid cells (~ 30 ft) of the 2D domain, and the alignment of the various lateral weir structures used in the model. The model included a variety of flows in the Naches and extended upstream to Nelson Dam and downstream to just east of 40th Avenue (flood waters into the City of Yakima were not simulated). The weir profile and a typical breach simulation for the south bank of Cowiche creek between Highway 12 and Powerhouse Road is shown in Figure 6-7. Simulations were typically run with a computation timestep of 5 seconds using the Full Momentum equation set.

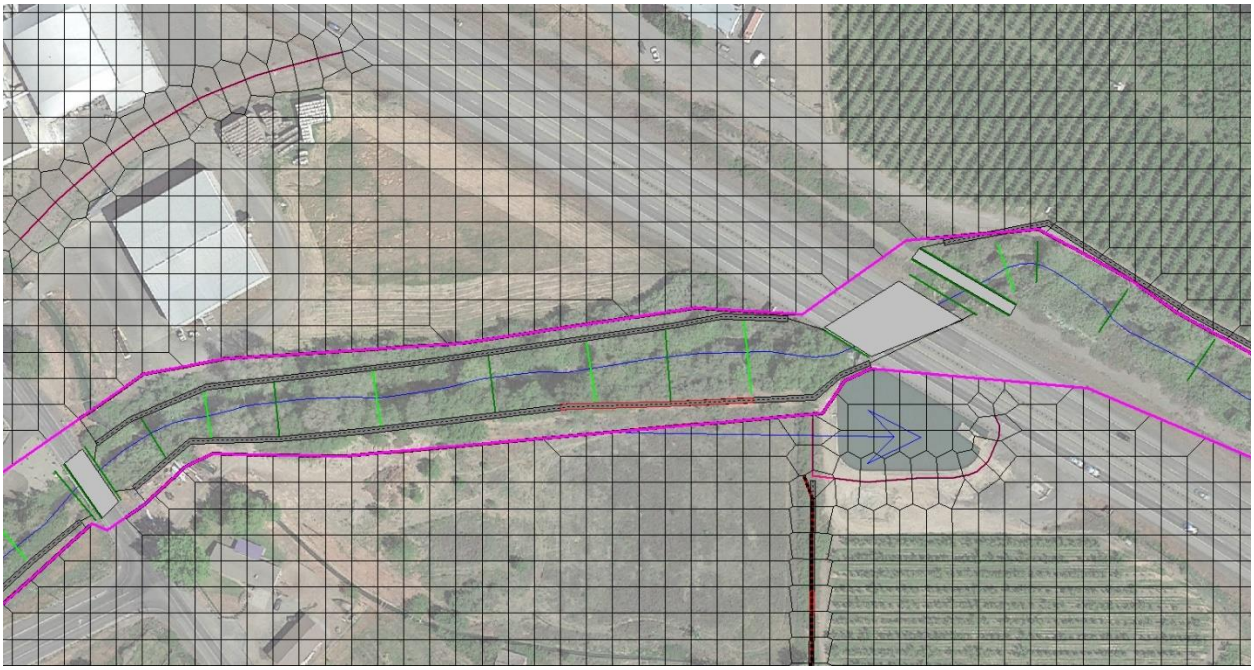


Figure 6-6. Typical 1D/2D model configuration

Using the hydrograph developed for the 2017 event, and reasonable assumptions for roughness values, and breach widths matching those observed in the field, the model yielded flood flow behavior and maximum inundation extents comparable to those observed in the field. The model was not calibrated further. Additional simulations were then developed to model larger flood flows and how the system would respond to various short-term maintenance actions (dredging, levee raising, etc.). The model was then updated to reflect the maintenance actions performed by the City, County, and WSDOT which included improved levee access, brush cleanup, and sediment removal. The model was again updated when 2017 LiDAR became available.

Using this latest version of the model and the larger flood flow simulations, the current estimated capacity of each creek section was estimated as shown in Figure 6-1. The range reflects uncertainty in the assumptions used for the roughness value (Manning's *n* value) and variability within the reach. These are estimates based on the condition of the channel in early 2018. The morphology of the channel is expected to continue to respond and evolve as flood flows interact with the maintenance action at the Highway 12 bridge and the recent re-construction of the Naches-Cowiche Canal Association's inverted siphon located just downstream of Powerhouse Road.

DOWNSTREAM IMPACTS FROM DEFICIENCIES OF COWICHE CREEK INFRASTRUCTURE

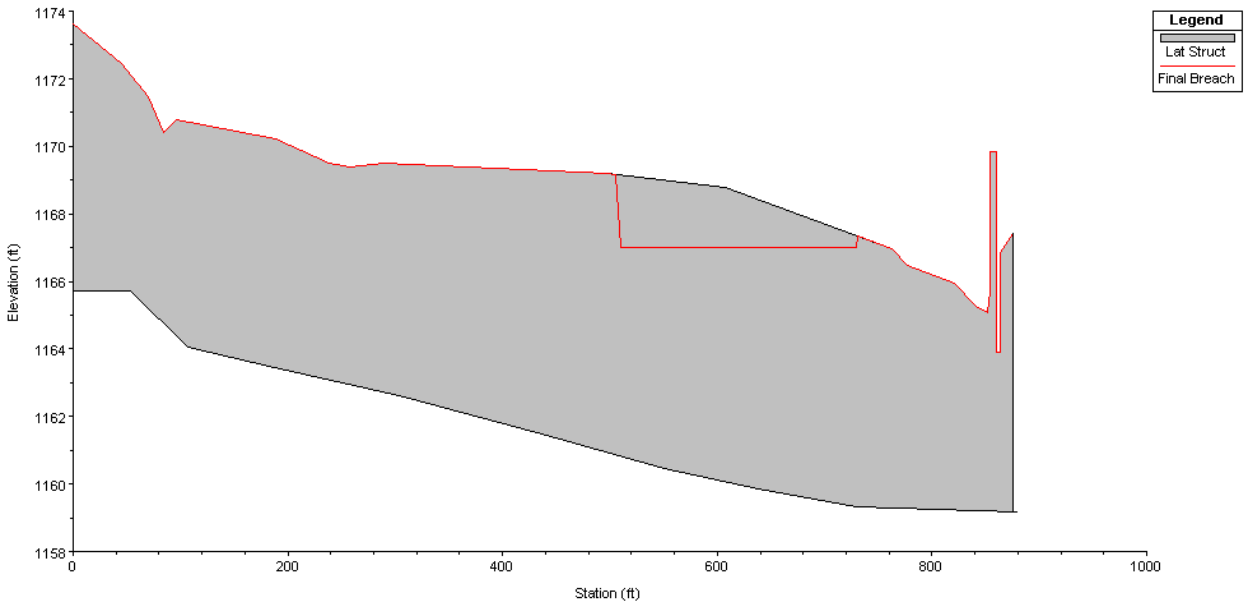


Figure 6-7. Typical lateral weir structure profile and breach scenario configuration

The new FIS 100-year floodmaps provide flood extents within Yakima City but are limited to east of 40th as Myron Lake was considered the downstream extent of the study. The flood extents noted during the March 2017 overflows on Figure 6-1 provide flood extents for a higher frequency Cowiche flood. The flood extents are much further into the City. To assess potential 100-yr

Cowiche flood extents into the City a hypothetical simulation was provided. This assumption limits outflows to Naches River under US 12.

100-YR FLOOD ROUTING IN CITY OF YAKIMA

Despite the flood risk reduction efforts completed after the 2016 and 2017 flood events, the updated conveyance capacity estimates revealed that a 100-yr event would still send significant flood flows into the City. To help inform the stakeholder group during the CFHMP, a set of derivative simulations were developed to consider potential flood routing within the City of Yakima under such a scenario. The model was built with an upstream boundary condition located along the south side of Cowiche creek between Highway 12 and Powerhouse Rd (the location where the creek failed in both 2016 and 2017). The fully 2D model domain was extended downstream as far as Yakima Ave on the south boundary, to US Highway 12 on the north, and to US Highway 82 to the east. To simulate overflows from the creek (through a breached south bank levee), the 2016 storm hydrograph was scaled up to the 100-yr peak flow for Cowiche Creek of Q = 2818 cfs, (West, 2011) reduced by the amount of water estimated could remain in the creek channel which would pass under Highway 12. The resulting hydrograph is shown in Figure 6-8.

The hydraulic model did not include any stormwater infrastructure and assumed a single representative roughness value for the entire domain. It assumes a fixed bed without any infiltration of floodwaters into the ground. It was intended as an initial, limited look at the potential severity of such an event and to develop potential risk areas for further study and analysis. The model was not calibrated. The simulation does not reflect actual risk to individual

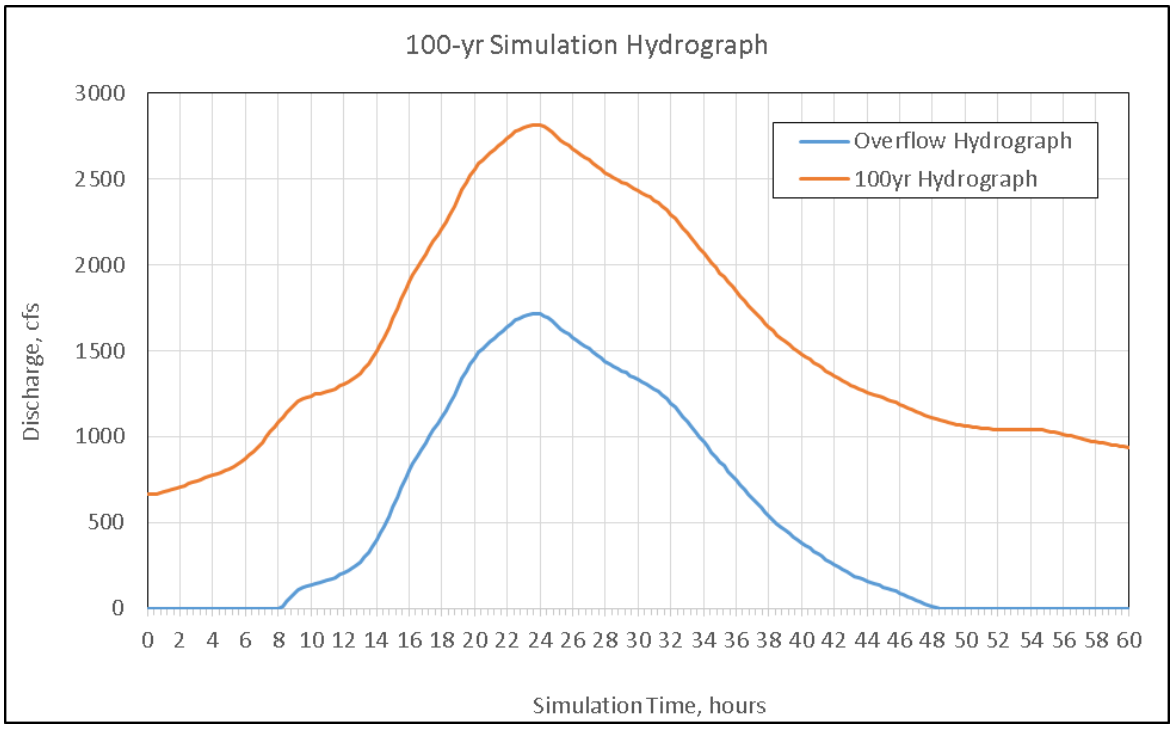


Figure 6-8. 100-yr Simulation hydrographs

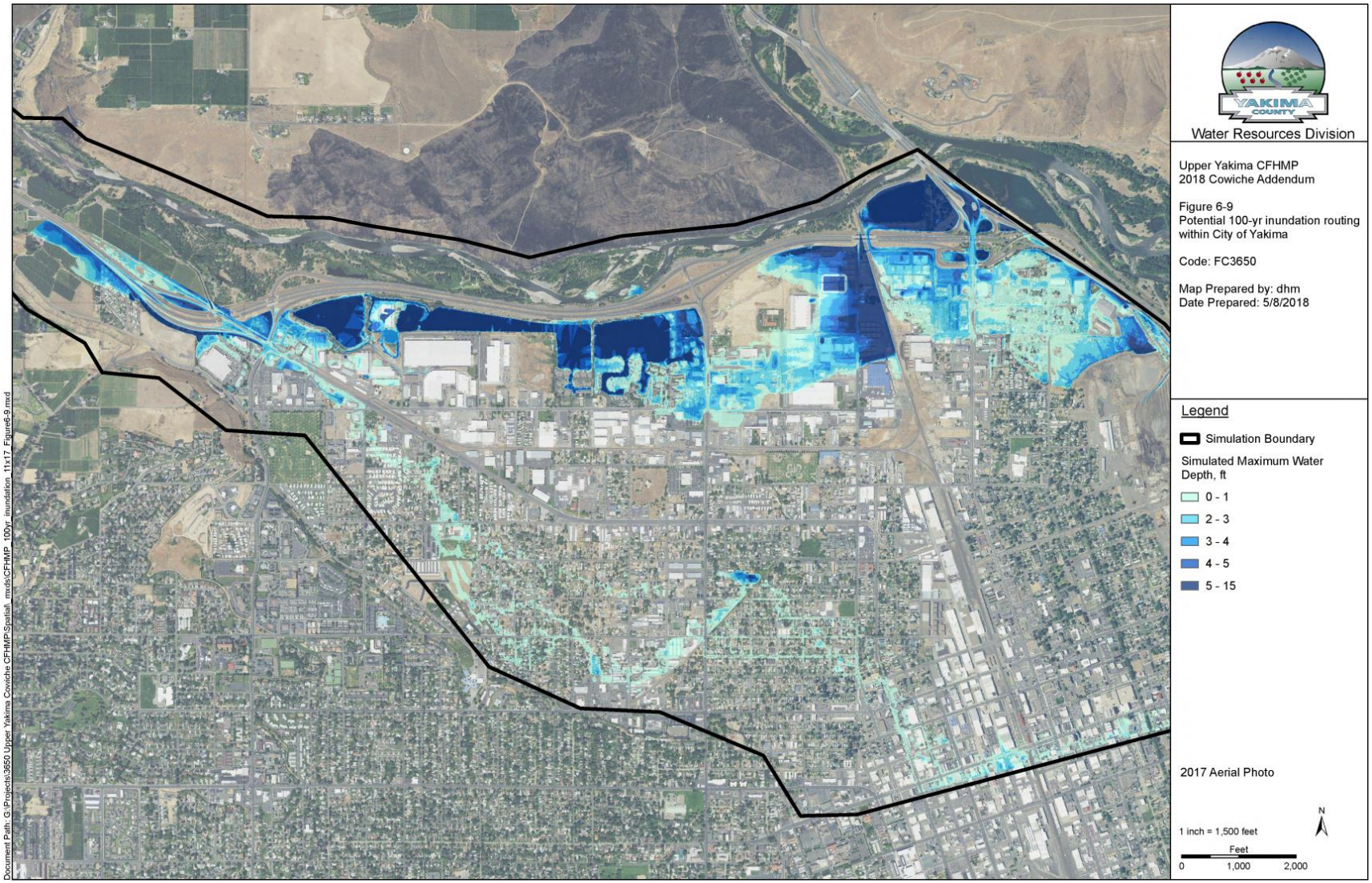


Figure 6-9. Potential 100-yr inundation routing within City of Yakima.

structures due to the assumptions but provides a measure of 100-year flood overall risk without taken actions. The simulated inundation results are depicted in Figure 6-9.

Following review of the above material the advisory Committee developed and ranked the Flood issues.

TABLE 6-1 FLOOD ISSUES TABLE
2018 ADVISORY COMMITTEE RANKING OF FLOODING ISSUES

ID	Flooding Issue	Rank
LC1	Inadequate facilities in floodplain, and hydraulic capacity of Lower Cowiche Creek to prevent flood overflows to City	1
LC2	Floodplain and Flood Risk Mapping not reflective of risk	2
LC3	Improve Public Awareness and Flood Insurance knowledge	2
LC4	Improve Formal Interagency coordination	2
LC5	Revision and Consistency of Flood Hazard, Critical Areas & Shoreline Ordinances for this location	2
LC6	Inadequate flood forecasting system	2 or 3
LC7	Define Clear Action Points to Initiate Emergency Response Activities for Cowiche Creek overflows	3
LC8	Funding for Flood Control Works and Restoration Project elements.	3
LC9	Extensive Flood Routing in (and outside of) the City of Yakima	4
LC10	Stability of berms on Lake Aspen/Myron/Willow & Aspen drainage	4
LC11	Risk to US 12 during major flood events	5
LC12	Threat of flooding to State, County, and City Roads	5
LC13	Lack of Space for Cowiche Creek Channel Migration	6
LC14	Availability of Centralized GIS Data & Modeling Impacts in planning and inventory	6
LC15	Ownership and Standards for new/upgraded Flood Control Facilities	6
LC16	Development pressures in affected areas promoting additional harm	6
LC17	Lack of space for Cowiche Creek low flow Channel Migration	6 or 7
LC18	Operation and Maintenance of Flood Control Facilities	7

TABLE 6-1 FLOOD ISSUES TABLE 2018 ADVISORY COMMITTEE RANKING OF FLOODING ISSUES		
ID	**Flooding Issue**	**Rank**
LC19	Acquisition/Preservation of Floodplain Open Space	8
LC20	Loss of Channel Capacity due to sediment accumulation and lateral confinement	9
LC21	Sediment accumulates in reach, reducing flood capacity	9
LC22	Nelson Dam and Fruitvale infrastructure reducing hydraulic capacity downstream of US 12	9
LC23	Erosion/Loss of Agricultural Land	

7.0 GENERATION OF ALTERNATIVES AND RECOMMENDATIONS

FLOOD PREPARATION, ACTIONS AND ALTERNATIVES

The flood mitigation preparation, including identification of vulnerabilities, was completed using the hydraulic analysis in Section 6.0 combined with the existing limited information, time available and funding. Fortunately, recent LiDAR data at resolutions smaller than 0.1 feet was available from a November 2017 flight, in addition to bridge sections from the FEMA FIS study. The analysis of past events and hydraulic modeling has highlighted vulnerabilities and opportunities for flood response actions with substantive benefits.

Recommendation actions are separated into near, short, and long-term. The near-term priorities with regard to potential flood events are: flood warning, minimizing overflows toward the city while notifying the public, including evacuation and preparedness, lessening existing development exposed including redirection of flows from vulnerable areas as far upstream as practical. Near-term actions were put in place for the upcoming 2017/2018 flood season and are not subject of this plan. The most beneficial of these actions is to reroute any Cowiche overflows back into the Naches below reaching the Fruitvale and 40th interchange. In this regard an ILA is being formed between the City, WSDOT and the FCZD, which will extend beyond the first flood season.

NEAR-TERM ACTION PLAN

The near-term action plan developed outside of this CFHMP is provided in Appendix A and the main components were to provide early public notification, reduce the frequency of overflow from Cowiche creek and the impacts of such overflows. The main components of the Near-Term Action Plan are listed below.

Emergency Action Plan and Public Notification – Cooperative notification through the Yakima Valley Office of Emergency Management has been set up with information provided by the Yakima FCZD, the City and WSDOT. Elements of this action should include: Monitoring of flood flows during Cowiche Creek and Regional flood events, Public Notification including evacuation based on warning times, Monitoring of flood berm stability during Cowiche Creek and Regional flood events.

Memorandum of Understanding and Interlocal Agreements – The City of Yakima has engaged in flood fights in association with the Corps of Engineers on their levee adjacent to the City Wastewater Treatment Plant. The City has not in the past stockpiled materials for flood fighting such as sandbags, riprap and other quarried rocks. The County and Flood Control Zone District has reserves of sandbags and riprap, and a larger fleet of trucks, equipment and operators. The City and FCZD should agree to coordinate on flood fighting actions in the city, including coordination of the declarations of Emergency by the City Council and Board of County Commissioners to allow cooperation during flood events, and the use of the Flood Control Zone District by either Office of Emergency Management. This cooperation would be extended by an ILA that also includes the Washington Department of Transportation.

Channel Cleanout– The current gradient of the stream limits the effectiveness of and ability to improve conveyance capacity in this reach. The City of Yakima has removed a significant amount of vegetation from the channel to increase conveyance, and cleared the top of the southern (towards City of Yakima) 3000-foot berm to allow for the 2017 survey of the channel, and also allow for visual inspection of the stream and berms on either side during flood events. It was reported that much of the 2017 event overflow was increased by a buildup of woody debris trapped in streamside vegetation in that narrow riparian corridor. In 2016 a large tree obstructed flow under the US1`2 bridge was also removed.

Repair and Raising of Private Cowiche Creek Levee The channel cleanout combined with the clearing of vegetation and raising of the berm with a gravel road will reduce the frequency of flood waters overflowing into Yakima. Having an equipment access to the channel along the berm will allow flood fighting including removal of vegetation and debris preceding and during flood events.

US 12 Bridge Cleanout -The US 12 bridge will benefit from removal of sediment trapped under the highway bridges and downstream through the new trail bridge. The trail bridge sediment is creating a downstream plug for sediment. Sediment removal of this nearly 200-foot-long plug in October increased conveyance capacity from below the 10-year flow to just above it. Until a more natural, steeper channel gradient downstream of the trail bridge is restored through lower Cowiche Creek relocation and restoration, the capacity of the existing bridges is limited to this sediment plug removal. In the medium term, the channel and conveyance capacity of the channel and bridges should be monitored and actions taken to maximize conveyance until the longer-term actions can be implemented.

The above 2017 cleanouts have raised the capacity of the reach to pass the 10-year flow of 1500 cfs.

Divert Cowiche Creek Flood Flows West of the 40th Avenue and Fruitvale Rd Interchange – As floodwaters move from Cowiche Creek, they travel along US 12, flooding the Riverview Manor Mobile Home Park, then continuing along US 12 to the Fruitvale Canal Culvert outlet, then continues to the intersection of 40th and Fruitvale. Without any diversion, some water will flow down Fruitvale, while the majority of water flows down the Greenway Trail, across the Parking Lot of Lakeside Court, or down the Myron Lake access road, all ending in Myron Lake. During the long duration flood event of 2017, water filled Myron Lake, and overflowed across the berm to Willow Lake, and Willow overflowed into Aspen Lake, and Aspen Lake eventually filled to the elevation of 16th Avenue, with water flowing across 16th to the east and down 16th to the south.

SHORT AND LONG-TERM ALTERNATIVES

Short and long-term flood mitigation priorities vary from the near-term priorities in accordance with their increased timelines. Long-term alternatives are geared to provide the required and agreed upon Cowiche Creek hydraulic capacity (within this plan), say 100-yr, to avoid routing of overflows into the City, and will have the longest timelines due to larger capital outlays and funding timelines. Short-term alternatives are required to bring about the interim changes before the long-term recommendations are in place and provide risk reduction actions can be undertaken to either increase hydraulic capacity, flood responsiveness and public awareness to minimize the potential damages from Cowiche overflows reaching the City. The goals and objectives for the short and long-term are contained in Tables 1-2 and 1-3 and are used in conjunction with the flood ranking issues in Table 6-1 to generate alternatives.

During the short-term, priorities during events would also focus on elements identified in the near action plan above such as intercepting overflows as far upstream as possible to minimize damages.

LONG-TERM ACTIONS

It is evident from the hydraulic capacity computations that the following long-term replacements will be required:

Construction of New Bridges – Cowiche Creek is crossed by 3 transportation routes – the Naches Greenway Trail, US 12, and Powerhouse Road. Both the road crossings have very low flood conveyance capacity.

> **WSDOT's US 12 Bridge –** This four-lane bridge requires replacement. Modeling has indicated that this span of bridge cannot pass the 100-yr flood even with excavation, so that a replacement or sister bridge would be required to pass the 100-yr flood.
>
> **Yakima County's Cowiche Creek Trail Bridge** - if the US 12 replacement wider bridge alignment results in misalignment or we sister a new bridge span adjacent to the existing structure, the realignment will probably require another trail bridge.
>
> **City of Yakima Powerhouse Road Bridge –**This bridge barely passes the 10-year flow. I was designed according to standards at the time, but it is old. All of the related infrastructure around it has already or will be modified this year, probably
>
> **Squire-Ingham Orchard farm bridge –** The orchard downstream of US 12 along Cowiche Creek currently uses a small 16-foot-wide bridge for both farming access and hauling freight out of both orchards toward US 12 on Clover Lane. Provision of alternative farm

and haul routes for the orchard also needs to be considered as the widening of the bridges on US 12 may make construction of a relatively narrow bridge infeasible.

New Cowiche Creek 100 Year Long-Term Levees Upstream of US 12 – Even with the replacement of the US 12 and Powerhouse Road Bridges the reach of Cowiche Creek between the bridges will need construction of a flood control structure to keep floodwaters from moving south from the Creek, downhill into the City of Yakima. Due to the economic consequences this levee would benefit from locations that reduce velocities, levee damages and failure risk. This reach lies on an alluvial fan and can be expected to aggrade over time, especially during long duration flood events. We expect that the area interior to the levee will require periodic cleanout (5 yrs?) of accumulated gravels The more channel and floodplain width allowed for the creek in this reach, the lower the frequency of needed cleanout and risk of damages and failure. This levee should be constructed to a standard that it can be enrolled in the USACE PL84-99 program, and ideally certified as a 100-year levee.

Lower Cowiche Creek Reconstruction Upstream of US 12 – The historic realignments of Cowiche creek downstream of Powerhouse Road by the Railroad Upstream of US 12, the Creek also needs reconstruction, other irrigation infrastructure upstream has been designed and will be constructed to allow for lowering of the channel bed and expansion of channel conveyance. The YBIP capital program currently contains some funding for this action. The most impoertant chage in this action, determimed by Hydraulic analysis in this study is that the Cowiche Creek bed requires lowering by 3 feet from previousl computations to allow containment of the 100-year flood in the corridor upstream of SR12. This drop would be continued upstreamo Powerhouse Road.

Both of the channel construction options can be started in the short-term if their design is coordinated with the remaining structural replacements. Their early design with lower inverts for example will increase the capacity of the bridges.

SHORT-TERM ACTIONS

Actions beyond those provided in the near-term Action Plan to reduces overflows into the City are required in the interim period before the long-term actions can be funded and constructed. Some of the more obvious are:

New Flood Insurance Rate Maps in the City of Yakima Currently, the residential structures that lie in the flood path are not required to have flood insurance, nor do the commercial/industrial facilities aware that they may want to find private flood insurance, at least in the near-term. The 2018 FIS flood maps, once adopted do not cover the complete Cowiche overflow threatened area. If a long-term corridor system for protecting the City from flooding during a 100-year

event cannot be implemented, as noted above due to financial or physical constraints, flood insurance maps that include the threatened City areas are required.

A critical element in determining the desired level of flood protection for the City and the economic rationale for the construction of long-term flood control works will be the annual insurance costs, both private and public, and the cost and effect of the increased construction standards (building elevation, floodproofing and overall site design) which will result from National Flood Insurance Program and related Building Code regulations for development in the mapped 100 year floodplain.

Nelson Dam Reconfiguration/Replacement – this project should occur in 2019 or 2020. The reconfiguration/replacement of Nelson Dam will allow the removal of the Fruitvale and Old Union Diversion facilities on the Naches River just downstream of the confluence with Cowiche Creek. Once the diversion infrastructure is removed, lower Cowiche Creek can be substantially re-configured to restore floodplain function and habitat with significantly improved channel and levee alignments and a higher overall conveyance capacity. While studies have found that the proposed reconfiguration of Nelson Dam will increase sediment transport to this reach, potentially increasing the bed elevation of the Naches River in the vicinity of Cowiche Creek, the change is expected to be gradual as much of the accumulated bed material behind Nelson Dam is currently immobilized by riparian vegetation. The flood risk reduction benefits of removing the irrigation infrastructure far outweigh the potential for a muted hydraulic aggradation trend at the confluence. Rather, the reconfiguration/replacement of Nelson Dam is a key action towards reestablishing a more predictable sediment transport regime in the Naches River and is critical toward enabling other infrastructure consolidation on Cowiche Creek to reduce flood risks.

Lower Cowiche Creek Reconstruction Downstream of US 12 (YRBWEP) – The historic realignments of Cowiche creek downstream of Powerhouse Road by the Railroad and State Highways has led to extensive modification of lower Cowiche Creek, including loss of its delta, loss of floodplains and conveyance capacity due to levees and bridge constrictions. Combined with starvation of Naches River below Nelson Dam and Fruitvale canal intake there has been significant alterations in the Cowiche Creek gradient. Yakima County Flood Control District has designed a new stream channel below US 12 and purchased an easement from Squire-Ingham Orchards to construct the channel. The new channel will have a 100-year flood conveyance capacity, lower the bed of the creek 3-4 feet downstream of the highway, and restore the steeper channel gradient. This action can be implemented prior to reconstruction of Nelson Dam and retirement of the Fruitvale Canal Diversion, but it would be more efficient to perform the retirement of the diversions and floodplain restoration/levee setback all at the same time.

GENERATION OF ALTERNATIVES

The Advisory Committee was provided with a list of updated generic flood hazard mitigation alternatives originally developed in the 1998 CFHMP, which is contained in Appendix B. Tables of their relative impacts and costs plus a summary table are also contained in appendix B. Flood

hazard mitigation alternatives were then generated for each of the Flood Issues listed in Table 6-1, then voted on need for inclusion within the recommendations. The generated alternatives and voting is contained in Appendix C. During that process the goals and objectives were reviewed and modified to ensure adequate containment within the recommendations.

COMBINATION OF ALTERNATIVES INTO RECOMMENDATIONS

The recommendations were created by combining the accepted (voting) alternatives from Appendix B. and then separated into functional implementation categories: Planning, Flood Preparedness, Public awareness and Structural Recommendation. The long-term Structural recommendations are contained in Table 7-1. The short-term recommendations, which bridge the gap prior to full implementation of the Structural alternatives are in Tables 7-2, 7-3 and 7-4 separated by their functional category, such as Planning. Each table is ordered by approximate implementation priority.

TABLE 7-1 PLANNING RECOMMENDATIONS – SHORT-TERM

ID	Recommendation	Estimated Cost in $	Lead Entities
PL1	**Provide a new Cowiche Creek riverine infrastructure corridor between Powerhouse Road and the Naches River to eliminate Cowiche overflows into the City.**	See below	City, WSDOT, FCZD
PL2	**Maintain interagency coordination, necessary flood fight ILAs and information exchange until existing Lower Cowiche corridor replaced.**	10,000/yr	City, FCZD, YVOEM, WSDOT
PL3	**Adopt the new Cowiche Creek FEMA preliminary maps for new development and use overflow scenario map as guidance.** Early community adoption of the FEMA maps reduces community risk,	10/000/yr	City, County
PL4	**Appoint a Planning Task Force to minimize Community risk from Cowiche Creek overflows to ensure planning and building measures are in step with structural measures over all phases of exposure.** The Task Force should provide corridor replacement timelines and sunsets for the measures.	10/000/yr	City, County
PL5	**Incorporate the 2017 flood extent map during the interim period for flood protection on development for drainage, stormwater, building design, siting, and layout.** Regulatory use of the actual 2017 flood extent and development guidance using the hypothetical 100-year overflow maps presented herein will reduce risk exposure within the City for the interim period prior to lower Cowiche Corridor replacement.	5,000	City

TABLE 7-1 PLANNING RECOMMENDATIONS – SHORT-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
PL6	**Provide Contingency Planning across jurisdictions & agencies as a living document for the following overflow scenarios: current day, the intervening period when individual corridor elements are replaced, and upon completion of rehabilitated corridor.** Contingency Plans must reflect changed conditions for all newly introduced infrastructure in addition to current lower capacity infrastructure. This coordination will require emergency preparedness, including action planning, and require supplemental basin data collection specifically for rain on snow storms, drainages studies for the vulnerable City areas, use of new flood risk maps and formation of a Planning Task forces to use the information and studies for decision making on interim measures.	5,000/yr	City, YVOEM, FCZD
PL7	**Provide an ILA or MOU to locate funding sources (local, state and federal) and secure funding to replace the Lower Cowiche stream and stream crossing corridor and increase reliability of flood warning.** Funding (local, private, state, and federal), needs to be established to permit the land acquisition and infrastructure replacement and be cooperative across agencies, including basin proponents, to ensure maximum support and effective utilization of public funds. Infrastructure leads should seek and secure local, state and federal funding to make improvements to this reach of Cowiche Creek. The CFHMP, and an overall hydraulic design study outlining benefits and common goals should be used and developed as a planning document to justify funding requirements.	10,000	City, County, WSDOT
PL8	**Provide a rehabilitation design that is hydraulically coordinated to replace the existing channel and crossings between Powerhouse Road and the confluence with the Naches River (Lower Cowiche)**. The channel's capacity will be increased to pass the 100-year discharge with adequate freeboard to meet FEMA flood mapping requirements. Jurisdictions and owners will coordinate the overall design. The model would be provided by the FCZD and designs of individual elements must fit within the agreed overall design that ensures removal of the City of Yakima from the extended 100-year floodplain from Cowiche Creek overflows, minimize design and operational risk failures from the features and interfaces of features. Due to the Yakima and Cowiche basin recovery value provided by this reach the overall and component designs will allow for habitat enhancement requirements outlined in the goals and objectives and for the planned removal of Fruitvale irrigation infrastructure at the Cowiche-Naches confluence. The new channel inverts made possible will result in a channel bed reduction of up to 3 feet along most of the channel length. The design will be sensitive to capital, operating and	60,000	City, FCZD, WSDOT

TABLE 7-1 PLANNING RECOMMENDATIONS – SHORT-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
	life cycle costs and provide costing numbers necessary for funding. Sediment passage elements required in this design are expected at Powerhouse and US 12 bridges, and sediment removal locations at channel segments upstream and downstream of US 12. The new trail bridge may require an extension.		
PL9	**Incorporate multi benefit considerations with the coordinated corridor design such as trails, open space, agricultural and habitat.** Preserve and/or expand open space and land uses including agricultural and recreational that not only reduce flood risk but enhance other preservation, nature benefits. Trail location options should be investigated.	5,000	City, County
PL10	**Acquire required land to increase the current Lower Cowiche corridor in accordance with goals and design standards (noted in Recommendation PL 8).** In order to reduce risk to an appropriate level the current corridor must be expanded to allow for the expansion of stream bed and stream crossing footprints and the necessary operational maintenance and access required to sustain and respond to the natural processes. The width of the corridor should also be designed to minimize need for ongoing sediment removal and large woody material management, and ensure that the low-flow channel supports typical flow conditions that are beneficial for fish and water quality. The variety of ownership requires coordination in accordance with design to promote adequate real property interests transfer and satisfactory incorporation of landowner concerns.	200,000	City, FCZD
PL11	**Assess Cowiche basin need for new snow, precipitation and stream gages to reduce risk and seek partners for regional small basin needs on the west slopes of Naches and Upper Yakima region (Cowiche, Wide Hollow and Ahtanum). Partners should include basin data collection agencies: USGS, Ecology and BOR**	100,000	FCZD, City
PL12	**Organize community-level funding districts of local funding that construct and maintain approved protective risk-reduction features.**	N/A	City
PL13	**Install the coordinated Cowiche corridor channel elements from downstream to upstream order to maximize upstream function, minimize cost and reduce transitory impacts.** Pursuit in this order lowers the channel bed bottlenecks by as much as three feet and increases hydraulic and habitat capacities for all components. This will require some existing infrastructure adjustments and retirements (existing City waterline and soon to be retired Fruitvale canal intake structure). It provides overall cost reductions to all replacement infrastructure noted in Recommendation PL1.	N/A	FCZD, City

TABLE 7-1 PLANNING RECOMMENDATIONS – SHORT-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
PL14	**Provide a Cowiche Creek overflow drainage study through the City**. This study will provide Contingency Planning guidance required in Recommendation PL6, identify problematic areas from Cowiche Creek overflows through town such as Cowiche drainage of Aspen Lake across 16th Avenue, routing through Myron and Willow lakes, and overflow drainage between 16th and 6th Avenues plus drainage options back to Naches River at or west of 6th Avenue, along with alternate drainage scenarios and preferences. Identify and retain routes to Naches River.	60,000	City, Landowners
PL15	**Review safety and drainage of Myron and Willow lake dams in response to Cowiche Creek overflow drainage for current day, interim and rehabilitated condition.** The dam owners need to assess dam safety issues related to Cowiche Creek overflows due to consequences of low-lying development and limited drainage	60,000	Landowners.
PL16	**Ensure all owners of critical infrastructure (defined by consequences of failure) develop operational plans and funding to sustain structure integrity.** These operational plans should be incorporated in overall and individual project and life cycle costs and ensure enhanced hydraulic and habitat performance with regard to potential overflows over structure life.	5,000	City, WSDOT
PL17	**Provide during SEPA or Shorelines comment period comment to City on development proposals in the overflow area regarding facility siting and layout based on mapping, inundation areas.** The FCZD does not have a regulatory role but can provide relevant flood specific information. This information transfer would be enhanced should the City provide a drainage study under Recommendation 14 with proposed measures and timelines.	5,000 yr	FCZD, City
PL18	**Coordinate existing ordinances to establish ability to provide interim and long-term protection from Cowiche creek overflows and/or dam failures.** Development in the overflow area should be designed to reduce incurred interim damages. The ordinance revision should be one of the topics of the Task Force in recommendation PL4.	20,000	City
PL19	**Allow within the planning and design process of structural elements for the insertion of trails and future Greenway overlay to connect Naches and Cowiche trails.** The feasibility of success of this measure is dependent on early discussions with all parties including landowners and trail groups. Various routes need to be investigated as noted in Recommendation PL9.	10,000	WSDOT, City, County, Greenway, WO Douglas
PL20	**Establish a gravel management plan in the Lower Cowiche corridor to reduce flood and habitat risk over the short and long-term.** Gravel removals are expected to be more critical upstream of US 12	20,000 & 1,000/yr	City, FCZD

TABLE 7-1 PLANNING RECOMMENDATIONS – SHORT-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
	due to the confinement above Powerhouse Road. Design of the entire reach should result in minimal gravel removals and vegetation preventing removals. There will be preferred areas for removals noted above. Lower frequency floods should not overly disrupt design elements requiring excessive disturbance.		
PL21	**Emphasize more natural riverine processes downstream of US 12 to maximize habitat enhancement for current and future species.** This reach is important for ESA species- steelhead and bull trout and habitat enhancement would be enhanced by the retention of agriculture/pastoral uses versus development and the emphasis on gravel and sediment transport and deposition through this reach. Specific zoning should be pursued**.**	100,000	FCZD
PL22	**Identify location for sediment removal and monitoring, and removal of identified sediment, especially upstream of US 12.** As per recommendation PL20 to limit disturbances	See PL20	City, FCZD
PL23	**Provide a future Cowiche Upper Basin CFHMP from the siphon upstream to South and North Cascade branches including hydrological effects including sediment releases or pulses on the reach**	100,000	FCZD

TABLE 7-2 FLOOD PREPAREDNESS RECOMMENDATIONS – SHORT-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
FP1	**Form ILAs or MOUs to allow cross coordinated flood response measures.** This enables multiple parties to assist City during Cowiche overflows.	completed	City, FCZD, County, WSDOT
FP2	**Provide a Cowiche Creek Overflows Flood Response Plan that includes a public Notification Plan.** The response plan should assign preferential road closures and evacuation routes.	Ongoing-Near-Term action plan	City, FCZD, YVOEM
FP3	**Provide flood fight locations on Cowiche Creek levee to minimize overflows.** City should affect arrangements with landowner to allow flood fighting at this most upstream section in order to improve public safety, based on PL20.	10,000	City, Landowners
FP4	**Provide emergency flood fight facilities to intercept overflows and reroute west of 40th interchange.** This requires coordination across landowners, WSDOT and resource agencies by the City	Completed & ongoing	City, WSDOT, YVOEM

TABLE 7-2 FLOOD PREPAREDNESS RECOMMENDATIONS – SHORT-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
FP5	**Emphasize short-term flood routes, maximizing Cowiche Creek overflows returns back to the Naches as far east as practical and identified in City Drainage study.** Based on PL20	10,000	City
FP6	**Increase the gaging stations in the upper watershed to increase flood response time at Lower Cowiche levee.** This requires funds and basin hydrologic assessment.	30,000/yr	City, FCZD, Ecology, USGS, USBOR
FP7	**Provide timely public notice of flood threat status to allow for timely private mitigation response.**	N/A	YVOEM
FP8	**Design emergency facilities to minimize fish stranding.** This requires discussion between City and WDFW This requires coordination across landowners, and resource agencies by the City	N/A	City, WDFW

TABLE 7-3 PUBLIC AWARENESS RECOMMENDATIONS – SHORT-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
PA1	**Increase general Public Awareness of current risk and measures.** Include landowners with large risk in specific discussions, including flood insurance implications.	5,000	City, FCZD
PA2	**Advise landowners on interim and long-term potential for flooding.** Landowners and developers need to know risk and the goals of the CFHMP to gage their response	5,000	City
PA3	**Share Action Plans.** City developed action plans need to be publicly available on web and other means, including permitting	5,000	City, FCZD, OEM
PA4	**Encourage local protections for individual infrastructure such as ring dikes around homes, barns, shops.** This allows specific structure related protections versus protection of entire property which would not be allowed because of impacts on others.	5,000	City
PA5	**Awareness of new FEMA Maps and limitations.** The new maps are not representative of the large failure consequences as evidence by the condition of Cowiche levees during the 2017 flood and will require further restrictions. FEMA map replacement will be made once new infrastructure are completed.	10,000	City, FCZD
PA6	**Engage upper management and politicians in plan for flood hazard mitigation.** Funding for the new interim and long-term infrastructure will not be attainable without political support by local jurisdictions	N/A	City, FCZD

TABLE 7-3 PUBLIC AWARENESS RECOMMENDATIONS – SHORT-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
PA7	**Garner public support for capital measures to remove flood risk areas through capital expenditures.**	10,000	City, FCZD
PA8	**Locate best Web sites(s) for public notification and use YVOEM response abilities as emergency declared.**	5,000	FCZD, YVOEM
PA9	**Notify public of flood threat status to allow private mitigation response.**	5,000	City, YVOEM

TABLE 7-4 STRUCTURAL RECOMMENDATIONS – LONG-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
S1	**Design and Implementation of all structural recommendations will be coordinated with the overall design in Recommendation PL8 and updated during implementation of each structural element.** The designs for each element will support habitat and sediment goals and objectives and incorporate sediment management and other operational issues. Develop design and maintenance standards, procedures and funding to ensure enhanced hydraulic and habitat performance.	20,000	City, FCZD, WSDOT
S2	**Replace Cowiche channel between US 12 and the Naches confluence with capacity to pass 100-yr flood and remove Cowiche overflows into City from 100-yr flood maps.** Widen the active floodplain to minimize need for ongoing sediment removal and large woody material management, and ensure that the low-flow channel supports typical flow conditions that are beneficial for fish and water quality. Lower the channel by 3 feet to allow upstream capacity.	800,000	FCZD
S3	**Coordinate removal of Fruitvale infrastructure at Cowiche-Naches confluence with downstream channel design.** This measure will maximize flood and habitat benefits for the Naches and Cowiche floodplain confluence**.**	10,000	City, FCZD
S4	**Replace Cowiche channel between Powerhouse Road and US 12 with capacity to pass 100-yr flood and remove Cowiche overflows into City from 100-yr flood maps.** Design channel and floodplains to minimize the need for gravel and debris removal while still allowing for unplanned removals, as outlined in Recommendation PL8.	2,000,000	City
S5	**Provide levees in the reach between Powerhouse Road and US 12 that prevent Cowiche overflows into the City and allow for enrollment in PL84-99 program, certification and accreditation, as**	700,000	City

TABLE 7-4 STRUCTURAL RECOMMENDATIONS – LONG-TERM			
ID	**Recommendation**	**Estimated Cost in $**	**Lead Entities**
	well as connection to a new US 12 bridge. FCZD can provide guidance on standards**.**		
S6	**Replace US 12 bridge capacity to pass 100-yr flood and remove Cowiche overflows into City from 100-yr flood maps.** This design must match all other replacement infrastructure at this point.	10,000,000	WSDOT
S7	**Remove city storage pond to increase hydraulic capacity for Recommendations S4, S5 & S6.**	100,000	City
S8	**Improve Naches Trail Bridge downstream of US 12 as necessary to pass 100-yr flood with planned wider channel.**	100,000	County, FCZD
S9	**Interim structural elements will be required east of 40th Avenue based on the Cowiche overflow drainage study.**	50,000	City, WSDOT
S10	**Spillway and drainage improvements for Myron and Willow dams.** Landowners will establish safe drainage of these lakes to minimize downstream consequences.	60,000	Landowners
S11	**City culvert improvements to route City overflows from Cowiche Creek** The means to move water downstream with the least damage should be established along with any event specific actions.	10,000	City
S12	**Replace Powerhouse bridge with capacity to pass 100-yr flood and remove Cowiche overflows into City from 100-yr flood maps.** Design will accommodate adjacent infrastructure and prevent overflows down Powerhouse Road to the City and to the north into Warehouse District.	2,000,000	City

8.0 FUNDING

FCAAP APPLICANT ELIGIBILITY

Counties, cities, and other entities with flood control responsibilities, such as flood control districts and diking districts, are eligible to receive state funding for flood control maintenance projects. Eligible entities must file a flood control budget with Ecology by February 15 each year.

To receive funding for flood control maintenance projects, the county, city, or town having planning jurisdiction over the project area must have its floodplain management activities approved by Ecology. The requirements include the following:

- Participation in the National Flood Insurance Program (NFIP)
- Certification of the local emergency response plan by the State Department of Emergency Management
- Restriction of land uses to flood-compatible uses within a river's meander belt or floodway.

Adoption of a Shoreline Master Program is also required.

MAINTENANCE PROJECT ELIGIBILITY

Evaluation of proposed FCAAP projects is based on cost-benefit relationships, local priority of projects, severity of local flood hazard management problems, and information in the CFHMP. Maintenance projects must reflect a comprehensive approach to flood hazard management planning and must meet specific guidelines with respect to project goals. Typical structural measures funded through FCAAP include installation of riprap on eroding stream banks, repair of riprap embankments, and the construction and maintenance of levees.

FCAAP legislation describes in general terms the type of maintenance work eligible for funding, including "maintaining and restoring the normal and reasonably stable river and stream channel alignment and capacity" and "restoring, maintaining, and repairing natural conditions, works and structures." State participation can also include "restoration and maintenance of natural conditions, works, or structures for the protection of lands and other property from inundation or other damage by the sea or other bodies of water" (RCW 86.26.090).

Funding for enhancement of flood control facilities was authorized by Engrossed Senate Substitute Bill (ESSB) 5411, enacted in July 1991. This expands FCAAP project eligibility to include purchase of flood-prone property or land to be used for flood storage, but only if these measures are identified in the applicable CFHMP (Ecology 1991).

Permits such as the Hydraulic Project Approval (HPA), Shoreline Substantial Development, and Conditional Use must be obtained before the project is funded by Ecology. All projects must be planned and designed in accordance with applicable SMPs and CFHMPs, and must benefit the public, as opposed to strictly private interests.

FCAAP EMERGENCY PROJECTS

A portion of the available FCAAP funding is reserved by law for emergency use. Projects considered emergencies are those that must be done immediately to protect life and property from "unusual, unforeseeable, and emergent flood conditions" (WAC 173-145-100). Release of emergency funds is contingent on an emergency declaration by the appropriate authority. Depending on the emergency measure, a shoreline permit or HPA may be required.

FLOODPLAIN BY DESIGN PROJECT ELIGIBILITY

This is a bi-annual state fund initiated in 2013 by efforts of the Nature Conservancy to combine flood and environmental benefits in response to basin wide river deficiencies, particularly in Puget Sound. East side applications that meet these goals are also welcome. Yakima and Pearce Counties have been two of the more successful applicants due to setback of levees proposals., receiving grants in each biennium. Typically, these funds are given to mainstem rivers like Yakima and Naches Rivers. The proximity of this Cowiche Creek reach to the Naches confluence and the basin tributary goals for fish passage and species reintroduction and augmentation for Cowiche Creek, makes this a potential source of funds. The County FCZD submitted a 2019-2021 biennium FBD pre-application for this reach for levee setbacks in February 2018, which was successfully accepted for the subsequent application stage in August 2018. The application covers parts of Recommendations PL8, PL20, PL22, S1 and S2

The fund is administered by the Department of Ecology. Awards over the 3 grant periods have ranged between $30 and 50 million. Local match is 20 percent.

FEMA PROJECT ELIGIBILITY

FEMA has multiple funding sources. The most favorable for this reach would be Pre-Disaster Mitigation grant, which allows applications up to $4.5 million and must display favorable cost benefits, and significant potential flood damages. The application process and award processes are lengthy requiring significant labor inputs before formal allocation of funds. This period can be up to 5 years for successful applications, so that construction can take 7 years.

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Appendix A

Near-Term Action Plan

October 16, 2017 Meeting Agenda
Cowiche & West Valley Joint (City/County/WSDOT) Flood Preparedness

ATTENDANCE

Bill Sauriol ..... Washington State Department of Transportation
Scott Anfinson ..... Washington State Department of Transportation
Scott Schafer ..... City of Yakima
David Brown ..... City of Yakima
Mike Price ..... City of Yakima
Charles Erwin ..... City of Yakima Office of Emergency Management
Matt Pietrusiewicz ..... Yakima County Department of Public Services
Jeff Emmons ..... Yakima County Office of Emergency Management
Horace Ward ..... Yakima County Office of Emergency Management
Terry Keenhan ..... Yakima County Flood Control Zone District
Joel Freudenthal ..... Yakima County Flood Control Zone District
Dale Meck ..... Yakima County Flood Control Zone District
David Haws ..... Yakima County Flood Control Zone District

MEETING AGENDA

1. Discuss Cowiche joint flood response roles, communication & coordination of resources for this fall/winter
2. Set Cowiche flood fight common priorities and understanding /communication/ coordination between agencies through discussion of this fall/winter planned short term joint actions (see meeting action summary below - all parties).
3. Discuss role of emergency management in communication including public notice
4. Discuss Upper Yakima CFHMP public participation and current longer term thoughts on actions
5. Discuss West Valley this fall/winter runoff period planned short term actions in order to identify emergency response as in 2 above

MEETING ACTIONS SUMMARY

Below is a summary list of meeting discussed short term (pre-flood & during flood) actions and commitments by agency that were developed over several meetings from limited technical investigations so that each agency can coordinate potential actions. These were established after review of the County established flood model and a quick estimate of capacity of Myron/Willow and Aspen lakes to receive water.

The hydraulic effort for the lakes was limited by available data and will be resumed in mid-term actions. The review did reveal a need to limit inflows towards the lakes due to capacity concerns. The short-term actions are separated by timeline in relation to flood onset. Emergency management would coordinate information flow and directives to the public. The below actions will be incorporated in the CFHMP amendment as a first step.

The below action plan, once finalized after the 23 to 27 October field trip, will act as the flood response plan for this fall/winter.

DRAFT (BEFORE FIELD TRIP) ACTION PLAN

Actions to be completed prior to flood season (before December 2017)

County Completed

- Facilitated Interagency coordination meetings
- Advice on initial clearing of south berm and debris along vulnerable reach
- Provided initial Levee fill materials (excluding rock)
- Extra survey and Hydraulic modeling (1d & 2d) expanding FEMA model of Cowiche Creek between Powerhouse Road and trail bridge plus modeled overflow area (2d) to Fruitvale in order to establish vulnerabilities, capacities, priorities and potential short term actions.
- Develop hydraulic model for vulnerability analysis and provide to WSDOT
- Transfer of Corps and FEMA threshold requirements and probable profiles to City for future City incorporation of levee in federal PL 84-99 or FEMA accreditation
- Quick analysis of Willow, Myron and Aspen lakes routing capacity from non-surveyed materials
- Quick Ownership analysis (currently incomplete and passed to mid- term actions) of flood and drainage facilities from Powerhouse Road to Aspen Lake.
- Historic compilation of Cowiche Creek realignments, infrastructure crossings, confinements and realignments in order to assess probable needs
- Provide HPA for excavation below SR12 and trail bridges
- County Excavation below trail bridge of 1 to 2 feet (with WSDOT)
- Arrange joint meeting with City & County emergency management
- Assessment of available rock materials at Summitview pit

County Pending

- Provide contour map for field trip week of 23-27 October (date being finalized)
- Draft CFHMP text for amendment to Upper Yakima CFHMP to be passed to the jointly selected CFHMP Amendment Advisory Committee that include short term actions and target mid and long term actions that are consistent with short term actions.
- City and County prepare council and Commission for joint session of CFHMP

City Completed

- Removal of large vegetation mass obstructing bridge inflows along south berm at storage pond just upstream of WSDOT bridge
- South berm clearing, repair in 2 phases of 1500 feet each (June and September)
- Channel clearing for Cross Sections and flood monitoring
- South berm temporary easement for flood fight and repairs
- Ingham permission to remove protective berm downstream of trail bridge during floods
- Preparation of stop log and related structure to block overflows into storage pond
- Establish materials stockpile for flood fight (use Ramblers and have Contractor assemble)
  Establish feasibility of potential breaks in Fruitvale ditch to increase overflow capacity

City Pending

- Pre-prepare emergency declaration to limit time needed
- Pre-prepare emergency contract for flood fight on berm
- Public Notice flyer to be sent to City and County Office of Emergency Management and residents (area determined by City)
- Establish feasibility of new inlet for abandoned pipe just north of Riverview Manor to route overflows under highway

- Establish feasibility of overflow acceptance for inlet in middle of Riverview Manor for potential routing under highway
- City and County prepare council and Commission for joint session of CFHMP

WSDOT Completed

- Excavate under US12 bridge 1 to 2 feet
- Bridge excavation investigations

WSDOT Pending

- Modify ditch in front of Riverview Manor to accept more flows with less flooding
- Identify best method to block ramp overflows at Subway (see field trip 23-27 October) to underpass before reach Fruitvale interchange to allows rerouting into Fruitvale ditch
- Have this group establish joint management team to discuss future SR12 bridge replacement

YVOEM Pending

- Use dispatch to mobilize FCZD
- Public Notice flyer for residents (area determined by City) received from City
- Communication plan received from City re reverse 911 etcetera

All Pending

- Field trip 23-27 October by WSDOT, City and County with contour map to confirm actions and where best to intercept water passing over repaired Cowiche berm.
- Establish joint management team to discuss future SR12 bridge replacement

Actions to be undertaken prior to flood (preparedness) or during emergency (flood imminent)

County Preparedness

- Monitor local gauges and weather for mid-elevation snowpack/ provide warning to agencies and Emergency Management- <u>some concerns expressed about overreliance on warning due to rapidity of basin response and weekends/after-hours staff availability matchup.</u>
- Provide some of emergency levee fill materials (non-rock at Ramblers, rock dependent on availabilty)
- Provide joint (4 agencies) flood response plan (this list) to all parties after finalization as a result of October 23-27 field trip

County Emergency

- Provide support to Emergency Management, City, WSDOT and County Roads if event arises

City Preparedness

- Work towards supplying Cowiche flood warning guage to reduce risk to citizens
- Stockpile/coordinate rock and levee materials for potential use on South side Cowiche berm
- If feasible construct inlets at Riverview Manor,
- Provide Northside Riverview manor emergency berm if landowner amenable
- Establish material requirements for Northside Riverview manor emergency berm

City Emergency

- Declare Emergency, provide contractor, activate materials stockpile for flood fight
- Flood watch south side Cowiche berm to address threat and address need for flood repairs
- Provide Northside Riverview manor emergency berm if not done before
- If feasible activate abandoned pipe inlet just north of Riverview Manor for inlet routing under highway
- If feasible activate inlet in middle of Riverview Manor for routing under highway
- Make breaks in Fruitvale ditch to increase overflow capacity

WSDOT Preparedness

- Monitor need to clean bridge US12 inlet
- Materials preparation for blockage of US12 ramp

WSDOT Emergency

- Modify ditch in front of Riverview Manor to accept more flows with less flooding

YVOEM Emergency

- Use dispatch to mobilize FCZD
- Communication plan received from City for both Cowiche and Wide Hollow Creeks– updates during event including reverse 911

Appendix B

Summary Sheets on Flood Hazard Management Options

TABLE B-1
PROBLEM ADDRESSED AND ENVIRONMENTAL IMPACT OF GENERIC FLOOD HAZARD MANAGEMENT MEASURES

Non-Structural Alternatives	Problem Solved (+ = problem solved; 0 = problem not addressed; - = problem aggravated)						NS	Impact (+ = positive impact; 0 = no impact; - = negative impact)					
	Channel Migration	Bank Erosion	Conveyance Capacity	Property Protection	Streambed Degradation / Aggregation	Public Knowledge	Long-term Flood Control Expenditures	Fisheries	Wildlife	Scenic/Aesthetic /Historic	Water Quality	Hydrology	Recreation
Flood Preparedness/ Emergency Management	0	0	0	+	0	+	+	0	0	0	0	0	0
Community Rating System													
Flood warning systems	0	0	0	+	0	+	+	0	0	0	0	0	0
Increase reliability of flood warning (gages, etc.)	0	0	0	+	0	0	+	0	0	0	0	0	0
Interagency action plans	0	0	0	+	0	0	+	0	0	0	0	0	0
Thresholds for evacuation plans	0	0	0	+	0	+	+	0	0	0	0	0	0
Public Information Program	0	0	0	+	0	+	+	0	0	0	0	0	0
FEMA or local map determinations	0	0	0	+	0	+	+	0	0	0	0	0	0
Outreach projects	0	0	0	+	0	+	+	0	0	0	0	0	0
Hazard disclosure	0	0	0	+	0	+	+	0	0	0	0	0	0
A flood protection library	0	0	0	+	0	+	+	0	0	0	0	0	0
Flood protection assistance													
Flood preparedness programs	0	0	0	+	0	+	-	0	0	0	0	0	0
Regulatory Measures/Mapping	+	0	+	+	0	0	+	0	0	0	+	0	0
Elevation certificates	0	0	0	+	0	+	+	0	0	0	0	0	0
Interim development standards or moratorium until risk abatement	+	0	+	+	0	0	+	0	0	0	+	0	0
Higher regulatory standards	+	0	0	+	0	0	+	+	+	+	+	0	+
Zoning/Land use designations	+	0	+	+	0	0	+	+	+	+	+	0	+
Open space preservation	+	0	+	+	0	0	+	0	+	+	+	+	+
Low density zoning	+	0	+	+	0	0	+	0	0	0	+	0	0
Stormwater management													
Ordinance consistency	+	0	+	+	0	0	+	0	0	0	0	0	0
Interagency agreements	0	0	+	+	0	+	+	0	0	0	0	0	0
Additional flood data, more accurate floodplain mapping	0	0	+	+	0	+	+	0	0	0	0	0	0
Flood data maintenance	0	0	+	+	0	+	+	0	0	0	0	0	0
Flood Damage Reduction of Existing Structures	0	+	+	+	+	+	+	0	0	0	0	0	0
Seek funding	0	0	+	+	0	+	+	0	0	0	0	0	0
Flood facility maintenance	0	+	0	+	0	+	-	-	0	0	0	0	0
Sharing information on river characteristics for infrastructure siting/design	+	+	+	+	+	+	+	+	+	+	+	+	+
Acquiring and relocating or removing flood-prone structures	+	+	+	+	+	+	-	+	+	+	+	+	+
Levee maintenance program													
Dam safety programs	0	0	+	+	-	+	+	-	-	-	0	-	+
Developing repetitive loss plans	0	0	0	+	+	+	+	0	0	0	0	0	0

New infrastructure	+	0	+	+	0	+	+	0	0	+	0	0	+
Interagency agreements	+	0	+	+	0	+	+	0	0	+	0	0	+
Improved design and siting	+	+	0 to +	+	+	+	+	0	0	+	0	0	+
Info sharing on design and siting													
Promote fish habitat enhancement													
No critical facilities in flood-prone areas	0	0	0	+	0	+	+	0	0	0	0	0	0

TABLE B-2
PROBLEM ADDRESSED AND ENVIRONMENTAL IMPACT OF GENERIC FLOOD HAZARD MANAGEMENT MEASURES

Structural Alternatives	Problem Solved (+ = problem solved; 0 = problem not addressed; - = problem aggravated)						NS	Impact (+ = positive impact; 0 = no impact; - = negative impact)					
	Channel Migration	Bank Erosion	Conveyance Capacity	Property Protection	Streambed Degradation / Aggregation	Public Knowledge	Long-term Flood Control Expenditures	Fisheries	Wildlife	Scenic/Aesthetic /Historic	Water Quality	Hydrology	Recreation
Alignment Control	+	+	-	+	-	0	-	0	-	-	0	-	0
Spur Dikes	+	+	-	+	-	0	-	+	0	0	+	0	0
Channel Realignment and Widening	+	+	+	+	+	0	-	+	+	+	+	0	+
Flow Realignment	+	+	-	+	-	0	-	-	-	-	-	-	-
Vane Dikes	+	+	-	+	-	0	-	-	-	-	+	-	0
Cutoff channels	+	+	-	+	-	0	-	-	-	-	-	-	-
Bank Protection	+	+	-	+	0	0	-	0	0	0	+	0	0
Reducing Bank Depth	+	+	+	0	0	0	0	0	0	0	0	0	0
Gabions													
Bioengineering	+	+	0	+	0	0	-	+	+	+	+	0	0
Cabling Trees	+	+	-	+	0	0	-	+	+	+	0	0	0
Approach Dikes/Guide Banks	+	+	-	+	-	0	-	-	-	-	-	-	0
Fencing	+	+	-	+	0	0	-	+	0	0	+	0	0
Windrow Revetment	+	+	-	+	-	0	-	0	0	0	+	0	0
Reducing Bank Slope	+	+	+	0	0	0	0	0	0	0	0	0	0
Trench Fill/Riprap	+	+	-	+	-	0	-	-	-	-	+	0	0
Conveyance Capacity	+	+	+	+	+	0	-	+	+	+	+	0	+
Gravel Bar Scalping	0	+	+	+	+	0	-	-	-	0	-	0	0
Overflow (Pilot) Channels	+	+	+	+	+	0	+	+	0 to +	+	+	0	+
Channel & Floodplain Space	+	+	+	+	+	0	-	+	+	+	+	0	+
Sediment Budget & Transport Design Management	+	+	+	+	+	0	-	+	+	+	+	0	+
Reverse Channel Aggradation	+	+	+	+	+	0	-	+	+	+	+	0	+
Vegetation & Debris Removal	0	-	0	0	- or +	0	-	-	-	-	-	0	- to 0
Channel Widening/Deepening	+	+	+	+	+	0	-	-	-	0	- to 0	0	- to 0
Floodplain Protection	+	0	-	+	-	0	-	0	0	0	0	0	+
Setback Levees	+	0	-	+	+	0	-	+	+	+	+	0	+
Low Dikes (Floodplain Levees)	+	0	-	+	-	0	-	-	-	- to 0	-	-	-
Ring Levees	+	-	-	+	-	0	-	0	0	- to 0	-	0	0
Cutoff Levees	+	-	-	+	_	0	-	-	-	- to 0	0	0	0
Storage Reservoirs	-	+	+	+	-	0	-	-	-	- to 0	- to 0	+	+
River Return Structures/Routes	+	+	+	+	-	0	-	+	+	+	0	0	+
Floodproofing of Structures	0	0	0	+	0	0	-	0	0	0	0	0	0
Streambed Control	+	+	0	0	+	0	-	-	-	-	+	0	0
Stabilizers	-	+	-	0	+	0	-	-	-	-	0	0	0
Lowering of Channel	+	-	+	+	+	0	-	0	0	0	+	0	0
Drop Structures	+	+	-	0	+	0	-	-	-	-	+	0	0

a. See Appendix G for further information on flood hazard reduction alternatives													

GENERIC ALTERNATIVES		Flood prb		Env		
2018 Alternatives Grouping	2018 Appendix Generic Alternatives	**SOLVED**	**COST**	**IMPACT**	Essentials of Generic Alternatives	Yellow=2018 addition
Non-Structural						
Public Information	(moved from here)					
	Map Determination	2		0	maps publicly available, jurisdiction adopt overflows map, new 100 year, wait too long for new maps	
	Outreach Programs	2	1	0	advise citizens of flood hazards specific to their location and availability of insurance and flood fight resourcess- meeting with City to discuss	
	Hazard Disclosure	2	1	0	advises prospective property owners and real estate agent of flood hazards prior to purchase	
	Flood Protection Library	2	1	0	provide sufficient flood hazard management & insurance information for public/municipalities (FEMA, COE)	
	Flood Protection Assistance	2	1	0	Provide flood protection advice to interested Landowners-how to prepare	
	Flood Preparedness Information Program	2	-1	0	provide flood protection procedures to jurisdictions and landowners prior to event Specific to areas-coordinate internal with Outreach programs	
Mapping & Regulations	Higher Regulatory Standards	2	1	0	Above minimum -Critical Areas, Shorelines, SEPA, Flood Overlay Zone,Prohibit Critical Facilities,density limits, use hazard maps	
	Promote Floodplain Open Space Preservation	2	-1	0	Preserve space for floodplain natural function- Land Use change, local open space ordinance, zoniing designation, public acquisitions	
	Ordinance Consistency	2	1	0	Consisitency City & County-flood hazard ordinance/critical areas	
	Interagency Agreements	2	1	0	Political mechanism for cross jurisdictional consistency, forum and roles in flood hazard management	
	Additional Flood Data	2	-1	0	Informed decision making with hydrology, sediment budget, infrastructure inventory,aerial photographs	
	Flood Data Maintenance	2	1	0	Quick & Efficient availability through GIS (High water marks,flood extents,road closures,flooded structures)	
	Stormwater Management	6	-1	6	Limit future development flooding impacts, Return overflows back to river, gates and weirs	
	Elevation Certificate (moved to here)	2	1	0	provide accurate building elevation data for flood insurance for all mortgaged buildings - first floor info	
	Interim Regulatory Standards	3	1	1	Flood Zone overlay? Critical Area-FFA?	
	Zoning/Land Use Designations	3	1	0	City? Methods to minimize potential damages for threatened citizens	
Flood Damage Reduction	Acquisition and Relocation	6	-2	6	Remove vulnerable structures, Establish public vs private ownership	
	Repetitive Loss Projects	3	-1	0	for FEMA repetitive loss properties -projects to remove or elevater	
	Drainage System Maintenance	3	-1	-1	Keep overflow route clear, have routes	
	Seek Funding - Existing Structures	3	1	0		
New Buildings & related Infrastructure	Info sharing on siting/design	6	1	2	City and WSDOT?	
	Area Specific Interagency agreements	5	1	2	City and WSDOT?	
	Improved design & siting	6	1	2	use hazard maps, drainage maps	
	Promote fish habitat enhancement	6	-1	6	often good for flood hazrd if designed right	
	SEEK FUNDING - New structures	3	2	0	Organize timelines- interagency cooperation	
Flood Preparedness/Emergency Mngmt	Community Rating Program (CRS)	2	1	0	Reduces insurance premiums, City join?	
	Comprehensive Planning	6	1	6	CFHMP-identify flood issues and solutions	
	Flood Warning System	2	1	0	timely flood identification transmiited through community	
	Levee and Flood Facility Maintenance Program	3	-1	-1	Need ownership and designs to facilitate design levels- Standards, O&M manual and inspections/repairs	
	Dam Safety	3	-1	0	Reduce probability of dam failure, available to community and emergency mgmt	
	Interagency Action Plans	5	1	2	Near term, short term	
	Increase gage reliability	2	-1	0	Planning agency & funds	
	Thresholds for evacuation	5		2	Dependent on near and short term measures	
Structural						
Alignment Control	Spur Dikes/Barbs	1	-1	2	reduce energy along channel bank	
	Flow Realignment	1	-1	-6	redirect flow near bridges, bends	
	Vane Dikes	1	-1	-3	for meandering rivers-to stabilize planform	
	Cutoff Channels	1	-1	2	Reduce flood stages -moves energy downstream with impacts	
	(moved from here)					
	Channel Realignment & widening	5	-1	5	To increase channel conveyance & reduce flood stage through increased cross sectional area and better alignment with topography and/or laterally confining structures such as bridges	
Bank protection	Cabling Trees	2	-1	3	Initial matrix for sediment accumulation-habitat friendly- not downstream bridge/structure friendly	
	Approach Dikes/Guide banks	1	-1	-5	aligns flow at bridges, increases discharge, reduces approach erosion	
	Gabions	1	-1	-5	provides small structures to orient/control flow and reuce erosion- not good in high energy environment	
	Fencing	2	-1	0	90 degrees to flow, reduces coneyance to save property, deflects flow onto others	
	Windrow Revetment	1	-1	1	Stone placement in anticipation of falling into ersion hole	
	Bank Slope Reduction	3	0	0	Reduces steep bank failure slopes	
	TrenchFill/Riprap revetment	1	-2	-2	Large stone engineered material bank protection, high cost land protection	
	Bioengineering (moved to here)	2	-1	4	provides structural support to eroding banks & habitatfriendly- only possible for lower velocities and sediment removal locations	
Conveyance Capacity	Gravel Bar Scalping	4	-1	-3	Increase channel flood conveyance area-lower stage	
	Overflow (Pilot) Channels	6	-1	5	Reduces main channel velocities and stage by taking percentage of flow, creates high value habitat and may capture main channel	
	Selective Vegetation & Debris Removal	3	-1	-4	Reduce roughness, increase conveyance	
	Channel Widening or Deepening	6	-2	-3	Enlarge channel cross sectional are, increase velocity, reduce stage . Common COE solution	
	N/A				upstream development limited- already under permit	
	N/A				upstream development limited- already under permit	
	Channel & Floodplain Expansion	5	-2	5	Widen both elements to reduce velocities and stage through increasing flow top-width over a range of flows	
	Manage Sediment Budget & Transport in design	5	-1	6	Allow for in design & have gravel mangement plan	
	Reverse channel aggradation	5		6	Techniques required where aggradation is a problem. Good design and still need removal locations	
Floodplain Protection	Setback Levee	4	-2	5	Pull existiing levee back or new levee, both allowing active floodplain	
	Low Dikes (Floodplain levees)	0	-1	-5	Placed on river bank cutting off floodplain	
	Ring Levee	-1	0	-1	Encircling structure(s) with a levee- common with WWTP & WTPs	
	Cut-off Levee	-2	-1	-2	Levees 90 degrees to stream to prevent overflow paths & damage	
	Floodproofing Structures	1	-2	0	Design or alteration of existing structures to reduce or eliminate flood damages, or elevate	
	Storage Reservoirs	-2	-3	-2	Not feasible short term	
	River Return Structures	3	-1	0	To return river flooding behind levees to the river minimizing damage. Overflows routed back to river in channel designed to minimize damage	
Streambed Control	Stabilizers/Grade Control Structures	0	-1	-3	Buried weirs to limit upstream channel scour & degradation	
	Lowering of channel	3	-1	1	To increase conveyance and reduce flood stage through excavation. increases freeboard and safety - must be in concert with overall gradient not to infill	
	Drop structure	2	-2	-2	not foreseen as desirable in Cowiche	

Appendix B

Non-Structural Alternatives

GROUP:	PUBLIC INFORMATION
ALTERNATIVE:	**ELEVATION CERTIFICATE**
PURPOSE:	To provide building elevation data for accurate flood insurance rating and promote awareness of flood insurance.
DESCRIPTION:	The National Flood Insurance Program requires communities to maintain a record of the elevation of the lowest flood for any new building or substantial improvements made to buildings in the Special Flood Hazard Area (SFHA). SFHA are shown on a community's Flood Insurance Rate Map. Elevation and related building information should be available for public inspection and insurance rating. To standardize the data records, FEMA provides elevation certificate forms. The elevation certificate contains property, Flood Insurance Rate Map (FIRM), building elevation, community, and certification information.
IMPLEMENTATION:	Complete an elevation certificate for each building constructed in a Special Flood Hazard Area.
AGENCY CONTACTS:	Local Community Building Official, Federal Emergency Management Agency, U.S. Army Corps of Engineers.

GROUP:	PUBLIC INFORMATION
ALTERNATIVE:	**MAP DETERMINATION**
PURPOSE:	Provide flood hazard information as a public information service.
DESCRIPTION:	Map determinations tell inquirers if a property is in a Special Flood Hazard Area (SFHA), which flood zone it is, and the base flood information. The public information service help banks, insurance and real estate agents, and anyone else who needs flood hazard information. Map determinations may include: • Reading a Flood Insurance Rate Map (FIRM) in response to a telephone call. • Helping a person who walks into the office to read the FIRM. • Completing a map determination form. • Refer inquirers to a commercial map determination service.
IMPLEMENTATION:	Provide the public service by dedicating staff trained in interpreting FIRMs and publicizing the service to the community.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Planning Department of local communities, Federal Emergency Management Agency.

GROUP:	PUBLIC INFORMATION
ALTERNATIVE:	**OUTREACH PROGRAMS**
PURPOSE:	To advise people of flood hazards and the availability of flood insurance and/or flood protection methods.
DESCRIPTION:	Research has proven that flood hazard awareness is not enough; people need to be told what they can do to reduce flood damage. A local public information program can effectively relay this information and motivate property owners to protect themselves from flood damage. The program can be in a form of newsletters, newspaper publications, brochures, public meetings, radio and television advertising, or flood awareness weeks. It should provide information on the local flood hazard, location of flood hazards, flood warning system, flood safety, flood insurance, property protection measures, floodplain development permit requirements, substantial improvement requirements, drainage system maintenance, and natural and beneficial functions of the floodplain.
IMPLEMENTATION:	Allocate funding resources to develop a program as outlined in FEMA's Community Rating System Credit for Outreach Projects.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Federal Emergency Management Agency.

GROUP:	PUBLIC INFORMATION
ALTERNATIVE:	**HAZARD DISCLOSURE**
PURPOSE:	Advises prospective property purchasers and real estate agents of possible flood hazards prior to a real estate transaction.
DESCRIPTION:	This alternative involves requiring a statement such as "This property is located within the FEMA-mapped floodplain and may be subject to flood damages" on all future deeds of sale for transfers or financing of parcels in floodplain areas. The same statement should be attached to the recorded plat map.
IMPLEMENTATION:	The best way to implement this activity is to have Realtors provide written notification to potential purchasers that the property exists in a special flood hazard area and requires the purchase of flood insurance. The State is currently developing this as a regulatory requirement.
AGENCY CONTACTS:	Federal Emergency Management Agency, Yakima Association of Realtors, Yakima County Auditor, Yakima County Assessor.

GROUP:	PUBLIC INFORMATION
ALTERNATIVE:	**FLOOD PROTECTION LIBRARY**
PURPOSE:	To ensure there is sufficient reference material on floodplain management and flood insurance for interested parties.
DESCRIPTION:	The local library should maintain documents related to flood insurance, flood protection, floodplain management, the natural and beneficial functions of floodplains, local information on flood warnings, how to be prepared for a flood, and what to do in case of a flood. Publications should be kept and distributed by the local libraries along with local contacts for additional information. In addition, local libraries may hold public information campaigns with displays and lectures.
IMPLEMENTATION:	Provide a listing or copies of the numerous publications published by FEMA, U.S. Army Corps of Engineers, U.S. Natural Resources and Conservation Service, and state and local agencies and announce the availability of publications through local newspapers.
AGENCY CONTACTS:	Yakima County Flood control Zone District,Federal Emergency Management Agency, U.S. Army Corps of Engineers, U.S. Natural Resources and Conservation Service, State National Flood Insurance Program Coordinator, Yakima County Planning.

GROUP:	PUBLIC INFORMATION
ALTERNATIVE:	**FLOOD PROTECTION ASSISTANCE**
PURPOSE:	Provide flood protection advice to interested property owners.
DESCRIPTION:	As a public service, a qualified person advises interested residents on flood insurance and flood protection. The advisors should be confident and willing to respond and help floodplain residents. Advice available should include: • How to prepare for a flood • What to do in case of a flood • Site visits to review flood hazards • Contractors available to flood proof homes or construct flood protection measures • How to obtain flood insurance and reduce the premiums • Base flood elevations and building elevations • Areas of high flood hazard
IMPLEMENTATION:	Staff a technical position in floodplain management. Periodically advertise the public service.
AGENCY CONTACTS:	Local Communities, Yakima Flood Control Zone District, Federal Emergency Management Agency, U.S. Army Corps of Engineers, State National Flood Insurance Program Coordinator.

GROUP:	PUBLIC INFORMATION
ALTERNATIVE:	**FLOOD PREPAREDNESS INFORMATION PROGRAMS**
PURPOSE:	Provide flood preparedness and protection procedures to partners and to at risk citizen group through public outreach.
DESCRIPTION:	Measures specific to at risk areas are developed beyond the wide scale generic measures for flood preparation available on websites.
IMPLEMENTATION:	Requires coordination between the County, Cities and the Yakima Valley Office of Emergency Management.
AGENCY CONTACTS:	Yakima Valley Office of Emergency Management, Local Jurisdiction websites, Yakima County Flood Control Zone District, US Army Corps of Engineers, Federal Emergency Management Agency.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**HIGHER REGULATOR STANDARDS**
PURPOSE:	To provide more flood protection than the minimum required by the National Flood Insurance Program (NFIP), and reduce public and private expenditures during floods.
DESCRIPTION:	Numerous flood-related regulations can be integrated into floodplain, zoning, shoreline, critical area, and land division ordinances to reduce flood damage. Although minimum NFIP standards provide flood protection, damages can be further reduced by adopting additional or stricter regulatory measures. These measures may involve: • Modification of the zoning ordinance to include a floodplain overlay zone (FOZ) that references pertinent floodplain regulations. • Modification of the zoning ordinance to have only flood tolerant zoning designations in the floodplain. • Adequate buffer zones and setbacks near critical areas. • Update building standards to reduce flooding impacts. • Modification of floodplain ordinances to require lowest levels of buildings be higher than the 100-year flood elevation or prohibit construction in or adjacent to the floodplain. • Modification of floodplain ordinances to prohibit critical facilities in the 500-year floodplain (requirement of federal funding) or require the lowest level elevation to be 3 feet above 100-year flood. • Prohibit filling within floodplain areas or require compensatory storage. • Prohibit development in highly erosive areas. • Update building standards to protect foundations from erosion and settlement. • Require full compliance with floodplain management regulations for proposed building improvements. • Require dry land access during a 100-year event for all development.
IMPLEMENTATION:	Requires drafting a new ordinance, legal notice, public meetings, public hearings, SEPA checklist, state review, and final adoption by Commissioners.
AGENCY CONTACTS:	WA Department of Ecology, WA Department of Commerce, Yakima County Planning, Yakima County Building, Federal Emergency Management Agency.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**OPEN SPACE PRESERVATION**
PURPOSE:	To preserve specific land types and designated environmentally sensitive areas from future development. Open space preservation allows the floodplain to provide its natural function and minimizes possible future flood damage.
DESCRIPTION:	Open space preservation is provided by land purchases, easements, tax incentives, transfer of development rights, development of density credits, and zoning requirements. Open space includes public land such as state and local parks, easements, nature preserves, and areas which have restrictive development regulations such as cluster developments and low-density zoning.
IMPLEMENTATION:	Open space preservation is achieved by adopting an open space ordinance consistent with Revised Code of Washington 84.33 and 84.34 or modifying local zoning ordinances. Open space ordinances provide tax incentives to property owners who agree to preserve specific land types and can also include a funding mechanism for land purchases. Zoning ordinances can also increase open space by limiting development densities and requiring specific conditions to protect sensitive areas.
AGENCY CONTACTS:	Yakima County and city of Yakima Planning, Federal Emergency Management Agency.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**ORDINANCE CONSISTENCY**
PURPOSE:	To ease the regulatory burden and ensure that the desired level of flood protection is being provided throughout and adjacent to the floodplain.
DESCRIPTION:	Flooding does not respect political boundaries. Watershed and floodplain areas extend over city, county, state, and federal jurisdictions. Therefore, regulations affecting flood hazard management can vary dramatically and possibly be contradictory. For example, shoreline and critical areas ordinances may have different buffer requirements or city and county floodplain ordinances may have different flood fringe development standards. A comprehensive review of all ordinances relating to development and environmental issues should be performed to eliminate inconsistencies, simplify permit requirements, and bring the overall regulatory requirements up to a common standard.
IMPLEMENTATION:	Review ordinances and make recommendations to combine, clarify, and simplify them to achieve consistency with overall flood management goals.
AGENCY CONTACTS:	Local communities, Federal Emergency Management Agency, Washington Department of Ecology, Yakima County Attorney, City Attorneys.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**INTERAGENCY AGREEMENTS**
PURPOSE:	Provide a political mechanism to create consistent flood hazard management across political boundaries.
DESCRIPTION:	An Interagency Task Force could be established to focus on regional flood hazard concerns. The Task Force provides a forum to exchange information between al agencies, to discuss technical issues, and recommend potential actions consistent with regional concerns. Each Task Force member is responsible for implementing the recommendation agreements within their local jurisdiction.
IMPLEMENTATION:	Implementation is dependent on the regional issues and the number of agencies involved. In general, implementation involves defining the specific goals and objectives of the interagency task force, assigning a lead agency to monitor and direct progress of the Task Force, and conducting meetings and public hearings in which agencies seek consensus before arriving at recommendations.
AGENCY CONTACTS:	Federal Emergency Management Agency, U.S. Army Corps of Engineers, U.S. Soils Conservation Service, U.S. Environmental Protection Agency, Washington Department of Ecology, Washington Department of Natural Resources, Washington Department of Fish and Wildlife, Yakima County Planning, City of Yakima Departments of Planning & Community Development, Yakama Nation.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**ADDITIONAL FLOOD DATA**
PURPOSE:	Allows informative floodplain management decisions.
DESCRIPTION:	Additional flood data provides a better understanding of natural processes affecting flooding. Informed management of flood hazards depends on information produced from detailed hydrologic, hydraulic, and environmental studies. Data collection will depend on existing flood issues but is likely to include: • Defining historic areas of flood water inundation and water surface elevations. • Information on critical areas such as wetlands, alluvial fans, mudflows, moveable streambeds, and habitat areas. • A bank erosion inventory. • Collection of sediment supply, transport, and deposition data to assess sediment movement through the river system. • River flow and precipitation gaging for flood forecasting. • Collection of historical aerial photographs to assess river migration. • Inventory of structures within the floodplain. • An inventory of critical facilities within the floodplain. • Levee inventory.
IMPLEMENTATION:	Collecting additional data involves 1) defining precisely the information needed to resolve and outstanding flood management issue, 2) developing a plan for data acquisition and data analysis that provides the information needed, 3) allocating funding and staff resources, 4) administering the plan for data collection and analysis.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Federal Emergency Management Agency, U.S. Army Corps of Engineers, Washington Department of Ecology, U.S. Bureau of Reclamation.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**FLOOD DATA MAINTENANCE**
PURPOSE:	To manage and archive available and future data such that useful information is provided quickly and efficiently for flood management decisions.
DESCRIPTION:	This alternative requires a long-term commitment to maintain data in a usable format. It typically involves digital geographic information system (GIS) mapping of historic flood boundaries, NFIP floodway, floodplain delineation, and flood elevations, plus historic flood elevations. Flood information is mapped in conjunction with physiographic features, parcel systems, corporate limits, zoning designations, critical areas, and watershed boundaries. Flood data maintenance can be used to update Flood Insurance Rate Maps (FIRM). Maps can be updated to a standard higher than required by FEMA, expanded to include historic flood hazard areas not covered by the FIRM, or modified to account for areas which have experienced changing conditions. Flood data maintenance may also include developing databases containing flood elevations throughout the floodplain, structures in the floodplain and their lowest flood elevations, road closures during flooding, and precipitation and river flow data.
IMPLEMENTATION:	Implementation involves dedicating resources to acquire, develop, update, and maintain the information system.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Federal Emergency Management Agency, U.S. Army Corps of Engineers, U.S. Bureau of Reclamation.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**STORMWATER MANAGEMENT**
PURPOSE:	To limit flooding and water quality impacts from future development and redevelopment.
DESCRIPTION:	As a watershed becomes more developed, stormwater runoff and pollutant availability increases. This results in more frequent and severe flooding and greater pollutant transport to receiving streams. Stormwater management involves developing the regulatory framework to control quantity and quality of stormwater runoff. Federal and state regulations have been promulgated to control stormwater runoff. Regulations require federal stormwater discharge permits, basic stormwater programs for most cities and counties, and comprehensive programs for urbanized areas. Stormwater programs may include: • Adoption of ordinances requiring stormwater controls for new development and redevelopment. • Incorporating Best Management Practices (BMPs) for water quality into new development and redevelopment. • Operations and maintenance programs for all public and private stormwater facilities. • Identifying and ranking significant pollutant sources and their relationship to the drainage system and receiving waters. • Investigations and corrective actions of problem storm drains. • Water quality response programs. • Establishment of funding for stormwater programs through surface water utilities. • A public education program.
IMPLEMENTATION:	Stormwater management is implemented by developing a comprehensive program to address stormwater issues.
AGENCY CONTACTS:	U.S. Environmental Protection Agency, Washington Department of Ecology.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**INTERIM REGULATORY STANDARDS**
PURPOSE:	Provide regulatory standards for high at risk locations while in waiting for implementation of short and long term flood risk mitigation measures.
DESCRIPTION:	Regulatory measures will take advantage of existing specific knowledge and delineation of the at-risk areas and are in addition to the wide scale existing regulatory measures for flood preparation available on websites. Potential vehicles include frequently flooded areas definition in critical areas, shoreline regulations, SEPA and the use of a Flood Overlay Zone. Mechanisms use for future development could limit development through density, interim open space, floodproofing or a moratorium before 100-year protection. Measures for existing at-risk development should include notification and potential regrading.
IMPLEMENTATION:	Requires the identification of most effective interim measures and the approval by the elected Board.
AGENCY CONTACTS:	Local Planning Department, Federal Emergency Management Agency, State Department of Ecology, Yakima County Flood Control Zone District.

GROUP:	MAPPING AND REGULATIONS
ALTERNATIVE:	**ZONING AND LAND USE DESIGNATIONS**
PURPOSE:	Provide regulatory standards for high at risk locations while in waiting for implementation of short and long term flood risk mitigation measures.
DESCRIPTION:	Regulatory measures will take advantage of existing specific knowledge and delineation of the at-risk areas and are in addition to the wide scale existing regulatory measures for flood preparation available on websites. Potential vehicles include zoning ordinance and use of a Flood Overlay Zone. Mechanisms could limit high risk development through density and interim open space, before 100-year protection.
IMPLEMENTATION:	Requires the identification of most effective interim and long term measures and the approval by the elected Board.
AGENCY CONTACTS:	Local Planning Departments, Federal Emergency Management Agency, State Department of Ecology, Yakima County Flood Control Zone District.

GROUP:	FLOOD DAMAGE REDUCTION
ALTERNATIVE:	**ACQUISITION AND RELOCATION**
PURPOSE:	To remove buildings from the flood hazard areas.
DESCRIPTION:	The most effective way to protect a structure from flood damages is to remove it from the floodplain. This typically involves acquisition of flood hazard property by a government agency and building demolition or building relocation to a location outside the floodplain.
IMPLEMENTATION:	Develop agreements between property owners and funding sources for property acquisition.
AGENCY CONTACTS:	Federal Emergency Management Agency, Department of Ecology, U.S. Natural Resources and Conservation Service, U.S. Army Corps of Engineers.

GROUP:	FLOOD DAMAGE REDUCTION
ALTERNATIVE:	**REPETITIVE LOSS PROJECTS**
PURPOSE:	To address repetitive flooding problems.
DESCRIPTION:	This activity documents the location of repetitive loss areas and prepares, adopts and implements a plan to reduce the flood problems in these areas. The activity involves: • Obtaining and reviewing the repetitive loss list produced by the Federal Emergency Management Agency (FEMA). • Mapping the repetitive loss areas. • Identifying the causes of the repetitive flooding. • Implementing a program to reduce losses from floods.
IMPLEMENTATION:	Each year the Federal Emergency Management Agency (FEMA) produces a list of repetitive loss properties within each National Flood Insurance Program (NFIP) community. This list can be obtained from FEMA regional offices. The community should review this list for accuracy and develop flood hazard reduction alternatives to address repetitive loss areas. Recommended alternatives should only include measures that the community can implement either through its own resources or from a confirmed outside source.
AGENCY CONTACTS:	Federal Emergency Management Agency, U.S. Natural Resources and Conservation Service, U.S. Army Corps of Engineers.

GROUP:	FLOOD DAMAGE REDUCTION
ALTERNATIVE:	**DRAINAGE SYSTEM MAINTENANCE**
PURPOSE:	To maintain the conveyance and storage capacity of natural drainageways or channels, man-made storm sewers and ditches, and detention/retention basins.
DESCRIPTION:	This activity involves: • Developing and implementing an inspection and maintenance plan for all drainageways. • Drainage inspections of catch basins, drainage channels, detention facilities, flow control structures, and pump stations. • Maintenance operations to clean catch basins, remove channel debris, clear culvert operations, remove sediment from detention facilities, vegetation planting to control channel erosion, removal of intrusive vegetation to increase channel conveyance capacity, and trash cleanup. • Adopt stream dumping regulations and inform residents about the regulations and how to report violations. • Developing an erosion protection program for areas susceptible to streambank, head cutting, and coastal erosion.
IMPLEMENTATION:	Implementation begins by conducting and maintaining a complete drainage inventory. All drainage channels, stormwater control facilities, piping networks, and natural channels should be inventoried and mapped. Based on the inventoried facilities, a maintenance plan can be developed. The plan should outline scheduled maintenance for each facility, clearly define who is responsible, outline reports to be used for inspection documentation, and detail what can and cannot be removed. Implementing agencies can include cities, counties, flood control districts, or drainage districts. Implementation should also include the adoption of stream dumping regulations. Public outreach programs (e.g. mailings or stream clean-up days) should be conducted to inform affected residents and detail how to report violations. “No Dumping” signs should be posted near problem areas.
AGENCY CONTACTS:	Local Community, Irrigation Districts, Department of Ecology, EPA, Corps of Engineers, Federal Emergency Management Agency, U.S. Natural Resources and Conservation Service.

GROUP:	FLOOD PREPAREDNESS
ALTERNATIVE:	**COMMUNITY RATING SYSTEM (CRS) PROGRAM**
PURPOSE:	To reduce flood insurance premiums and increase public knowledge of flood hazards by implementing nonstructural flood damage reduction alternatives through the Federal Emergency Management Agency's (FEMA) Community Rating System.
DESCRIPTION:	FEMA's Community Rating System program provides a reduction of flood insurance premiums for communities that initiate flood protection activities beyond the minimum National Flood Insurance Program (NFIP) requirements. Credits are earned by public education, mapping and regulatory, flood damage reduction, and flood preparedness activities.
IMPLEMENTATION:	A CRS program requires dedicated staff to administer, document, and promote the program. Community participation in the Community Rating System is voluntary. Any community in full compliance with the rules and regulations of the NFIP may apply for CRS classification. To be recognized by the Community Rating System, community floodplain management activities must be described, measured, and evaluated. FEMA's CRS schedule sets forth the application procedures, creditable activities, and credit points assigned to each activity. The community submits complete application worksheets with appropriate documentation to the FEMA Regional Office for review and possible flood insurance rate reductions. Each year the community must reverify that it is continuing to perform the activities credited by CRS.
AGENCY CONTACTS:	Local community, Federal Emergency Management Agency.

GROUP:	FLOOD PREPAREDNESS
ALTERNATIVE:	**COMPREHENSIVE PLANNING**
PURPOSE:	To guide a community through its flooding problems by identifying flooding issues and describing appropriate solutions to reduce flood damage and protect the natural functions of the floodplain.
DESCRIPTION:	The comprehensive floodplain management plan involves the following planning steps: • Problem identification. • An inventory of existing and future land use conditions in flood hazard areas including number and types of buildings, development trends, development constraints (soils, ownership, regulations), critical facilities (hospitals, fire stations, chemical storage), areas of natural beneficial uses (wetlands, sensitive areas, wildlife habitat) and community needs, goals, and plans for the area. • Coordination with neighboring communities and other agencies that implement floodplain management activities by creation of an advisory committee. • Identification of flood issues, plus goals and objectives. • A review of possible flood reduction alternatives. • Developing an appropriate action plan with recommended alternatives that clearly identifies who does what, when it will be done, and how it will be funded. • Obtaining public input on the draft plan. • Adoption and implementation by the community's governing body. • Periodically evaluate and update the plan.
IMPLEMENTATION:	Implementation requires a commitment by the governing agency. The adopted plan should not sit on a shelf gathering dust but should be reviewed periodically for progress, updated, and appropriately funded to reach the plans goals.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Washington Department of Ecology, Federal Emergency Management Agency, Yakima County Planning Department.

GROUP:	FLOOD PREPAREDNESS
ALTERNATIVE:	**FLOOD WARNING SYSTEM**
PURPOSE:	To provide timely identification of impending flooding, communicate warnings to floodplain occupants, and coordinate flood response activities so that protective measures can be taken.
DESCRIPTION:	Combining a flood threat warning system and emergency response plan will greatly reduce flood damage. The National Weather Service provides flood warnings for specific locations on the Yakima and Naches Rivers; however, communities can augment flood threat information by developing their own flood warning system for urban or smaller streams. Flood warning systems involve: • Meteorological and hydrologic data collection and analysis. This may include volunteer monitoring of upstream river stages and rain gages, gathering or electronically accessing USGS, NOAA, U.S. Army Corps of Engineers, U.S. Weather Service, or other agency rainfall and river flow data, and use of hydrologic computer models to convert river and rainfall data to a flood prediction. • A documented emergency response plan keyed to specific flood levels. The plan should detail standard operating procedures, responsible agencies or staff, coordination activities, communication protocols, and use of critical facilities and resources during flood response efforts (e.g. shelters, sandbags, etc.) • Periodic drills and/or appropriate training of emergency response personnel. • Timely dissemination of flood warnings through radio, TV, the Emergency Broadcast System, sirens, telephone, or door-to-door floodplain resident contact. • Post-flood recovery program to assist residents, assess damages, repair impacted public roads and facilities, and evaluate performance of the warning system. • Public outreach programs to inform residents on emergency response procedures.
IMPLEMENTATION:	Implementation involves developing an emergency response plan, developing institutional knowledge of levee performance and vulnerabilities; training personnel, and performing mock drills to ensure readiness.
AGENCY CONTACTS:	National Weather Service, YFCZD, U.S. Army Corps of Engineers Washington Emergency Management Division.

GROUP:	FLOOD PREPAREDNESS
ALTERNATIVE:	**LEVEE MAINTENANCE PROGRAM**
PURPOSE:	To ensure levees are properly maintained and operated.
DESCRIPTION:	This activity involves routine inspection and repair of existing levees in accordance with operation and maintenance procedures. Levees accorded National Flood Insurance Program (NFIP) accreditation must be certified by owners to those standards. The levee operations and maintenance program should include: • Levee locations and level of protection. • A detailed maintenance schedule. • Levee design standards and typical sections for repairs. • Emergency response plan that specifies actions for various flood stages.
IMPLEMENTATION:	All county levees are inventoried, mapped, and evaluated for level of protection. The levees' level of protection is agreed with the U.S. Army Corps of Engineers or another federal agency and inspections performed by a professional engineer to ensure program (NFIP, PL84-99) enrollment requirements are met. Substandard levees should be prioritized and repaired.
AGENCY CONTACTS:	Levee owners (County, City or private), U.S. Army Corps of Engineers, U.S. Natural Resources and Conservation Service.

GROUP:	FLOOD PREPAREDNESS
ALTERNATIVE:	**DAM SAFETY**
PURPOSE:	Reduce the probability of dam failure.
DESCRIPTION:	This activity involves a dam safety program that includes: • Operation and maintenance procedures and Checklists • Annual reports on the safety and operations status. • Regular Inspections • Communication checks between dam operators and emergency officials. • Emergency response and community notification procedures when a dam appears threatened by high water. • Dam failure inundation maps. • Evacuation routes and warning procedures. • Periodic mock exercises of emergency action.
IMPLEMENTATION:	Coordination between YVOEM, communities and dam operators to ensure dam safety programs are up to date and address warning and evacuation procedures for downstream communities.
AGENCY CONTACTS:	Dam owners, Washington Department of Ecology, Yakima Valley of Emergency Management, U.S. Army Corps of Engineers

GROUP:	FLOOD PREPAREDENESS
ALTERNATIVE:	**INCREASE GAGE RELIABILITY**
PURPOSE:	To provide watershed data more representative of the rapid flood response on smaller basins. The National Weather Service predictions require more local basin snow, rain and stream gage data before and during flood actual events.
DESCRIPTION:	Stream gage responses on the Cowiche existing stream gages appear to provide only a few hours warning as opposed to Ahtanum Creek upper watershed stream gages. Rain, radar, snow and stream gages in the upper watershed promote better flood action responses.
IMPLEMENTATION:	Implementation would require the identification of a responsible party and data collection agency along with funding.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Yakima City, WSDOT, State Department of Ecology, Federal Emergency Management Agency.

GROUP:	FLOOD PREPAREDENESS
ALTERNATIVE:	**INTERAGENCY ACTION PLANS**
PURPOSE:	Provide a cross agency operational action plan to provide a coordinated resource management and response to flood events.
DESCRIPTION:	The plan identifies flood response actions for specific area(s) and responsible parties to allow more seamless implementation and transfer of resources when responding to the flood event. The plan would also identify means of communication which would be spearheaded through the Yakima valley Office of Emergency Management. At a minimum the City, County, WSDOT and the Yakima valley Office of Emergency Management would be represented and draw up the plan.
IMPLEMENTATION:	The afflicted area be it the City or County would initiate the Action Plan with the YVOEM and as the event escalate, require a Declaration of State of Emergency in order to mobilize maximum resources as quickly as possible.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Yakima City, WSDOT, State Department of Ecology, Federal Emergency Management Agency.

GROUP:	FLOOD PREPAREDENESS
ALTERNATIVE:	**THRESHOLDS FOR EVACUATION**
PURPOSE:	Provide event and area specific thresholds for evacuation of citizens and businesses incorporated in action plans and connected to flood predicted risk.
DESCRIPTION:	The thresholds are related to predicted flood flows and predicted/observed response of the flood protection facilities. The detail is dependent on downstream vulnerabilities and the local jurisdictions ability to reroute dangerous flows back to less dangerous routes. The thresholds would be in the flood action plan that would combine predicted and observed conditions. Communication which would be spearheaded through the Yakima valley Office of Emergency Management and the local jurisdiction. At a minimum the City, County, WSDOT and the Yakima valley Office of Emergency Management would agree on the thresholds to be included in the action plan.
IMPLEMENTATION:	The afflicted area, either the City or County, would initiate the Action Plan thresholds with the YVOEM and as the event escalates, require a Declaration of State of Emergency in order to mobilize maximum resources as quickly as possible.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Yakima City, WSDOT, State Department of Ecology, Federal Emergency Management Agency.

GROUP:	FLOOD DAMAGE REDUCTION-NEW INFRASTRUCTURE
ALTERNATIVE:	**AREA-SPECIFIC INTERAGENCY AGREEMENTS**
PURPOSE:	Provide a political mechanism to implement consistent flood hazard measures and establish funding.
DESCRIPTION:	An interagency Task Force could be established to focus on flood hazard concerns in chronic high risk areas. The Task Force would provide a forum to exchange technical information and present recommendations on future course of action. The agreement can also establish a joint approach for funding required actions. At a minimum the City, County, WSDOT and the Yakima valley Office of Emergency Management would be represented.
IMPLEMENTATION:	In general, implementation involves defining the specific goals and objectives of the interagency task force, assigning a lead agency to monitor and direct progress of the Task force, and conducting meetings in which agencies seek consensus before arriving at recommendations.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Yakima City, WSDOT, State Department of Ecology, Federal Emergency Management Agency.

GROUP:	FLOOD DAMAGE REDUCTION-NEW INFRASTRUCTURE
ALTERNATIVE:	**IMPROVED FACILITY SITING AND DESIGN**
PURPOSE:	To incorporate the shared information on flood risk from the Flood Control Zone District in evaluating proposals for existing and proposed infrastructure or developments and housing. This information will be utilized to reflect short and long term flood risk mitigation in at risk areas.
DESCRIPTION:	The hydraulic and physical conditions and risk provided by the Flood Control Zone District to Planning and Engineering divisions of the City, County, WSDOT and the Yakima valley Office of Emergency Management will be used to modify siting and designs to minimize risk.
IMPLEMENTATION:	The FCZD transfers data and models to all parties for planning and design usage.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Yakima City, WSDOT, State Department of Ecology, Federal Emergency Management Agency

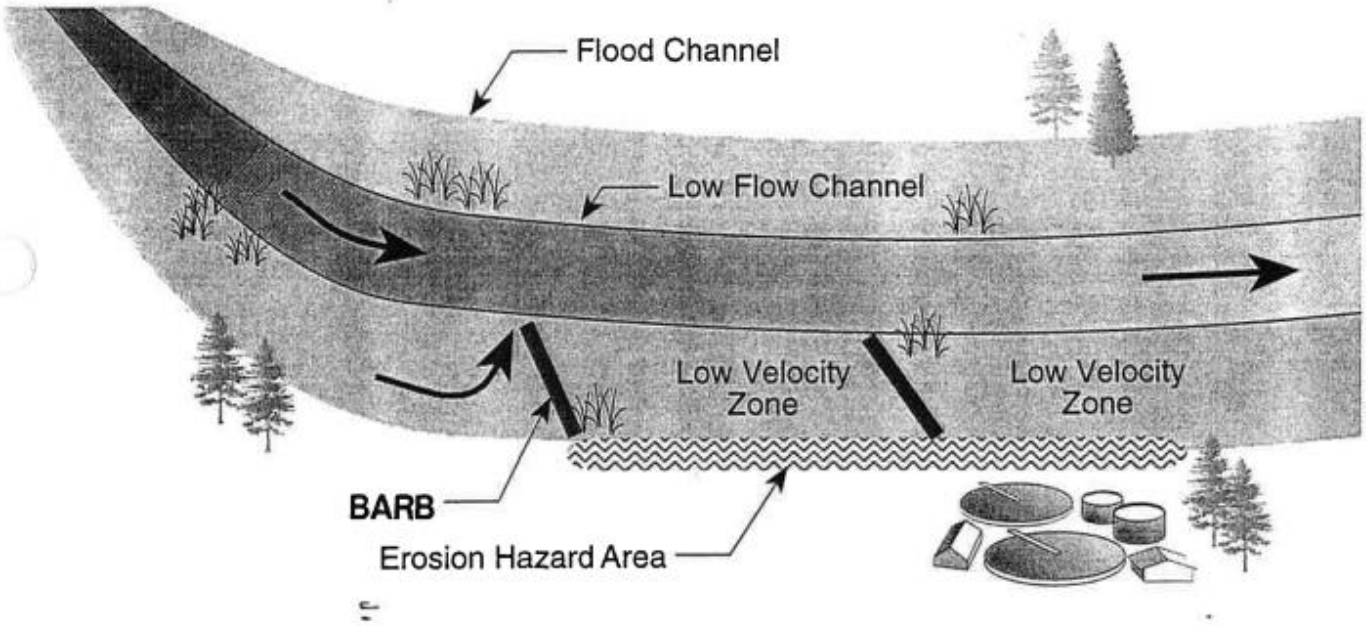
GROUP:	FLOOD DAMAGE REDUCTION-NEW INFRASTRUCTURE
ALTERNATIVE:	**INFORMATION SHARING ON FACILITY SITING AND DESIGN**
PURPOSE:	Provides the technical knowledge of depths, velocities and routes of overflow flood paths to improve location selection for new facilities to obtain lower risk options for both proposed and existing structures. These measures are while in waiting for implementation of short and long term flood risk mitigation measures.
DESCRIPTION:	The hydraulic and physical conditions for at risk scenarios are provided by the Flood Control Zone District to Planning and Engineering divisions of the City, County, WSDOT and the Yakima Valley Office of Emergency Management. This information provides justification for interim and higher regulatory standards that the City wishes to implement and enables the planning and engineering of these parties to operate on a common information platform. This information could be provided on the jurisdiction's website.
IMPLEMENTATION:	The FCZD transfers data and models to all parties.
AGENCY CONTACTS:	Yakima County Flood Control Zone District, Yakima City, WSDOT, State Department of Ecology, Federal Emergency Management Agency.

GROUP:	FLOOD DAMAGE REDUCTION-NEW INFRASTRUCTURE
ALTERNATIVE:	**PROMOTE FISH HABITAT ENHANCEMENT**
PURPOSE:	Provide the opportunity in flood hazard reduction projects to enhance fisheries habitat directly and indirectly through the restoration of natural river and floodplain functions. Typically, these are coincident with flood reduction benefits and funding but should be consciously prescribed.
DESCRIPTION:	Vested, interested and mandated agencies and staff should be included in the design to allow habitat benefits to all species and in particular ESA and salmon species. In some cases, additional floodplain habitat benefits to wildlife should also be incorporated particularly in arid climates where the floodplain has particular significance. Naturally varying habitats present additional value.
IMPLEMENTATION:	Implementation involves defining the specific habitat goals and objectives for a specific location and may require monitoring to evaluate success.
AGENCY CONTACTS:	Washington Fish and Wildlife, NOAA, NMFS, US Fish and Wildlife, Washington Department of Ecology, Yakima Nation, Yakima County Flood Control Zone District, Yakima City.

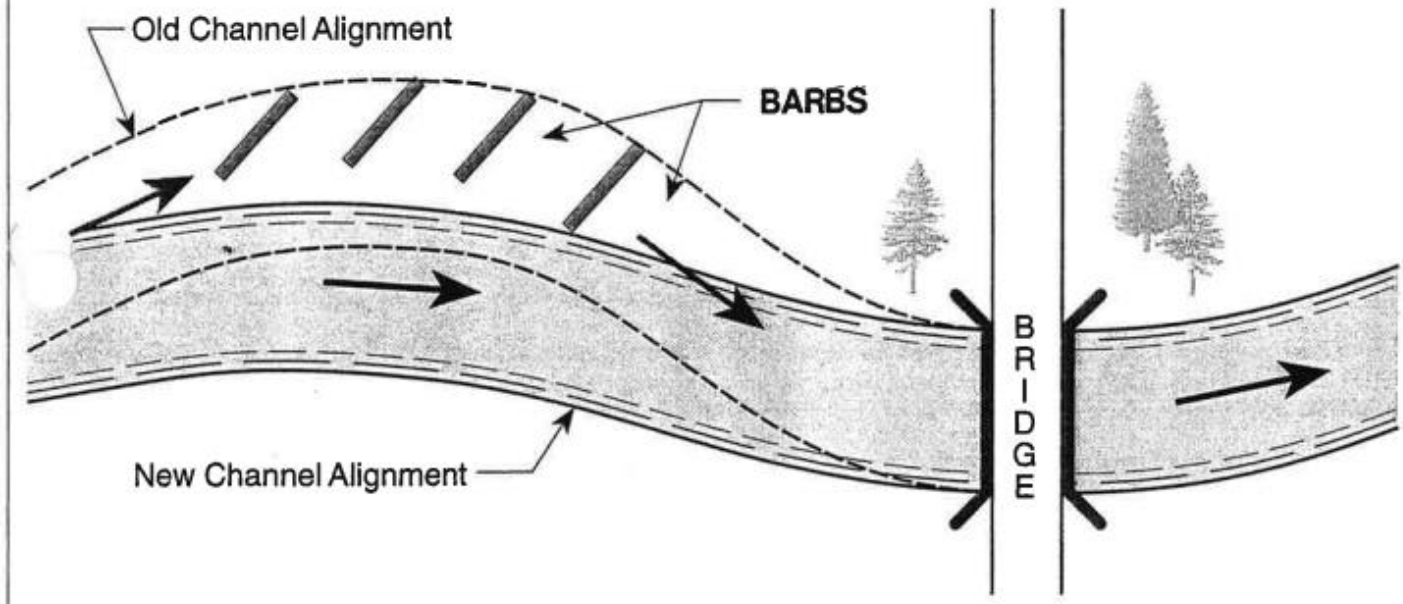
Appendix B

Structural Alternatives

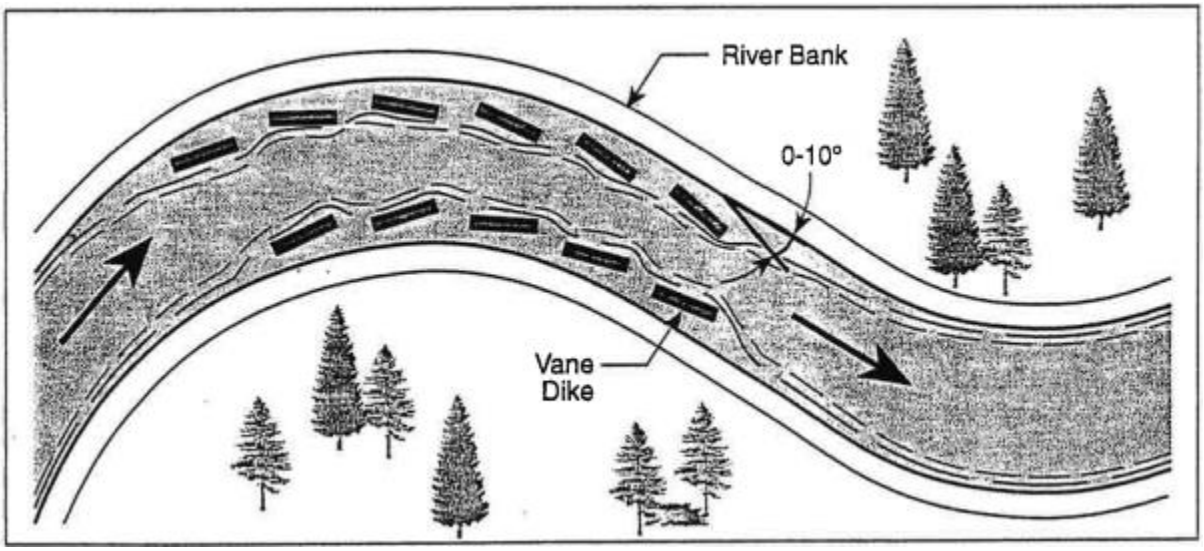
GROUP:	ALIGNMENT CONTROL
ALTERNATIVE:	**BARBS**
PURPOSE:	Reduce the energy along the bank by moving the faster flowing water towards the center of the channel.
DESCRIPTION:	A structure is installed at an angle with the bank (determined through engineering analysis) to deflect flow towards the center of the river. The structure may consist of a low rock berm, trees or a combination of both. The length of the barb is determined by its location (in a crossing, bend, cutoff channel, etc.), amount of channel constriction desired, and spacing of dikes in a system.
SKETCH:	*See Next Page*
IMPACTS:	Well-designed structures can improve channel fish habitat(+) and water quality.
IMPLEMENTATION:	
Design Requirements:	Analysis of change in effective channel cross-section, estimate of design flood stage, site survey, design drawings.
Materials:	Rock, timber, native plantings materials.
Equipment Needs:	Drag line with clam bucket, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Certification.
MONITORING/ MAINTENANCE:	Replace materials as needed. Observe performance and stability of structure, particularly during high flows.


Flood Channel
Low Flow Channel
Low Velocity Zone
Low Velocity Zone
BARB
Erosion Hazard Area

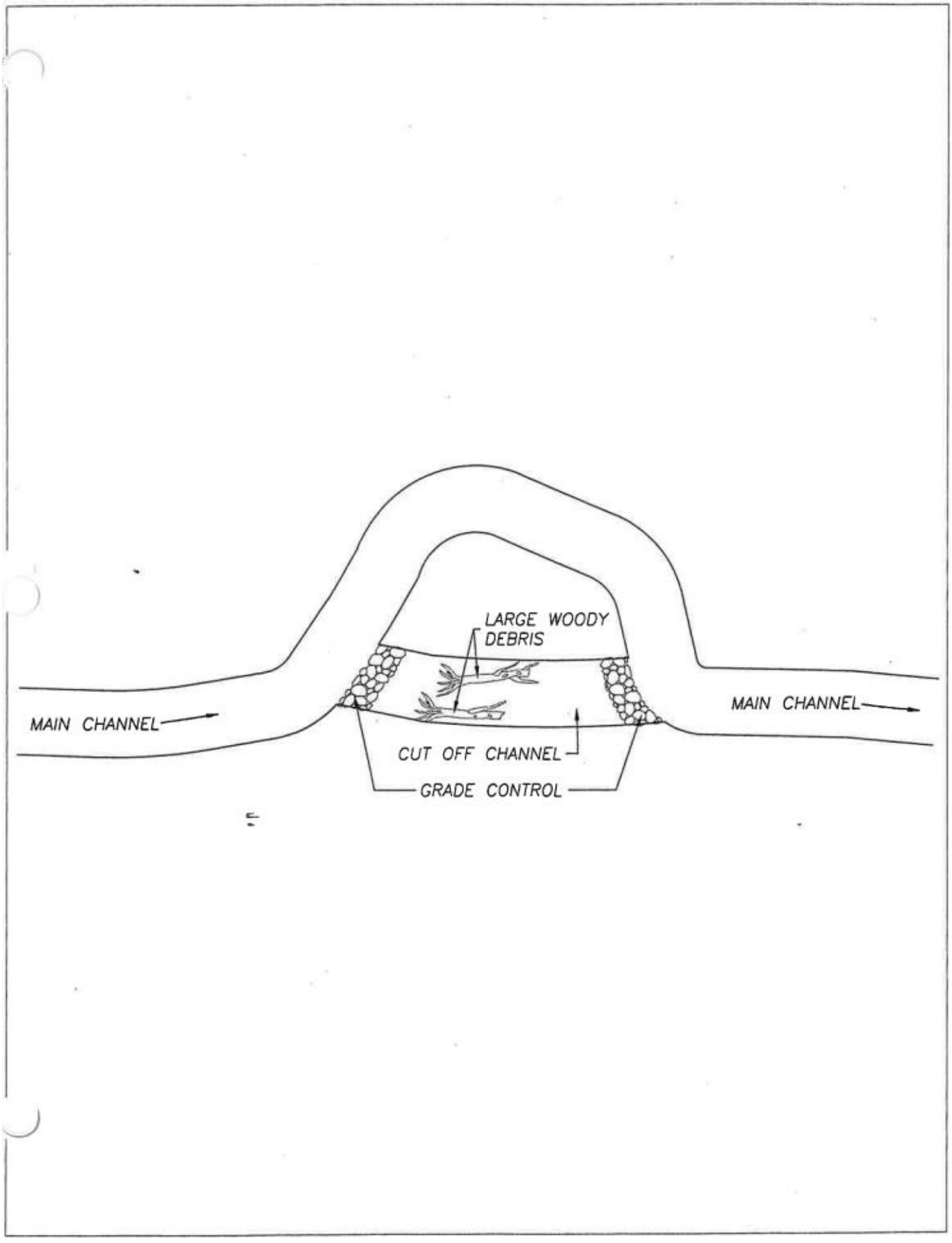
GROUP:	ALIGNMENT CONTROL
ALTERNATIVE:	**FLOW REALIGNMENT**
PURPOSE:	Redirect flow around bends, and/or near bridge approaches.
DESCRIPTION:	The channel is moved by redirecting the energy and reinforcing the banks to create a better approach to a bridge or other structure.
SKETCH:	*See Next Page*
IMPACTS:	Fish, wildlife, scenic/ aesthetic/historic resources, navigation, water quality, hydrology and recreation. Well-designed structures can improve the above.
IMPLEMENTATION:	
Design Requirements:	Analysis of effect of realignment on channel scour, bridge hydraulics, and bank erosion, site survey, design drawings.
Materials:	Large rip rap, woody debris, native plantings for revegetation.
Equipment Needs:	Bulldozer with appropriate blade (for moving rip rap and site access if necessary), excavator with thumb, dump trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Resurvey channel one year after construction to verify stability of realigned reach. Observe channel changes during high flows.


Old Channel Alignment
BARBS
BRIDGE
New Channel Alignment

GROUP:	ALIGNMENT CONTROL
ALTERNATIVE:	**VANE DIKES**
PURPOSE:	Stabilize and improve the alignment of meandering rivers, with a concurrent deepening of the channel in these locations.
DESCRIPTION:	Low longitudinal stone fill structures are placed in the stream in orientations nearly parallel to the flow in order to constrict and deepen the channel and direct the flow without increasing the roughness. Flow will occur over and between the vanes at higher discharges and the longitudinal orientation will result in minimal increases in roughness.
SKETCH:	*See Next Page*
IMPACTS:	Negative: Fish resources; wildlife, scenic, navigation; recreation; and hydrology. Water quality can improve.
IMPLEMENTATION:	
Design Requirements:	Observation or dye testing of flowpaths so that data on velocity vectors can be used in determining appropriate placement of structures, site survey, design drawings.
Materials:	Rock
Equipment Needs:	Excavator or clam bucket, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Replace materials as needed, observe performance and stability of structure, particularly during high flows.


River Bank
0-10°
Vane
Dike

GROUP:	ALIGNMENT CONTROL
ALTERNATIVE:	**CUTOFF CHANNELS**
PURPOSE:	Eliminate bank erosion along river bends and reduce stages.
DESCRIPTION:	Construction of a cutoff channel in an area where a natural cutoff is developing will result in a more gradual and controlled shift in river regimen and associated erosional processes. A pilot channel is excavated in the dry, with a plug left in the excavated cut until construction is completed. The plug can be removed after construction is completed or designed to be overtopped and washed out by the river at a specific design discharge. The pilot channel is designed to be enlarged to full channel dimensions through the erosive action of the river over time. If conditions are such that a pilot channel will not enlarge satisfactorily, the full cross section of the channel should be excavated. Large woody debris should be incorporated and grade control structures may be necessary at each end and throughout the channel if the gradient is steep enough.
SKETCH:	*See Next Page*
IMPACTS:	Well-designed channels can improve fish habitat, water quality, and recreation.
IMPLEMENTATION:	
Design Requirements:	Analysis of historical changes in river alignment using aerial photography, site survey, design drawings, hydraulic analysis.
Materials:	Stone or other materials for armoring bank and training new channel, soil, large woody debris, and vegetation for bank fill and stabilization, other materials as needed depending on concurrent use of other structural alternatives. Natural materials should be available on site.
Equipment Needs:	Excavator, bulldozer, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor new channel for stability, particularly during high flows.

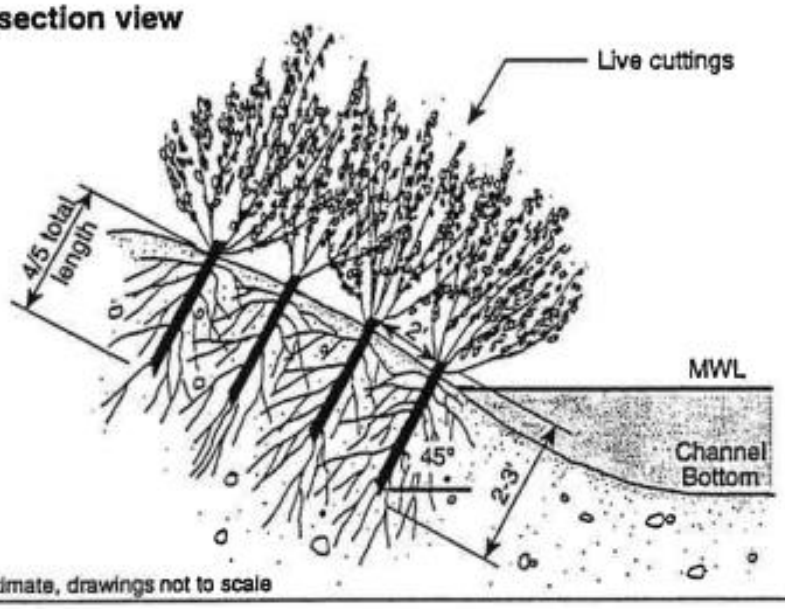

LARGE WOODY DEBRIS
MAIN CHANNEL
MAIN CHANNEL
CUT OFF CHANNEL
GRADE CONTROL

GROUP:	ALIGNMENT CONTROL
ALTERNATIVE:	**CHANNEL AND FLOODPLAIN EXPANSION**
PURPOSE:	To reduce velocities and stage through increasing flow top-width in the channel and floodplain over a range of flows.
DESCRIPTION:	Channels and floodplains that have been confined laterally, previously realigned or do not align well either with lateral constrictions or topography benefit from channel and floodplain expansion. The expansion of available floodplain may require new floodplain channels. If so, the main channel may not need expansion as it could contract in reponse. Channel design should consider historical channels at the location for probable reoccupation. Evidence of modern depositional areas should consider pilot or starter channels, sediment transfer and sediment budget in design to reverse the process.
SKETCH	*See Next page*
IMPACTS	Positive Impact to Fisheries, Wildlife, Scenic/ Aesthetic, Water Quality and Recreation if designed to establish benefits.
IMPLEMENTATION:	
Design Requirements:	Hydraulic and hydrologic analysis, analysis of sediment transport regime (i.e., determining whether there is an upstream sediment source), site survey (multiple cross sections), design drawings, estimates of quantities to be removed.
Materials:	Removal of channel/floodplain materials. Vegetation and other materials contingent on structural alternatives used.
Equipment Needs:	Bulldozer, front end loader, haul trucks.
Typical Permits:	Yakima County or City Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Yakima County Flood Control Zone District or proponent.

GROUP:	ALIGNMENT CONTROL
ALTERNATIVE:	**CHANNEL REALIGNMENT AND WIDENING**
PURPOSE:	To increase channel conveyance and reduce flood stage through increased cross sectional area and better alignment with topography and/or laterally confining structures such as bridges.
DESCRIPTION:	Channels and floodplains that have been confined, previously realigned or do not align well with lateral constrictions or topography benefit from realignment. In some cases, the channel has been moved from its original alignment and produces additional risk through floodplain overflows. Channel design should consider any design changes to levees or bridges. Where minimal floodplain is present the alignment should provide for floodplain widths allowing channel self- readjustment and maintenance.
SKETCH	*See Next page*
IMPACTS	Positive Impact to Fisheries, Wildlife, Scenic/ Aesthetic, Water Quality and Recreation if designed to establish benefits.
IMPLEMENTATION:	
Design Requirements:	Hydraulic and hydrologic analysis, analysis of sediment transport regime (i.e., determining whether there is an upstream sediment source), site survey (multiple cross sections), design drawings, estimates of quantities to be removed.
Materials:	Removal of channel/floodplain materials. Vegetation and other materials contingent on structural alternatives used.
Equipment Needs:	Bulldozer, front end loader, haul trucks.
Typical Permits:	Yakima County or City Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Yakima County Flood Control Zone District or proponent.

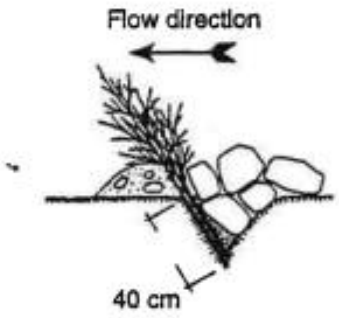
GROUP:	BANK/IN-STREAM STRUCTURE PROTECTION
ALTERNATIVE:	**BIOENGINEERING**
PURPOSE:	Protect banks and shorelines that are actively eroding.
DESCRIPTION:	River Willow, Red Osier Dogwood, or other suitable vegetation are placed into streambanks and along shorelines to stabilize them and provide structural support. Bioengineering may be used in conjunction with other structural alternatives such as barbs or bank stabilization (for stabilizing lower banks). Site must be graded prior to vegetation placement and protected during the initial growth stage.
SKETCH:	*See Next Page*
IMPACTS:	Construction activity needs to be planned to have minimal impact on the riverine system. Positive impacts to fisheries, wildlife, scenic, water quality and recreation.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings.
Materials:	Live plant cuttings, wooden stakes, iron bar to produce starter holes, fill and topsoil, seed, rip rap.
Equipment Needs:	Bioengineered projects typically constructed by hand. Front end loader to place and grade fill or existing soils as needed prior to installation, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor to ensure plants are growing and bioengineered structure is stable. Maintain with new plant materials as needed.

Live stakes- section view

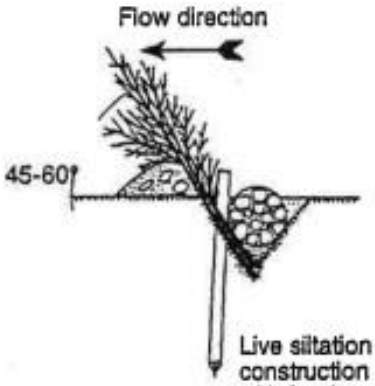


All dimensions approximate, drawings not to scale

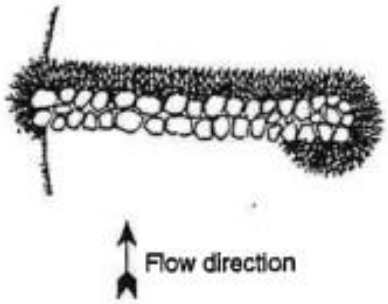
Live siltation construction



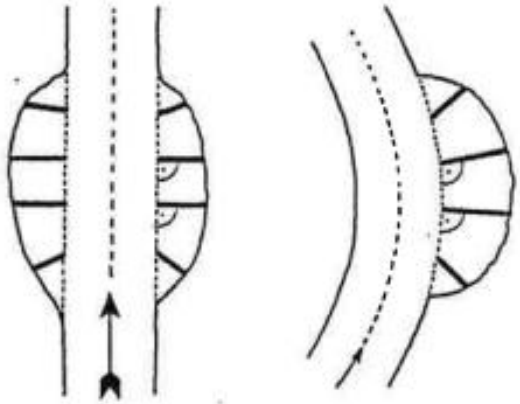
Live siltation construction with rip-rap (section)



Live siltation construction with fascines for stabilization (section)

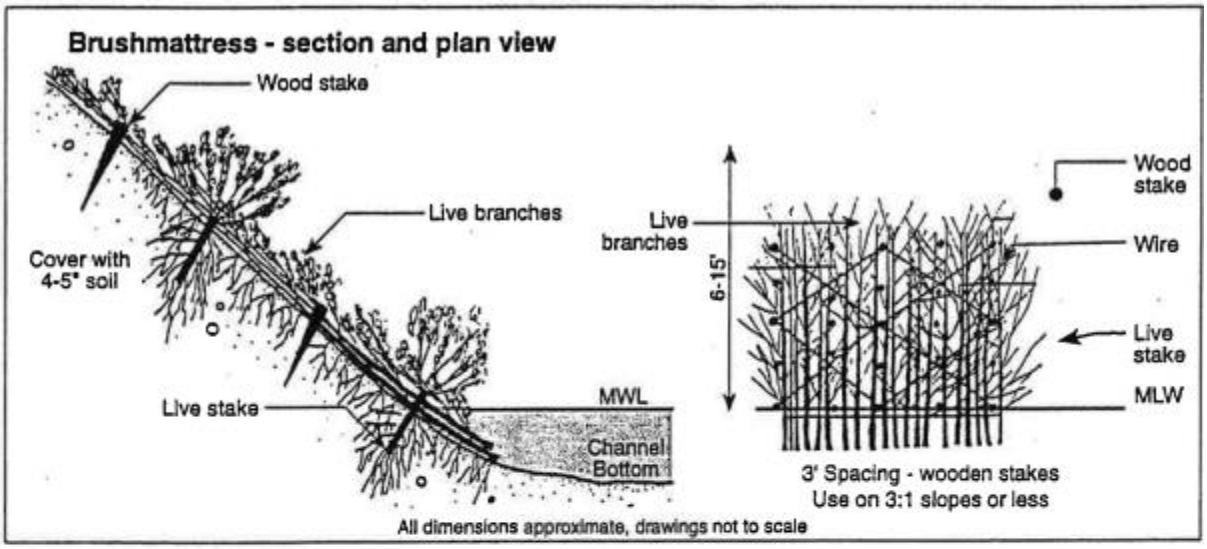


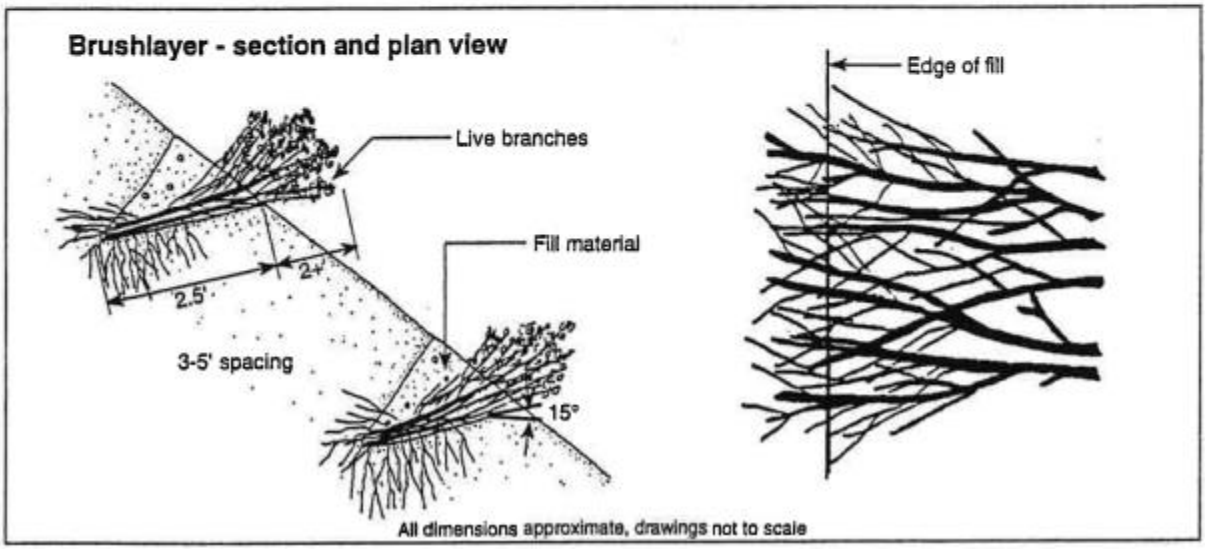
Live siltation construction with rip-rap (plan view)

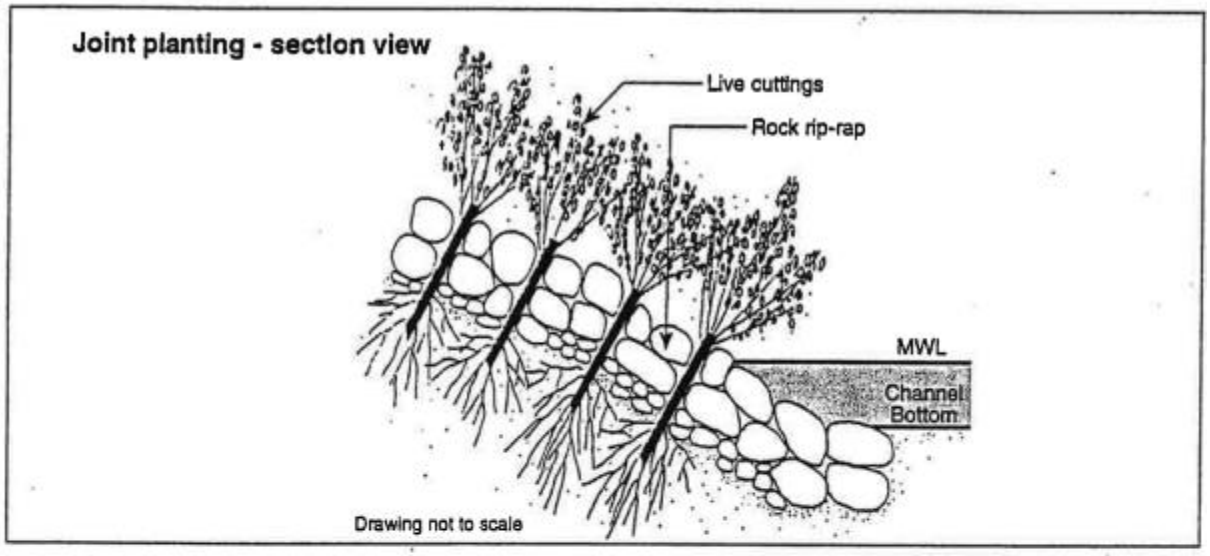


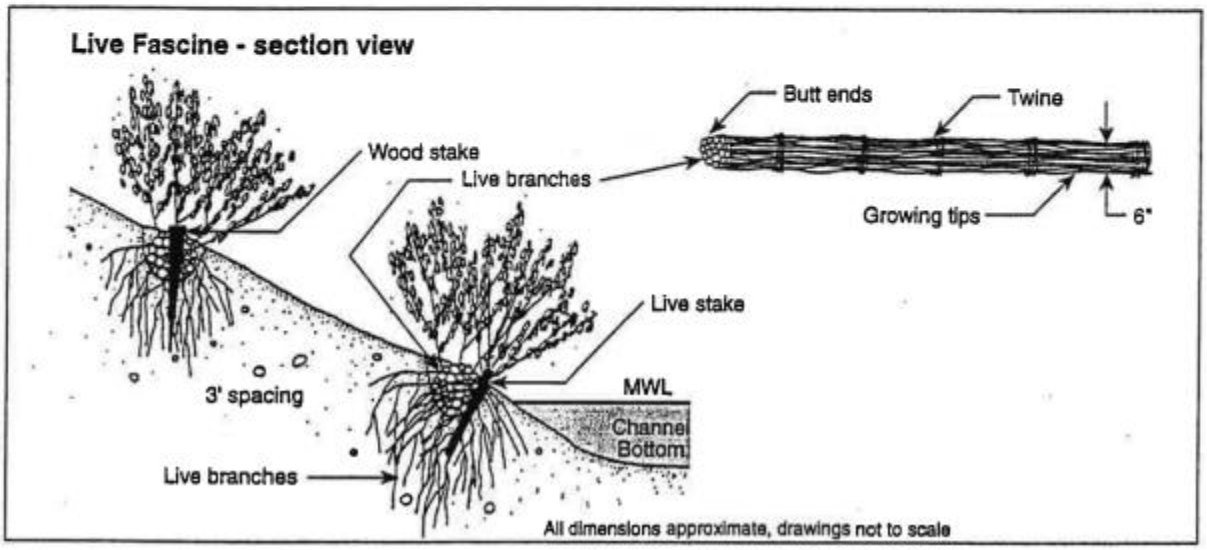
Diagrams of arrangements for live siltation construction for restoration of shore breaks

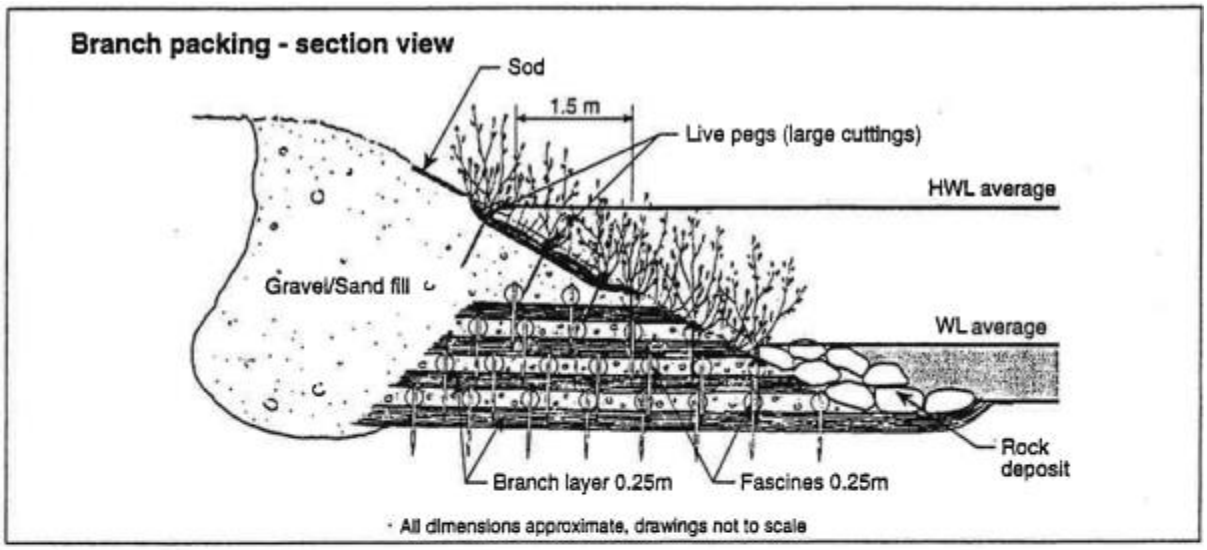
All dimensions approximate, drawings not to scale

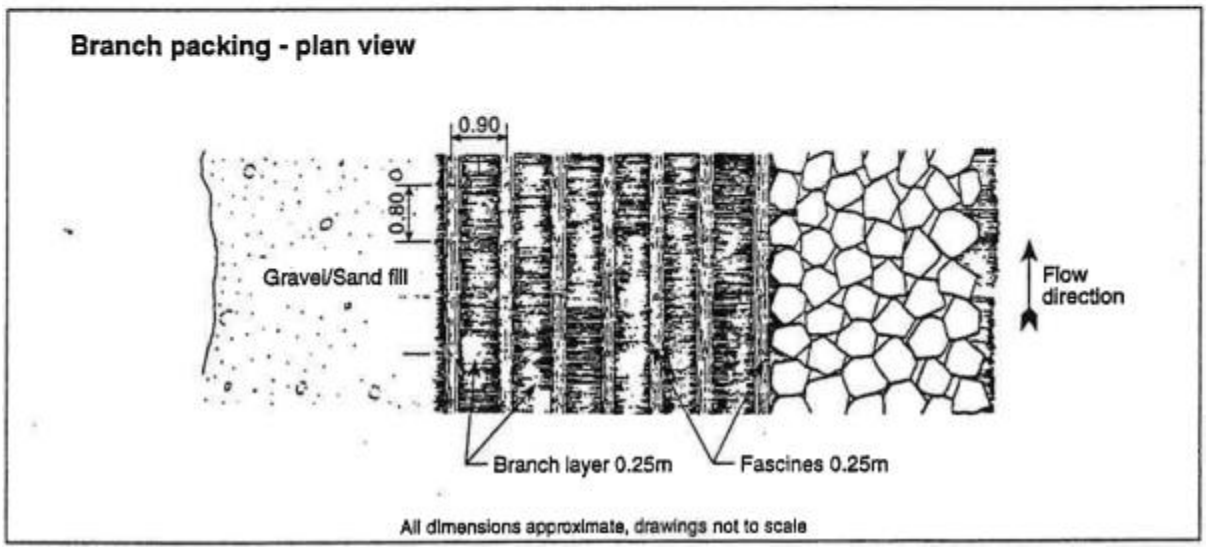

Brushmattress - section and plan view
Wood stake
Live branches
Cover with 4-5" soil
Live stake
MWL
Channel Bottom
Live branches
6-15'
Wood stake
Wire
Live stake
MLW
3' Spacing - wooden stakes
Use on 3:1 slopes or less
All dimensions approximate, drawings not to scale


Brushlayer - section and plan view
Live branches
Fill material
2'
2.5'
3-5' spacing
15°
Edge of fill
All dimensions approximate, drawings not to scale

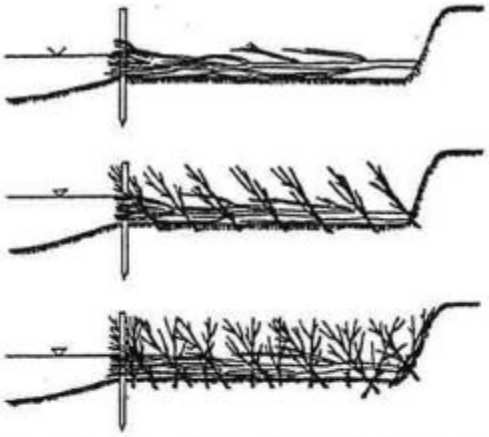

Joint planting - section view
Live cuttings
Rock rip-rap
MWL
Channel Bottom
Drawing not to scale


Live Fascine - section view
Butt ends
Twine
Wood stake
Live branches
Growing tips
6"
Live stake
3' spacing
MWL
Channel Bottom
Live branches
All dimensions approximate, drawings not to scale

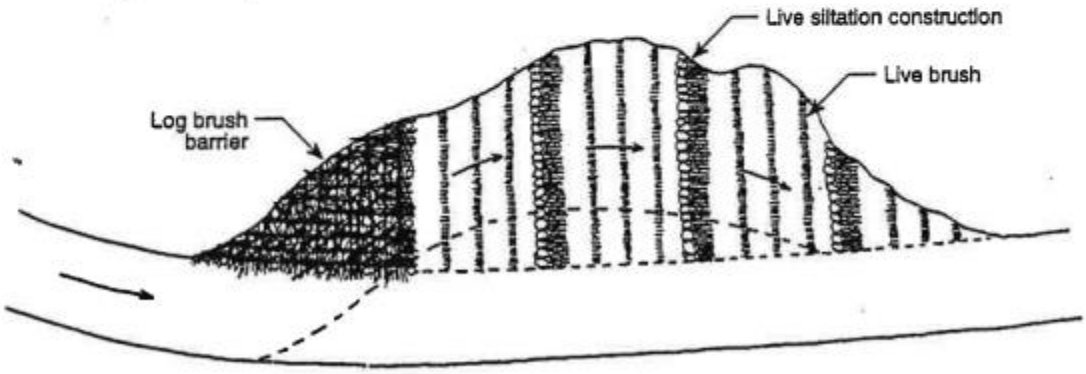

Branch packing - section view
Sod
1.5 m
Live pegs (large cuttings)
HWL average
Gravel/Sand fill
WL average
Rock deposit
Branch layer 0.25m
Fascines 0.25m
All dimensions approximate, drawings not to scale


Branch packing - plan view
0.90
0.80
Gravel/Sand fill
Flow direction
Branch layer 0.25m
Fascines 0.25m
All dimensions approximate, drawings not to scale

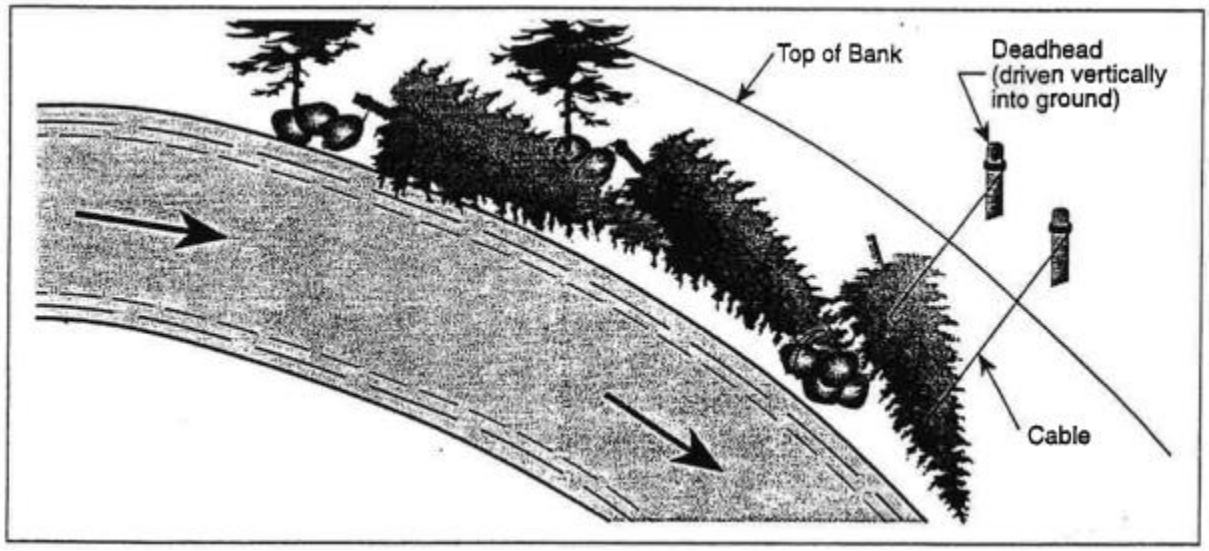
Log brush barrier- section view



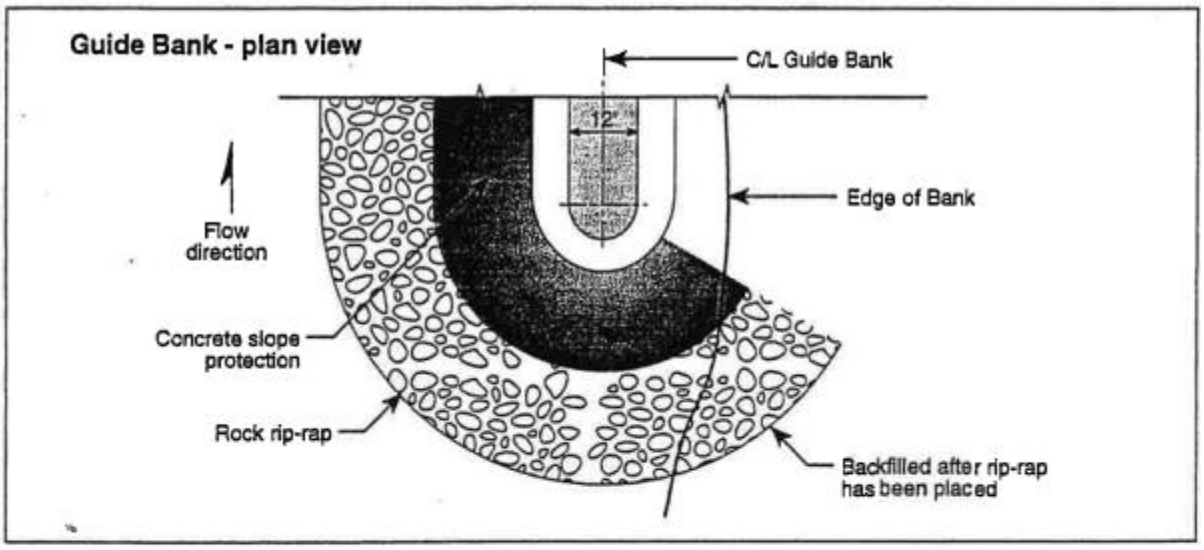
Brush log barrier - plan view

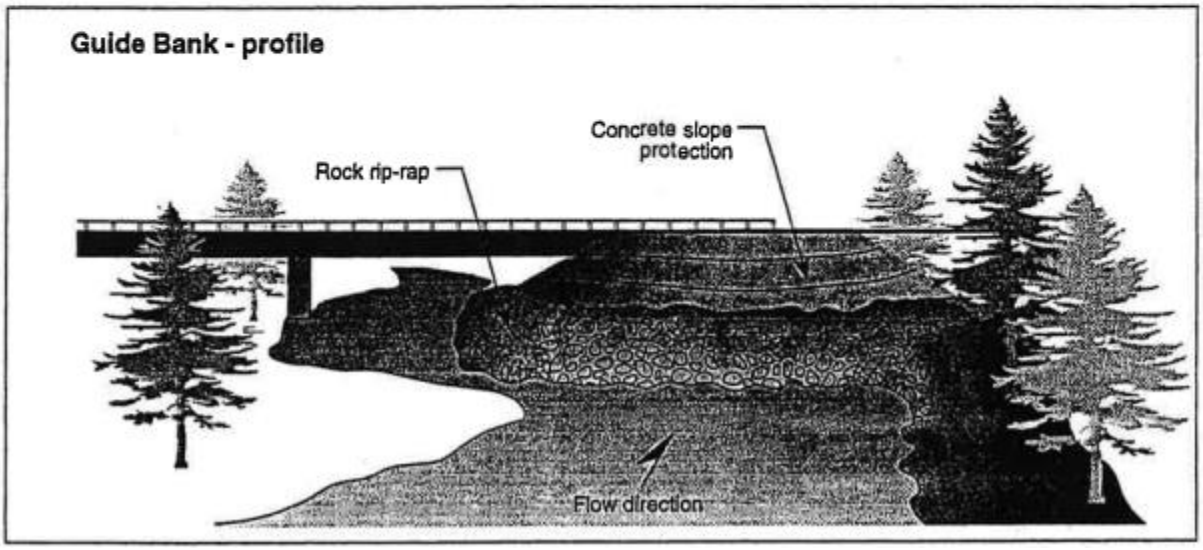


GROUP:	BANK/IN-STREAM STRUCTURE PROTECTION
ALTERNATIVE:	**CABLING TREES**
PURPOSE:	Provide a matrix for bank stabilization and create cover for fish.
DESCRIPTION:	Trees 4 inches or greater in diameter with branches still on the trunk are cable anchored to rocks, existing trees, or "deadheads." Placement occurs along the tow of eroding banks, the edge of low flow channels, or on a diagonal into the stream to create fish habitat. Sediment accumulation around trees stabilizes the structure and bank. (This alternative contrasts with bioengineering in that cabled trees are not live.)
SKETCH:	*See Next Page*
IMPACTS:	Public Safety issues when structures dislodge and move down river in mass. Positive impacts to habitat.
IMPLEMENTATION:	
Design Requirements:	Site survey (including horizontal and vertical locations of existing rocks and trees), design drawings.
Materials:	Coniferous trees, 3/8" min. diameter cable, iron rods.
Equipment Needs:	Track excavator with bucket thumb, front end loader, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor stability of structure, maintain if cables break or pull out, rocks move, or trees move.


Top of Bank
Deadhead
(driven vertically
into ground)
Cable

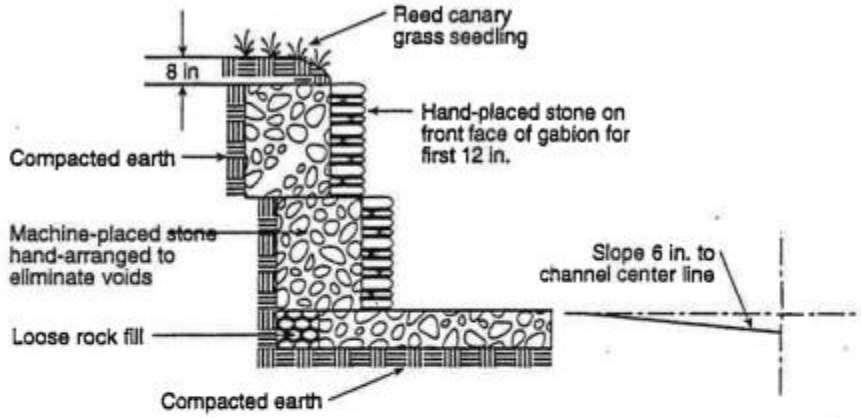
GROUP:	BANK/IN-STREAM STRUCTURE PROTECTION
ALTERNATIVE:	**APPROACH DIKES/GUIDE BANKS**
PURPOSE:	Confine flow to a single channel, improve distribution across the waterway opening, control angle of attack on piers, break up meander patterns, and/or prevent erosion of approach ends.
DESCRIPTION:	Upstream and/or downstream banks adjacent to bridge abutments are rip-rapped at the base and covered with concrete on the upper bank, directing flow smoothly through the waterway opening.
SKETCH:	*See Next Page*
IMPACTS:	Fish, wildlife, scenic/ aesthetic/historic resources, navigation, water quality, hydrology and recreation. Well-designed structures can improve the above.
IMPLEMENTATION:	
Design Requirements:	Hydraulic/Hydrologic analysis (may include numerical modeling) of change in channel cross section and effect of structure length, plan shape, and height on upstream and downstream channel hydraulics, as built drawings of existing bridge and site survey, design drawings, historical aerial photographs of the site.
Materials:	Concrete and concrete forms, pump trucks, rock rip-rap, steel rebar.
Equipment Needs:	Excavator, haul trucks, concrete pump truck, concrete truck.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor for structural integrity, modify the design if necessary. Survey structure following completion for as-built drawings.


Guide Bank - plan view
C/L Guide Bank
12'
Edge of Bank
Flow direction
Concrete slope protection
Rock rip-rap
Backfilled after rip-rap has been placed

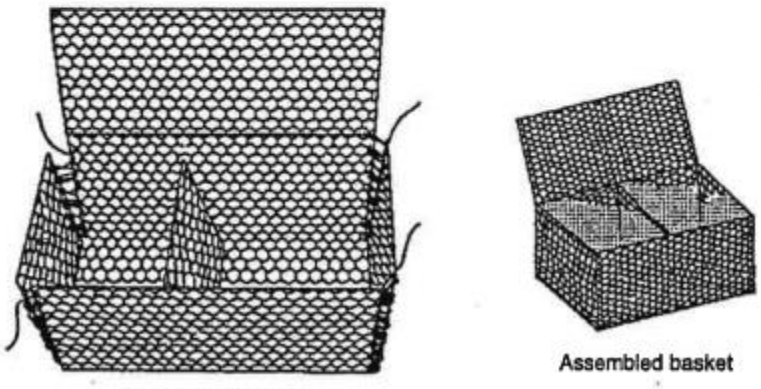

Guide Bank - profile
Concrete slope protection
Rock rip-rap
Flow direction

GROUP:	BANK/IN-STREAM STRUCTURE PROTECTION
ALTERNATIVE:	**GABIONS**
PURPOSE:	Provide protection of banks, bridges, or other in-stream structures.
DESCRIPTION:	Gabions are wire mesh boxes constructed on site and filled with relatively small stones (i.e., less than 8 inches in diameter). Gabions provide an additional measure of structural support over riprap using similar diameter stone. They act as large heavy porous masses to protect banks and structures, and have a measure of flexibility. A filter fabric or filter cloth may be used to prevent leaching of base materials or undermining of the baskets.
SKETCH:	*See Next Page*
IMPACTS:	Fish, wildlife, scenic/ aesthetic/historic resources, navigation, water quality, hydrology and recreation.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings.
Materials:	Gabion cage, rock (slightly larger than wire mesh, maximum available density, able to withstand abrasion, and resistant to weathering).
Equipment Needs:	Excavator, front end loader, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor for structural integrity, place additional gabions or replace existing gabions as necessary.

Gabion revetment, typical section

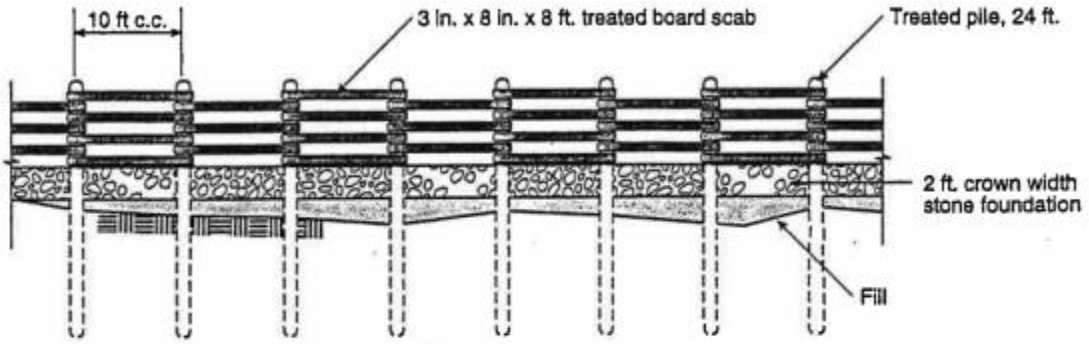


Typical gabion basket assembly

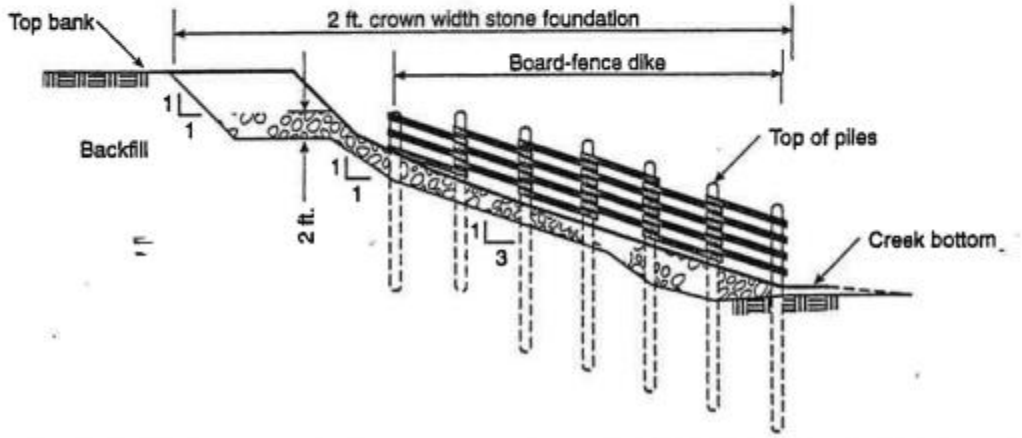


GROUP:	BANK/IN-STREAM STRUCTURE PROTECTION
ALTERNATIVE:	**FENCING**
PURPOSE:	Protect stream banks from erosion due to high velocity waters.
DESCRIPTION:	Fencing constructed of various types of new or used materials is used to reduce local velocities, trap debris, and facilitate sediment deposition and the establishment of native vegetation. Fencing can be constructed as revetment parallel to the bank, or as dikes at an angle to the flow.
SKETCH:	*See Next Page*
IMPACTS:	Fish resources, wildlife and safety. Improves water quality.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings
Materials:	Posts: treated or untreated wood, used rails, pipe, steel beams, concrete; Fencing material: wood, wire; fill soil; rock.
Equipment Needs:	Excavator with pile driver attachment, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor for structural integrity, replace posts or boards as necessary.

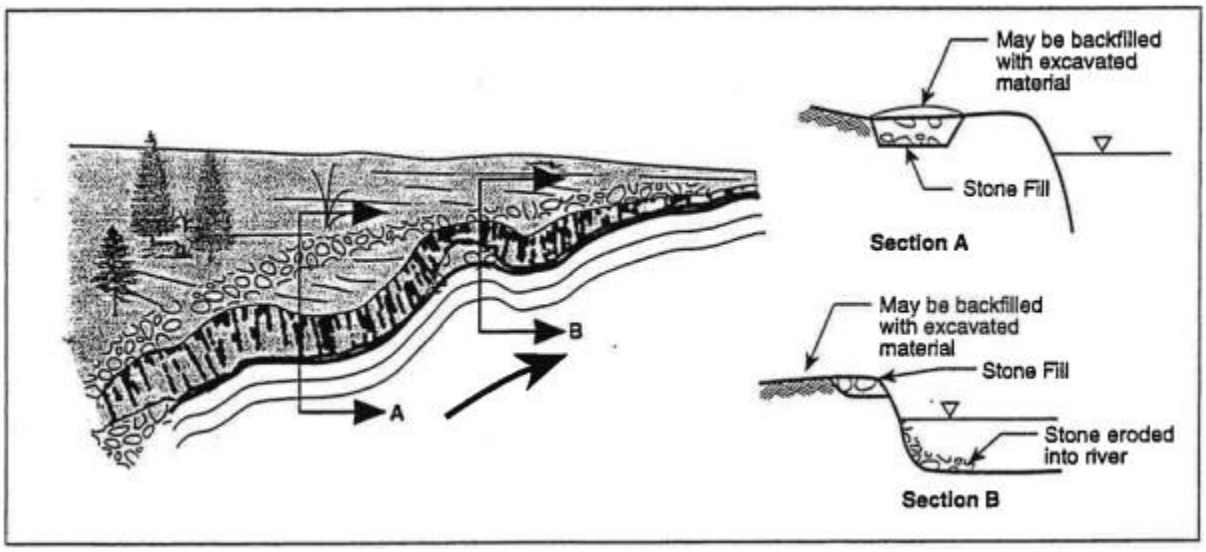
Typical longitudinal board fence



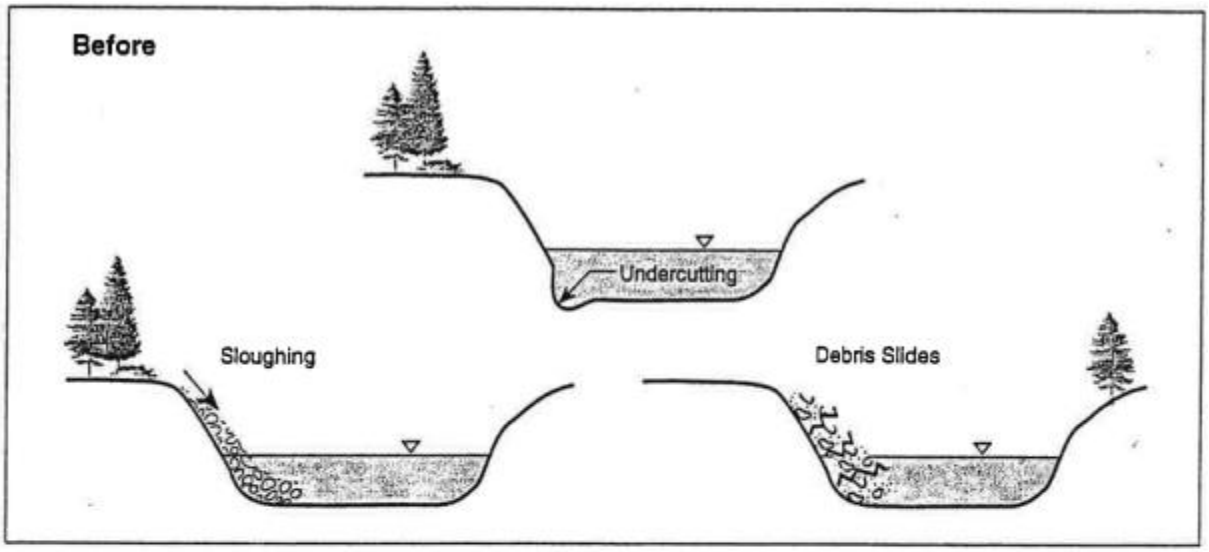
Typical transverse board fence

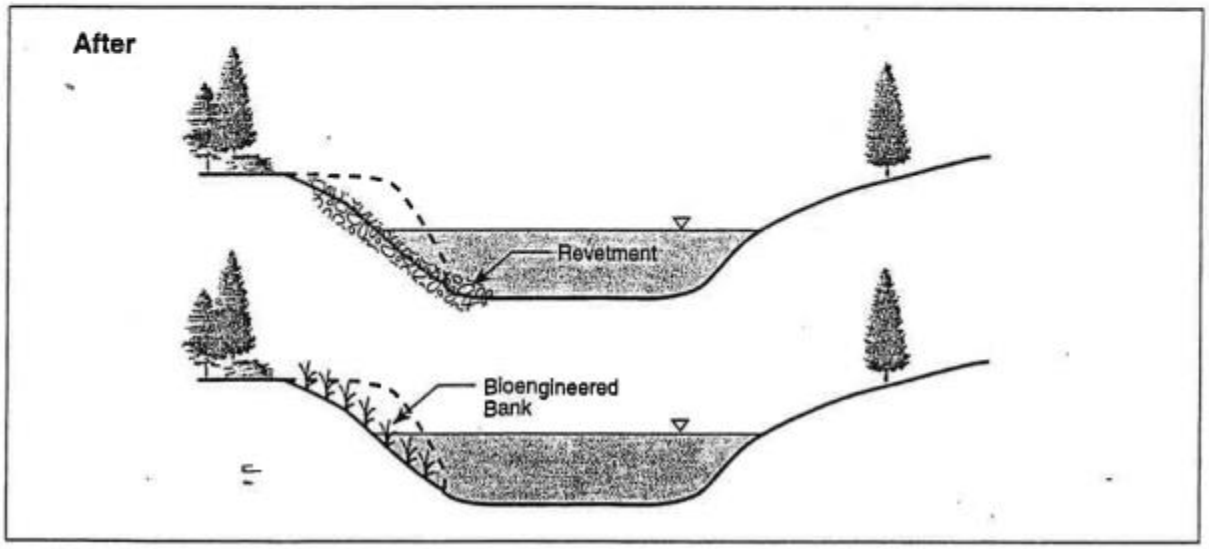


GROUP:	BANK/IN-STREAM STRUCTURE PROTECTION
ALTERNATIVE:	**WINDROW REVETMENT**
PURPOSE:	Provide protection of banks, bridges, or other in-stream structures.
DESCRIPTION:	Windrow revetment consists of a line of stone placed along the top of an eroding bank, either on the ground surface or partially buried. The stone fill is undercut as the adjacent stream bank is eroded and is launched down the bank, moving into the underwater bank area and protecting the bank from additional erosion. Stone fill may be interplanted with saplings, providing an additional vegetative component to long-term protection.
SKETCH:	*See Next Page*
IMPACTS:	Positive for water quality.
IMPLEMENTATION:	
Design Requirements:	Analysis of the volume of stone necessary (depending on channel depth, bank height, material size, and estimated maximum bed scour), design drawings, site survey.
Materials:	Rock.
Equipment Needs:	Haul tricks, excavator, backhoe.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor to verify that launched stone is sufficient to protect the bank. Add rock as necessary. Alternative or supplementary structural control may be necessary if resulting protection is inadequate.

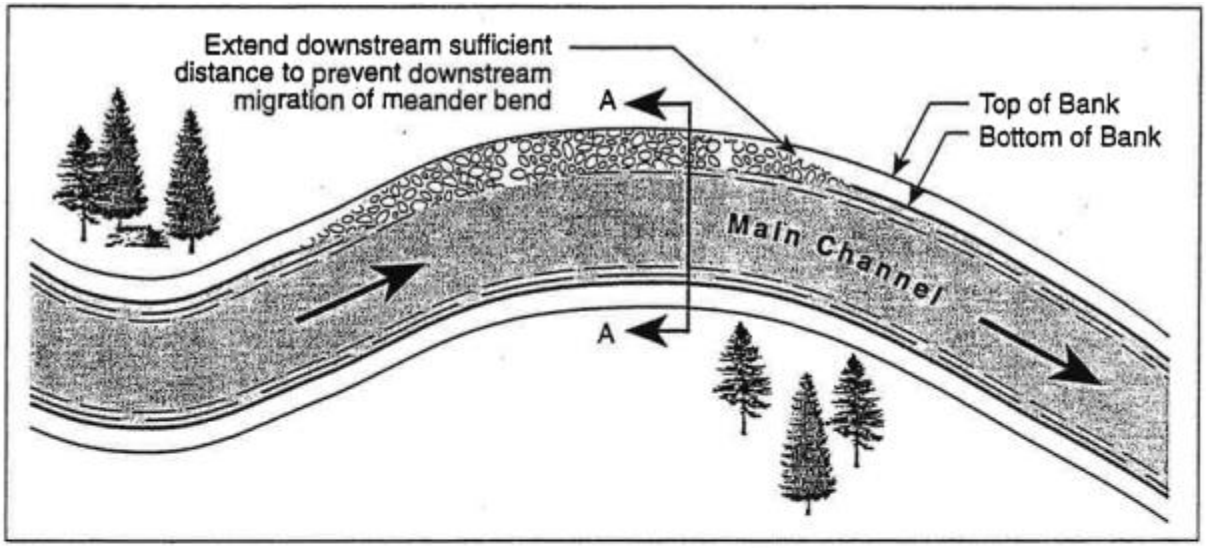

May be backfilled with excavated material
Stone Fill
Section A
May be backfilled with excavated material
Stone Fill
Stone eroded into river
Section B
A
B

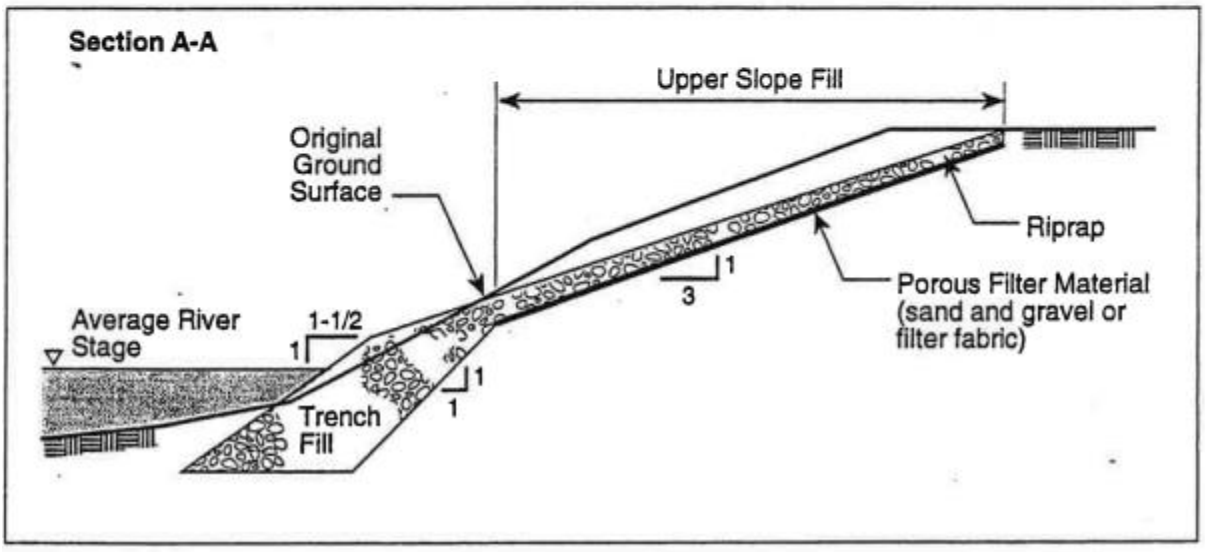
GROUP:	BANK/IN-STREAM STRUCTURE PROTECTION
ALTERNATIVE:	**BANK SLOPE REDUCTION**
PURPOSE:	Protect bank along river reaches with steep slopes that may be subject to failure due to undercutting, debris slides or sloughing.
DESCRIPTION:	Bank slopes are reduced by cutting the highest portion of the bank back away from the channel, then stabilizing the bank using bioengineering techniques, riprap, or other methods.
SKETCH:	*See Next Page*
IMPACTS:	None.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings.
Materials:	Materials required contingent on structural alternative(s) used with bank slope reduction.
Equipment Needs:	Excavator, haul trucks, grader.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor stability of new slope after construction. Maintain as appropriate, depending on alternative(s) used.


Before
Undercutting
Sloughing
Debris Slides

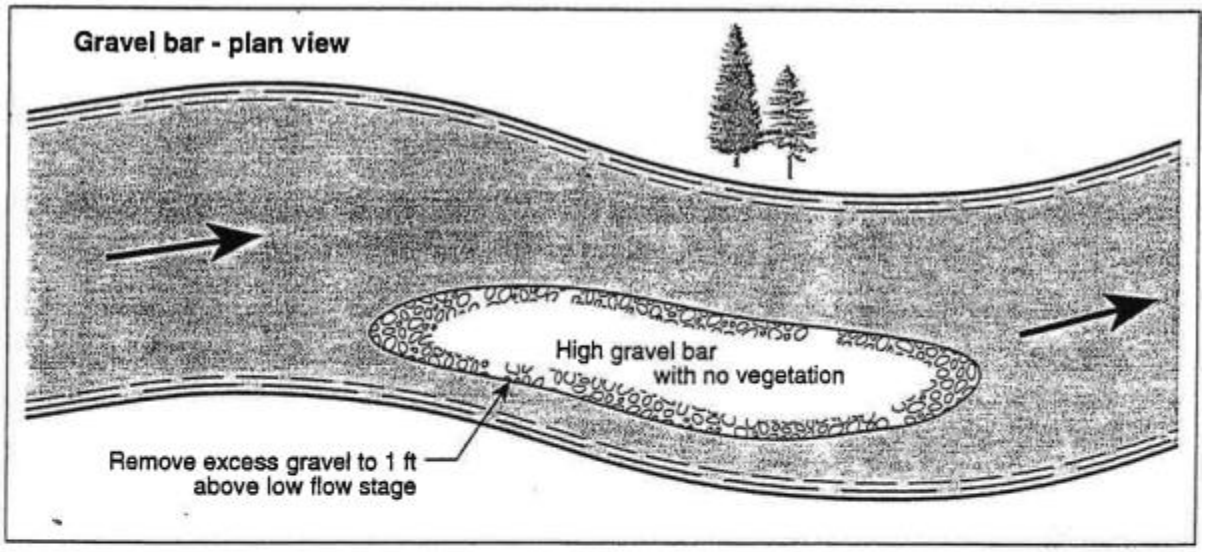

After
Revetment
Bioengineered
Bank

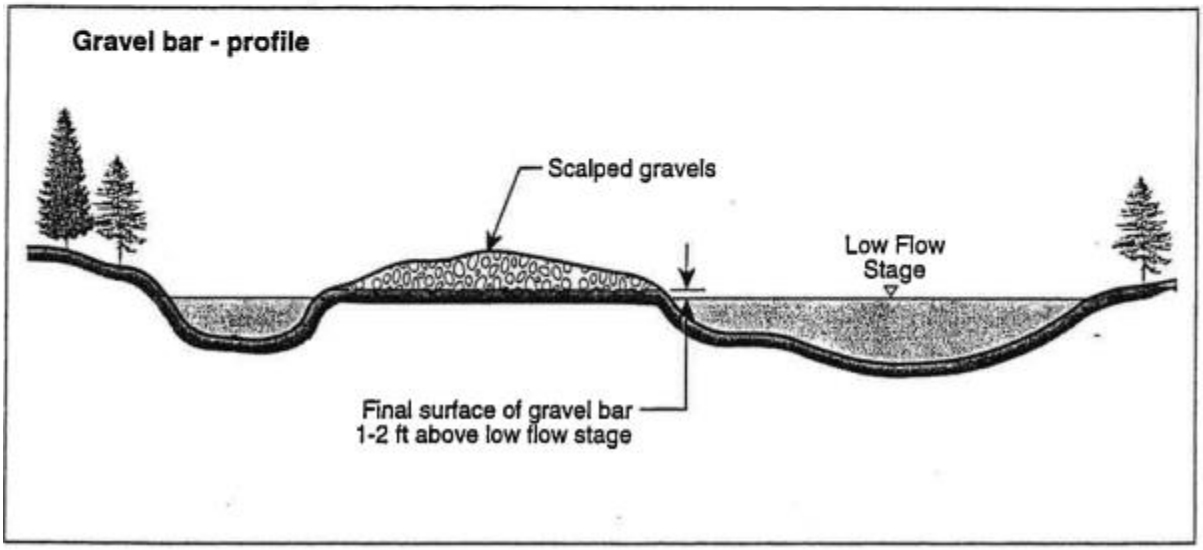
GROUP:	BANK/IN-STREAM STRUCTURE PROTECTION
ALTERNATIVE:	**STANDARD TRENCH FILL/RIPRAP REVETMENT**
PURPOSE:	Provide bank protection along stream reaches where bank erosion mitigation or prevention is necessary.
DESCRIPTION:	The stream bank is "paved" with riprap and a large mass of stone is placed into a trench on the riverward edge of the revetment. As the bank erodes and the toe of the bank is scoured, the riprap in the trench falls and paves the newly eroded lower slope, while the upper slopes remain stable.
SKETCH:	*See Next Page*
IMPACTS:	Fish resources; wildlife, scenic/ aesthetic/ historic resources; navigation.
IMPLEMENTATION:	
Design Requirements:	Analysis of shape, size, and weight of stone required to meet stability requirements, analysis of thickness, length, and location requirements, estimates of low and high flow stages, site survey, design drawings.
Materials:	Rock, gravel or porous filter material (placed directly over graded bank to allow seepage), filter fabric.
Equipment Needs:	Bulldozer to grade slope as necessary, haul trucks, excavator, front end loader.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor stability of riprapped slope and replace rock as necessary, monitor downstream effects.


Extend downstream sufficient distance to prevent downstream migration of meander bend
A
A
Top of Bank
Bottom of Bank
Main Channel

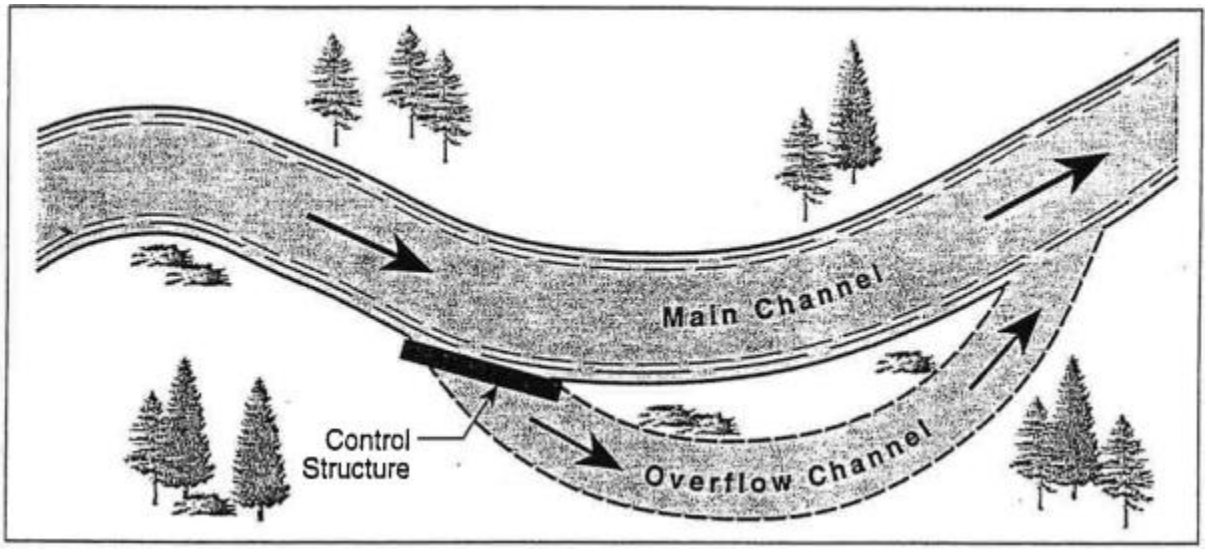

Section A-A
Upper Slope Fill
Original Ground Surface
Riprap
Porous Filter Material (sand and gravel or filter fabric)
3
1
Average River Stage
1-1/2
1
1
1
Trench Fill

GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**GRAVEL BAR SCALPING**
PURPOSE:	Increase cross-sectional area, resulting in lower flood stage, increased conveyance capacity and reduced flooding potential.
DESCRIPTION:	Heavy equipment is used to remove the upper portions of gravel bars and haul the material out of the river channel. Gravel bar scalping may be considered as an interim measure or as required maintenance. Persistent development of gravel bars and associated loss of conveyance capacity may require use of alternatives that are more effective in the long term. Special care must be taken not to disturb low flow channel stream bed and/or spawning gravels when implementing this alternative.
SKETCH:	*See Next Page*
IMPACTS:	Fish resources; wildlife, water quality.
IMPLEMENTATION:	
Design Requirements:	Identification of location that will receive gravel.
Materials:	None.
Equipment Needs:	Bulldozer, front end loader, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Monitor sediment transport regime and channel hydraulics following gravel removal to detect any resulting changes.

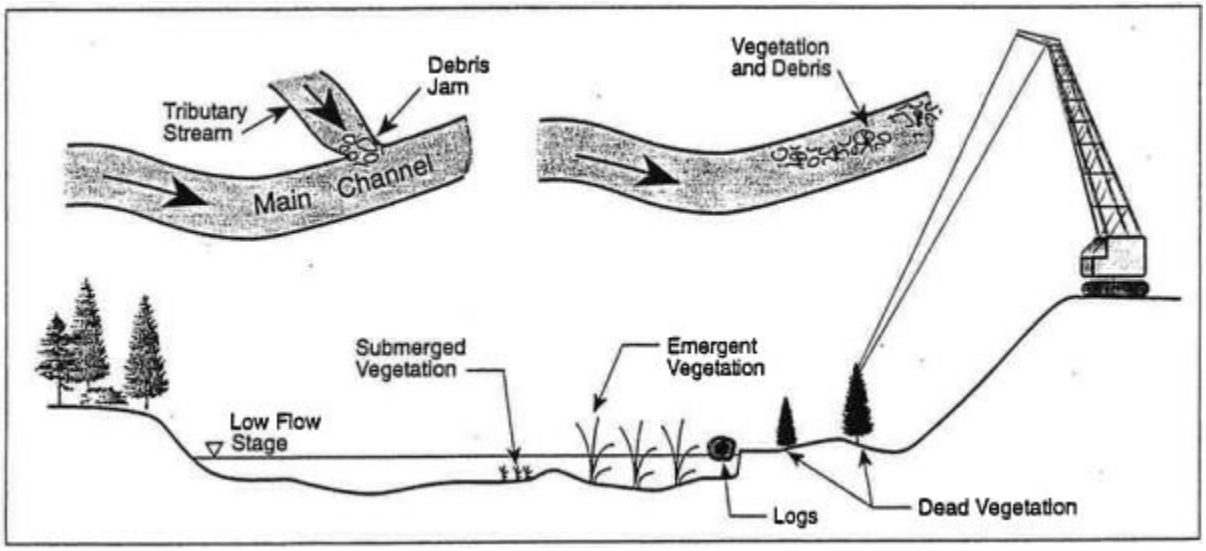

Gravel bar - plan view
High gravel bar
with no vegetation
Remove excess gravel to 1 ft
above low flow stage


Gravel bar - profile
Scalped gravels
Low Flow
Stage
Final surface of gravel bar
1-2 ft above low flow stage

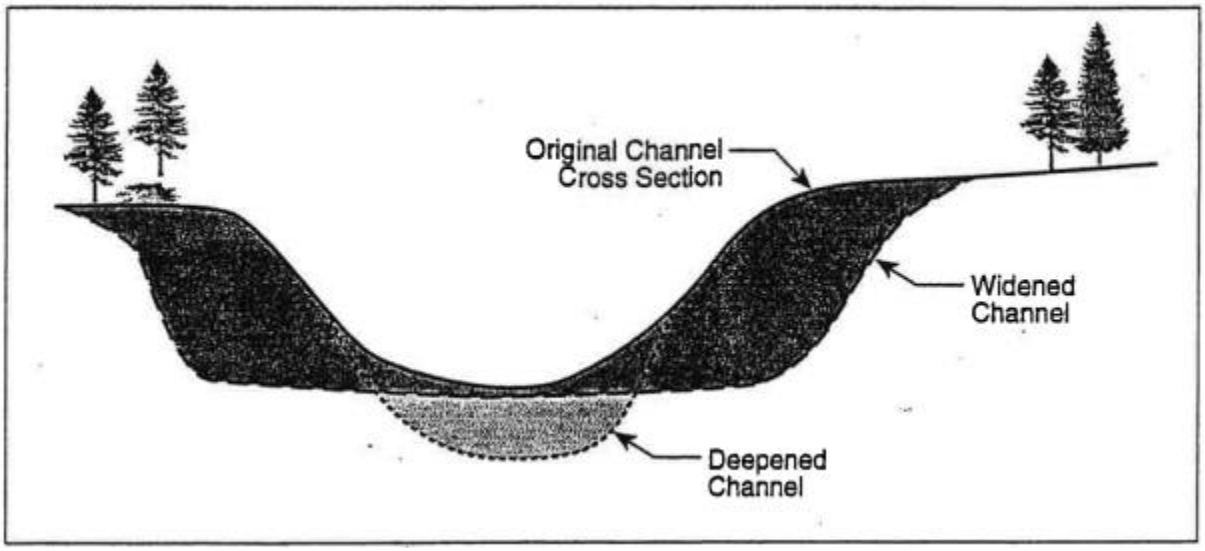
GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**OVERFLOW (PILOT) CHANNELS**
PURPOSE:	Reduce localized velocities to decrease erosion associated with high energy reaches. Decrease local overbank flooding.
DESCRIPTION:	A separate channel is constructed adjacent to the main channel to which flood flows are routed, resulting in an increase in total channel capacity and a reduction in overbank flood stages and areas of flooding. Banks of the overflow channel may be stabilized with rock riprap or bioengineering techniques.
SKETCH:	*See Next Page*
IMPACTS:	Well-designed structures can improve fish resources; scenic, aesthetic, and historic resources; navigation, water quality, hydrology and recreation.
IMPLEMENTATION:	
Design Requirements:	Hydrologic and hydraulic analysis, site survey, design drawings (including fish passage considerations).
Materials:	Inlet and outlet control structures (concrete, etc.), upstream and downstream fish screens, topsoil, vegetation.
Equipment Needs:	Bulldozer, excavator, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Maintain inlet and outlet control structures, remove debris, and revegetate as needed. Monitor flows in and out of overflow channel.


Main Channel
Control Structure
Overflow Channel

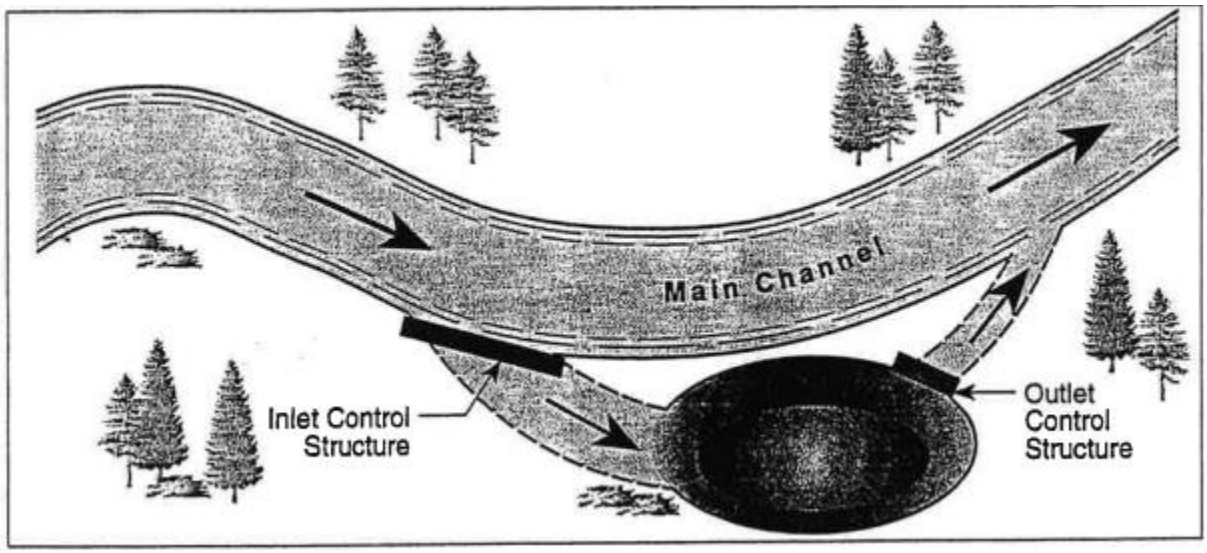
GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**SELECTIVE VEGETATION AND DEBRIS REMOVAL**
PURPOSE:	Increase conveyance capacity and decrease roughness, thereby reducing flood stages, the extent of flooding, and potential for damage to bridges.
DESCRIPTION:	Bank vegetation is removed by mechanical and/or chemical means. Mechanical harvesting of bank vegetation would target larger shrubs and smaller trees, leaving as much understory vegetation as possible, while the use of chemical herbicides would remove vegetation without size discrimination. Submerged or emergent plants can be removed by manual cutting, automated cutting by boat, use of herbicides, or grazing by fish such as carp. Fallen trees and debris jams are removed from the channel through mechanical means. Removal of vegetation will decrease roughness, resulting in increased velocities, which may increase erosion downstream. Vegetation removal may also result in habitat loss.
SKETCH:	*See Next Page*
IMPACTS:	Fish, wildlife, scenic/ aesthetic/historic resources, water quality, hydrology and recreation.
IMPLEMENTATION:	
Design Requirements:	None.
Materials:	None.
Equipment Needs:	Bulldozer with trash blade, haul trucks, drag line.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Visually observe channel/bank erosion after removal of vegetation or debris. Monitor accumulation of new debris or new vegetation growth.


Debris
Jam
Tributary
Stream
Main Channel
Vegetation
and Debris
Submerged
Vegetation
Emergent
Vegetation
Low Flow
Stage
Logs
Dead Vegetation

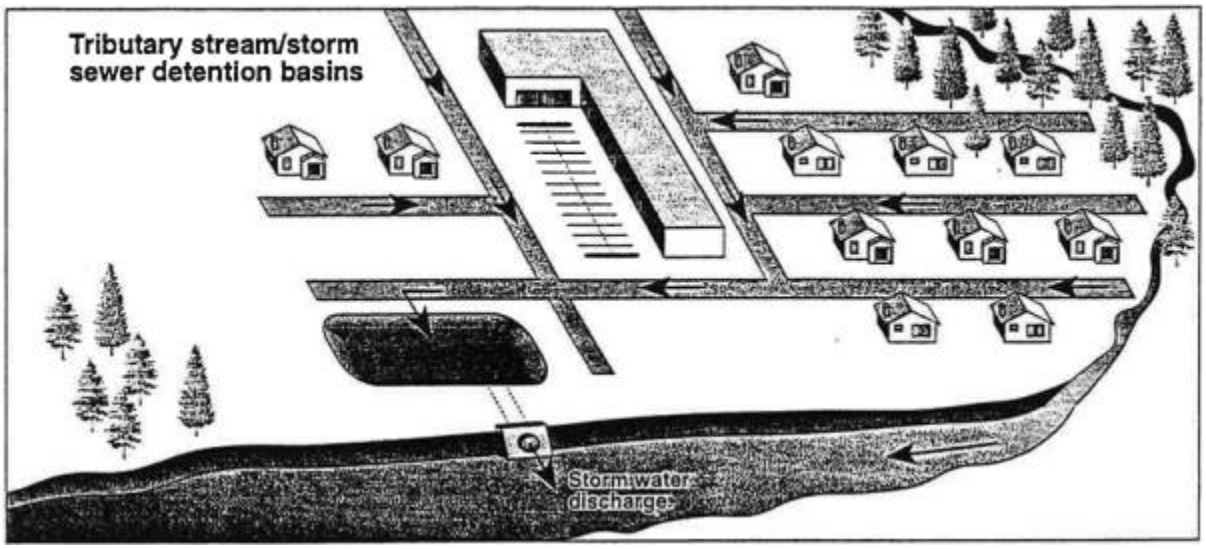
GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**CHANNEL WIDENING OR DEEPENING**
PURPOSE:	Enlarge a channel cross-sectional area to contain more floodwaters within the channel banks and reduce overbank flooding.
DESCRIPTION:	A channel is excavated to a new depth and/or width to contain a specific design discharge. Channel cross-section shape and dimensions are determined by the stability of bank materials, porosity of the streambed, and adjacent structures. This alternative is typically used in conjunction with other structural alternatives. Revegetation of bioengineering techniques are strongly recommended for use in conjunction with channel widening or deepening to ensure long-term stability in the affected reach. Special care must be taken to replace any lost spawning gravels.
SKETCH:	*See Next Page*
IMPACTS:	Fish, wildlife, scenic/ aesthetic/historic resources, water quality, hydrology and recreation.
IMPLEMENTATION:	
Design Requirements:	Hydraulic and hydrologic analysis, analysis of sediment transport regime (i.e., determining whether there is an upstream sediment source), site survey (multiple cross sections), design drawings, estimates of quantities to be removed.
Materials:	Vegetation and other materials contingent on structural alternatives used in conjunction with channel widening or deepening.
Equipment Needs:	Backhoe, drag line, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Resurvey channel cross sections following construction and one year after construction to assess changes in channel cross section/alignment. Provide additional bank and channel stabilization as necessary.


Original Channel
Cross Section
Widened
Channel
Deepened
Channel

GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**OFF-STREAM INFILTRATION/DETENTION BASIN**
PURPOSE:	Reduce volume of water conveyed downstream (infiltration basin) or reduce peak flows during flood events (detention basin). Reduction of volumes and/or peak flows will decrease the extent and duration of downstream flooding.
DESCRIPTION:	An off-stream basin is excavated, with inflow and outflow channels and control structures installed to regulate flows to and from the main channel of the river. Water in infiltration basins will be recharged to groundwater, resulting in a reduction in volumes received by downstream river reaches. Temporary storage of water in a detention basin during high discharge periods will reduce peak flows and flood-related damages at downstream locations.
SKETCH:	*See Next Page*
IMPACTS:	Positive impact for water quality, hydrology.
IMPLEMENTATION:	
Design Requirements:	Hydraulic and hydrologic analysis, site survey and design drawings (including fish passage considerations), identification of areas where sufficient infiltration capacity is available.
Materials:	Inlet and outlet control structures (concrete, etc.), upstream and downstream fish screens, topsoil, vegetation, fencing, material for dikes (if included in design).
Equipment Needs:	Bulldozer, front end loader, backhoe, excavator, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Maintain inlet and outlet control structures, remove debris, and revegetate as needed. Monitor flows in and out of basin, adjust inlet and outlet control structures as necessary.


Main Channel
Inlet Control Structure
Outlet Control Structure

GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**TRIBUTARY STREAM/STORM SEWER DETENTION BASINS**
PURPOSE:	Reduce the volume of water conveyed in the main channel or the peak flows during flood events by constructing a detention basin along a tributary system or storm sewer system. Reduction of volumes and/or peak flows will abate the extent and duration of downstream flooding.
DESCRIPTION:	Detention basins are constructed in creeks or storm sewer conveyance systems to detain excess flow from the river during peak periods of storm runoff. Stormwater is detained in the basin until peak flows have passed on the main river channel. Stormwater is then released at a rate that can be accommodated by the river. (Because of the significant natural flood storage provided by wetlands, this alternative also includes wetlands preservation and constructed wetlands.)
SKETCH:	*See Next Page*
IMPACTS:	Positive impact Fish resources, water quality, hydrology.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings, hydraulic and hydrologic analysis.
Materials:	Inlet and outlet control structures (concrete, etc.), upstream and downstream fish screens, topsoil, vegetation, fencing, material for dikes (if included in design.)
Equipment Needs:	Bulldozer, front end loader, excavator, backhoe, haul trucks.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Maintain inlet and outlet control structures, remove debris, and revegetate as needed. Monitor flows in an out of basin. Adjust inlet and outlet control structures as necessary.

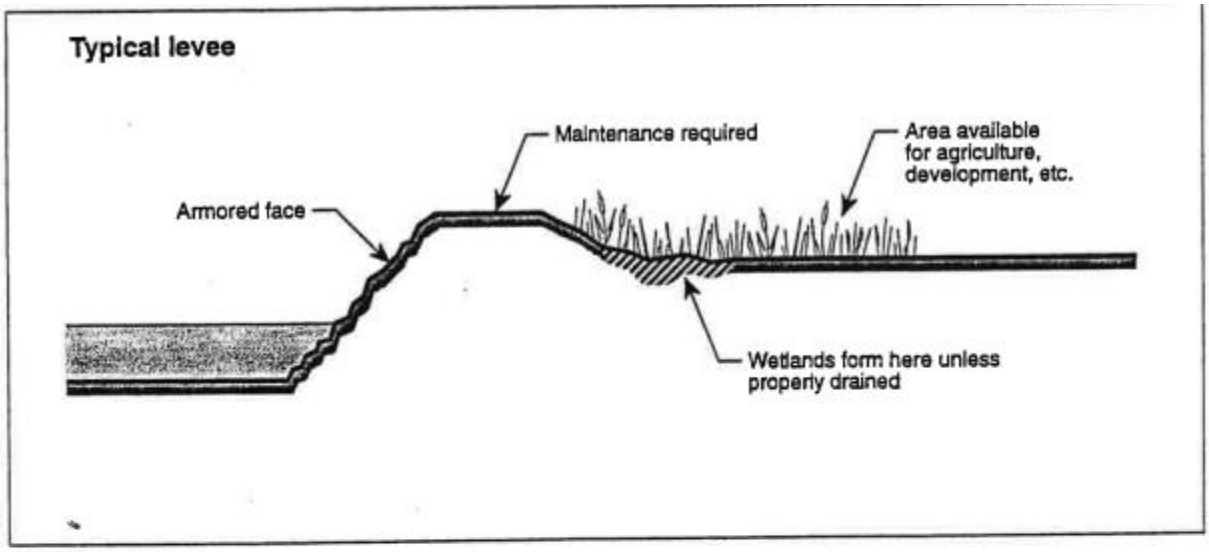

Tributary stream/storm sewer detention basins
Storm water discharge

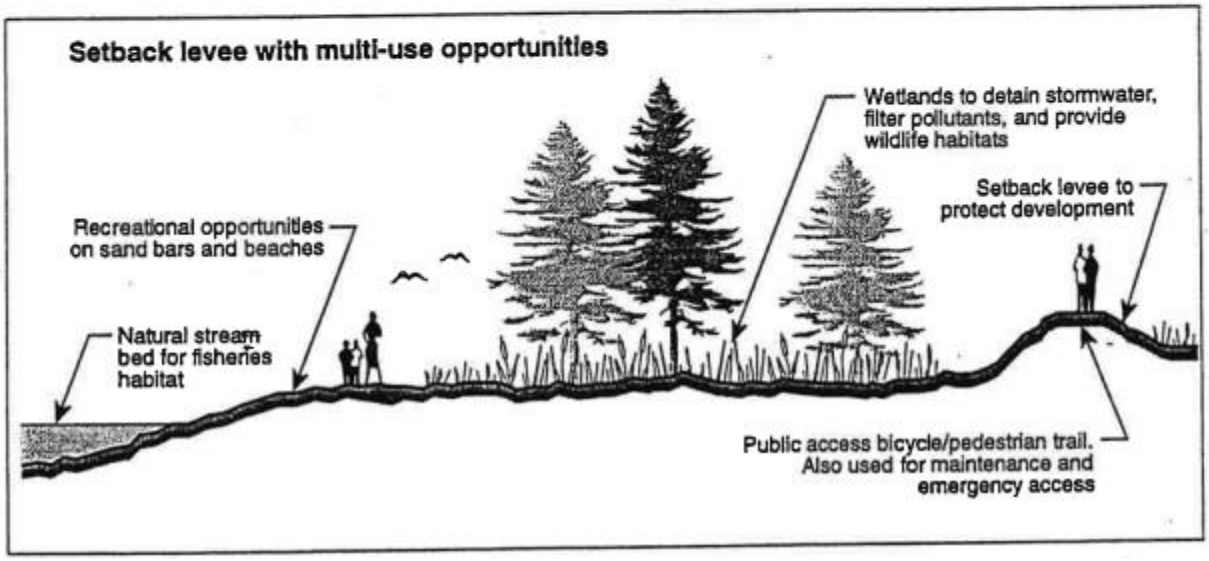
GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**MANAGE SEDIMENT BUDGET & SEDIMENT TRANSPORT IN DESIGN**
PURPOSE:	To provide the basis for reasonable permanence in designs through the incorporation of sediment scour, deposition and transfer in the design reach.
DESCRIPTION:	The success of the long-term goals for infrastructure designs in the channel and floodplain require not only scour and deposition calculations but their locations coupled with the sediment transfer and budget through the design reach, Channels and floodplains that have been confined laterally will respond through floods to the designs and must be ensure success.
SKETCH	*See Next page*
IMPACTS	Positive Impact to Fisheries, Wildlife, Scenic/ Aesthetic, Water Quality and Recreation if designed to establish benefits.
IMPLEMENTATION:	
Design Requirements:	Hydraulic and hydrologic analysis, analysis of sediment transport regime (i.e., determining whether there is an upstream sediment source), site survey (multiple cross sections), design drawings, estimates of quantities to be removed.
Materials:	Removal of channel/floodplain materials. Vegetation and other materials contingent on structural alternatives used.
Equipment Needs:	Bulldozer, front end loader, haul trucks.
Typical Permits:	Yakima County or City Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Yakima County Flood Control Zone District or proponent.

GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**REVERSE CHANNEL AGGRADATION**
PURPOSE:	Techniques required where aggradation is a problem.
DESCRIPTION:	Removal of materials is usually part of the solution but must be accompanied by other methods that address the cause. Once this is identified designs that address the cause through other alternatives on a reach basis are required.
SKETCH	*See Next page*
IMPACTS	Positive Impact to Fisheries, Wildlife, Scenic/Aesthetic, Water Quality and Recreation if designed to establish benefits.
IMPLEMENTATION:	
Design Requirements:	Hydraulic and hydrologic analysis, analysis of sediment transport regime (i.e., determining whether there is an upstream sediment source), site survey (multiple cross sections), design drawings, estimates of quantities to be removed.
Materials:	Removal of channel/floodplain materials. Vegetation and other materials contingent on structural alternatives used.
Equipment Needs:	Bulldozer, front end loader, haul trucks.
Typical Permits:	Yakima County or City Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Yakima County Flood Control Zone District or proponent.

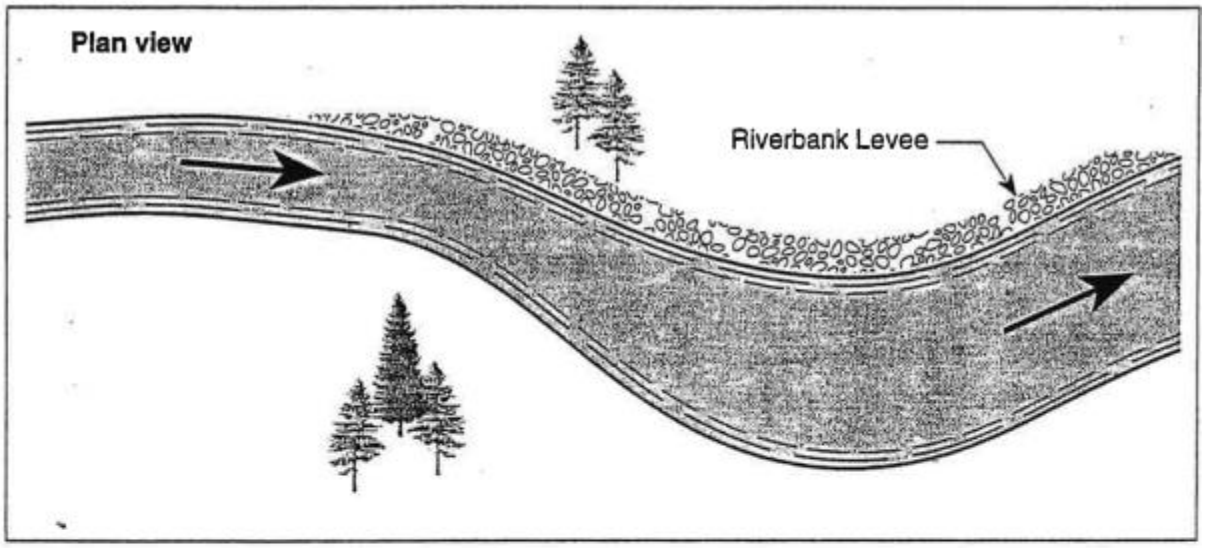
GROUP:	CONVEYANCE CAPACITY
ALTERNATIVE:	**RIVER RETURN STRUCTURES**
PURPOSE:	To return river flooding behind levees to the river, minimizing damage.
DESCRIPTION:	Floodwaters can find routes into developed areas behind levees through failures or capacity exceedance. Such waters can create significant residential and commercial damage if not directed back to the river quickly through structures designed to relieve pressure.
SKETCH	*See Next page*
IMPACTS	Neutral impact to Fisheries, Wildlife, Scenic, Water Quality and Recreation.
IMPLEMENTATION:	
Design Requirements:	Hydraulic and hydrologic analysis, analysis of sediment transport regime (i.e., determining whether there is an upstream sediment source), site survey (multiple cross sections), design drawings, estimates of quantities to be removed.
Materials:	Removal of channel/floodplain materials. Vegetation and other materials contingent on structural alternatives used.
Equipment Needs:	Bulldozer, front end loader, haul trucks.
Typical Permits:	Yakima County or City Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Yakima County Flood Control Zone District or proponent.

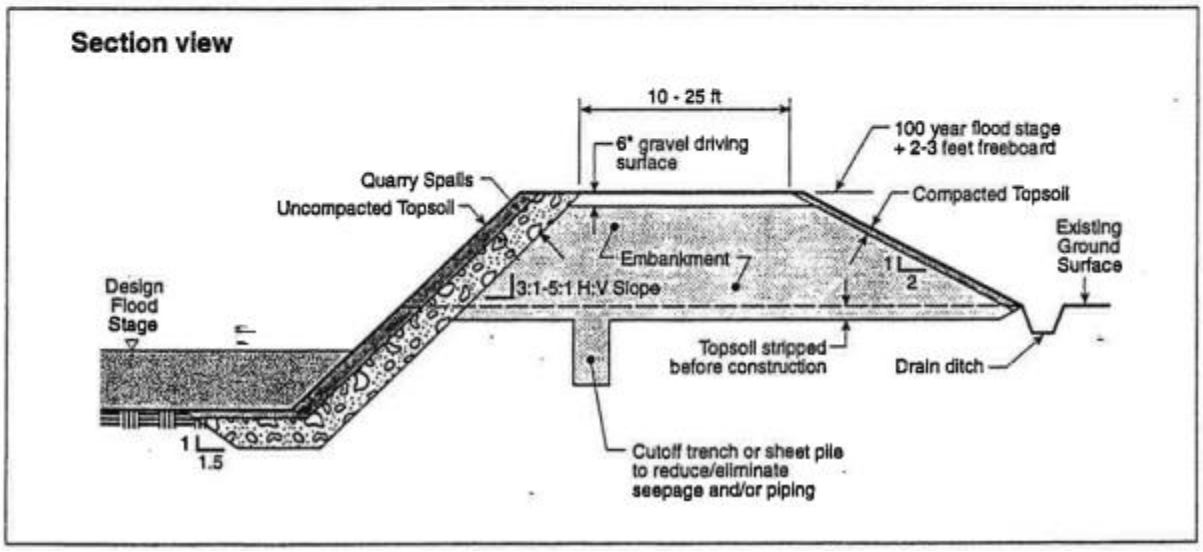
GROUP:	FLOODPLAIN PROTECTION
ALTERNATIVE:	**SETBACK LEVEE**
PURPOSE:	Protect land and property from floodwaters while maintaining all or part of the natural floodplain.
DESCRIPTION:	A levee is installed away from the channel bank to contain flood waters. The height of the levee depends on the level of flood protection to be provided. (The levee may be constructed using bioengineering methods.)
SKETCH:	*See Next Page*
IMPACTS:	Well-designed structures can improve fish, wildlife, scenic/ aesthetic/historic resources, navigation, water quality, hydrology and recreation.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings, analysis to determine design flood stage, geotechnical work to determine foundation soil parameters.
Materials:	Rock, fill soil, topsoil, vegetation.
Equipment Needs:	Haul trucks, bulldozer, grader.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Check condition of levee annually and after major flood events, replace/repair damaged sections, revegetate as necessary, inspect for animal burrows.


Typical levee
Maintenance required
Area available for agriculture, development, etc.
Armored face
Wetlands form here unless properly drained

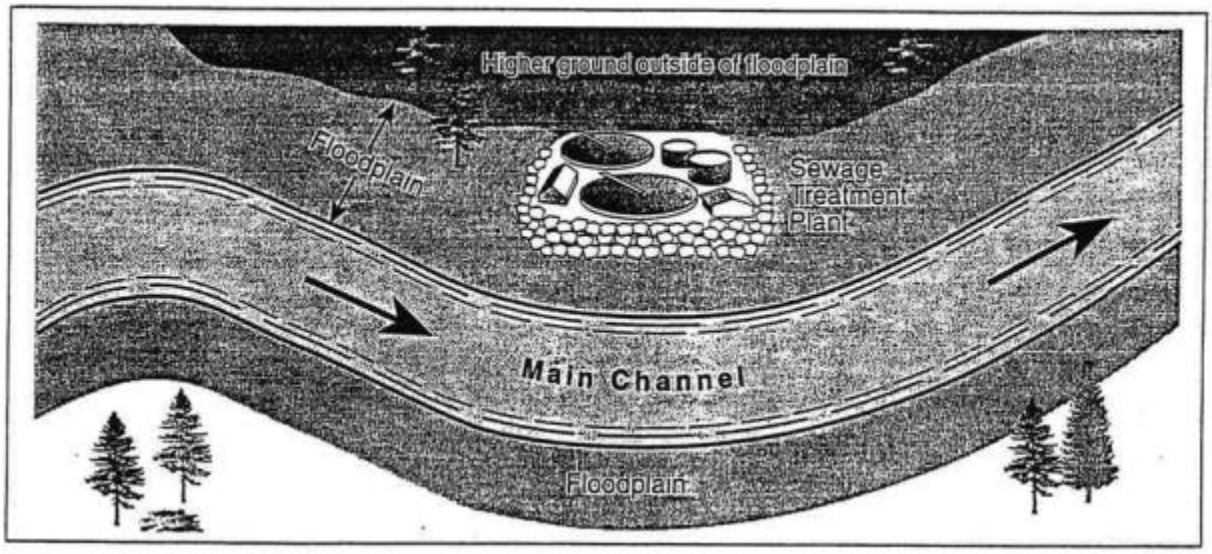

Setback levee with multi-use opportunities
Wetlands to detain stormwater, filter pollutants, and provide wildlife habitats
Setback levee to protect development
Recreational opportunities on sand bars and beaches
Natural stream bed for fisheries habitat
Public access bicycle/pedestrian trail. Also used for maintenance and emergency access

GROUP:	FLOODPLAIN PROTECTION
ALTERNATIVE:	**RIVERBANK LEVEE**
PURPOSE:	Protect floodplain areas from flooding.
DESCRIPTION:	A rock or rock/earth embankment is constructed on the river bank to protect floodplain areas from flood waters. The height of the levee depends on the level of flood protection to be provided.
SKETCH:	*See Next Page*
IMPACTS:	Fish resources; scenic, aesthetic, and historic resources; wildlife resources; recreation.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings, analysis to determine design flood stage, geotechnical work to determine foundation soil parameters.
Materials:	Rock, fill soil, topsoil, vegetation.
Equipment Needs:	Haul trucks, bulldozer, grader.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Check condition of levee annually and after major flood events. Specifically, investigate areas of erosion upstream of the levee that may result in damage to the levee, and areas of erosion downstream of the levee that may be caused by the levee. Replace/repair damaged levee sections, revegetate as necessary, inspect for animal burrows.

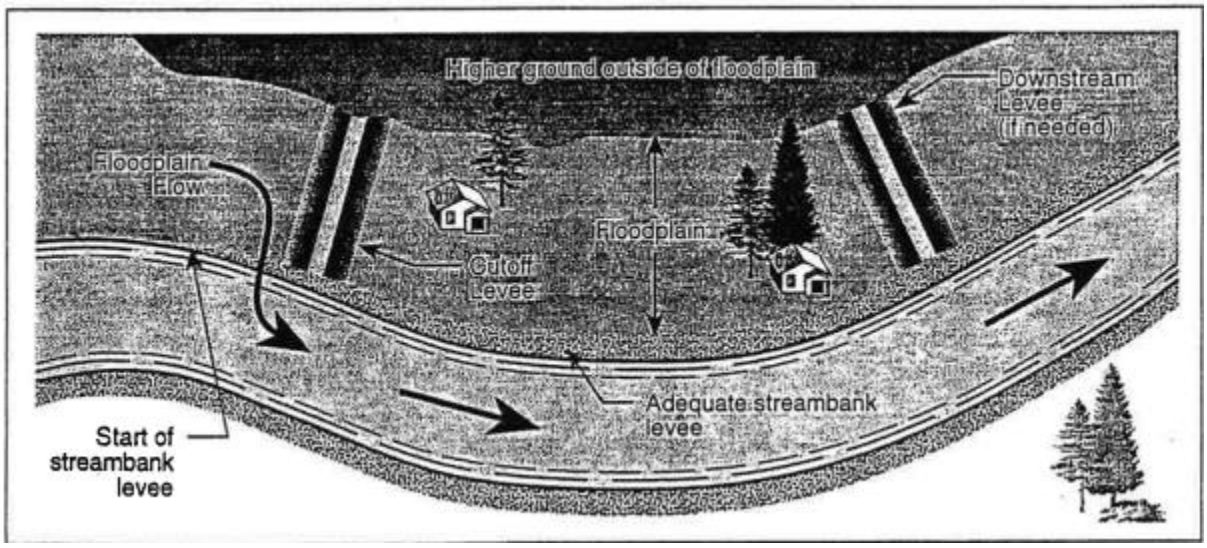

Plan view
Riverbank Levee


Section view
10 - 25 ft
6" gravel driving surface
100 year flood stage + 2-3 feet freeboard
Quarry Spalls
Uncompacted Topsoil
Compacted Topsoil
Existing Ground Surface
Embankment
3:1-5:1 H:V Slope
1
2
Design Flood Stage
Topsoil stripped before construction
Drain ditch
1
1.5
Cutoff trench or sheet pile to reduce/eliminate seepage and/or piping

GROUP:	FLOODPLAIN PROTECTION
ALTERNATIVE:	**RING LEVEE**
PURPOSE:	Protect a critical structure or parcel of public or private land by encircling it with a levee.
DESCRIPTION:	A rock or rock/earth embankment is constructed to surround critical structures or parcels of land located in the floodplain. Protection from damages due to the design flood is limited to the critical structure or parcel encircled by the ring levee.
SKETCH:	*See Next Page*
IMPACTS:	Water Quality.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings, analysis to determine design flood stage, geotechnical work to determine foundation soil parameters.
Materials:	Rock, fill soil, topsoil, vegetation.
Equipment Needs:	Haul trucks, bulldozer, grader.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Check condition of levee every 1 to 2 years or after major flood events. Replace/repair damaged sections, revegetate as necessary, inspect for animal burrows.


Higher ground outside of floodplain
Floodplain
Sewage Treatment Plant
Main Channel
Floodplain

GROUP:	FLOODPLAIN PROTECTION
ALTERNATIVE:	**CUTOFF LEVEE**
PURPOSE:	Protect a critical parcel of public or private land and existing or new riverbank levees. Prevent floodplain flow behind an otherwise adequate levee.
DESCRIPTION:	A rock or rock/earth embankment is constructed perpendicular to the stream channel to prevent movement of water along the floodplain. The cutoff levee will also prevent degradation of downstream streambank levees due to erosion and undercutting of the landward slide.
SKETCH:	*See Next Page*
IMPACTS:	Fish, wildlife, Scenic, aesthetic, and historic resources.
IMPLEMENTATION:	
Design Requirements:	Site survey, design drawings, analysis to determine design flood stage, geotechnical work to determine foundation soil parameters.
Materials:	Rock, fill soil, topsoil, vegetation.
Equipment Needs:	Haul trucks, bulldozer, grader.
Typical Permits:	Yakima County Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Check condition of levee annually and after major flood events. Replace/repair damaged sections, revegetate as necessary, inspect for animal burrows.


Higher ground outside of floodplain
Downstream Levee (if needed)
Floodplain Flow
Floodplain
Cutoff Levee
Adequate streambank levee
Start of streambank levee

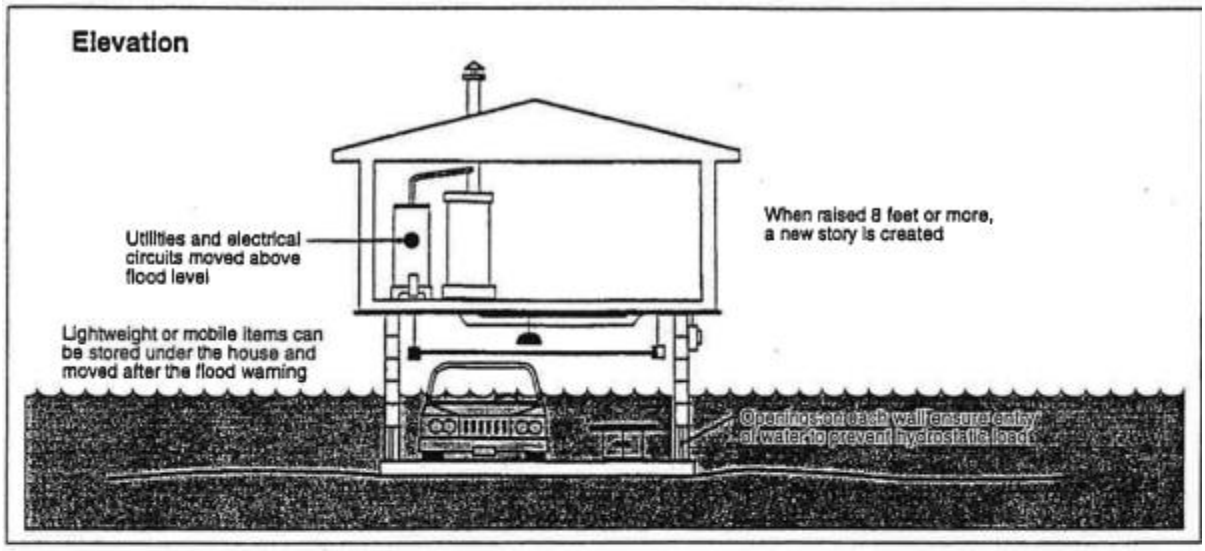
GROUP:	FLOODPLAIN PROTECTION
ALTERNATIVE:	**FLOODPROOFING STRUCTURES**
PURPOSE:	Reduce or eliminate flood damages through use of structural (or non-structural) changes or adjustments incorporated in the design, construction, or alteration of individual buildings or properties.
DESCRIPTION:	Floodproofing is accomplished through one or more of the following measures (see summaries below for additional information): • Elevating structures on fill, pilings, or slabs to elevations above the 100-year flood stage base (base flood level). • Constructing berms or floodwalls around structures. • Waterproofing structures; sealing all openings (with provision for watertight closures around windows and doors. • Elevating valuables and other contents within the structure above the base flood level, including service facilities such as electrical, heating, ventilation, and plumbing facilities. • Anchoring buildings and associated structures (above ground tanks, sheds, etc.) to prevent flotation, collapse, or lateral movement. • Relocating buildings to locations outside the floodplain.
SKETCH:	*See Next Page*

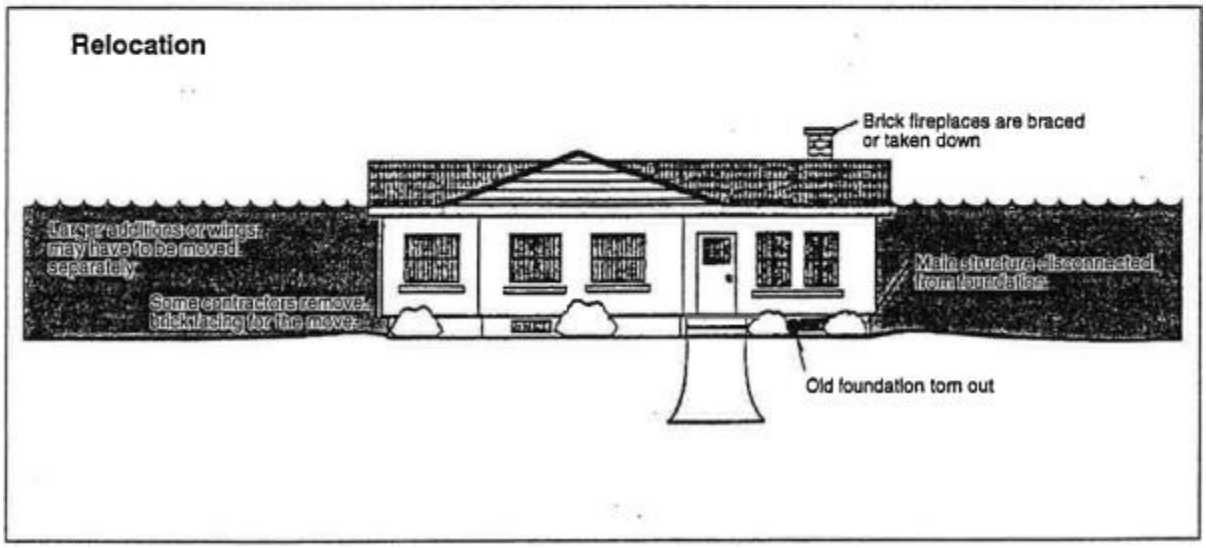
SUMMARIES OF FLOODPROOFING APPROACHES:

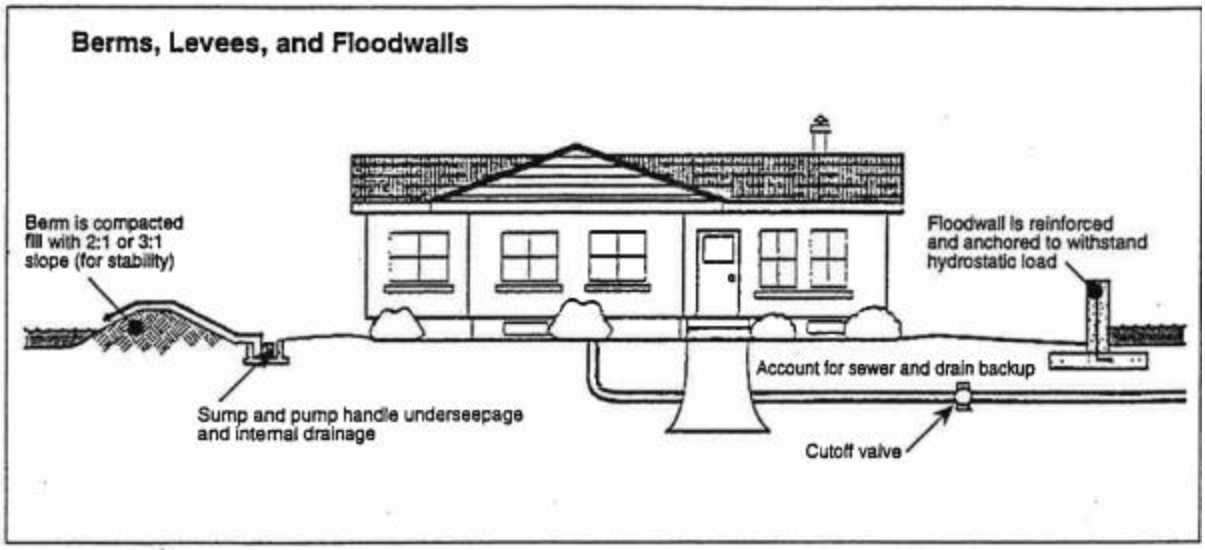
Raising or Moving the Structure:
Raising or moving the structure is a permanent floodproofing technique since it removes the damageable portions or the entire structure from risk. Raising the structure involves jacking up the structure and setting it on a new or extended foundation. The lowest habitable floor of the raised structure should be located above the predicted 100-year flood stage. Moving the structure involves relocating the structure to a portion of the building lot outside the floodplain or to a nearby lot entirely outside the floodplain. While relocation is costly, it is particularly appropriate where continued occupancy in high hazard areas is unsafe.

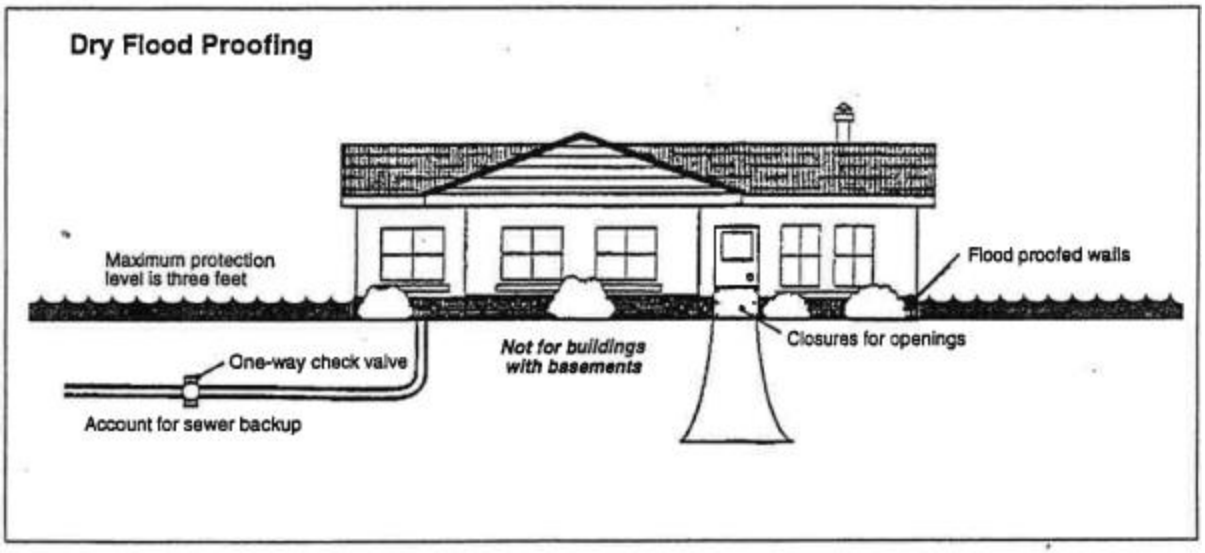
Construction of Barriers:
Barriers stop floodwaters from reaching damageable portions of structures. They can be free-standing barriers not attached to the structure or involve sealing a building so that floodwaters cannot enter (called "dry floodproofing"). Free-standing barriers include berms, levees, and floodwalls. Berms are typically earthen structures constructed close to the structure, while levees are typically constructed along the river bank (see river bank levee alternative). Dry floodproofing is accomplished by making all areas below the flood protection level (100-year flood stage) water tight. Openings such as doors, windows, sewer lines, and vents are closed with permanent closures or removable shields, sandbags, valves, or other materials.

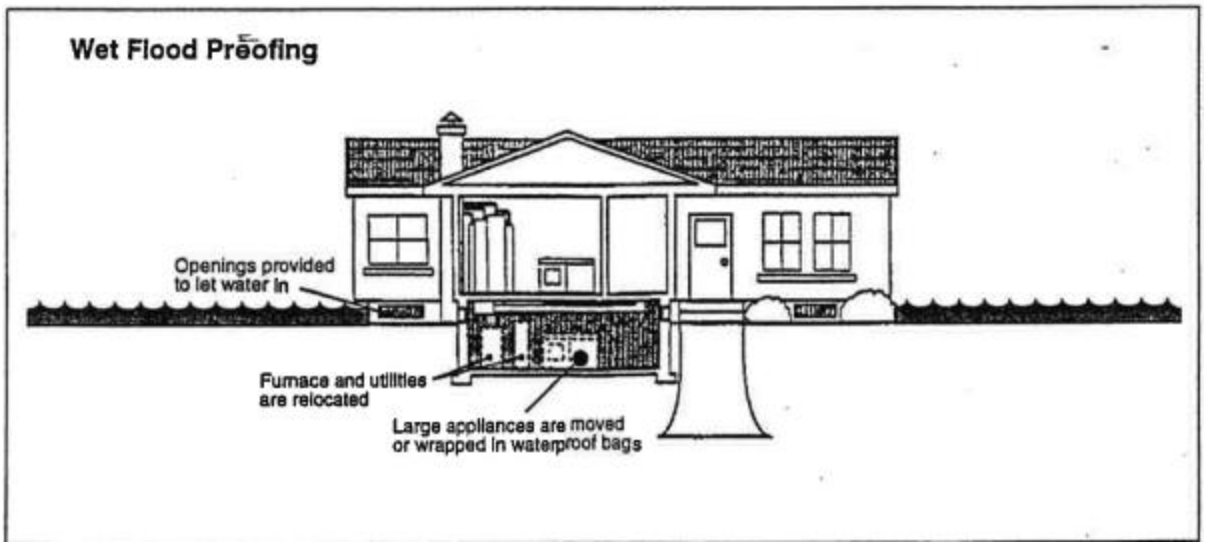
Wet Floodproofing:
This approach involves modifying the structure to allow floodwaters inside but ensuring that there is minimal damage to the building and contents. This approach is generally appropriate when areas are available above flood levels to which damageable items can be relocated or temporarily stored. Utilities and furnaces are protected or relocated to an area above the predicted 100-year flood stage. Special caution should be used in employing this alternative where safety hazards may result from flooding areas containing sources of electricity or hazardous materials.


Elevation
Utilities and electrical circuits moved above flood level
When raised 8 feet or more, a new story is created
Lightweight or mobile items can be stored under the house and moved after the flood warning
Openings on each wall ensure entry of water to prevent hydrostatic load


Relocation
Brick fireplaces are braced or taken down
Large additions or wings may have to be moved separately
Some contractors remove bricks/siding for the move
Main structure disconnected from foundation
Old foundation torn out

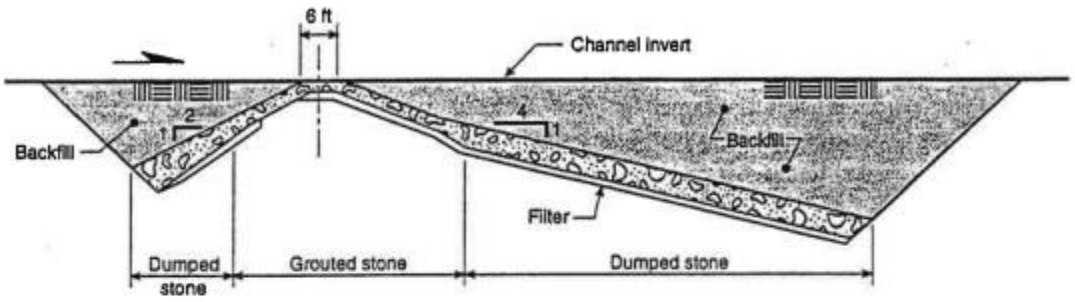

Berms, Levees, and Floodwalls
Berm is compacted fill with 2:1 or 3:1 slope (for stability)
Floodwall is reinforced and anchored to withstand hydrostatic load
Account for sewer and drain backup
Sump and pump handle underseepage and internal drainage
Cutoff valve


Dry Flood Proofing
Maximum protection level is three feet
Flood proofed walls
Not for buildings with basements
Closures for openings
One-way check valve
Account for sewer backup

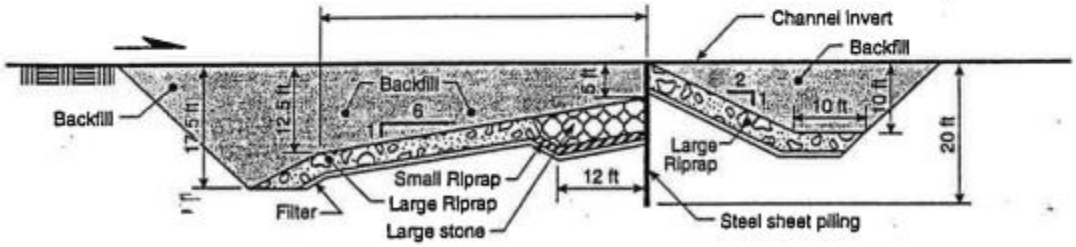

Wet Flood Proofing
Openings provided to let water in
Furnace and utilities are relocated
Large appliances are moved or wrapped in waterproof bags

GROUP:	STREAMBED CONTROL
ALTERNATIVE:	**STABILIZERS**
PURPOSE:	Limit channel scour and degradation.
DESCRIPTION:	Stabilizers are essentially buried weirs which extend laterally across the channel. They channel invert upstream and downstream of the structure is about the same and coincides with the crest of the weir. Stabilizers limit channel scour and degradation and are applicable primarily in higher energy systems in which channel scour and degradation are excessive.
SKETCH:	*See Next Page*
IMPACTS:	Fish, wildlife, scenic/ aesthetic/historic resources.
IMPLEMENTATION:	
Design Requirements:	Analysis of historical channel bed-slope changes, hydraulic analysis of proposed structure, site survey, design drawings, geotechnical work to determine streambed foundation parameters.
Materials:	Stabilizer may be constructed of grouted or ungrouted rock, sheet piling, concrete sills, and gabions, or a combination of materials; also requires fill material appropriate for use in channel bed.
Equipment Needs:	Haul trucks, excavator, concrete pump, concrete trucks, forms.
Typical Permits:	Yakima County-City Critical Areas or Shoreline Permit, DOE Stormwater Construction Permit with Temporary Modification of Water Quality Criteria, SEPA Checklist, JARPA,WDFW HPA, Yakima Nation Code (where applicable), COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Check condition of structure annually and after major flood events. Inspect channel bed upstream and downstream for excessive scour or other detrimental changes in channel characteristics.

Grouted Stone Stabilizer



Sheet Piling Stabilizer



GROUP:	STREAMBED CONTROL
ALTERNATIVE:	**LOWERING OF CHANNEL**
PURPOSE:	To increase conveyance and reduce flood stage through excavation.
DESCRIPTION:	Stages are reduced across all flows including floods through direct excavation. The changes can be reversed by deposition along the reach over time. Best used where a constriction is being removed downstream.
SKETCH	*See Next page*
IMPACTS	Negative impact to Fisheries and short term Water Quality. Neutral impact to Wildlife, Scenic/ Aesthetic, Hydrology and Recreation.
IMPLEMENTATION:	
Design Requirements:	Hydraulic and hydrologic analysis, analysis of sediment transport regime (i.e., determining whether there is an upstream sediment source), site survey (multiple cross sections), design drawings, estimates of quantities to be removed.
Materials:	Removal of channel/floodplain materials. Vegetation and other materials contingent on structural alternatives used.
Equipment Needs:	Bulldozer, front end loader, haul trucks.
Typical Permits:	Yakima County or City Critical Areas or Shoreline Permit, DOE Stormwater Permit, Temporary Modification of Water Quality Criteria, SEPA Checklist, WDFW and/or Yakima Nation HPA, COE Individual Permit, Floodplain Permit.
MONITORING/ MAINTENANCE:	Yakima County Flood Control Zone District or proponent.

Appendix C

2018 Advisory Committee Voting Results

APPENDIX C April 13, 2018
2018 Advisory Committee Members Voting Results on Flood Hazard Reduction Alternatives

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads*
Inadequate facilities in floodplain, and hydraulic capacity of Lower Cowiche Creek to prevent flood overflows to City (LC1)				
a. Construct new Powerhouse Rd Bridge that will pass the 100-year flood event with three feet of freeboard	S12	10	0	City
b. Widen US12 bridge, allowing 100-year levees to connect to the road prism.	S6	12	0	City, WSDOT
c. Remove City storage pond for floodplain/bridge space	S7	10	0	City
d. Provide minimum 100-yr flow capacity channel between Powerhouse road and US12 bridge, while allowing FEMA freeboard and width for channel floodplain capacity and natural habitat functions.	PL8	12	0	City
e. Minimum 500-yr flow capacity floodplain system downstream of US12 bridge that is unarmored and deformable, and accesses the floodplain at the 2-yr flow, or more often.	PL10	10	2	FCZD
f. Seek and secure local, state and federal funding to make improvements to this reach of Cowiche Creek	PL7	10	0	City, FCZD
g. Downstream of US12, widen the active floodplain to minimize need for ongoing sediment removal and large woody material management, and ensure that the low-flow channel supports typical flow conditions that are beneficial for fish and water quality.	PL10	10	2	FCZD
h. Coordinated design all items from d/s to u/s to reduce overflows in risk area and meet 100-year accreditation	PL13	10	0	FCZD, City
i. Action Plan: Any Flood Facilities for Interim Period be coordinated between agencies in design and implementation	PL6	10	0	FCZD, City, YVOEM
j. Design channel and floodplains to minimize the need for gravel and debris removal while still allowing for unplanned removals	S4	9	0	City, FCZD
k. Continue to explore, then construct interim action to alleviate flood east of 40th Ave.	S9	12	0	City, WSDOT

l. Design channel and floodplain systems which allow self-building and self-sustaining habitat characteristics, while minimizing armoring and maintenance.	PL10	11	0	City, FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Floodplain and Flood Risk Mapping not reflective of risk. (LC2)				
a. Adopt new FEMA regulated maps	PL3	10	0	City, County
b. Review and consider interim combined Naches River and Cowiche Creek flood of record under FFA for building restrictions	PL5	9	1	City
c. Review risk map for planning restrictions	PL5	10	0	City
d. FCZD provide comment regarding mapped and estimated flooding inundation areas during SEPA comment period.	PL17	12	0	FCZD
e. Regulate to extent allowed by CAO and Shorelines, also using flood of record.	PL17	11	0	City, County
f. Task Force to resolve planning/regulatory interim measures	PL4 PL6 PL18	9	1	City
g. Flood information provided by County/FEMA for facility siting and design	PL17	10	0	FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Improve Public Awareness and Flood Insurance knowledge. (LC3)				
a. Inform Public of new FEMA and flood risk map early to allow lower cost insurance	PA1 PA5	10	0	City, FCZD
b. Advise property owners of potential for flooding and encourage flood insurance	PA2	11	0	City, FCZD
c. Assist public with preparation planning that minimizes flood damages	PA4	10	0	City, FCZD
d. Garner public support for capital measures to remove flood areas through capital expenditures	PA7	10	0	City, FCZD

e. Site and design of facilities to avoid overall flood damages	FP4 FP8	11	0	City

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Improve Formal Interagency coordination. (LC4)				
a. Extend Interagency coordination between all appropriate agencies during all Cowiche phases	PL2	12	0	City, FCZD
b. Seek upper management and elected official support for Cowiche flood mitigation	PA6	12	0	City, FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Revision and Consistency of Flood Hazard, Critical Areas & Shoreline Ordinances for this location. (LC5)				
a. Ordinances must coordinate for interim measures in this area (CAO, SMA, SEPA, Zoning)	PL18	12	0	City, County
b. Create Task Force with public involvement for purpose of reviewing ordinances	PL18	7	0	City, County
c. Establish a channel migration zone to the edge of the levees on the Cowiche.	PL13	10	0	City, County

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Inadequate flood forecasting system. (LC6)				
a. Improve and add to climate and surface water monitoring technologies to improve flooding response time, including additional snow, rain, temperature, streamflow data and quicker retrieval. New gages and telemetry.	PL11	11	0	FCZD, City
b. Evaluate flood forecasting system after new components are added	PL11	10	0	FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Define Clear Action Points to Initiate Emergency Response Activities for Cowiche Creek overflows. (LC7)				
a. Identify response thresholds for notifications and actions in Near and Short-Term Action Plans prior to removal of areas from flood threat, updated as needed	FP2 FP7	11	0	City, County WSDOT, YVOEM
b. Improve flood forecasting to update Near and Short-Term Action Plans	FP2 FP7	12	0	City, FCZD
c. Develop City of Yakima Public Works Emergency Response Plan with specific flood elements.	FP2 FP7	12	0	City, County WSDOT, YVOEM

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Funding for Flood Control Works and Restoration Project elements. (LC8)				
a. Seek local political support	PL7 PA6 PA7	11	0	City, FCZD
b. Seek property owners' support to enable local measures – may need local funding mechanism	PL7 PA7	11	0	City
c. Seek local support to garner Federal, State and WSDOT funding	PL7 PA7	11	0	City, FCZD
d. Preparation of flood hazard mitigation measures, consistent with the CFHMP, to receive funding from grant or disaster programs	PL7	11	0	City, FCZD
e. To the extent possible, flood hazard mitigation measures should be consistent with, or implement, basin plans	PL7	11	0	City, FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Extensive Short-Term Emergency Flood Routing in (and outside of) the City of Yakima. (LC9)				
a. Evaluate drainage and plan for improvements within the CFHMP planning area to mitigate short-term damages from overflows	PL14	10	0	City
b. Construct short-term routes and structures to direct waters back to Naches River or more appropriate watercourses	PL14 FP5	11	0	City
c. During emergencies, plan to minimize fish stranding with flood hazard mitigation measures, and fish salvage from existing infrastructure. Design structures for safe up- and downstream fish passage especially during known spawning runs.	FP8	11	0	City, WSDOT
d. Encourage local protections to protect individual infrastructure such as ring dikes around homes, barns, shops; rather than entirely prohibiting floodplain flow on a property.	PL15 PA4	11	0	City

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Stability of berms on Lake Aspen/Myron/Willow & drainage of Aspen Lake. (LC10)				
a. Provide comprehensive drainage study to assess capacity of drainage from Myron Lake back to Naches River at 6th Ave	PL14	10	0	City
b. Establish ownership of drainage facilities and identify additional drainage options as needed	PL14	10	0	City, Owners
c. Have Myron and Willow Lake dam owners consider spillway improvements and long-term management	PL14 S10	11	0	Landowners
d. Consider Constructing Aspen Lake outflows under 16th Avenue and route adjacent to US12	S9	11	0	City

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Risk to US12 During Major Flood Events. (LC11)				
a. Design a new bridge using WDFW's stream crossing design guidelines with more flow conveyance capacity to reduce overtopping and closure of US12 and ramps.	S1 S6	10	0	WSDOT

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Threat of flooding to State, County, and City Roads. (LC12)				
a. Plan preferential road closures and detour routes to mitigate impacts	FP2	11	0	City, County WSDOT, YVOEM
b. Reduce City Road damages from overflows by culvert placement	S11	11	0	City

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Lack of Cowiche Creek historical flow data. (LC13)				
a. Identify key locations for additional stream, rain and snow gages to more accurately estimate flood flows.	FP6	10	0	FCZD, City
b. Secure funding to install, monitor and maintain additional stream, rain and snow gages, and to incorporate data into flood estimates and flood forecasting.	FP6	10	0	City

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Availability of centralized GIS data & modeling impacts in planning and inventory. (LC14)				
a. Continue collection of Flood of record (FFA: Frequently flooded areas)	PL5	11	0	FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Operation and Standards for new/upgraded Flood Control Facilities. (LC15)				
a. Develop design and maintenance standards, procedures and funding to ensure enhanced hydraulic and habitat performance	PL6	11	0	City, FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Development pressures in affected overflow areas/potential additional harm. (LC16)				
a. Design development in the overflow area during interim (before secure 100-year facilities) to minimize damages to proposed and existing development	PL3 PL5 PL18	11	0	City

Flood Issue / Proposed Alternatives	Acceptable	Not Acceptable	Leads
Lack of Space for Cowiche Creek low flow Channel Migration. (LC17)			

No items

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Operation and Maintenance of Proposed Flood Control Facilities. (LC18)				
a. Secure dedicated Funding to maintain operational standards, enrollment in PL84-99 or accreditation to ensure continuing attention and repair	S5	11	0	City
b. Organize community-level funding districts or local funding that construct and maintain approved risk-reduction features.	PL12	11	0	City

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Acquisition/Preservation of Floodplain Open Space. (LC19)				
a. Expand Greenway Overlay, where appropriate	PL19	10	1	City, County, Greenway
b. Acquire or manage land use to create sufficient open space downstream of US12 to allow for riverine processes.	PL10	11	0	FCZD
c. Develop an implementation and funding plan to acquire/preserve parcels to increase floodplain extent and minimize the need for sediment removal.	PL10	11	0	City, FCZD
d. Preserve open space land uses (ex: wildlife reserve, park, orchard, and pasture land) in this area through zoning.	PL9 PL21	11	0	City, County

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Loss of Channel Capacity due to Sediment Accumulation and lateral confinement. (LC20)				
a. Upstream of US12, design for minimal periodic gravel removals to maintain channel capacity.	PL20	11	0	City, FCZD
b. Downstream of US12, widen the active floodplain to minimize need for ongoing sediment removal and large woody material management, and assure that the low-flow channel supports typical flow conditions that are beneficial for fish and water quality.	PL20	11	0	FCZD
c. Include in channel/floodplain design processes for gravel storage, erosion (deform), gravel transport; and sustainable vegetation stands.	PL20	11	0	City, FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Sediment accumulates in reach, reducing flood capacity. (LC21)				
a. Identify location for sediment removal and sediment monitoring, and removal of identified sediment, especially upstream of US12	PL22	11	0	City, FCZD,
b. During Upper Cowiche CFHMP, consider effects of sediment releases or pulses on the reach.	PL23	10	0	FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Nelson Dam and Fruitvale infrastructure reducing hydraulic capacity downstream of US12. (LC22)				
a. Design Naches floodplain infrastructure removals resulting from the combined diversions to maximize Cowiche Creek capacity and fish passage	S3	10	0	City, FCZD

Flood Issue / Proposed Alternatives		Acceptable	Not Acceptable	Leads
Erosion/Loss of Agricultural Land. (LC23)				
a. Downstream of Powerhouse Road and upstream of US12, acquire land to accommodate/confine flood flows within a corridor.	PL10 PL21	10	0	City, FCZD
b. Downstream of US12, maintain Agricultural land uses to reduce flood risk vs higher risk development	PL21	9	0	FCZD

* First party named in Leads column has primary responsibility