APPENDIX J

Draft EDT Assessment of Aquatic Habitat in the Lower Willamette River Mainstem

Organization of the Analysis

Reach Structure and Geographic Areas

The EDT assessment of the Lower Willamette River was organized hierarchically. At the finest scale, information was developed for stream reaches that described the physical and biological environment of the stream. Twenty-three reaches were delineated based on geomorphic and land use characteristics. The reaches were grouped into 4 geographic areas described below.

- **North Segment -** The North Segment begins at the confluence of the Columbia and Willamette Rivers and extends upstream (south) 6 miles to the St. Johns Bridge. A portion of the Multnomah Channel, which runs along the south edge of Sauvie Island and joins the Columbia farther downstream, is included in this river segment. Land uses are predominantly industrial along this reach, with a large expanse of port facilities. There is some important open space along this segment (e.g., Kelley Point Park, Harborton Wetlands. The Multnomah Channel, Columbia Slough, Miller Creek, Doane Creek, and the Willamette-Columbia confluence are also some critical habitat features along this segment.

- **Industrial Segment -** The Industrial Segment extends from the St Johns Bridge to the Steel Bridge and comprises most of Portland's working harbor. Industrial land uses also dominate this segment. Nearly all of the historical tributaries draining to this reach have been piped underground. Remaining key habitat features include Willamette Park and the Swan Island Beach.

- **Downtown Segment -** The Downtown Segment extends from the Steel Bridge to the Ross Island Bridge. Land uses in this reach are a mix of commercial, industrial and high-density residential. The few streams that historically discharged to this reach have all been piped underground, and the few remaining habitat features are limited and small scale (e.g., Eastbank Crescent beach)

- **South Segment -** The South Segment extends from the Ross Island Bridge to the Urban Services Boundary south of the Sellwood Bridge. The segment has considerable open space, as well as commercial and industrial land uses. The reach has lost some historical tributaries, but Stephens Creek provides high quality tributary confluence habitat, and Ross Island, Oaks Bottom and Willamette Park provide important habitat features.

Scenario Development

Two scenarios were described by the technical team. First, the current conditions were described based on existing empirical and expert knowledge regarding physical and biological conditions in the McKenzie Subbasin. Second, a reference or template condition was described. This reference condition defined a fully restored condition for the McKenzie River, tributaries, and the downstream reaches of the Willamette River. A third scenario that is contained within the EDT model describes a fully degraded condition for the system. Placing the current condition between these two "bookends" allowed us to define good and bad conditions and to analyze how the McKenzie Subbasin and downstream Willamette River reaches function in terms of the spring chinook salmon population.

Lower Willamette River Information Sources

The tables below document the sources of data and information used to rate the condition of the environmental attributes EDT uses to evaluate habitat quality in the Lower Willamette River.

Flow Attributes:

EDT Attribute	Data Source
Confinement - Hydromodifications	Bank Design Notebook
Confinement - natural	GIS analysis of topography/shaded relief maps
Flow - change in interannual variability in high flows	USGS Flow Gauge data; Klingman and Wyrick (2001) analyses
Flow - changes in interannual variability in low flows	
Flow - Intra daily (diel) variation	
Flow - intra-annual flow pattern	
Hydrologic regime - natural	BPJ
Water withdrawals	No known unscreened diversions locally

Habitat Attributes:

EDT Attribute	Data Source
Bed scour	Hill & McLaren 2001
Channel length	GIS analysis
Channel month Maximum width (ft)	
Channel month Minimum width (ft)	
Embeddedness	Tetra Tech 1994; Hill & McLaren 2001
Fine sediment	
Gradient	GIS analysis of bathymetry and channel data
Habitat Type - Shallow Water	
Habitat Type - Deep Water	
Obstructions to fish migration	No migratory obstructions in Willamette
Bank Condition	Bank Design Notebook
Turbidity	BES WQ data

Water Quality Attributes:

EDT Attribute	Data Source
Temperature - daily maximum (by month)	BES continuous temperature gauges
Temperature - daily minimum (by month)	
Temperature - spatial variation	Expert Opinion
Alkalinity	BES WQ data
Dissolved oxygen	
Metals - in water column	
Metals/Pollutants - in sediments/soils	Qualitative interpretation of Superfund findings[1]
Miscellaneous toxic pollutants - water column	
Nutrient enrichment	BES WQ data
Salmon Carcasses	ODFW/NMFS summaries of Willamette Salmon Populations; observation

Biological Attributes:

EDT Attribute	Data Source
Benthos diversity and production	Tetra Tech 1993; 1994
Fish community richness	Altman et al. 1997; Hughes and Gammon 1987; Tetra Tech 1993; Ward and Nigro 1993; Farr and Ward 1993
Fish pathogens	Knowledge of Willamette hatchery history
Hatchery fish outplants	
Fish species introductions	Farr and Ward 1993
Harassment	Observation
Predation risk	Fishman 2001

[1] The single most critical data "gap". A large amount of data actually exists on sediment contaminants in the Lower Willamette, but this has not yet been evaluated by formal risk assessment. Risk assessment and improving the ability of EDT to evaluate toxic contaminants are the two steps required to address this.

Ecosystem Diagnosis and Treatment Results

Overview

Because populations of target species do not spawn locally within the Lower Willamette River, the impacts of conditions in this section on target species populations are evaluated through the series of population analyses conducted through the Willamette Basin. Reference to McKenzie River, Clackamas River, Johnson Creek and Tryon Creek sections will provide information on the impact of conditions in the Lower Willamette on these populations.

Attributes Limiting Target Species Populations

Evaluation of population analyses though the Willamette Basin reveal several consistent habitat attributes that limit these populations. Impacts to a specific population are described in the section describing the basin. In general it is clear that conditions in the channel and floodplain in the lower Willamette River have been dramatically changed over the last 150 years. The channel has been deepened, narrowed and simplified; the banks have been hardened and lined. Floodplain and off-channel habitats have been filled and destroyed and banks steepened throughout the length of the river within the City. Seasonal patterns of flow have changed; winter and spring flood peaks have been reduced and summer base flows are now significantly higher than in the past. Urban pollutants have accumulated in the sediments of the lower river to levels significant enough to warrant Superfund listing.

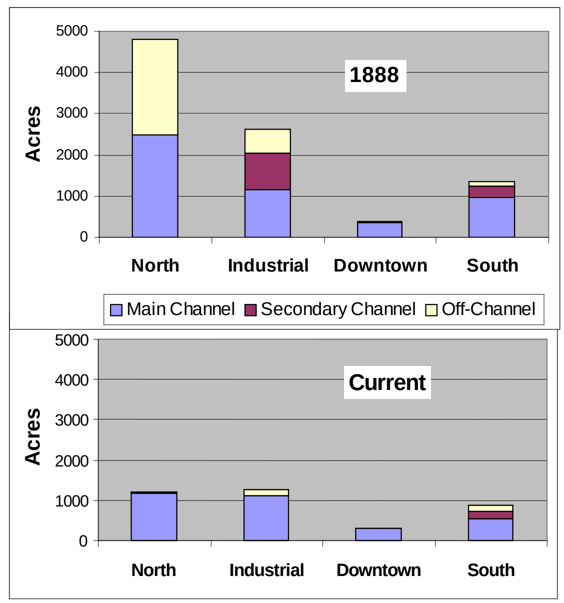


Figure 1: Changes in the amount of mainstem, secondary and off-channel habitat in the Lower Willamette River through Portland; 1888 – 2001.

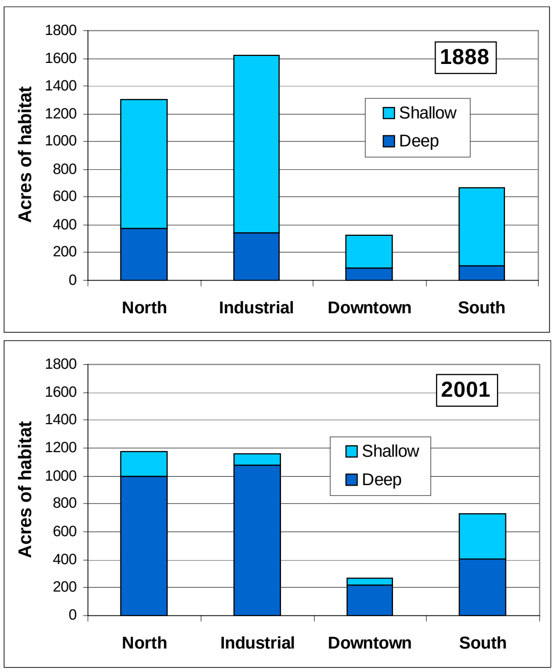
These marked changes in habitat conditions have significant impact on populations of focal species throughout the Willamette Basin. EDT analysis of conditions in the Lower Willamette indicate the following limiting factors.

Habitat Diversity: Changes in the channel decreased habitat diversity throughout the course of the lower river through Portland. Loss of shallow water habitat, lack of wood, bank hardening and reconfiguration and loss of off-channel habitats have been some of the factors that have reduced habitat diversity. These conditions impact the migratory and rearing stages of Chinook, coho and steelhead that use the lower river.

Historically, the Willamette River in the Portland area comprised an extensive and interconnected system of active channels, open slack waters, emergent wetlands, riparian forest, and adjacent upland forests on hill slopes and Missoula Flood terraces. Prior to

settlement, the river was embedded in the regional forest network, and intricately connected to the Columbia floodplains. Areas along the riverbank were probably difficult to distinguish from the surrounding green forested environment.
Significant dredging, diking, and channeling of the mainstem Willamette has altered many of these historical conditions. The mainstem has been narrowed and deepened, and off-channel habitat has been virtually eliminated. The river's banks have been hardened precluding important naturally caused channel changes and minimizing the interaction between the river and riparian and floodplain vegetation. Habitat has been simplified and large tracts of riparian vegetation have been cleared. As a result of these actions, significant amounts of shallow water, floodplain and off-channel habitats have been lost.

Figure 2: Changes in the proportion and total amount of shallow and deep water habitat in the Lower Willamette River through Portland.



The Lower Willamette River historically had a number of large off-channel lakes that provided high quality rearing and refuge areas (e.g., Guilds, Kitteredge, Doane and Ramsey lakes). Over time floodplain fill, vegetation removal, bank alterations, and channel clearing destroyed floodplain, off-channel and riverine habitats and altered their physical structure. Guilds Lake and Ramsey Lake were filled to provide land for downtown and port development, while Doane Lake was reduced in size and its connection to the river severed. Eighty-nine percent of the historical off-channel was destroyed. These losses have been most extensive in the North and Industrial sections which historically had the highest amount of off-channel habitat (Figure 1). The South Segment is the only segment which retains a percentage of its former off-channel habitat because of the presence of Ross Island.

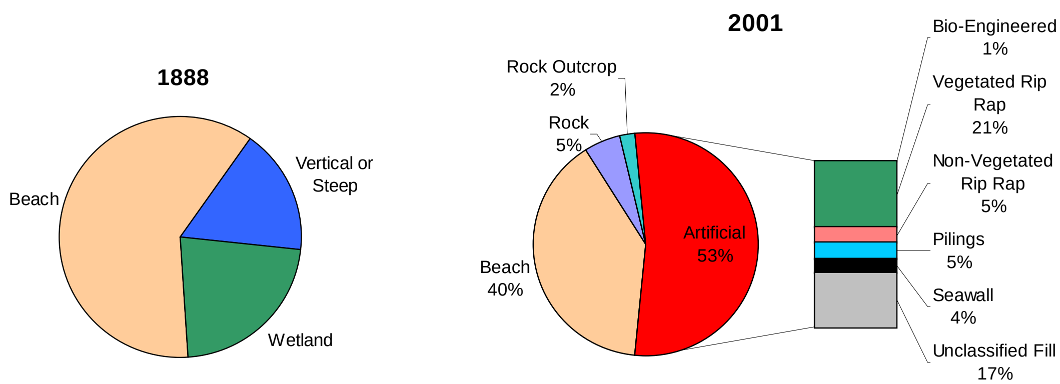
Over the same time period, the mainstem channel was undergoing many changes to improve conditions for navigation, port access to the channel and ostensibly to provide "flood control". As a result, the channel has been deepened, narrowed and its banks steepened over time. Seventy-nine percent of the shallow water habitat through the lower river was lost through channel deepening (Figure 2). Similar to the pattern in changes in off-channel habitat, these losses were most extensive in the North and Industrial sections which historically had the most extensive amount of shallow water habitats, and the South segment retains the highest proportion of its historical shallow water habitat.

To maintain these changes in channel configuration and support the infrastructure for port, industrial and other urban uses, the banks of the lower river were "hardened" with riprap, sheet pile and other human-made structures. These features alter the velocity and timing of river and stream flows, disconnect rivers and streams from their floodplains, and limit the establishment of native vegetation and the natural maintenance of gravel beds and other important habitats. River banks were historically dominated by beach, with significant components of wetland and vertical steep banks (Figure 3). Currently, the majority of the banks are comprised of artificial substrates of one type or another. Although beach habitats are still a significant component, riparian wetlands have been completely eliminated.

There is no historical information on the amount of wood in the Lower Willamette, and there have not been any quantitative surveys to assess current levels. It is likely that current levels of wood are dramatically lower than historical levels. The mouths of large rivers often accumulated huge debris jams. These debris jams were cleared to support river navigation, and the channels and banks have continued to be cleared over time to protect urban infrastructure and maintain navigation.

Key Habitat Quantity: While habitat diversity refers to the *quality* of habitat available, it is also clear that the *quantity* of habitat available for key life history stages is limiting. Lack of off-channel habitat, low levels of wood and shallow water habitat, and lack of channel and bank complexity all result in insufficient amounts of key habitat available for migration and rearing stages of chinook, coho and steelhead using the lower river.

Figure 3: Changes in bank types along the North Segment of the Lower Willamette River.



Chemical Contamination: Because of the level of pollution in lower Willamette River sediments, the Portland Harbor was added to the federal Superfund cleanup list in December 2000. The Portland Harbor Superfund Site currently covers a 5.7 mile section of the Willamette River from the upstream end of Sauvie Island (RM 3.5) and Swan Island (RM 9.2), so the northern 2.5 miles of the site are in the North Segment of the study area and the southern 3.2 miles of the site are in the industrial segment of the study area. Pollutants introduced through industrial discharges, toxics carried by stormwater, and other sources have contributed to elevated levels of many urban pollutants. Preliminary assessments indicate that DDT, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals are some of the key risk drivers in lower Willamette River sediment. More extensive analyses of patterns of chemical contamination are described in Weston (1998?).

The Oregon 303(d) list divides the Willamette River into segments, including one that covers river mile (RM) 0 to RM 24.8. The current 303(d) listings for that river segment are summarized below:

Parameter	**Season(s)**	**Sample Matrix**	**Year Listed**	**Notes**
Fecal Coliform	Winter/Spring/ Fall	Water column	1998	
Dieldrin	All	Fish tissue	2002	
DDT	All	Fish tissue Water column	2002	
DDE	All	Fish tissue	2002	
PAHs	All	Water column	2002	
Biological Criteria	Not specified	Water column	1998	Listing based on skeletal deformities in juvenile squawfish.
Mercury	All	Fish tissue	1998	
Aldrin	All	Fish tissue	2002	
Temperature	Summer	Water column	1998	
PCBs	All	Fish tissue	2002	
Manganese	All	Water column	2002	
Iron	All	Water column	2002	
Pentachlorophenol	Not specified	Sediment	1998	Listing basis is OSHD alert regarding fishing & swimming near Baxter & McCormick Superfund site.

Restoration and Protection Strategies

Habitat complexity and key habitat quantity consistently ranked as the most significant factors limiting the survival of salmonids. One of the key hypotheses guiding restoration is that increasing habitat complexity will be one of the most important approaches to improving the status of salmonid populations. For this approach to be successful, it should be focused on restoring the processes that maintain habitat complexity as well as re-introducing the structural components that contribute to complexity (City of Portland 2004). Normative hydrology and healthy riparian and floodplain vegetative assemblages are key components that maintain habitat complexity. Although introducing wood and restructuring channels, banks and floodplains are likely to improve conditions for salmonids, it is unlikely that these improvements will persist over the long term if the components maintaining these features such as normative hydrology and appropriate floodplain vegetation are lacking. The hypotheses and strategies below thus focus on features that are related to the key limiting factors as well as the limiting factors themselves.

Restore Normative Hydrology – Hydrology is one of the most basic and critical forces shaping the structure, dynamics and function of riverine habitat (Poff et al. 1997, Stanford et al. 1996, ISG 2000). Restoring habitat will require restoring at least some degree of the habitat forming and maintaining functions that are strongly dependent on normative hydrologic conditions. The Willamette River is a regulated river in which dam operations have reduced peak flows and substantially increased base flows from their historical condition. Habitat restoration throughout the system will be dependent on managing the dams to more closely mimic historical seasonal patterns of flow.

Seasonal variability in flow is one of the major environmental cues to which plant and animal life histories respond. Seasonal changes in water level define the patterns of inundation and exposure that create seasonal wetlands, and are important signals for the onset of critical biological processes such as emergence, migration and reproduction. Wetland plants, salmon, aquatic insects and other plants and animals have adapted to the seasonal patterns of flow over thousands of years, and their life histories reflect this ecological history. The rapid, human-induced changes in flow patterns mean that many native species are no longer adapted to the range and timing of flow conditions, adversely affecting their productivity, behavior and survival. Floodplain areas that normally would be exposed during the summer and develop into seasonal wetlands as exposure stimulates wetland plant growth are now no longer exposed in the amounts, frequencies, or timing that they were in the past because dry season water levels are considerably higher than they were historically. Many plants (for example, wapato Sagittaria latifolia) are critically dependent on this seasonal pattern and timing of exposure.

Reduction in the magnitude and frequency of peak flow events alters habitat-forming and –maintaining processes. Floods are critical for maintaining many elements of riverine habitat, including channel and floodplain morphology, substrate composition, and wood accumulations (Junk and others 1989; Regier and others 1989; Poff and others 1997). Reducing the frequency and size of floods affects a number of important ecological processes including transport of sediment and wood, the frequency of channel-forming flows, and the disturbance events needed to create a mosaic of diverse habitat patches that provide habitat suitable for a wider range of species.

Hypothesis: ***Managing dam regulation to more closely mimic normative seasonal hydrologic patterns will improve habitat conditions by improving habitat forming and maintaining processes, re-creating a pattern of seasonal water level variability that favors the development of seasonal wetlands, and more closely approximating the conditions to which plants and animals have evolved over millennia.***

Strategy Hydr1: Work with the Corps of Engineers during Section 7 consultation to identify measures that restore normative seasonal patterns in flow. Implement the flow management strategies described throughout this subbasin plan.

Increase Habitat Complexity and Key Habitat Quantity - Changes in the channel decreased habitat diversity throughout the course of the lower river through Portland. Loss of shallow water, low velocity habitats, lack of wood, bank hardening and reconfiguration and loss of off-channel habitats have been some of the factors that have reduced habitat diversity. These conditions impact the migratory and rearing stages of Chinook, coho and steelhead that use the lower river.

Hypothesis: *Increasing the amount of shallow water and off-channel habitat in the Lower Willamette River will improve survival during migration and will provide additional rearing habitat for yearling and subyearling Chinook and coho.*

Strategy Chem1: Identify sites along the river where bank hardening structures can be removed, the banks can be pulled back and bank slopes can be lowered to increase the amount of shallow water habitat.

Strategy Chem2: Identify vacant or unused lands within the floodplain that can be excavated or otherwise restructured to provide off-channel habitat.

Strategy Chem3: Daylight at least the confluence (if not the entire piped section) of the piped tributaries (e.g., Saltzman Creek, Doane Creek) to create high quality tributary confluence habitat.

Riparian and floodplain have largely been filled, developed and disconnected from the main channel. The inability of the river to access the floodplain diminishes potential wintering habitat for fish communities, most notably, wetlands and off-channel pools. Riparian and floodplain connectivity helps moderate stream temperatures (via subsurface and hyporheic flows), filters sediments, supplies nutrients (organics), and supplies bed-form substrate materials (gravels and cobbles).

Hypothesis: *Increasing the amount of floodplain habitat accessible to the river will improve Chinook, coho and steelhead yearling and subyearling survival during rearing and migration in the lower river.*

Strategy Chem4: In conjunction with Strategy Hab1 & 2, identify areas where the banks can be restructured and lands adjacent to the river configured to function as floodplain habitat during winter high flows. Remove impervious surfaces, remediate soil contamination, remove any remaining structures, recontour topography to allow seasonal submergence, remove invasive plants and plant native floodplain vegetation.

Strategy Chem5: Protect high quality riparian, floodplain and wetland habitats through property acquisition and conservation easements.

Strategy Chem6: Identify opportunities to remove relict anthropogenic structures along the banks and in the floodplain. Work in partnerships with property owners, acquire vacant properties, and evaluate existing public properties to remove or move back any structures along the bank or in riparian and floodplain areas.

Habitat and channel complexity are highly influenced by large wood. Large wood complexes provide important overwintering habitat to salmon. Adding large wood instream and buried pieces in the floodplain will improve channel roughness. Benefits include attenuated erosive flows (e.g., reduce flood flow energy), it will aid habitat-forming processes, and add instream refugia. Indirect positive effects include capturing sediments, reclaiming (or enhancing) riparian and floodplain connectivity, and providing substrate (and detritus) for macroinvertebrate production.

Hypothesis: *Increase in the number of large pieces and densities of wood will improve Chinook, coho and steelhead yearling and subyearling survival during rearing and migration in the lower river.*

Strategy Chem7: Add large wood in the form of rootwads, log jams, single key pieces, and similar structure that mimic natural functions provided by embedded and dynamic wood clusters.

Strategy Chem8: Develop City policy to retain existing wood in and along the river.

Strategy Chem9: Increase the density of woody vegetation in riparian and floodplain areas to provide long-term source material. Focus Revegetation Program efforts in riparian and floodplain areas along the river.

Strategy Chem10: Enforce City land use protection codes that impact riparian and floodplain areas.

Reduce Chemical Contamination - Pollutants introduced through industrial discharges, toxics carried by stormwater, and other sources have contributed to elevated levels of many urban pollutants. Preliminary assessments indicate that DDT, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals are some of the key risk drivers in lower Willamette River sediment.

Hypothesis: *Reducing levels of key ecological risk drivers will improve Chinook, coho and steelhead yearling and subyearling survival during rearing and migration in the lower river.*

Strategy Chem1: Implement the source identification and control strategies identified through Portland Harbor Superfund efforts. Implement measures identified through the City of Portland Outfall Pilot Project and expand pilot to other high priority outfalls throughout Portland Harbor.

Strategy Chem2: Remediate sediment hot spots presenting significant ecological risks according to strategies identified through the Portland Harbor Sediment Management Plan. Continue existing efforts in site discovery, remedial actions/feasibility studies, and remedial actions.

Strategy Chem3: Implement TMDL provision to or reduce localized and system-wide sediment and toxic chemical sources.

Strategy Chem4: Implement City's Stormwater Management Manual and Stormwater Program Best Management Practices.

Strategy Chem5: Implement CSO control strategies to reduce combined sewer overflows to the river.

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APPENDIX K

Draft EDT Assessment of Aquatic Habitat in the McKenzie Subbasin

Organization of the Analysis

McKenzie Subbasin Information Sources

A McKenzie Watershed Council technical team, with advice from federal and state biologists who are familiar with the Subbasin, developed information for the McKenzie River EDT analysis. The team summarized information from existing sources to describe the current state of knowledge on conditions in the McKenzie Subbasin. Attribute ratings were based on historical and current conditions, including riparian and aquatic habitat, water quality, hydrologic regime, fish passage, and biological characteristics. Key assumptions underlying the ratings are described below for each of the geographic areas.

Willamette River Information Sources

The purpose of the EDT assessment of the Willamette River above the falls was to allow detailed analysis of the McKenzie River spring Chinook salmon population. Because of the provisional nature of the EDT analysis to date, we calibrated the juvenile survival rate calculated in EDT to an estimate of the survival rate. Oregon Department of Fish and Game (ODFW) estimated survival of yearling spring Chinook from Eugene to Willamette Falls for the years 1999-2001 using PIT tags. The ODFW estimate of spring Chinook survival over that period averaged 48 percent for wild migrants and 17 percent for hatchery migrants (K. Kenaston, ODFW, personal communication, 2004). We calibrated the EDT calculated survival from Eugene to the falls to the ODFW estimate of survival for wild migrants. Because the resulting analysis is based on the reach level EDT estimate of Chinook life stage survival, the resulting survival from Eugene to the falls is shaped by the underlying environmental conditions. As a result, although the conditions are as yet imperfectly captured, the analysis does provide initial insights into the effect of Willamette River conditions on spring Chinook potential in the McKenzie River.

Three significant limitations in the EDT analysis of the Willamette River should be addressed in future work. The first limitation is the need for an improved environmental description discussed above. A second limitation that should be addressed is the need to include additional habitat types and species rules to account for the complexity of the large river environment in the Willamette River. EDT is based on the existing scientific literature regarding salmonid-habitat relationships. The great bulk of that literature focuses on “wadeable” streams where observations and data collection is relatively easy. Large river habitats for salmon have not been extensively studied not only because of the difficulties in studying these environments but also because large rivers are often viewed as simple migration corridors rather than complex spawning and rearing areas. Habitat types developed for smaller streams (e.g. Hawkins and others 1993) may be inadequate depictions of large river habitats. The meandering Willamette River channel represents considerable habitat complexity. For a complete analysis, these habitats will need to be described and incorporated into EDT.

A third point that needs to be addressed in future work is the use of off channel habitat in large rivers as over-winter habitat by juvenile spring Chinook salmon. Reflecting most scientific accounts, the habitat rating rules in EDT do not allow the use of off channel habitats by juvenile Chinook salmon although they are used in the model as key winter habitat for juvenile coho salmon. However, there is increasing evidence and reports of off channel habitats in the Willamette River by juvenile spring Chinook salmon. Future work will explore the need for improved habitat rating rules for spring Chinook salmon in large river-floodplain systems like the Willamette River.

Scenario Development

Two scenarios were described by the technical team. First, the current conditions were described based on existing empirical and expert knowledge regarding physical and biological conditions in the McKenzie Subbasin. Second, a reference or template condition was described. This reference condition defined a fully restored condition for the McKenzie River, tributaries, and the downstream reaches of the Willamette River. A third scenario that is contained within the EDT model describes a fully degraded condition for the system. Placing the current condition between these two “bookends” allowed us to define good and bad conditions and to analyze how the McKenzie Subbasin and downstream Willamette River reaches function in terms of the spring Chinook salmon population.

Reach Structure and Geographic Areas

The EDT assessment of the McKenzie Subbasin and the Willamette River was organized hierarchically. At the finest scale, information was developed for stream reaches that described the physical and biological environment of the stream. The technical team defined reaches based on geomorphic and land use criteria and known spring Chinook salmon spawning and rearing areas in the river and tributaries. In some portions of the watershed, the team used reaches that had been defined for other stream surveys especially those conducted in the watershed by the Oregon Department of Fish and Game as part of their Aquatic Inventory Project (Moore and others 1997). The McKenzie River, tributary streams, and fish passage obstructions (Dams, culverts, etc.) were divided into 276 reaches (see Map 2, *McKenzie Subbasin Reach and Geographic Area Structure*).

Reaches were grouped into 14 geographic areas (Table 1) throughout the McKenzie Subbasin and the downstream reaches of the Willamette River. The geographic areas were delineated to reflect Subbasin function (e.g., dominate hydrologic regime), key spring Chinook salmon habitat areas (e.g., tributaries and the mainstem) and land use management (e.g., Upper Subbasin is primarily in federal lands and Lower Subbasin dominated by private lands). Stream reaches for the EDT assessment also included obstruction reaches. In EDT an obstruction such as culvert or dam is treated as a reach and hydrologically routed to other reaches. Each obstruction is rated as to its impediment to upstream or downstream movement of adult and juvenile fish.

Table 1. Structure of the McKenzie Subbasin EDT geographic areas.

Section	Geographic Area	Description
McKenzie Subbasin	**Upper McKenzie River**	The mainstem upstream of Quartz Creek (RM 54) to the end of historical salmon spawning habitat
	Upper McKenzie River Tributaries	Horse Creek, Lost Creek, and other tributaries that have historical Chinook salmon spawning at Tamolitch Falls (RM 85)
	South Fork McKenzie River	S.F. and larger tributaries (French Pete, Roaring River and others)
	Blue River	Blue River and key tributaries
	Lower McKenzie River	The mainstem from the Willamette River to Quartz Creek to the end of historical salmon spawning at
	Lower McKenzie River Tributaries	Larger tributaries (Cedar, Gate, and Martin and others) up to and including Quartz Creek
	Mohawk Subbasin	Mohawk River, Mill Creek, and other larger tributaries
Willamette River	**Eugene**	From the confluence with the McKenzie River to the confluence with the Santiam and Luckiamute Rivers
	Salem	Mainstem from the confluence with the Santiam / Luckiamute Rivers to the confluence with the Yamhill River
	Newberg	Mainstem from the confluence with the Yamhill River to Willamette Falls
	Portland	Willamette Falls to the confluence with the Columbia River

Focal Species and Populations

The focal species for the assessment was chosen to characterize the environment and to capture habitat issues of concern to managers. The McKenzie River spring Chinook salmon population was used in the EDT assessment of the McKenzie Subbasin. Bull trout, cutthroat trout, and Oregon chub are also focal species present in the McKenzie Subbasin. These species were not analyzed through the EDT process.

Ecosystem Diagnosis and Treatment Results

Overview

EDT assesses habitat in terms of four output parameters:

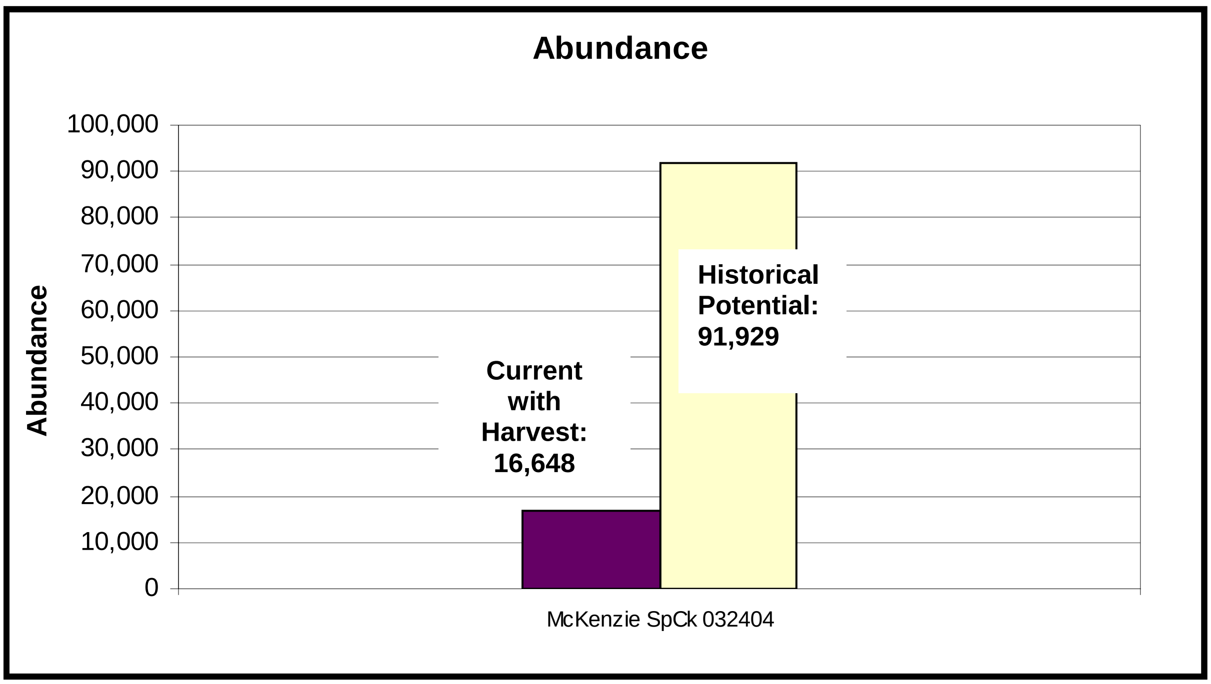
1. Biological capacity (quantity of habitat)
2. Biological productivity (quality of habitat)

3. Equilibrium abundance (quantity and quality of habitat)
4. Life history diversity (breadth of suitable habitat)

Population Potential

Population potential provides an assessment of the "size" and quality of the McKenzie River spring Chinook salmon population. Figure 1 compares the estimated current abundance potential to the abundance potential of the habitat under the reference or template condition. Note that this is an index of habitat potential and that the actual abundance of fish observed in the McKenzie River will vary greatly from year to year as a result of factors within and outside the subbasin, especially variation in ocean conditions. For the McKenzie River spring Chinook salmon population, the current potential is about 18 percent of that under the reference habitat conditions. The percent change is a measure of the overall degradation of habitat conditions in the McKenzie Subbasin, primarily as a result of anthropogenic changes to the habitat in the McKenzie River, the South Fork McKenzie River, larger spawning tributaries, and the lower Willamette River.

Figure 1. Estimated fish abundance potential as a function of habitat in the current and reference conditions for the McKenzie River spring Chinook population.



Parameters for McKenzie spring Chinook salmon population is provided in Table 2. Capacity and productivity are parameters of a Beverton-Holt production function; abundance is calculated from this relationship. Life history diversity is listed as a Diversity Index that is the percentage of viable trajectories sustainable under the current condition relative to the reference condition.

Table 2. Population parameters for McKenzie River spring Chinook salmon estimated as a function of habitat.

Scenario	Capacity	Productivity[1]	Abundance[2]	Diversity Index[3]
Current with harvest	18,914	8.3	16,648	68%
Reference (template condition)	95,179	29.3	91,929	97%

Relative Importance of Geographic Areas For Protection And Restoration Measures

The results of the EDT reach analysis were aggregated to provide an estimate of the changes in the McKenzie River spring Chinook salmon population abundance, productivity, and diversity for each of the eleven geographic areas (Table 3). Figure 2 illustrates the changes in the population attributes for the geographic areas within the McKenzie Subbasin the Willamette River.

The changes in McKenzie spring Chinook salmon population attributes provide an estimate of the relative importance of the geographic areas for habitat protection and restoration measures (Table 3, Figure 2). The geographic areas priorities are based on 1) an estimate in the changes in spring Chinook salmon population abundance, productivity, and diversity at each life stage under conditions of habitat degradation from the current state (protection benefit) and habitat restoration to the historical potential (restoration benefit) and 2) the extent to which the geographic area is used by each of the life stages.

Table 3. An estimate of the changes in the McKenzie River spring Chinook salmon population abundance, productivity, and diversity for each of the geographic areas. The estimates are based on the EDT analysis.

Geographic Area	Restoration Rank	Percent Change With Restoration		
		Abundance	Productivity	Diversity
Lower McKenzie River	1	86%	52%	1%
South Fork McKenzie R. Subbasin	1	20%	13%	15%
Upper McKenzie River	2	22%	19%	3%
Willamette River, Eugene Reach	3	14%	9%	1%
Willamette River, Portland Reach	4	12%	11%	0%
Blue River Subbasin	5	5%	1%	8%
Willamette River, Salem Reach	6	8%	6%	0%
Upper McKenzie River Tributaries	7	7%	8%	0%
Mohawk River Subbasin	8	1%	0%	7%
Willamette River, Newberg Reach	9	6%	5%	0%
Lower McKenzie River Tributaries	10	1%	1%	0%

[1] Productivity is the density independent survival rate in a Beverton-Holt production function measured as return / spawner.

[2] Abundance is the equilibrium abundance in a Beverton-Holt production function.

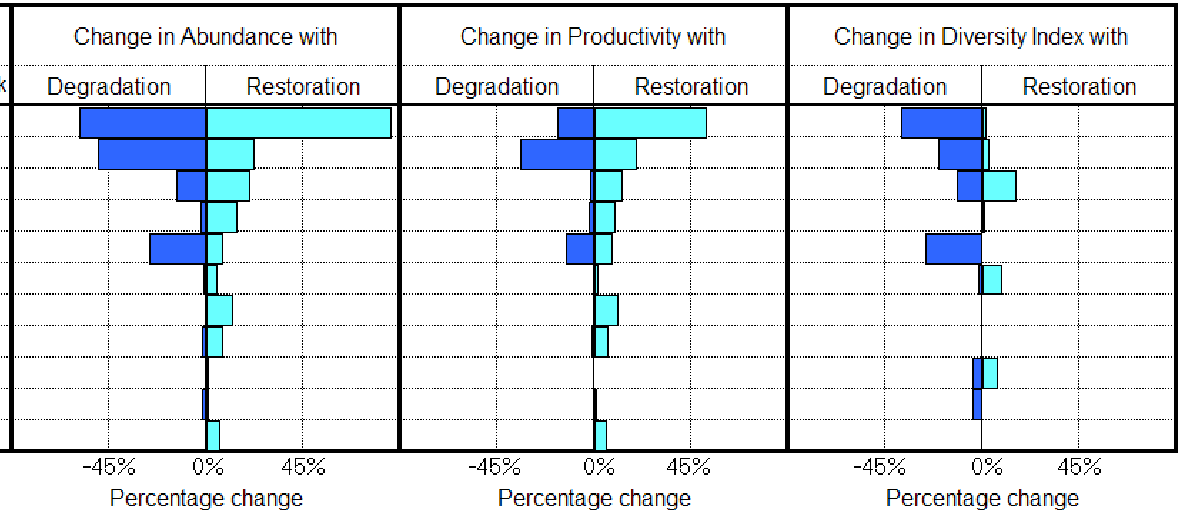
[3] Diversity index is the percentage of sustainable life history trajectories in the current condition relative to the reference condition.

Figure 2. Relative importance of the EDT analysis geographic areas for protection and restoration measures for the McKenzie River spring Chinook salmon population.

McKenzie Spring Chinook

Relative Importance Of Geographic Areas For Protection and Restoration Measures

Geographic Area	Protection benefit Category/rank		Restoration benefit Category/rank	
Lower McKenzie River	A	1	A	1
Upper McKenzie River	B	2	B	2
South Fork McKenzie River Watershed	C	4	A	1
Eugene	C	5	B	3
Upper Watershed Tributary	B	3	D	7
Blue River Watershed	E	8	C	5
Portland	E	9	C	4
Salem	E	8	D	6
Mohawk Watershed	D	7	E	8
Lower Watershed Tributary	D	6	E	10
Newberg	E	9	E	9



Based on this analysis, the Lower McKenzie River has the highest protection and restoration benefits (protection rank = 1, restoration rank = 1). All of the spring Chinook salmon population (as adults and juveniles) migrates through the Lower McKenzie River and it provides important habitats for juvenile rearing. While there have been significant losses of habitat within the Lower McKenzie River (documented below), there are still some high quality aquatic and floodplain habitats remaining. The South Fork McKenzie Watershed is also ranked as the highest restoration benefit priority (rank = 1) and a moderately high protection benefit priority (rank = 4). Cougar Dam on the South Fork has resulted in significant loss access to historically productive spring Chinook salmon habitat. The South Fork's protection benefits are due to the
large amounts of high quality habitat remaining above the dam. In contrast to the other parts of the Subbasin, the Lower McKenzie River Tributaries were ranked last for restoration benefit (rank = 10) and near the bottom for protection benefit (rank = 6). There is almost no spring Chinook salmon spawning in the Lower McKenzie River tributaries and use by juveniles is confined to refuge habitat in the lower portions of the streams (e.g., lower Cedar Creek).

The following sections provide an explanation for the relative protection and restoration benefits for each of the McKenzie River spring Chinook salmon population geographic areas.

Attributes Limiting the Spring Chinook Salmon Population

The EDT analysis of habitat, water quality, fish passage and other attributes influencing McKenzie River spring Chinook salmon provides a description of the factors limiting the population and the relative importance of the geographic areas for habitat improvement. This information is useful for developing habitat restoration strategies. Figure 3 provides an overview of the EDT attribute classes and relative influence (high, medium, or low) on limiting spring Chinook salmon population abundance, productivity, and diversity in each of the geographic areas.

Several EDT attribute classes have a disproportionate affect on McKenzie River spring Chinook salmon populations. Obstructions to fish passage have the greatest impact on the distribution and productivity of spring Chinook salmon in the Subbasin. Dams on the Upper McKenzie River, South Fork, and Blue River restrict access to large amounts of historical habitat. To a lesser degree, culverts and other fish passage obstructions limit the population in the Mohawk Watershed. Altered habitat diversity (channel confinement, riparian function, wood in the channel, and other attributes) has affected all of the spring Chinook salmon life stages in the geographic areas, with larger impacts in the Blue River Watershed, Lower McKenzie River, Lower Subbasin Tributaries, and Mohawk Watershed. Key habitat quality also has a dominant impact on the population. Habitats that affect spawning (e.g., coarsening of channel substrate) and juveniles (e.g., loss of backwater habitats) impact most geographic areas, particularly in the South Fork McKenzie, Lower McKenzie River, and Mohawk Watershed.

Figure 3. EDT analysis of aquatic and riparian protection and restoration priorities by attribute class for the McKenzie River spring Chinook salmon population. The relative protection and restoration benefit ranking for spring Chinook salmon should be used to weight the priority restoration attribute ratings for each geographic area. For example, while obstructions have a large impact in the Mohawk Watershed, there is very little relative restoration benefit to spring Chinook salmon populations because very few fish historically spawned in the Watershed.

McKenzie Spring Chinook
Protection and Restoration Strategic Priority Summary

Geographic area priority			Attribute class priority for restoration															
Geographic area	**Protection benefit**	**Restoration benefit**	*Channel stability/landsc.1/*	*Chemicals*	*Competition (w/ hatch)*	*Competition (other sp)*	*Flow*	*Food*	*Habitat diversity*	*Harassment/poaching*	*Obstructions*	*Oxygen*	*Pathogens*	*Predation*	*Sediment load*	*Temperature*	*Withdrawals*	*Key habitat quantity*
Upper McKenzie River	○	○						•	•		⬤				•			•
Upper Watershed Tributary	○							•	•									•
South Fork McKenzie River Watershed	∘	◯						•	•		●				•			●
Blue River Watershed		∘	•				•	•	●		⬤				●	•		
Lower McKenzie River	◯	◯	•				•	•	●	•						•		●
Lower Watershed Tributary			•				•	•	●							•		•
Mohawk Watershed			•		•		•	•	●		⬤				●	●		●
Eugene	∘	○			•		•	•	•				•	•		•		•
Salem									•					•		•		
Newberg				●					•					•				
Portland		∘		●					•					•				•

1/ "Channel stability" applies to freshwater areas; "channel landscape" applies to estuarine areas.

Key to strategic priority (corresponding Benefit Category letter also shown)

A		B		C		D & E	
◯ / ⬤	High	○ / ●	Medium	∘ / •	Low	(blank)	Indirect or General

Habitat Priorities by Area: McKenzie Subbasin EDT Geographic Area Descriptions

The following sections provide specific information on the key EDT attribute classes affecting the McKenzie River spring Chinook salmon population in each of the geographic areas. Information on habitat quality and other factors that were used to develop the SRE attribute ratings are outlined.

Upper McKenzie River

Protection benefit rank: 2
Restoration benefit rank: 2

The Upper McKenzie River Geographic Area encompasses the mainstem of the river from Quartz Creek (RM 54) to the end of historical Chinook distribution at Tamolitch Falls (RM 85). The Willamette National Forest manages most of the upper Subbasin. EWEB manages Trail Bridge (RM 82) and Carmen (RM 88) Dams and reservoirs on the Upper McKenzie River. Highway 126 follows the course of the river, often paralleling the channel. Historically, the Upper McKenzie River provided very productive spring Chinook salmon spawning and rearing habitat.

The EDT analysis for the Upper McKenzie River and individual reaches provides a rating of the relative restoration priorities for the attribute classes. In comparison to the other attribute classes, fish passage obstruction at Trail Bridge Dam, which limits access to high quality spawning and rearing habitat, has the largest impact on spring Chinook salmon populations. In addition, habitat diversity and key habitat quality for a range of life stages have a secondary impact on salmon populations in this portion of the Subbasin. Food sources and sediment load also have some impact. Alterations to food sources are primarily due to reductions in salmon carcasses from historical abundance, which limits nutrients contributing to juvenile salmon survival. Sediment load has increased in some reaches due to fine sediment delivery from roads and other management changes.

Most vulnerable life stages and life history strategies (e.g., habitat preferences) in the Upper McKenzie River include: spawning, pre-spawn holding, egg incubation, fry colonization, and juvenile rearing (winter and summer).

Obstructions

At the upper end of the mainstem McKenzie River, EWEB's Trail Bridge dam exclude spring Chinook salmon from approximately 4 miles of their historical range in the upper river and 3 miles in the Smith River.

Obstructions have has an extreme impact on the spawning life stage.

<u>Spawning</u> – Loss of access to the upper McKenzie River due to Trail Bridge Dam has had an extreme impact on the spring Chinook salmon spawning life stage.

Habitat Diversity

Habitat diversity in the Upper McKenzie River has been changed though actions that have confined the channel, modified riparian conditions, and limited wood in the channel.

Portions of the upper river are constricted by Hwy 126 and confined by riprap, particularly in the vicinity of McKenzie Bridge (RM 69). Between Rainbow Bridge (RM 53) and Finn Rock (RM 54) the river's channel has straightened (Minear 1994).

There has been extensive modification of riparian areas in the Upper McKenzie River. The percentage of mature conifers in riparian areas in the reach between Trail Bridge Dam and Belknap Springs decreased from 62% to 39% between 1949 and 1986 (Minear 1994). In addition, the proximity of Highway 126 to sections of the river has limited riparian vegetation. Between Rainbow Bridge and the confluence with the South Fork (RM 49) the percentage of mature conifers declined from 53% to 17%, while the percentage of second-growth conifers increased. Below the confluence with the South Fork McKenzie to Quartz Creek, the valley is very wide, and much of the riparian vegetation (including that on islands) was logged in the late 1950s (Minear 1994).

Changes in riparian condition along the Upper McKenzie River and changes in processes below the dams have affected the delivery of large wood. All of the large wood discharged from the Smith River, Bunchgrass Creek, and other upper tributaries is captured in Carmen, Smith, or Trail Bridge reservoirs, depriving the McKenzie River below the dams of large wood. In the reach above Trail Bridge Dam there are fewer than 7 pieces of large wood (>24 inches in diameter) per mile, far below the historical potential (McKenize Ranger District 2004). Large wood was removed from the mainstem McKenzie between Trailbridge Dam and Belknap Springs after the 1964 and 1972 floods in an effort to improve aquatic habitat and wood continues to be removed by recreational boaters (WNF MRD 1995). Large wood is also retained behind Cougar and Blue River Dams, impacting wood deposition in downstream reaches.

Changes in habitat diversity in the Upper McKenzie River have had moderate to high impacts on the following life stages: Pre-spawn holding; fry colonization; 0-age active rearing and migrant; 1-age active rearing and migrant.

<u>Pre-spawn Holding</u> – Loss of cover over deep pools has affected the quality of habitat for pre-spawning spring Chinook salmon that are holding in Upper McKenzie River pools.

<u>Fry Colonization</u> – The amounts and distribution of stable gravels and slow velocity water has been modified in the Upper McKenzie River which impacts fry colonization.

<u>Juvenile Rearing and Migrant</u> – Juvenile rearing and migration habitats have been affected by limited large wood and associated reductions in slow velocity areas and pool cover.

Key Habitat Quantity

There have been a number of changes to the quantity and distribution of key habitats that affect the expression of spring Chinook life stages in the Upper McKenzie River. Channel areas with gravels and small cobbles provide key spring Chinook salmon spawning habitats; pools and backwater areas provide important habitats for juvenile rearing.

Throughout most of the upper McKenzie River large wood levels have decreased, contributing to loss of pool habitats, and reduction in gravel deposition areas. In addition to limiting delivery of wood to downstream reaches, the dams have also retained gravels and other substrate. Pool habitat has declined and bedload size has increased in the reaches below Trail Bridge Dam (Minear 1994, Sedell et al. 1992).

Changes in key habitat quantity in the Upper McKenzie River have had moderate to high impacts on the following life stages: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.

Pre-spawn Holding – Loss of cover over deep pools has affected the quantity of habitat for pre-spawning spring Chinook salmon that are holding in Upper McKenzie River pools.

Juvenile Rearing and Migrant – The quantity of juvenile rearing habitats have been affected by reductions in large wood levels and associated changes in slow velocity areas and pool cover.

Habitat Protection Benefits

In addition to the restoration benefits in the Upper McKenzie River, the area retains high quality habitats that offer protection benefits. For instance, between Belknap Springs (RM 75) and Rainbow Bridge, riparian vegetation had changed little form 1949 (Minear 1994). There are high quality riparian and channel habitats in the dynamic delta areas where Horse Creek and the South Fork join the McKenzie River. An extensive alluvial fan and broad floodplain at the mouth of Horse Creek, for example, provides very complex habitat for spring Chinook salmon spawning and rearing.

Upper McKenzie River Tributaries

Protection benefit rank: 3
Restoration benefit rank: 7

The Upper McKenzie River Tributaries Geographic Area includes Smith River, Deer, Horse and Lost Creeks. Both Lost and Horse Creek have spawning reaches. The Willamette National Forest manages most of the land area encompassed by the upper river tributaries. EWEB manages Smith Dam on the Smith River, which drains into Trail Bridge Reservoir. Historically, Horse Creek was the most productive tributary for spring Chinook salmon in the McKenzie Subbasin.

The EDT analysis for the Upper McKenzie River Tributaries and individual reaches provides a rating of the relative restoration priorities for attribute classes. Changes in habitat diversity and key habitat quality have had some impact on spring Chinook salmon populations. Changes in food sources also have some impact. Alterations to food sources are primarily due to reductions in salmon carcasses from historical abundance, which limits nutrients contributing to the juvenile food supply.

Habitat Diversity

Habitat diversity in the Upper McKenzie River Tributaries has been changed though actions that modified riparian conditions and limited wood in the channel. Following the 1964 flood, the Willamette National Forest and the Oregon Department of Fish and Wildlife installed rip-rap along the lower reach of Horse Creek and removed large wood from a number of reaches. The 1996 flood and stream restoration activities in the early 1990s have restored some of the large wood in the drainage, and the relatively undisturbed, mature riparian areas in the Horse Creek drainage are capable of recruiting large wood (WNF MRD 1997). Riparian vegetation along Deer Creek has been altered, reducing canopy cover and increasing water temperatures. Alterations in habitat diversity have primarily affected juvenile rearing and migrant life stages.

Changes in habitat diversity in the Upper McKenzie River Tributaries have had moderate impacts on the following life stages: Pre-spawn holding and spawning; 0-age active rearing and migrant; and 1-age active rearing and migrant.

Pre-spawn Holding – Loss of cover over deep pools has affected the quality of habitat for pre-spawning spring Chinook salmon that are holding in Upper McKenzie River Tributary pools.

Juvenile Rearing and Migrant – Juvenile rearing habitats have been affected by reductions in large wood and associated slow velocity areas and pool cover.

Key Habitat Quantity

There have been some changes to the extent and distribution f key habitats that affect spring Chinook salmon life stages in the Upper McKenzie River Tributaries. Channel areas with gravels and small cobbles provide key spring Chinook salmon spawning habitats; pools and backwater areas provide important habitats for juvenile rearing.

In some tributary reaches large wood levels have decreased, contributing to loss of pool habitats, and reduction in gravel deposition areas. Since the 1937 habitat surveys, there has bee a 38% decrease in large pools in lower Horse Creek. Similar loss of large wood and pools has occurred in Deer Creek and the lower portions other tributaries. Loss of large wood form the channels has probably contributed to reduced retention of gravels and small cobbles that form spawning habitat.

Changes in habitat quality in the Upper McKenzie River Tributaries have had low to moderate impacts on the following life stages: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.

Pre-spawn Holding – Loss of cover over deep pools has affected the quantity of habitat for pre-spawning spring Chinook salmon that are holding in Upper McKenzie River Tributary pools.

Juvenile Rearing and Migrant – The quantity of juvenile rearing habitats have been affected by reductions large wood and associated slow velocity areas and pool cover.

Habitat Protection Benefits

Riparian vegetation in most tributaries to the upper McKenzie River includes a high percentage of old-growth conifers, ranging from 45% to 59% of the landscape (WNF BRRD 1995). Horse Creek is one of the largest undammed tributaries in the Subbasin, and plays a vital role in recruitment of sediment and large wood into the McKenzie River; Horse Creek provides valuable holding and spawning habitat for spring Chinook salmon. Most riparian areas within the Horse Creek drainage are relatively undisturbed by human activities. An extensive alluvial fan and broad floodplain has formed in Horse Creek just above its confluence with the McKenzie River, which provides very complex habitat for rearing and spawning Chinook salmon. Actions taken after the 1996 flood and other stream restoration activities in the early have restored some of the large wood in the Horse Creek drainage, and the relatively undisturbed, mature riparian areas in the drainage are capable of recruiting large wood (WNF MRD 1997).

South Fork McKenzie River

Protection benefit rank: 4
Restoration benefit rank: 1

The South Fork McKenzie River Geographic Area includes the South Fork from the confluence with the McKenzie River to the headwaters in the Three Sisters Wilderness Area. Cougar Dam at RM 4.5 prevents access by adult spring Chinook migrants into the upper river reaches and tributaries. Key tributaries include French Pete, and Augusta Creek, and the Roaring River. The Willamette National Forest manages the land area encompassed by the South Fork river tributaries. USACE manages Cougar Dam and reservoir. The South Fork McKenzie River and tributaries were historically important spring Chinook spawning areas. Currently, the lower 4.5 miles of the South Fork below Cougar Dam provides important spawning habitat.

The EDT analysis for the South Fork McKenzie River Geographic Area and individual reaches provides a rating of the relative restoration priorities for the attribute classes. In comparison to the other attribute classes impacting spring Chinook abundance, productivity and diversity, Cougar Dam, which limits access to high quality spawning and rearing habitat, has the largest impact on spring Chinook salmon populations. In addition, habitat diversity and key habitat quality for a range of life stages have a secondary impact on salmon populations in this portion of the Subbasin. Habitat diversity and key habitats are impacted above and below Cougar Dam. Food sources and sediment load also have some impact. Alterations to food sources are primarily due to reductions in salmon carcasses from historical abundance, which limits nutrients contributing to juvenile salmon survival. Sediment load has increased in some reaches due to fine sediment delivery from roads and other management changes.

In addition to the attributes highlighted in the EDT analysis that affect spring Chinook salmon populations, changes in the water temperature regime below Cougar Dam have had extreme impacts on spring Chinook spawning activity and the timing of egg emergence.

Obstructions

Construction of Cougar Dam at RM 4.5 on the South Fork McKenzie River in 1963 blocked access to at least 25 miles of high quality spawning habitat. The South Fork was generally considered to be the best spring Chinook production area in the McKenzie Basin (USFWS 1948). In 1956, 805 redds were observed in the South Fork (Willis et al. 1960). Although Cougar Dam was built with fish passage facilities, these did not function as intended and were no longer used for this function after 1966. Loss of access to the upper South Fork

McKenzie River and tributaries has had an extreme impact the spring Chinook salmon spawning life stage.

Spawning – Loss of access to the upper South Fork McKenzie River due to Cougar Dam has had an extreme impact on the spring Chinook salmon spawning life stage.

Water Temperatures

Changes in water temperature regimes below Cougar Dam have had extreme impacts on the spring Chinook salmon population. Cooler water temperatures in the late spring and summer have probably impeded the upstream migration of spring Chinook salmon compared to the predevelopment condition. Warmer fall and winter temperatures accelerate egg incubation and the timing of fry emergence. These factors may subject Chinook fry to unfavorable conditions, such as high flows and scarce food, leading to poor survival. The apparent shift to later spawn timing could be a result of environmental conditions favoring late-emerging fry (Homolka and Downey 1995).

The USACE is modifying the intake structure on Cougar Dam to allow the water released below the dam to be drawn from different depths (i.e., temperature strata) in the forebay. After construction, the USACE plans to operate the project to restore stream temperatures in the South Fork McKenzie and to partially restore pre-project temperatures in the mainstem McKenzie River.

Changes in water temperature regimes in the South Fork McKenzie River below Cougar Dam had extreme impacts on the following life stages: Pre-spawn holding and spawning; egg incubation; and fry colonization.

Pre-spawn Holding – Cooler water temperatures below Cougar Dam in the late spring and summer have probably impeded the upstream migration of spring Chinook salmon.

Egg Incubation – Warmer fall and winter temperatures below Cougar Dam accelerate egg incubation.

Fry Colonization – Warmer fall and winter temperatures below Cougar Dam accelerate timing of fry emergence, subjecting fry to high winter river flow velocities and reduced survival.

Habitat Diversity

Modified riparian conditions and reductions in large wood in channels have modified habitat diversity in the South Fork McKenzie River and tributaries. In the drainage, 38% of riparian areas are late successional, 37% mature, 11% young, and 5% early (WNF BRRD 1995). Cougar Reservoir inundated 200 acres of riparian hardwoods along the South Fork McKenzie and its tributaries (BPA 1985). Inventories indicate that most tributaries in the upper South Fork do not meet their target level of 80 pieces (greater than 24 inches diameter) per mile, but portions of the Roaring River, East Fork South Fork, and Elk, Augusta, Boone, and Hardy Creek drainages have reaches that approach or exceed these objectives (WNF 1995). The upper mainstem South Fork and the East Fork South Fork have the highest large wood delivery potential in the South Fork drainage. Large wood was removed between 1964 and the early 1980s in the South Fork above Cougar Dam (WNF BRRD 1994). Because Cougar Reservoir retains large wood delivered from the upper South Fork McKenzie River and tributaries, there is very little large wood in the reaches below the dam.

Changes in habitat diversity in the South Fork McKenzie River and tributaries have had moderate to extreme impacts on the following life stages: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.

<u>Pre-spawn Holding</u> – Loss of cover over deep pools has affected the quantity of habitat for pre-spawning spring Chinook salmon that are holding in South Fork McKenzie River pools.

<u>Juvenile Rearing and Migrant</u> – The quantity of juvenile rearing habitats have been affected by reductions large wood and associated changes in slow velocity areas and pool cover in the South Fork McKenzie River.

Key Habitat Quantity

Key habitats that affect spring Chinook life stages in the South Fork McKenzie River and Tributaries have been modified and reduced in extent. Channel areas with gravels and small cobbles provide key spring Chinook salmon spawning habitats; pools and backwater areas provide important habitats for juvenile rearing.

Large wood removal between 1964 and the early 1980s reduced large wood in the South Fork above Cougar Dam, causing the river to abandon side channels and simplify (WNF BRRD 1994). New side channels probably will not form without supplementation with large wood. Pool habitat in the mainstem South Fork decreased from 1937 to 1938 levels by 60% to 90%, with the greatest-reductions occurring upstream of French Pete Creek.

Cougar Dam has reduced the delivery of large wood and spawning substrate to downstream reaches. The South Fork McKenzie River downstream from Cougar Dam, an important spawning and rearing area for spring Chinook salmon, has experienced reductions in gravels and small cobbles suitable for spawning and rearing habitats. In areas downstream of the dam, the area of exposed gravel and cobble bars decreased by 43% following the 1964 flood, and the channel has downcut and become armored and there has been a loss of side channels (WNF BRRD 1994). Riparian vegetation is now colonizing gravel bars along the lower South Fork below Cougar Dam, which are associated with secondary channels that, before project construction, were frequently inundated and reworked by the river during high-flow events (WNF BRRD 1994). There is very little large wood in the channel below the dam, which has affected pool depth and cover and the retention of spawning gravels (WNF BRRD 1994).

Modified key habitats in the South Fork McKenzie River and tributaries have had moderate to extreme impacts on the following life stages: Spawning; fry colonization; 0-age active rearing and migrant; and 1-age active rearing and migrant.

<u>Spawning</u> – Retention by the dam and loss of large wood has affected the quantity of spawning gravels which has affected spawning habitat in South Fork McKenzie River.

Fry Colonization – The amounts and distribution of stable gravels and slow velocity water has been modified in portions of the South Fork McKenzie River which impacts fry colonization.

Juvenile Rearing and Migrant – The quantity of juvenile rearing habitats have been affected by reductions in slow velocity areas and pool cover.

Habitat Protection Benefits

Large portions of the South Fork McKenzie River Geographic Area are protected within the Three Sisters Wilderness. A large proportion of the riparian areas outside of the wilderness designation are in old-growth or mature conifer conditions.

Blue River Watershed

Protection benefit rank: 8
Restoration benefit rank: 5

The Blue River Watershed Geographic Area includes the mainstem of Blue River and tributaries. The Willamette National Forest manages most of the land area within the Blue River Subbasin. USACE manages Blue River Dam and reservoir. Historical spring Chinook salmon production was limited in Blue River because a waterfall blocked access to the Upper Subbasin.

The EDT analysis for the Blue River Watershed Geographic Area and individual reaches provides a rating of the relative restoration priorities for the attribute classes. In comparison to the other attribute classes impacting spring Chinook abundance, productivity and diversity, Blue River Dam, which limits access to spawning and rearing habitat, has the largest impact on spring Chinook salmon populations. In addition, habitat diversity, changes in the flow regime below the dam, channel stability (due to loss of large wood in the channel), and increased water temperatures have had secondary impacts on salmon populations in this portion of the Subbasin. Sediment load has increased in reaches below the dam and above the reservoir due to fine sediment delivery from roads and other management changes. Modified food sources have some impact. Alterations to food sources are primarily due to reductions in salmon carcasses from historical abundance, which limits nutrients contributing to juvenile salmon survival.

Obstructions

Blue River Dam was built without fish passage facilities. Before impoundment, 4.5 miles of Blue River were accessible to adult spring Chinook salmon, up to a 6- to 10-foot falls that was passable only under high spring flows (Wallis 1960). When Blue River Dam was built at RM 1.8, the falls were under water, but the dam itself blocked access to 2.7 miles of historical habitat below the falls.

Spawning – Loss of access to the upper Blue River due to Blue River Dam has had an extreme impact on the spring Chinook salmon spawning life stage.

Temperature

The Oregon DEQ database indicates that temperatures in the lower 1.8 miles of Blue River have exceeded maxima for salmonid spawning, incubation, and emergence.

Changes in the temperature regimes have impacted the following spring Chinook salmon life stages: Spawning; egg incubation and fry colonization.

Spawning – Cooler water temperatures below Blue River Dam in the late spring and summer have probably impeded the upstream migration of spring Chinook salmon and impacted spawning success.

Egg Incubation – Warmer fall and winter temperatures below Blue River Dam accelerate egg incubation.

Fry Colonization – Warmer fall and winter temperatures below Blue River Dam accelerate timing of fry emergence, subjecting fry to high winter river flow velocities and reduced survival.

Habitat Diversity

Modified riparian conditions and reductions in large wood in channels have modified habitat diversity in the Blue River and tributaries. Many of the tributaries have roads constructed adjacent to the stream, which has decreased streamside shading and modified both large wood and sediment delivery to the channels (WNF BRRD 1996). Through past practices, many streams were harvested down to the stream channel and had logs yarded up the middle of the channel, causing extensive erosion of the floodplain and riparian areas. Hardwoods instead of conifers now dominate riparian areas, and the percentage of early and young successional riparian areas in the Blue River drainage ranges from 29 to 48% (USACE 2002). A road that paralleling Blue River has reduced large wood input, channel-floodplain interactions, and stream shading in Blue River, which now has significantly less pool habitat and large wood than in 1937. Additionally, Blue River Reservoir inundated 975 acres of stream channels, riparian forest, and upland vegetation (BPA 1985). The reaches below Blue River Dam are deprived of large wood from the headwaters.

Altered habitat diversity in the Blue River has had moderate to extreme impacts on the following life stages: Spawning; fry colonization; 0-age active rearing and migrant; and 1-age active rearing and migrant.

Spawning – Reduced amounts of large wood and retention of substrate and wood behind Blue River Dam have affected the quality of spawning substrate.

Fry Colonization – The amounts and distribution of stable gravels and slow velocity water has been modified in the Blue River which impacts fry colonization.

Juvenile Rearing and Migrant – Juvenile rearing and migration habitats have been impacted by reductions in large wood and associated slow velocity areas and pool cover.

Lower McKenzie River

Protection benefit rank: 1
Restoration benefit rank: 1

The Lower McKenzie River Geographic Area encompasses the mainstem of the river from the confluence with the Willamette River to Quartz Creek (RM 54). The Bureau of Land Management manages scattered tracks along the Lower McKenzie River and tributaries. Almost all of the floodplain along the Lower McKenzie River is in private ownership. EWEB manages Leaburg Dam (RM 39), Leaburg Diversion Channel (RM 39 to RM 33) and Walterville Diversion Channel (RM 28 to RM 21). Historically, the Lower McKenzie River provided abundant rearing habitat for juveniles that moved into the lower river from the upper Subbasin spawning areas.

The EDT analysis for the Lower McKenzie River and individual reaches provides a rating of the relative restoration priorities for the attribute classes. Habitat diversity and key habitats have the largest impact on spring Chinook population abundance, productivity and diversity in the Lower McKenzie River. Alterations in channel stability, flow, food sources, harassment, and water temperatures have had secondary impacts on spring Chinook populations. Channel stability has been altered through loss of wood in the channel and reduced trees along the riverbank. Changes in flow, primarily due to management actions (e.g., rip-rap) confining the channel and reducing the amount of in low velocity habitats, have impacted fry colonization and rearing life stages. Food sources and sediment load also have some impact. Alterations to food sources are primarily due to reductions in salmon carcasses from historical abundance, which limits nutrients contributing to juvenile salmon survival. The popularity of the Lower McKenzie River for fishing and recreational boating, combined with loss of large wood that provides hiding cover for spring Chinook salmon, has resulted in increased harassment of pre-spawning adults. Changes in water temperature regimes in the Lower River impact spawning activity.

Habitat Diversity

Confinement of the channel, altered riparian conditions and reductions in large wood in the river has resulted in large changes to habitat diversity in the Lower McKenzie River.

Below Hendricks Bridge young hardwood trees between 15 and 39 years old are common within 500 feet of the river throughout most of the McKenzie, but hardwoods greater than 40 years old are scarce. MWC (2000) suggests that the flood of 1964 cleared much of the vegetation near the river, and the present-day stands are those that established on open surfaces created by the flood. Willows are found downstream of Hayden Bridge, and are more common than in 1944, as reduced peak flows have probably enabled willows to colonize gravel bars that historically would be inundated or re-shaped by high flows (MWC 2000).

Additional changes to floodplain and riparian vegetation include residential, recreational, and commercial development along Hwy 126 that has decreased the quantity and quality of riparian habitat along the north bank of the McKenzie River (MWC 1996). Historically, the riparian forest along the McKenzie was between 1,000 feet and 4,000 feet wide, but is now confined to a narrow band next to the river (MWC 2000).

The dams in the Upper McKenzie River Subbasin and other practices have altered the transport of large wood and spawning gravels into the Lower McKenzie River. The Trail Bridge complex in the upper McKenzie, and to a greater extent, Cougar Dam on the South Fork McKenzie and Blue River Dam on the Blue River, intercept large wood and sediment from 35% of the McKenzie's headwaters (USACE 2002). In addition it is common practice for landowners and recreational boaters to remove large wood from the channel for flood control, navigation purposes, or to sell marketable wood (Minear 1994).

Changes in habitat diversity in the Lower McKenzie River have had moderate to extreme impacts on the following life stages: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.

Pre-spawn Holding – Loss of cover over deep pools has affected the quality of habitat for pre-spawning spring Chinook salmon that are holding in Lower McKenzie River pools.

Juvenile Rearing and Migrant – Juvenile rearing and migration habitats have been affected by reductions in slow velocity areas due to limited amounts of large wood (particularly in large log jams), loss of side-channels and other backwater habitats, and actions (e.g., revetments) that have confined the channel.

Key Habitat Quantity

There have been substantial changes to quantity and distribution of key habitats that have impacted spring Chinook salmon life stages in the Lower McKenzie River. Changes to key habitats include limited channel areas with gravels and small cobbles that provide important spring Chinook salmon spawning habitats and reduced pools and backwater areas that provide important habitats for juvenile rearing.

Reductions in peak flows caused by flood control operations at Blue River and Cougar dams have contributed to the loss of habitat complexity in the McKenzie River by substantially reducing the magnitude of the channel-forming high flows (i.e., the 1.5- to 2-year flood) and greatly extending the return intervals of larger floods. Over time, flood control has altered channel complexity by reducing the frequency of side channels and recruitment of large wood to the channel. Side channels, backwaters, and large wood accumulations all provide slow water velocity habitats that are important for juvenile spring Chinook salmon rearing. The lack of channel-forming flows has also decreased the frequency with which floodplains are inundated, which decreases nutrient, organic matter, and sediment exchanges between the floodplain and the river and does not allow juvenile salmon access to flooplain refugia in high-water events.

Storage of sediment and woody debris behind the dams in the upper Subbasin has limited the quantity of suitable gravels and small cobbles for spawning. Armoring (the process of increasing the dominant substrate particle sizes) also reduces the availability of suitable spawning substrates. Channel armoring has been documented in the lower McKenzie

River (EA 1991, Minear 1994). Minear (1994) found that the percent of substrate particles larger than 150 mm increased from 56% during 1937 through 1938, to 75% in 1991, suggesting substrate coarsening.

Changes in flow regimes, sediment and large wood supplies, and channel confinement have all interacted to reduce key habitats in the Lower McKenzie River. Between 1930 and 1990, the river lost 53% of islands, 51% of island area, and 59% of island perimeter habitat in the reach between Deerhorn Park and the confluence with the Willamette River (USACE 2002). Between Hendricks Bridge and Hayden Bridge, side channels are much less abundant than in 1944, while alcoves have increased (MWC 2000). Sedell et al. (1991) report that the number of large pools in the lower McKenzie below Leaburg Dam decreased by 67% between 1938 and 1991.

Changes in key habitat quality in the Lower McKenzie River have had moderate to extreme impacts on the following life stages: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.

Pre-spawn Holding – Loss of cover over deep pools has affected the quantity of habitats available for pre-spawning spring Chinook salmon that are holding in Lower McKenzie River pools.

Juvenile Rearing and Migrant – The quantity of juvenile rearing and migration habitats has been reduced through loss of large wood (particularly large log jams), reduced side-channel area and other backwater habitats, and actions (e.g., revetments) that have confined the channel.

Habitat Protection Benefits

Although there has been significant loss of floodplain and channel habitats in the Lower McKenzie River, some high quality habitats remain. There are large remnants of floodplain forest and complex river channel habitats in the area near the confluence of the McKenzie and Willamette Rivers and on the edge of Springfield.

Lower Subbasin Tributaries

Protection benefit rank: 6
Restoration benefit rank: 10

The Lower McKenzie River Tributaries Geographic Area includes Quartz, Gate, Martin, Camp Cedar and other creeks. Gate Creek is the only Lower McKenzie River tributary with historical spawning reaches. Timber companies primarily own the forested upland areas along the tributaries. The Bureau of Land Management manages scattered tracks along Martin Creek, Bear Creek and other tributaries. Almost all of area where the tributaries flow through the McKenzie River floodplain is in private ownership. With the exception of Gate Creek, and to a lesser extent the lower portions of some other tributaries (e.g., Quartz Creek), there was historically little spring Chinook salmon production in the Lower McKenzie River Tributaries. The lower portions of these tributaries, however, do provide juvenile rearing and refuge habitat.

The EDT analysis for the Lower McKenzie River Tributaries and individual reaches provides a rating of the relative restoration priorities for attribute classes. Changes in habitat diversity and key habitat quality have had some impact on spring Chinook salmon populations in the tributaries. Alterations in channel stability, flow, food sources, and water temperatures have had secondary impacts on spring Chinook populations. Channel stability has been altered through loss of wood in the channel and trees along the riverbank. Changes in flow, primarily due to management actions (e.g., rip-rap) confining channels and reducing the amount of in low velocity habitats, have impacted fry colonization and rearing life stages. Alterations to food sources are primarily due to reductions in salmon carcasses from historical abundance, which limits nutrients contributing to juvenile salmon survival. High summer time water temperatures in most of the tributaries have affected the quality of aquatic habitat.

Habitat Diversity

Confinement of channels, altered riparian conditions and reductions in large wood in the river has resulted in large changes to habitat diversity in the Lower McKenzie River Tributaries.

Quartz Creek has relatively low levels of large wood and low large wood recruitment potential (MWC 2000; BLME 1995). None of the reaches of smaller tributaries of the lower McKenzie River have adequate large wood, and an estimated 58% of the riparian stands along these tributaries have inadequate near-term large wood recruitment potential (Weyerhaeuser 1994).

Changes in habitat diversity in the Lower McKenzie River Tributaries have had moderate impacts on the following life stages: 0-age active rearing and migrant; and 1-age active rearing and migrant.

<u>Juvenile Rearing and Migrant</u> – The quality of juvenile rearing habitats, particularly winter refuge habitats, have been affected by reductions in large wood and associated slow velocity areas and pool cover.

Key Habitat Quantity

There have been substantial changes to the quantity and distribution of key habitats the Lower McKenzie River Tributaries. Limited wood in stream channels has dramatically reduced the quantity and depth of pools. Pools and the cover provided by large wood provide important spring Chinook juvenile rearing habitat where the lower portions of the tributaries cross the McKenzie River floodplain.

Changes in key habitat quantity in the Lower McKenzie River Tributaries have had moderate impacts on the following life stages: 0-age active rearing and migrant; and 1-age active rearing and migrant.

<u>Juvenile Rearing and Migrant</u> – Juvenile rearing habitats, particularly winter refuge habitats have been affected by reductions in large wood and changes in the quality of associated slow velocity areas and pool cover.

Mohawk Subbasin

Protection benefit rank: 7
Restoration benefit rank: 8

The Mohawk Subbasin Geographic Area includes the Mohawk River and key tributaries, including Parsons, Cartwright, Shotgun and Mill Creeks. The upper Mohawk River and Mill Creek are the only areas with historical spawning reaches. Timber companies primarily own the forested upland areas along the tributaries and the upper river. The Bureau of Land Management manages tracks in the upper portions of the tributaries on the north side of the Subbasin. Almost all of area where the tributaries flow through the lower Mohawk River floodplain is in private ownership. Historically there was minimal spring Chinook salmon production in the Mohawk Subbasin. The lower portions of river and some tributaries, however, do provide juvenile rearing and refuge habitat.

The EDT analysis for the Mohawk Subbasin and individual reaches provides a rating of the relative restoration priorities for attribute classes. Fish passage obstructions at road crossings have had the largest impact on habitat. Changes in habitat diversity, sediment load, and water temperatures, and key habitat quality have had a secondary impact on habitat quality. The Mohawk River and a number of tributary streams have high summertime water temperatures. Alterations in channel stability, competition with hatchery fish, flow, and food sources have also had an impact on the system. Channel stability has been altered through loss of wood in the channel and trees along the riverbank. Changes in flow, primarily due to management actions (e.g., rip-rap) confining channels and reducing the amount of in low velocity habitats, have impacted fry colonization and rearing life stages. Alterations to food sources are primarily due to reductions in salmon carcasses from historical abundance, which limits nutrients contributing to juvenile salmon survival.

Water Temperatures

Summer water temperature in the Mohawk River and tributaries has increased due to loss of riparian vegetation and water withdrawals.

Increased summer water temperatures in the Mohawk Subbasin have had a moderate impact on the following life stages: 0-age active rearing and migrant; and 1-age active rearing and migrant.

<u>Juvenile Rearing and Migrant</u> – Juveniles rearing in the Lower Mohawk River and tributaries are impacted by increased water temperatures.

Habitat Diversity

Confinement of channels, altered riparian conditions and reductions in large wood in the river has resulted in large changes to habitat diversity in the Mohawk River and tributaries. The Mohawk River has relatively low levels of large wood and low large wood recruitment potential (MWC 2000; BLME 1995).

Changes in habitat diversity in the Mohawk River and tributaries have had moderate impacts on the following life stages: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.

Pre-spawn Holding – Loss of cover over deep pools has affected the quality of habitat for pre-spawning spring Chinook salmon that are holding in Mohawk River pools.

Juvenile Rearing and Migrant – Juvenile rearing habitats have been affected by reductions in large wood and associated slow velocity areas and pool cover.

Key Habitat Quantity

There have been substantial changes to key habitats the Mohawk. Limited wood in stream channels has dramatically reduced the quantity and depth of pools. Pools and the cover provided by large wood provide important spring Chinook juvenile rearing habitat in lower portions of the Mohawk River and tributaries.

Changes in key habitat quantity in the Mohawk River and tributaries have had moderate impacts on the following life stages: 0-age active rearing and migrant; and 1-age active rearing and migrant.

Juvenile Rearing and Migrant – Juvenile rearing habitats have been affected by reductions in large wood and associated slow velocity areas and pool cover.

Willamette River: Eugene Reach

Protection benefit rank: 5
Restoration benefit rank: 3

The Willamette River's Eugene Reach encompasses the mainstem of the river from the confluence with the McKenzie River downstream to the confluence with the Luckiamute and Santiam Rivers.

The EDT analysis for the Eugene Reach of the Willamette River and individual reaches provides a rating of the relative restoration priorities for the attribute classes. Habitat diversity and key habitats quantity have the largest impact on spring Chinook salmon population abundance, productivity and diversity in the Eugene Reach of the Willamette River. Modified flow, changes in food sources, increased pathogens and predation, and warm water temperatures have had secondary impacts on spring Chinook populations. Changes in flow, primarily due to management actions (e.g., rip-rap) confining the channel and reducing the amount of in low velocity habitats, have impacted fry colonization and rearing life stages. Food sources have some impact. Alterations to food sources are primarily due to reductions in salmon carcasses from historical abundance, which limits nutrients contributing to juvenile salmon survival. Fish pathogens have increased with hatchery introductions. High summer water temperatures and the presence of the fish parasite *Certomyxa shasta* affect the Willamette River below the confluence with the Marys River. Introduced fish, such as large-mouth bass, impact juvenile spring Chinook salmon through predation.

Habitat Diversity

Confinement of the channel, altered riparian and floodplain conditions and reductions in large wood in the river has resulted in large changes to habitat diversity in the Eugene Reach of the River.

There has been extensive loss of historical side channels, alcoves and other backwater habitats along this portion of the Willamette River, particularly between Harrisburg and Eugene (Benner and Sedell 1997). The channel is constrained by extensive revetments and the floodplain vegetation is fragmented and reduced in width (Pacific Northwest Ecosystem Research Consortium 2002).

Changes in habitat diversity in the Eugene Reach of the Willamette River have had moderate to extreme impacts on the following life stages: 0-age active rearing and migrant; and 1-age active rearing and migrant.

Juvenile Rearing and Migrant – Juvenile rearing and migration habitats have been affected by reductions in slow velocity areas due to limited amounts of large wood (particularly in large log jams), loss of side-channels and other backwater habitats, and actions (e.g., revetments) that have confined the channel.

Key Habitat Quantity

There have been substantial changes to key habitat quantity and distribution that have impacted spring Chinook salmon life stages in the Eugene Reach of the Willamette River. Changes to key habitats include reduced pools and backwater areas that provide important habitats for juvenile rearing.

Reductions in peak flows caused by flood control operations at upstream dams have contributed to the loss of habitat complexity in the Willamette River by substantially reducing the magnitude of the channel-forming high flows (i.e., the 1.5- to 2-year flood) and greatly extending the return intervals of larger floods. Over time, flood control has altered channel complexity by reducing the frequency of side channels and recruitment of large wood to the channel. Side channels, backwaters, and large wood accumulations all provide slow water velocity habitats that are important for juvenile spring Chinook salmon rearing. The lack of channel-forming flows has also decreased the frequency with which floodplains are inundated, which decreases nutrient, organic matter, and sediment exchanges between the floodplain and the river and does not allow juvenile salmon access to flooplain refugia in high-water events.

Changes in flow regimes, sediment and large wood supplies, and channel confinement have all interacted to reduce key habitats in this reach of the Willamette River (Pacific Northwest Ecosystem Research Consortium 2002).

Changes in key habitat quality in the Eugene Reach of the Willamette River have had moderate to extreme impacts on the following life stages: 0-age active rearing and migrant; and 1-age active rearing and migrant.

Juvenile Rearing and Migrant – The quantity of juvenile rearing and migration habitats has been reduced through loss of large wood (particularly large log jams), reduced side-channel area and other backwater habitats, and actions (e.g., revetments) that have confined the channel.

Habitat Protection Benefits

Although there has been significant loss of floodplain and channel habitats in the Eugene Reach of the Willamette River, some high quality habitats remain. There are large remnants of floodplain forest and complex river channel habitats in the area near the confluence of the McKenzie and Willamette Rivers and in scattered areas along the river channel, particularly between Corvallis and the mouth of the McKenzie River.

Willamette River: Salem Reach

Protection benefit rank: 8
Restoration benefit rank: 6

The Willamette River's Salem Reach encompasses the mainstem of the river from the confluence with the Luckiamute and Santiam Rivers downstream to the confluence with the Yamhill River.

The EDT analysis for the Salem Reach of the Willamette River and individual reaches provides a rating of the relative restoration priorities for the attribute classes. Habitat diversity has the greatest impact on spring Chinook salmon population abundance, productivity and diversity in the Salem Reach of the Willamette River. Increased predation and warm water temperatures have had secondary impacts on spring Chinook salmon populations in this portion of the river. High summer water temperatures and the presence of the fish parasite *Certomyxa shasta* affect the Willamette River below the confluence with the Marys River. Introduced fish, such as large-mouth bass, impact juvenile spring Chinook salmon through predation.

Habitat Diversity

Confinement of the channel, altered riparian and floodplain conditions and reductions in large wood in the river has resulted in large changes to habitat diversity in the Salem Reach of the River.

There has been some loss of historical side channels, alcoves and other backwater habitats along this portion of the Willamette River. The channel is constrained by revetments and the floodplain vegetation is fragmented and reduced in width (Pacific Northwest Ecosystem Research Consortium 2002).

Changes in habitat diversity in the Salem Reach of the Willamette River have had moderate to extreme impacts on the following life stages: 0-age active rearing and migrant; and 1-age active rearing and migrant.

Juvenile Rearing and Migrant – Juvenile rearing and migration habitats have been affected by reductions in slow velocity areas due to limited amounts of large wood (particularly in large log jams), loss of side-channels and other backwater habitats, and actions (e.g., revetments) that have confined the channel.

Willamette River: Newberg Reach

Protection benefit rank: 9
Restoration benefit rank: 9

The Willamette River's Newberg Reach encompasses the mainstem of the river from the confluence with the Yamhill River to Willamette Falls

The EDT analysis for the Newberg Reach of the Willamette River and individual reaches provides a rating of the relative restoration priorities for the attribute classes. Chemical contaminants have the greatest impact on spring Chinook salmon population abundance, productivity and diversity in this reach of the Willamette River. Lost habitat diversity and increased predation have had secondary impacts on spring Chinook salmon populations in this portion of the river. Confinement of the channel, altered riparian and floodplain conditions and reductions in large wood in the river has resulted in changes to habitat diversity in this portion of the river. Introduced fish, such as large-mouth bass, impact juvenile spring Chinook salmon through predation.

Chemical contaminants

Pollutants introduced through industrial discharges, toxics carried by stormwater, and other sources have contributed to elevated levels of many pollutants in this portion of the Willamette River (Pacific Northwest Ecosystem Research Consortium 2002).

Changes in habitat diversity in the Salem Reach of the Willamette River have had moderate to extreme impacts on the following life stages: 0-age active rearing and migrant; and 1-age active rearing and migrant.

Juvenile Rearing and Migrant – Juvenile rearing and migration could be affected by increased chemical contaminants in this portion of the Willamette River.

Willamette River: Portland Reach

Protection benefit rank: 9
Restoration benefit rank: 4

The Willamette River's Portland Reach encompasses the mainstem of the river from the base of Willamette Falls to the river's confluence with the Columbia River.

The EDT analysis for the Salem Reach of the Willamette River and individual reaches provides a rating of the relative restoration priorities for the attribute classes. Chemical contaminants have the greatest impact on spring Chinook salmon population abundance, productivity and diversity in this reach of the Willamette River. Lost habitat diversity, reduced key habitat quantity and increased predation have had secondary impacts on spring Chinook salmon populations in this portion of the river. Confinement of the channel, altered riparian and floodplain conditions and reductions in large wood in the river has resulted in changes to habitat diversity in this portion of the river. There have been dramatic reductions in key habitats, such as shallow water margins, that are important for spring Chinook salmon rearing and migration. Introduced fish, such as large-mouth bass, impact juvenile spring Chinook salmon through predation.

Chemical contaminants

Because of the level of pollution in lower Willamette River sediments, the Portland Harbor was added to the federal Superfund cleanup list in December 2000. The Portland Harbor Superfund Site currently covers a 5.7 mile section of the Willamette River from the upstream end of Sauvie Island (RM 3.5) and Swan Island (RM 9.2), so the northern 2.5 miles of the site are in the North Segment of the study area and the southern 3.2 miles of the site are in the industrial segment of the study area. Pollutants introduced through industrial discharges, toxics carried by stormwater, and other sources have contributed to elevated levels of many urban pollutants. Preliminary assessments indicate that DDT, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and heavy metals are some of the key risk drivers in lower Willamette River sediment.

Juvenile Rearing and Migrant – Juvenile rearing and migration could be affected by increased chemical contaminants in this portion of the Willamette River.

McKenzie Subbasin Restoration and Protection Strategies

In summary, a lack of large wood and sediment, reduced peak flows, loss of riparian vegetation, and installation of revetments has contributed to simplification of the McKenzie and Willamette River and tributaries. Loss of complex habitats, including deep pools with abundant wood, side channels, and backwater habitats, coarsening of the river's substrate, and changed water temperature regimes below Cougar and Blue River Dams, all interact to change the quality and quantity of habitat in the McKenzie Subbasin. Changes in habitats and habitat-forming processes have impacted spring Chinook abundance, productivity, and diversity for all of the life stages.

Based on the EDT analysis and other information on the factors limiting spring Chinook salmon populations, the following working hypotheses were developed to help guide restoration and protection action strategies and develop research and monitoring approaches. Protection and restoration strategies were not identified for the Salem and Newburg Reaches of the Willamette River, because the EDT analysis did not provide detailed information for these reaches. Strategies for the Portland Reach of the Willamette River are identified in the Lower Willamette portion of the Subbasin Plan.

Upper McKenzie River

Key factors limiting spring Chinook salmon populations in the Upper McKenzie River include loss of habitat diversity and key habitat quantity. Most of these changes are the result of reductions in large wood, a modified flow regime, and impacts to riparian areas.

Backwater habitats

Changes in the magnitude and frequency of peak flows, loss of large wood in the channel, modified riparian areas and an altered sediment regime has contributed to the loss of backwater habitats. Backwater habitats, such as side channels, alcoves and the margins of complex wood jams, provide a diverse array of water depths and velocities, which provide rearing and refuge areas for juvenile spring Chinook salmon.

Hypothesis 1: ***Increased backwater habitats, side channels, and other complex habitats in the Upper McKenzie River will improve survival for the following spring Chinook salmon life stages: 1) 0-age active rearing and migrant; 2) 1-age active rearing and migrant; and pre-spawning migrants.***

Strategy 1: Create backwater habitats within and along the upper McKenzie River.

Large Wood

Processes that transport and deliver large wood to the Upper McKenzie River have been altered through changes in delivery below the dams, and modified riparian areas. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., wood trapped behind the dams). Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring Chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered through the Upper McKenzie Subbasin. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river and tributaries.

Hypothesis 2: ***Increased large wood in the Upper McKenzie River channel and backwater areas and improved riparian conditions, width and connectivity will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 2: Add large wood to created and existing backwater habitats as individual pieces and in large logjams.

Strategy 3. Restore floodplain and riparian vegetation

Current status of the strategies

The Forest Service is adding large wood in the river and side-channel areas and restoring riparian areas in the Upper McKenzie River Channel and side-channel areas.

Proposed focus areas:

- Upper McKenzie River above and below the Carmen-Smith complex.

Upper McKenzie River Tributaries

Key factors limiting spring Chinook salmon populations in the Upper McKenzie River Tributaries include loss of habitat diversity and key habitat quantity. Most of these changes are the result of reductions in large wood, and associated changes in hiding cover for pre-spawning adults and reduced pool complexity that provides habitat for rearing and migrating juveniles.

Large Wood

Adding large wood, as pieces or in accumulations, to the tributary channel to provides complex habitat for juvenile spring Chinook salmon and hiding cover for pre-spawning adults. Additions of wood to the lower portions of tributaries should focus on creating complex winter refuge habitat for juvenile spring Chinook. Emphasize actions in key spring Chinook salmon juvenile rearing and refuge areas and pre-spawning holding reaches.

Hypothesis 3: ***Increased large wood in the Upper McKenzie River Tributary channels and backwater areas will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 4: Improve channel complexity by adding large wood lower end of tributary streams.

Current status of the strategy

The Forest Service is adding large wood to sections of tributaries.

Proposed focus areas:

- Upper McKenzie River tributaries, particularly Horse Creek and the lower portions of tributaries that offer refuge habitat.

South Fork McKenzie River Subbasin

Key factors limiting spring Chinook salmon populations in the South Fork McKenzie River include loss of habitat diversity and key habitat quantity and modified water temperature regimes Most of these changes are the result of reductions in large wood, a modified flow regime, and impacts to riparian areas.

Spawning areas
Storage of sediment and woody debris behind the dams in the upper Subbasin has limited the quantity of suitable gravels and small cobbles for spawning spring Chinook salmon. Armoring (the process of increasing the dominant substrate particle sizes) also reduces the availability of suitable spawning substrates. Reduced large wood in the channel has limited retention of gravels and small cobbles.

Hypothesis 4: ***Improved composition of gravels and small cobble substrate below the dams through addition on substrate and adding large wood to capture materials will improve the quality and quantity of spring Chinook salmon spawning habitat in the South Fork McKenzie River.***

Strategy 5: Improve channel substrate composition and retention in the South Fork McKenzie River and South Fork by placing large wood pieces and jams to retain substrate and adding appropriate gravels and small cobbles to the system.

Water temperature regime

Changes in water temperature regimes below Cougar Dam have had extreme impacts on the spring Chinook salmon population. Cooler water temperatures in the late spring and summer have probably impeded the upstream migration of spring Chinook salmon compared to the predevelopment condition. Warmer fall and winter temperatures accelerate egg incubation and the timing of fry emergence.

Hypothesis 5: ***Modifying the water temperature regime below Cougar Dam to match natural patterns will improve the success of spring Chinook salmon 1) adult pre-spawning, 2) spawning, 3) egg incubation, and 4) emergence.***

Strategy 6: Improve the water temperature regime below Cougar Dam by matching the natural water temperature patterns throughout the year.

Backwater habitats

Changes in the magnitude and frequency of peak flows, loss of large wood in the channel, modified riparian areas and an altered sediment regime has contributed to the loss of backwater habitats. Backwater habitats, such as side channels, alcoves and the margins of complex wood jams, provide a diverse array of water depths and velocities, which provide rearing and refuge areas for juvenile spring Chinook salmon.

Hypothesis 6: ***Increased backwater habitats, side channels, and other complex habitats in the South Fork McKenzie River will improve survival for the following spring Chinook salmon life stages: 1) 0-age active rearing and migrant; 2) 1-age active rearing and migrant; and pre-spawning migrants.***

Strategy 7: Create backwater habitats within and along the South Fork of the McKenzie River and larger tributaries such as Roaring River.

Large wood

Processes that transport and deliver large wood to the South Fork McKenzie River have been altered through changes in delivery below the dams, and modified riparian areas. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., wood trapped behind the dams). Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring Chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered through the South Fork McKenzie Subbasin. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river and tributaries.

Hypothesis 7: ***Increased large wood in the South Fork McKenzie River channel and backwater areas and improved riparian conditions, width and connectivity will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 8: Add large wood to created and existing backwater habitats as individual pieces and in large logjams.

Strategy 9. Restore floodplain and riparian vegetation

Current status of the strategies

The USACE is modifying the intake structure on Cougar Dam to allow the water released below the dam to be drawn from different depths. After construction, the USACE plans to operate the project to restore stream temperatures in the South Fork McKenzie and to partially restore pre-project temperatures in the mainstem of the Upper McKenzie River. The Forest Service has placed wood in the South Fork McKenzie River and Roaring River in order to retain suitable spawning substrate and create complex habitats, and the agency is improving riparian conditions along the South Fork and tributaries.

Proposed focus areas:

- Water temperatures: South Fork McKenzie River below Cougar Dam (this action will also influence a portion of the upper McKenzie River below the confluence with the South Fork).
- Substrate additions: South Fork McKenzie River below Cougar Dam.
- Creating backwater habitats, adding large wood and restoring floodplain and riparian vegetation: South Fork McKenzie River below and above Cougar Dam and larger tributaries (e.g., Roaring River).

Lower McKenzie River

Key factors limiting spring Chinook salmon populations in the Lower McKenzie River include loss of habitat diversity and key habitat quantity, particularly loss of channel width, side-channel area, and floodplain vegetation connectivity and extent. Most of these changes are the result of reductions in large wood, a modified flow regime, and channel confinement.

Backwater habitats

Changes in the magnitude and frequency of peak flows, loss of large wood in the channel, modified riparian areas and an altered sediment regime has contributed to the loss of backwater habitats. Backwater habitats, such as side channels, alcoves and the margins of complex wood jams, provide a diverse array of water depths and velocities, which provide rearing and refuge areas for juvenile spring Chinook salmon.

Hypothesis 8: ***Increased backwater habitats, side channels, and other complex habitats in the Lower McKenzie River will improve survival for the following spring***

Chinook salmon life stages: 1) 0-age active rearing and migrant; 2) 1-age active rearing and migrant; and pre-spawning migrants.

Strategy 10: Create backwater habitats within and along the Lower McKenzie River.

Large Wood

Processes that transport and deliver large wood to the Lower McKenzie River have been altered through changes in delivery below the dams, and modified riparian areas. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., wood trapped behind the dams). Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring Chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered along Lower McKenzie Subbasin. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river and tributaries.

Hypothesis 9: ***Increased large wood in the Lower McKenzie River channel and backwater areas and improved riparian conditions, width and connectivity will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 11: Add large wood to created and existing backwater habitats as individual pieces and in large logjams.

Strategy 12: Restore floodplain and riparian vegetation.

Hypothesis 10: ***Protecting high quality floodplain, side-channel, and riparian habitats, in association with restoration actions to increase habitat width and connectivity will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 13: Protect high quality floodplain, and riparian habitats along the Lower McKenzie River.

Current status of the strategies

The McKenzie Watershed Council has identified creating backwater habitats and adding large wood to river and side-channel areas as priority actions. Most of the focus on creating backwater habitats and creating channel complexity (such as large wood placement) is in the lower McKenzie Reaches where there are is very little river-side development that could create conflicts with restoration actions. The McKenzie River Trust, in partnership with the

Council and other organizations, is providing conservation protections for important habitats along the river and tributaries. Many of these areas focus on floodplain and side channel habitats, including Green Island at the confluence of the McKenzie and Willamette Rivers, and Big Island on the McKenzie River near Springfield.

Proposed focus areas:

- Lower McKenzie River below Deerhorn park
- McKenzie-Willamette River confluence area

Lower McKenzie River Tributaries

Key factors limiting spring Chinook salmon populations in Lower McKenzie River tributaries include the loss of deep pools and complex habitat that provide winter refuge areas for juvenile fish.

Large wood and shade.

The addition of large wood, as pieces or in accumulations, to the lower portions of tributary channels provides complex habitat for juvenile spring Chinook salmon. Improved riparian conditions will improve shade and water temperatures.

Hypothesis 11: ***Increased large wood in the Lower McKenzie River Tributary channels and backwater areas and improved riparian conditions, width and connectivity will increase survival for: 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 14: Improve channel complexity by adding wood to the lower end of tributary streams that are used by juvenile spring Chinook salmon for rearing and refuge habitat.

Strategy 15: Improve riparian conditions along tributaries.

Hypothesis 12: ***Protecting high quality floodplain, side-channel, and riparian habitats in the Lower McKenzie River Tributaries, in association with restoration actions to increase habitat width and connectivity will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 16: Protect high quality aquatic, floodplain, and riparian habitats along Lower McKenzie River tributaries that are used by juvenile spring Chinook salmon for rearing and refuge habitat.

Current status of the strategies

The McKenzie Watershed Council has identified creating backwater habitats, riparian enhancement, and adding large wood to tributary areas as priority actions. The McKenzie

River Trust, in partnership with the Council and other organizations, is providing conservation protections for important habitats along tributaries. Many of these areas focus on floodplain and side channel habitats.

Proposed focus areas:

- **Lower McKenzie River Tributaries that are used for juvenile rearing and refuge habitat.**

Mohawk Subbasin

Key factors limiting spring Chinook salmon populations in Mohawk River and tributaries include increased water temperatures and the loss of complex habitats that provide winter refuge areas for juvenile spring Chinook salmon.

Large wood and shade

The addition of large wood, as pieces or in accumulations, to the lower portions of tributary channels provides complex habitat for juvenile spring Chinook salmon. Improving riparian conditions will improve future delivery of large wood and improve shading and water temperatures.

Hypothesis 13: ***Increased large wood in the Mohawk River and tributary channels and backwater areas and improved riparian conditions, width and connectivity will increase survival for: 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 17: Improve channel complexity by adding wood to the river and lower end of tributary streams that are used for rearing and refuge habitat by juvenile spring Chinook salmon.

Strategy 18: Improve riparian conditions along the Mohawk River and tributaries.

Hypothesis 14: ***Protecting high quality floodplain, side-channel, and riparian habitats in the Mohawk Subbasin, in association with restoration actions to increase habitat width and connectivity will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 19: Protect high quality aquatic, floodplain, and riparian habitats within the Mohawk Watershed

Current status of the strategies
The McKenzie Watershed Council has identified creating backwater habitats, adding large wood to the aquatic system, and improving riparian conditions as priority actions. The Council has implemented a number of large wood and riparian restoration actions. The McKenzie River Trust, in partnership with the Council and other organizations, is providing

conservation protections for important habitats along tributaries, including the Mohawk River. Many of these areas focus on floodplain and side channel habitats.

Proposed focus areas:

- Lower Mohawk River and tributaries.

Willamette River: Eugene Reach

Key factors limiting spring Chinook salmon populations in the Eugene Reach of the Willamette River include loss of habitat diversity and key habitat quantity, particularly loss of channel width, side-channel area, and floodplain vegetation connectivity and extent. Most of these changes are the result of reductions in large wood, a modified flow regime, and channel confinement.

Backwater habitats

Changes in the magnitude and frequency of peak flows, loss of large wood in the channel, modified riparian areas and an altered sediment regime has contributed to the loss of backwater habitats. Backwater habitats, such as side channels, alcoves and the margins of complex wood jams, provide a diverse array of water depths and velocities, which provide rearing and refuge areas for juvenile spring Chinook salmon.

Hypothesis 15: ***Increased backwater habitats, side channels, and other complex habitats in the Eugene Reach of the Willamette River will improve survival for the following spring Chinook salmon life stages: 1) 0-age active rearing and migrant; 2) 1-age active rearing and migrant; and pre-spawning migrants.***

Strategy 20: Create backwater habitats within and along the Eugene Reach of the Willamette River.

Large Wood

Processes that transport and deliver large wood to the Eugene Reach of the Willamette River have been altered through changes in delivery below the dams, and modified riparian areas. As a result, it is necessary to add large wood to the system while processes recover (e.g., through riparian restoration) and to compensate for lost sources (e.g., wood trapped behind the dams). Large wood in the river channel, alcoves, and side channels, provide complex habitats and low water velocities, which contributes to improved areas for spring Chinook salmon juvenile rearing and pre-spawning adult hiding cover. The extent and composition of native riparian vegetation has been altered along this reach of the Willamette River. Reduced riparian trees and limited conifers have impacted the delivery of large wood to the river and tributaries.

Hypothesis 16: ***Increased large wood in the Eugene Reach of the Willamette River channel and backwater areas and improved riparian conditions, width and connectivity will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 21: Add large wood to created and existing backwater habitats as individual pieces and in large logjams.

Strategy 22. Restore floodplain and riparian vegetation.

Hypothesis 20: ***Protecting high quality floodplain, side-channel, and riparian habitats, in association with restoration actions to increase habitat width and connectivity will increase survival for: Pre-spawn holding; 0-age active rearing and migrant; and 1-age active rearing and migrant.***

Strategy 23: Protect high quality floodplain and riparian habitats.

Current status of the strategies
The McKenzie Watershed Council has identified creating backwater habitats and adding large wood to river and side-channel areas as priority actions. The Council is working with the sand and gravel industry and other landowners in the McKenzie-Willamette River confluence area to restore side-channels, create alcoves, and increase the width and connectivity of floodplain vegetation. The McKenzie River Trust, in partnership with the McKenzie Watershed Council and other organizations, is providing conservation protections for important habitats along the river and tributaries. Many of these areas focus on floodplain and side channel habitats, including Green Island at the confluence of the McKenzie and Willamette Rivers.

Proposed focus areas:

- **McKenzie-Willamette River confluence area**
- **The Willamette River between Corvallis and the mouth of the McKenzie River**