Lower Cowlitz River and Floodplain Habitat Restoration Project Siting and Design

Final Revised Report

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EXECUTIVE SUMMARY

This report documents the results of the Lower Cowlitz River Restoration Project Siting and Design Study. The purpose of this project is to identify specific locations along the Lower Cowlitz River and its floodplain where fish and wildlife habitat restoration projects are needed and would feasible. The study area is the mainstem and its floodplain from the confluence of the Cowlitz with the Columbia River upstream to Mayfield Dam at Rivermile (RM) 52. The lower ends of tributaries are included as appropriate. Flows on the Cowlitz River are modified by hydropower production, flood control, and recreational operations of Mayfield and Mossyrock Dams, and to a lesser extent Cowlitz Falls Dam.

This project builds upon the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (Recovery Plan) prepared by the Lower Columbia Fish Recovery Board (LCFRB) in 2004. The Recovery Plan identified several limiting factors in the Lower Cowlitz River subbasin: 1) modified hydrology; 2) reduced habitat connectivity; 3) poor substrate/sediment conditions; 4) reduced habitat diversity; 5) channel instability; 6) reduced riparian function; and 7) reduced floodplain function. The Recovery Plan (LCFRB 2004) also includes and evaluation using the Ecosystem Diagnosis and Treatment (EDT) model to help identify which reaches would be most adversely affected by further degradation and which reaches would provide the most fish benefits from restoration actions. Reaches were ranked into Tiers 1 through 4, with Tier 1 and 2 reaches being the highest priority for restoration or protection actions.

The LCFRB has also prepared a Six-Year Habitat Work Schedule (LCFRB 2007) that is frequently updated, with more specific restoration objectives to address the limiting factors in the subbasin. These include: 1) create/restore of off-channel and side channel habitats; 2) restore floodplain functions and channel migration processes; 3) restore access to habitats blocked by artificial barriers; 4) restore riparian conditions; and 5) restore channel structure and stability. However, no site or reach-specific locations for these actions were identified. It is postulated that if these types of restoration actions are taken in Tier 1 and 2 reaches then significant gains can be made towards the recovery of salmonid populations. This study undertook an investigation and evaluation of potential locations to undertake the various types of restoration actions identified above.

Within the 52 mile study reach from the confluence to Mayfield Dam this study identified six distinctive geomorphic reaches or segments as follows that are used for general discussions of restoration opportunities and locations:

- Reach 1. River Mile (RM) 0.0 to 5.0 – Cowlitz Mouth to Highway 4 Bridge
- Reach 2. RM 5.0 to 10.0 – Highway 4 Bridge to Leckler Creek
- Reach 3. RM 10.0 to 20.0 – Leckler Creek to Toutle River
- Reach 4. RM 20.0 to 32.0 – Toutle River to Salmon Creek
- Reach 5. RM 32.0 to 42.0 – Salmon Creek to Blue Creek (Cowlitz Hatchery)
- Reach 6. RM 42.0 to 52.0 – Blue Creek to Mayfield Dam

The primary limitations on restoration in the Lower Cowlitz are the high sediment load coming from the Toutle River and affecting all reaches downstream of the Toutle confluence; the regulation of flows from the dams affecting reaches upstream of the Toutle confluence that can cause rapid disconnections of side channel and fish stranding, and also reduce natural channel migration and formation of habitats; and existing and proposed development within the floodplain and along the riparian zone the reduces the potential for restoration.

In Reach 1, the primary opportunities for habitat restoration are for reconnection of the historical wetlands and distributary side channels that are currently inaccessible or filled from dredged material disposal. The loss of distributary channel and slough areas to industrial and commercial uses and placement of dredged material significantly limits the amount of available tidal slough and marsh habitat. The projects identified in this reach include riparian restoration and side channel restoration and enhancement (reconnect distributary channel). The riparian restoration projects, while feasible, would not likely be highly effective due to the width of the river and the land use constraints (could not provide desired riparian corridor width). Restoration of tidal channel and marsh habitat would primarily benefit 0-age Chinook and chum that rear extensively in shallow water tidal areas by providing cover and a greater quantity of habitat.

However, these projects do not rank highly overall on the list because they will only provide narrow and isolated habitats within a highly urbanized area. Also, the on-going risk from future sediment deposition and/or dredging activities limits the potential life-time of projects in this reach and their certainty of success.

In Reach 2, the primary opportunities for habitat restoration are reconnections of the historical floodplains currently inaccessible due to levees or filled from dredged material disposal, and riparian restoration. The projects identified in this reach include riparian restoration with minor floodplain restoration; dredged materials removal; tributary enhancement; and bar and island enhancement. Because habitat diversity is a major issue in this reach, tributary confluence enhancement (placement of wood) and bar and island enhancement (placement of wood to provide cover and high flow refugia) could provide increased habitat diversity. However, these projects do not rank highly overall on the list because they will only provide narrow and isolated habitats within a highly constrained reach. Also, the on-going risk from future sediment deposition and/or dredging activities limits the potential life-time of projects in this reach and their certainty of success. Restoration of in-stream, riparian and floodplain habitats in Reach 2 would primarily benefit 0-age Chinook and chum that rear extensively in shallow water tidal areas by providing cover and increased habitat diversity/complexity.

The highest priority restoration actions for this reach are to reconnect any floodplain areas that are feasible and provide a natural riparian and floodplain zone for refuge and habitat complexity, but overall, this reach has the lowest opportunity and potential benefit from restoration of any of the reaches in the Lower Cowlitz.

In Reach 3, there are three major types of opportunities for fish habitat enhancement from a geomorphologic perspective. First is the restoration and reconnection of floodplain features in the remaining floodplains (primarily between RM 11 and 15). Second is restoration and enhancement of bar and side channel features in the main channel. And lastly is partial or complete removal of dredged materials with riparian and floodplain restoration. Some secondary opportunities include bioengineering of existing revetment areas by placement of wood and vegetation along rock banks or plan for incorporating self mitigating features into anticipated future bank stabilization projects in the reach. The primary constraint on restoration of this reach is the potential risk of continued sediment deposition due to Toutle River elevated sediment supply. Other constraints are the potential conflicts between floodplain restoration and adjacent development in urbanizing areas near Castle Rock, and the high cost of dredged material removal.

Projects identified in this reach include: riparian restoration and dredged material removal; bar and island enhancement; side channel restoration and enhancement; tributary enhancement; and dredged material removal. The side channel restoration and enhancement projects rank most highly because they would provide a significant quantity of habitat that would be highly beneficial for 0-age and smolt rearing for all salmonid species and could provide adult holding habitat. However, their certainty of success is low to moderate because the continued high sediment load will make it difficult to keep the side channels scoured open. The placement of wood will promote channel scouring, as well as providing in-stream cover, but may not be able to withstand the extremely high sediment load. It would be highly beneficial to experiment with placement of wood in this reach to determine how feasible some of these projects are.

In Reach 4, the primary opportunities are associated with side channel enhancement and restoration upstream from RM 23 and reconnecting/restoring the gravel mined floodplain to a flow-through side channel at RM 27.5. The Hog Island side channel at RM 23.2 is the first stable side channel going upstream on the mainstem and providing more side channels as “stepping stones” up the river would provide rearing and holding habitat for both juvenile and adult salmon and could provide spawning habitat. Projects identified in this reach include: dredged material removal; off-channel and floodplain restoration; bar and island enhancement, tributary enhancement; riparian restoration; channel migration zone easement; and side channel restoration and enhancement. The channel migration zone easements and side channel restoration and enhancement projects rank most highly because they would provide a significant quantity of habitat that would be highly beneficial for 0-age and 1-age rearing for all salmonid species and could provide adult holding habitat, and potentially spawning habitat. This reach does not have a high sediment load, but the regulated flows can cause rapid disconnections of side channels and the river cannot really form its own habitats in much of this reach, except near the confluence of Salmon Creek and just upstream of I-5. The placement of wood will promote channel scouring, as well as providing in-stream cover. It would be highly beneficial to place wood and restore side channel habitats in this reach. Additionally, the channel migration processes should be protected wherever they continue to occur. The channel migration zone easement at the confluence of Salmon Creek ranked highly.

Overall, this reach has many very good restoration opportunities and potential for benefits. Overall, the Tier 1 and 2 reach projects rank highly.

In Reach 5, the primary opportunity for fish habitat restoration in the Toledo reach is to preserve currently functioning and dynamic sections of the river and floodplain. The areas of interest occur at RM 32 to 34 upstream of the Salmon Creek confluence and RM 38 to 40. The Salmon Creek confluence has shown recent active channel migration with a recent avulsion and reoccupation of the historical channel on the left side of the valley shown in the historical GLO maps, and significant movement of the main channel in the winter of 2006-2007 due to new gravel bar deposition. Restoration of several side channels through the extensive bars and islands up to the Toledo Bridge would help relieve hydraulic pressure on the privately owned lands and reduce the need for likely future bank armoring. Placement of LWD to promote scour of the channels, provide cover and to divert flows away from existing structures would also be beneficial.

Projects identified in this reach include: side channel restoration and enhancement; gravel mined floodplain acquisition; gravel mined floodplain restoration; channel migration zone easement; riparian restoration; and bank enhancement. Five of the projects in this reach rank in the top 6 projects for the entire subbasin because they would provide a significant quantity of habitat that would be highly beneficial for 0-age and 1-age rearing for all salmonid species and could provide adult holding and spawning habitat. This reach has regulated flows that can cause rapid disconnections of side channels and significant fish stranding, so all restoration projects in this reach should be designed to allow connections at a wide range flows that will dramatically reduce the disconnection problems. The placement of wood will promote channel scouring, as well as providing in-stream cover. It would be highly beneficial to place wood and reconnect side channels in this reach.

The upper channel migration zone at RM 38.0-40.0 is one of the most notably dynamic and functioning channel and floodplain areas in the Lower Cowlitz. Future development and encroachment within this area would be highly detrimental to these processes which provide excellent conditions for salmon spawning and rearing habitats. This area presents a singular and extremely important opportunity for acquiring conservation easements and protecting natural floodplain areas and channel migration zones. Minor excavation to reconnect the Springer channel could be conducted at RM 40 to reconnect a very lengthy and high quality side channel.

The highest priority restoration actions in this reach are to enhance and restore side channels and channel migration zones. Overall, this reach has the best opportunities for both habitat protection and restoration in the Lower Cowlitz River.

In Reach 6, the primary opportunities for salmon habitat restoration are protection and enhancement of side channel and bar areas. The main limitations associated with the side channel enhancement projects are access and the ability to utilize a low impact construction and placement technique that keeps wood relatively stable. Helicopter placement may be a viable solution for installing large wood as part of side channel enhancement projects.

Projects identified in this reach include: tributary enhancement; bar and side channel enhancement; and side channel restoration and enhancement. These projects generally rank in the top 20 projects for the entire subbasin, because they would provide a significant quantity of habitat that would be highly beneficial for Chinook and steelhead spawning, and 0-age and 1-age rearing for all salmonid species. This reach has regulated hydrology that can cause rapid disconnections of side channels and cause fish stranding, but the placement of wood will promote channel scouring, as well as providing in-stream cover. It would be highly beneficial to place wood and reconnect side channels in this reach.

Overall, this reach is a high priority for habitat protection, with a few side channel enhancement or restoration opportunities. It does not appear that the Blue Creek to Barrier Dam reach of the river is at risk for development and encroachment.

Additional, supplemental projects were included on the lower ends of several tributaries. The Lower Toutle River and the lower end of Olequa Creek are Tier 1 reaches and off-channel projects in these reaches also rank very highly.

A total of 15 of the highest priority projects were developed to the concept level with project layouts and cost estimates. These projects are located in Reaches 4, 5 and 6 in Tier 1 or 2 reaches, and there is one project each in the lower Toutle River and the lower end of Olequa Creek.

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1. <u>Introduction</u>

1.1 Study Purpose

The Cowlitz River is one of seventeen major tributaries to the Lower Columbia River in Southwestern Washington (**Figure 1**). This watershed historically supported large populations of several salmon species including: spring and fall Chinook, chum, and coho salmon, summer and winter steelhead and sea-run cutthroat trout. The salmon populations have declined dramatically in this watershed and the Columbia Basin in general. As a result, several species and Evolutionary Significant Units (ESUs) of salmonids in the Columbia Basin were listed under the federal Endangered Species Act (ESA) beginning in 1999, including Lower Columbia River Chinook, coho, and steelhead, and Columbia River chum (all federally listed as Threatened).

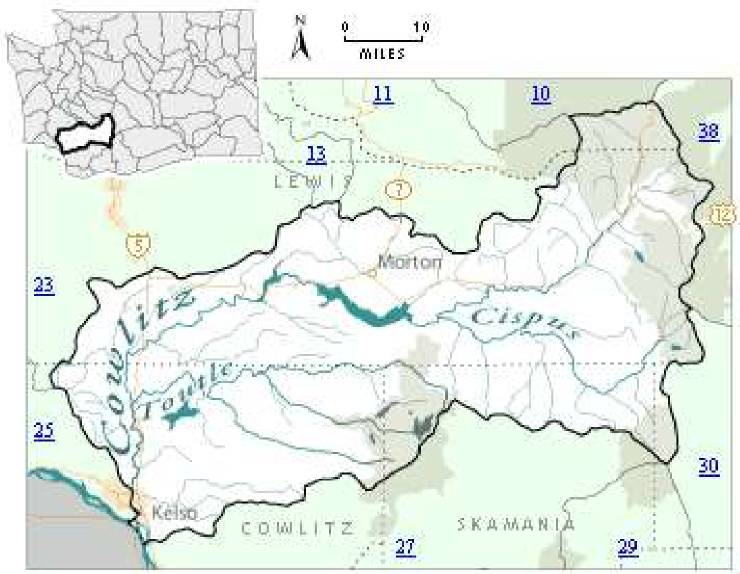


Figure 1. Cowlitz Watershed Vicinity Map.

The Lower Columbia Fish Recovery Board (LCFRB) and its partners and stakeholders in the Lower Columbia region developed the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan (hereafter called the Recovery Plan) in 2004 (LCFRB 2004). This plan included a technical assessment of conditions in each subbasin within the overall Lower Columbia subbasin, an inventory of current and past efforts at habitat protection and restoration, and a management plan with goals, objectives and strategies for future actions to protect and recover fish and wildlife populations and their ecosystems. The Recovery Plan was adopted by NOAA Fisheries as an Interim Regional Recovery Plan in February 2006. The Recovery Plan and subsequent work plans developed by the LCFRB identified a number of protection and restoration goals and potential actions for the Lower Cowlitz subbasin. However, the potential restoration actions did not include any site-specific detail.

1.2 Study Approach

This report documents the results of a study intended to identify, rank, and conceptually design restoration projects at resulting high priority locations in the Lower Cowlitz River and its floodplain (including the lower confluence portions of tributaries). These projects will directly address limiting factors and high priority restoration needs identified in the Recovery Plan (LCFRB 2004). This study is not a monitoring plan or program, or a habitat assessment. The approach used in this study is to build on the previous work done in the Recovery Plan (LCFRB 2004); document restoration opportunities and constraints by reaches; identify specific project sites where restoration actions are appropriate; prioritize the projects based on physical, biological and engineering feasibility factors; and then provide conceptual designs and cost estimates for the highest ranked projects. The conceptual designs and cost estimates will be used as the basis for future grant applications and actions by the LCFRB and other entities in the subbasin.

A key component of this study is the involvement of a Working Group, including representatives from Washington Department of Fish and Wildlife (WDFW), U.S. Army Corps of Engineers (Corps), National Marine Fisheries Service (NMFS), Cowlitz Conservation District (CCD), Lewis Conservation District (LCD), Tacoma Power, Cowlitz Tribe, Friends of the Cowlitz, Cowlitz Game and Anglers, Lower Columbia Flyfishers, Lower Columbia Fish Enhancement Group (LCFEG), LCFRB, and technical consultants. The Working Group met at several key points during the study to provide input on restoration opportunities, project prioritization and ranking, and proposed next steps.

2. Lower Cowlitz River Subbasin Description

2.1 Watershed Conditions

The Cowlitz River is located on the western slopes of the Cascade Mountains in Washington State (**Figure 2**). It is a 2,543 square mile watershed originating on the Cowlitz Glacier on Mount Rainier. The basin ranges in elevation from 0 to 14,410 feet. Two major dams and one smaller dam, Mossyrock and Mayfield dams, and the hatchery barrier dam (upstream to downstream) are owned and operated by Tacoma Power. Mossyrock and Mayfield dams provide hydroelectric power generation, flood control, recreation, and flows for fish enhancement downstream. Their recently reissued FERC license gives the Corps authority to assist in project regulation during major flood events (FERC 2002). Lewis County PUD owns and operates a dam at Cowlitz Falls.

The following description for the Lower Cowlitz River is summarized from the description provided in the Recovery Plan (LCFRB 2004) and a review of current and historic aerial photos (1994, 1978, and 1939), unless otherwise referenced. The Lower Cowlitz River is defined as the river from the confluence with the Columbia River upstream to Mayfield Dam at approximately river mile (RM) 52[1]. The watershed area of the Lower Cowlitz subbasin is 440 square miles. The

[1] Mileage along the Lower Cowlitz River varies depending on the source used. For the purposes of this study, the mileage as delineated on the 1978 Corps of Engineers map folio is used. This does not match the USGS mileage shown on the quad maps.

two major tributaries to the Lower Cowlitz are the Coweeman and Toutle Rivers that enter the Cowlitz at RMs 1.3 and 20, respectively (their watershed areas of 200 $mile^2$ and 513 $mile^2$, respectively, are not included in the Lower Cowlitz watershed area and are generally not discussed in this study). The Cowlitz River enters the Columbia River near Longview, Washington. Other notable Lower Cowlitz tributaries include Salmon, Lacamas, Olequa, Delameter, and Ostrander Creeks. Fish passage is completely blocked at Mayfield Dam; however, fish are collected at the Cowlitz Salmon Hatchery Barrier Dam (RM 49.5) for transport into the upper basin. The hatchery barrier dam is a partial fish passage barrier. Tacoma Power will be conducting studies to determine how to provide volitional passage for adult and juvenile salmonids at Mayfield Dam over the next few years.

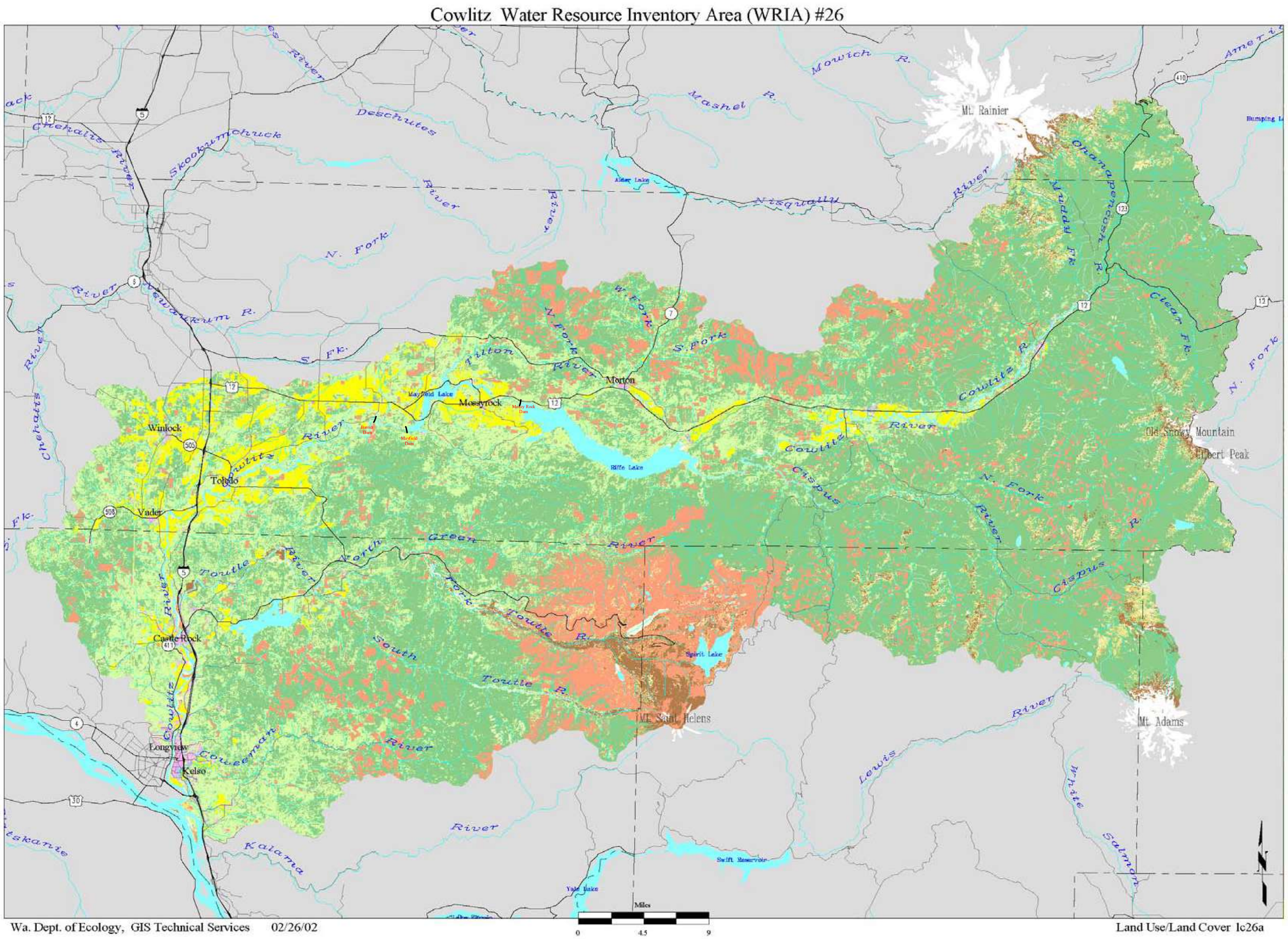
Approximately 80% of the Lower Cowlitz subbasin is forested timberlands (primarily privately owned) in various seral stages, with the remaining 20% a mix of agricultural, rural residential, urban, and industrial. The cities of Castle Rock, Kelso, and Longview are along the lower river (below RM 20). Land uses and the operation of the dams on the mainstem have changed the hydrologic runoff characteristics of the basin. Peak flood flow management, hydroelectric power operations affecting release rates and ramping, and summer time flow augmentation are all changes from the historical flow regime of the Cowlitz River.

A unique feature of this subbasin is that the eruption of Mt. St. Helens in 1980 caused a massive mud and debris flow in the Toutle basin and deposited enormous quantities of sediment and debris in the Lower Cowlitz River. This material was subsequently dredged from the river and placed along the adjacent floodplain both upstream and downstream of the Toutle-Cowlitz River confluence. This material is primarily comprised of fine sands. The Corps of Engineers installed a sediment retention structure (SRS) on the North Fork Toutle River to reduce the quantity of sediment moving downstream and into the Cowlitz and Columbia Rivers. A significant quantity of sediment is continuing to move through the Toutle system that is not blocked by the SRS and this material is continuing to deposit in the Lower Toutle River and Lower Cowlitz River. Periodic dredging has occurred in the Lower Cowlitz and was part of the overall response plan for Mt. St. Helens. The Corps estimates that the SRS will completely fill with sediment in approximately 2035 (USACE 2007). The Corps is currently studying the sediment supply and transport rate and the potential need for additional actions to reduce sediment supply or provide additional flood control measures in the Cowlitz River downstream of the Toutle confluence.

2.1.1 Geologic Setting

The Cowlitz River arises from the Cowlitz glacier on the southeastern flank of Mt. Rainier, the highest peak in Washington State. The headwaters and tributaries in the upper basin are all fed by the mountains of the Southern Washington Cascade Range. The Southern Washington Cascade Range is primarily volcanic in origin with extensive activity during the Pleistocene and recent times. Andesitic and basaltic flows are the dominant features with only minor areas of igneous intrusive, sedimentary or metamorphic rocks. Large areas surrounding the major peaks (Mts. Rainier, St. Helens, and Adams) are mantled with pumice and ash deposits (Franklin & Dyrness 1988). Soils derived from the volcanic deposits range from gravelly coarse sands to silt loams.

Figure 2. Cowlitz River Watershed (from WDOE 2002).



General historical and current sedimentation processes and trends play a key role in the morphological composition of the river. Historically, the Cowlitz valley was formed through a series of glacial advances and retreats and volcanic events. Glacial inflows typically have high sediment loads including both bedload and suspended materials. The Upper and Middle reaches of the Cowlitz River flow through erodible glacial outwash deposits. Downstream from Mayfield Dam, the Cowlitz primarily flows through alluvial river deposits and is bordered by a variety of glacial outwash, marine terraces and volcanic deposits. One of the current sedimentary influences is the volcanic eruption materials being transported by the Toutle River downstream into the Cowlitz. Current predictions are that without dredging operations the Cowlitz River bed elevations are expected to rise between 0 to 2 feet, in upstream areas near the Toutle River confluence, and between 3 to 5 feet in downstream areas (USACE 2002). The predicted sedimentation translates into a predicted rise in water surface elevations on the order of 1.5 feet downstream from the Toutle River confluence. These are significant considerations that should be considered for all restoration project plans downstream from the Toutle River confluence.

Alluvial deposits along the valley floor are coarse-textured, typically gravelly sands to sandy loams. These alluvial deposits are bordered by elevated coarse glacial outwash terraces that extend from the Cowlitz River Salmon Hatchery to the town of Vader, just downstream from the I-5 bridge. These deposits are from glaciation associated with Mt. Rainier and are dominated by cobbles, gravels, and sands. Glacial outwash deposits also fill the Jackson Prairie area separating the Cowlitz and Chehalis drainage basins.

The Lower Cowlitz subbasin, downstream of Toledo, is confined between the hillslopes of the Southern Washington Cascades to the east, and the Willapa Hills (Coast Range) to the west. The lower half of the basin flows through the Puget-Willamette lowland and has moderate gradient relief with a broad floodplain. Below the confluence with the Toutle River (RM 20) the Cowlitz River channel has been almost completely armored and diked, and most of the floodplain has been filled with deposits from the eruption of Mount St. Helens (Wade 2000). The river margins are flanked by lahar deposits near the Toutle River confluence from the 1980 (and other previous historical) Mt. St. Helens eruptions. These materials consist of underlying, poorly or unsorted cobbles and boulders, with a supporting matrix of sand and mud deposits (Lippman and Mullineaux 1981).

The Willapa Hills, between Vader and Castle Rock, are comprised of Eocene aged marine sedimentary siltstone and sandstones and areas of marine basalt flows. Soils derived from siltstones and sandstones are often fine textured with silty clays and silty clay loams. Soils derived from basalts in the Coast Range are generally clay loams and silty clay loams but may be shallow and stony (Franklin and Dyrness 1988).

The valley from Castle Rock to the confluence with the Columbia River has similar valley margin geology, with areas of quaternary terraced sediments. These formations have a variety of sources and materials ranging from proglacial outwash, glacial outburst, older alluvium, lahars and uplifted coastal marine and estuarine deposits. Alluvial deposits at the Cowlitz-Columbia confluence, in the Kelso-Longview area, span tens of miles across the floodplain of the Columbia River.

2.1.2 Climate and Precipitation

The Cowlitz River subbasin is located in the western slopes of the Cascade Mountains. The climate is characterized as predominantly mid-latitude, west coast, marine (USACE 2000). Typical weather patterns are for westerly flow of Pacific marine systems that carry a majority of precipitation in October through April, with relatively dry months occurring during summer. The broad range of elevation in the basin (sea level to the top of Mt. Rainier at 14,410 feet) results in highly variable precipitation. Mean precipitation for the entire watershed is approximately 52 inches per year. The watershed annual average varies from 40-50 inches per year in the Lower Cowlitz near Kelso to 140-150 inches per year at the highest elevations on Mt. Rainier (**Figure 3**). Additionally, precipitation falls as rain in lower elevations and snow at higher elevations during winter months. Rainfall intensity is also highly variable ranging from 4-6 inches per 24-hour period in the prairie areas north of Kelso, to 12-14 inches per 24-hour period at the highest elevations for the 100-year storm event (**Figure 4**).

2.1.3 Hydrology

The Cowlitz River subbasin is a 2,543 square mile basin with headwaters originating on the flanks of Mt. Rainier and major tributary headwaters on Mt. St. Helens and Mt. Adams with the terminus at the Columbia River in Kelso, Washington. The three major hydrologic sources to the river are rainfall, snowmelt and glacial melt runoff. Major tributaries to the Cowlitz include the Cispus River, Tilton River, Toutle River and Coweeman River. Two major dams are located on the Cowlitz, namely Mayfield and Mossyrock dams (**Figure 5**).

The dams are part of the Tacoma Power Cowlitz River hydropower project. The project has a 460 megawatt (MW) capacity (Tacoma Power 2007). Mayfield Dam is located at RM 52, was built in 1963 and impounds the 13-mile long Mayfield Lake upstream. Mayfield Dam pool elevations can fluctuate 10 feet on a given day and is operated as a run of the river dam. At RM 65, Mossyrock Dam is the tallest dam in Washington State at 606 feet in height with the 23-mile long Riffe Lake impounded upstream. The lake can be drawn down 178.5 feet in the winter months for flood control storage. The dams are primarily operated for hydroelectric power generation, with the additional purposes of flood control and the protection of aquatic resources. Flood control operations are coordinated with the Corps with a flood control objective to generally maintain flows to less than 70,000 cubic feet per second (cfs) at Castle Rock.

Two smaller dams exist on the Cowlitz, the Barrier Dam for the Cowlitz River Hatchery at RM 50 and Lewis County PUD’s Cowlitz Falls hydroelectric project (70 MW), immediately upstream of Riffe Lake.

Cowlitz River flooding is driven primarily by rain on snow events. The maximum recorded flood event on the Lower Cowlitz at Castle Rock was 139,000 cfs on December 23, 1933. Since 1968, the Cowlitz has been regulated for flood control by Mossyrock Dam. The maximum discharge since regulation was on February 8, 1996 when flows were estimated at 112,000 cfs at Castle Rock. Regulated 100-year flood frequency flows are estimated to be 102,000 cfs at the Castle Rock gage (USACE 2002).

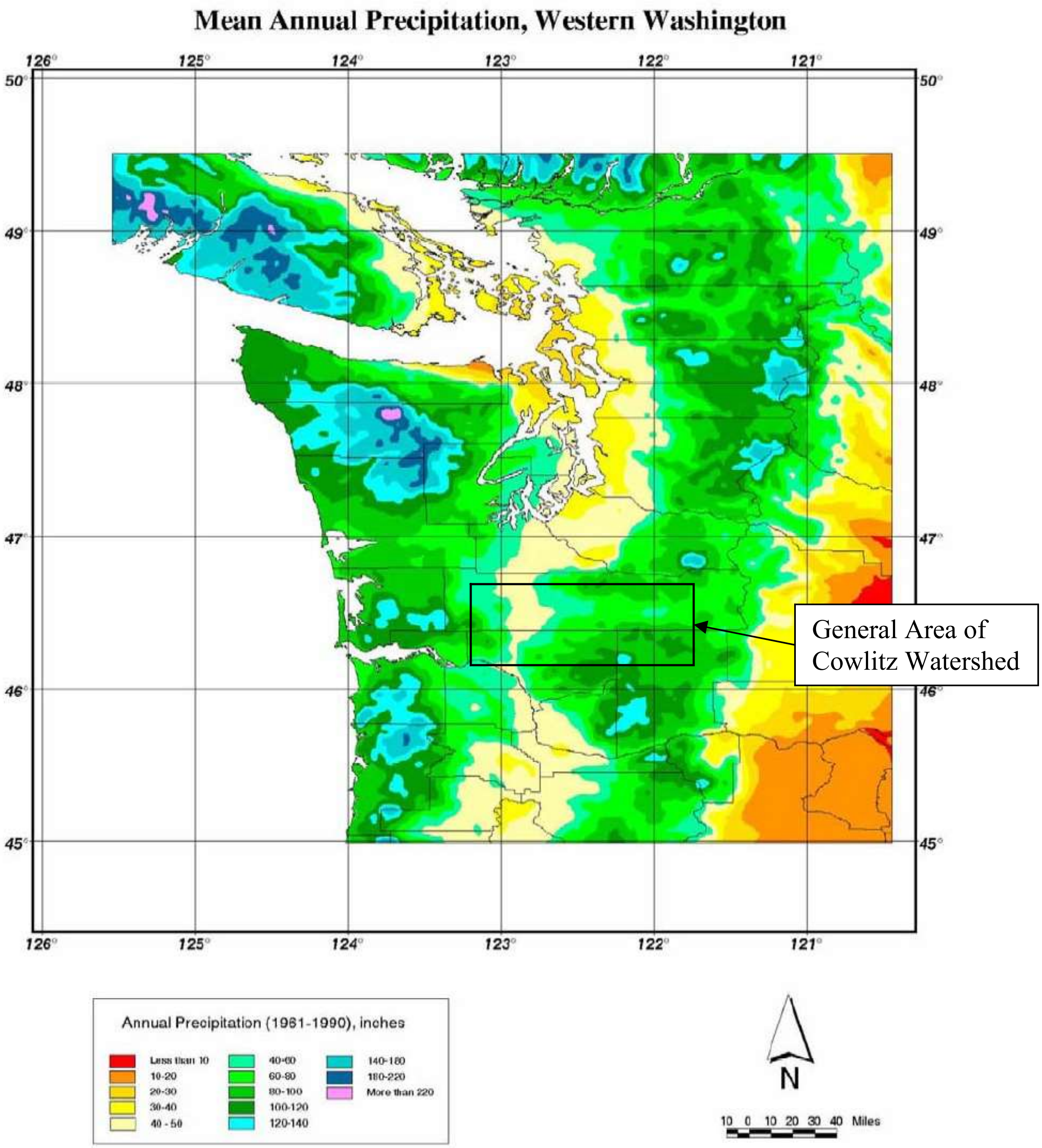


Figure 3. **Mean Annual Precipitation for Western Washington (OSU 2000)**

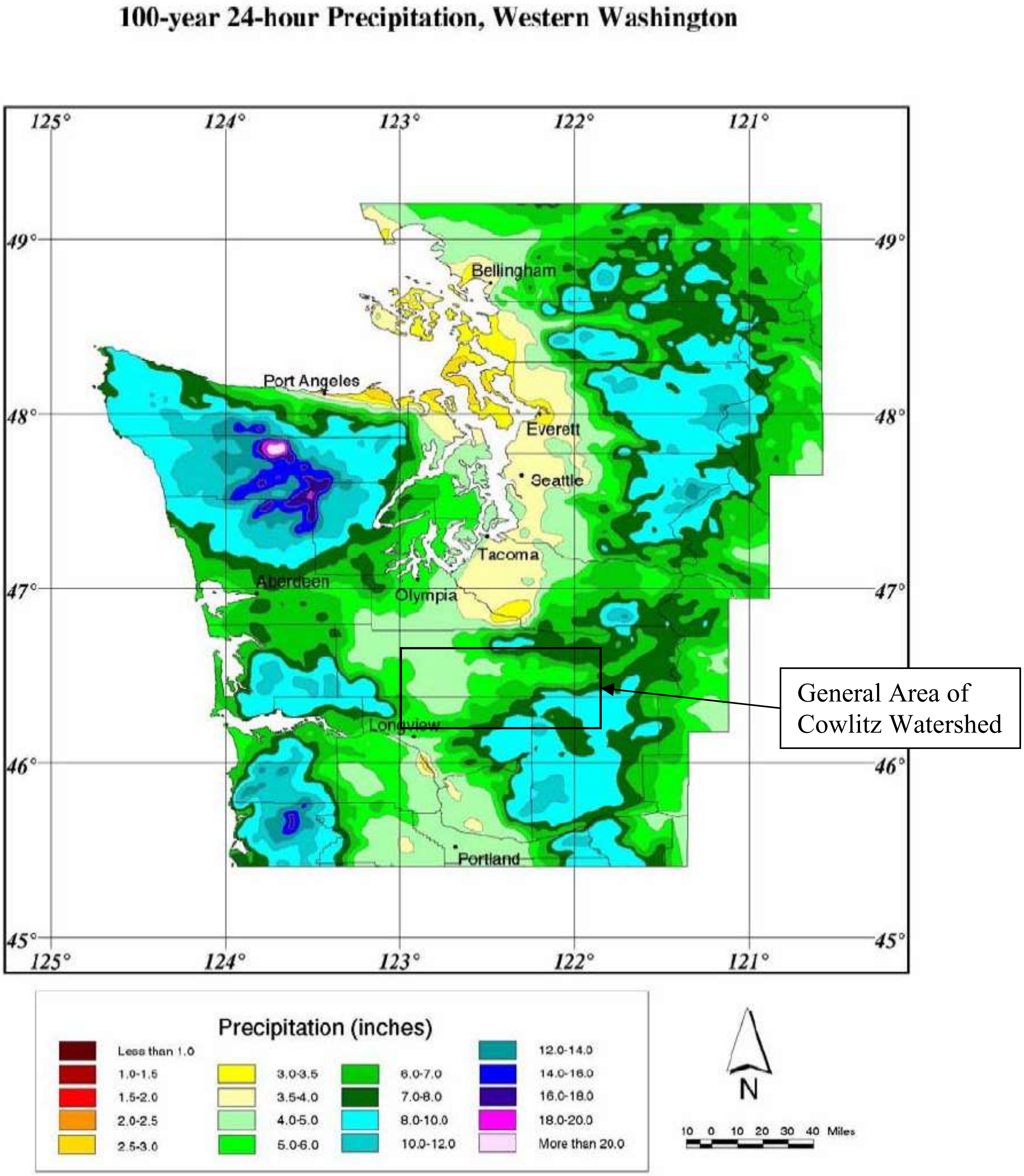


Figure 4. 24-hour/100-year Precipitation Events for Western Washington (OSU 2000)

One significant variable in hydrologic conditions is the Toutle River. The Toutle River, which is not regulated, has its confluence with the Cowlitz River at RM 20. Flood runoff from the Mount St. Helens eruption in May 1980 was recorded as the third largest flow in the Lower Cowlitz during the period of record (USACE 2002). In addition to the volcanic debris avalanche and lahar event in 1980, the Toutle River now has a higher probability of contributing increased flood flows due to the changes in watershed hydrologic conditions. Pre-eruption, 100-year flood frequency discharge was estimated at 44,500 cfs and post-eruption at 64,000 cfs. It is expected that the Toutle River will experience hydrologic recovery as the watershed returns to a mature forested condition.

Historically, low flows occurred on the Cowlitz during the late summer and early fall months. With regulation, the low flow period still occurs in late summer and early fall, where 90% of the time flows are at or equal to 2,500 cfs near Castle Rock, and approximately 2,100 cfs upstream of the Toutle River confluence. Since dam construction, the major shifts in hydrologic characteristics are increases in daily flow during winter months due to pool release and drawdown, lower flow rates due to flood storage in the spring months and increases in summer and fall flows due to flow augmentation.

Construction and operation of the Mayfield and Mossyrock Dams has changed both the daily mean flow and peak flood characteristics (Harza 1998). Existing conditions with the dams have reduced daily mean averages runoff flows during spring (March through July). Existing conditions with the dams have higher flows during typical low flow summer months (July through October). Peak flows have been reduced to less than the 50-year event. Peak flows from the 50-year to 100-year event remain fairly similar in size. Extremely large peak flow events, greater than the 100-year event, have increased in size (Harza 1998).

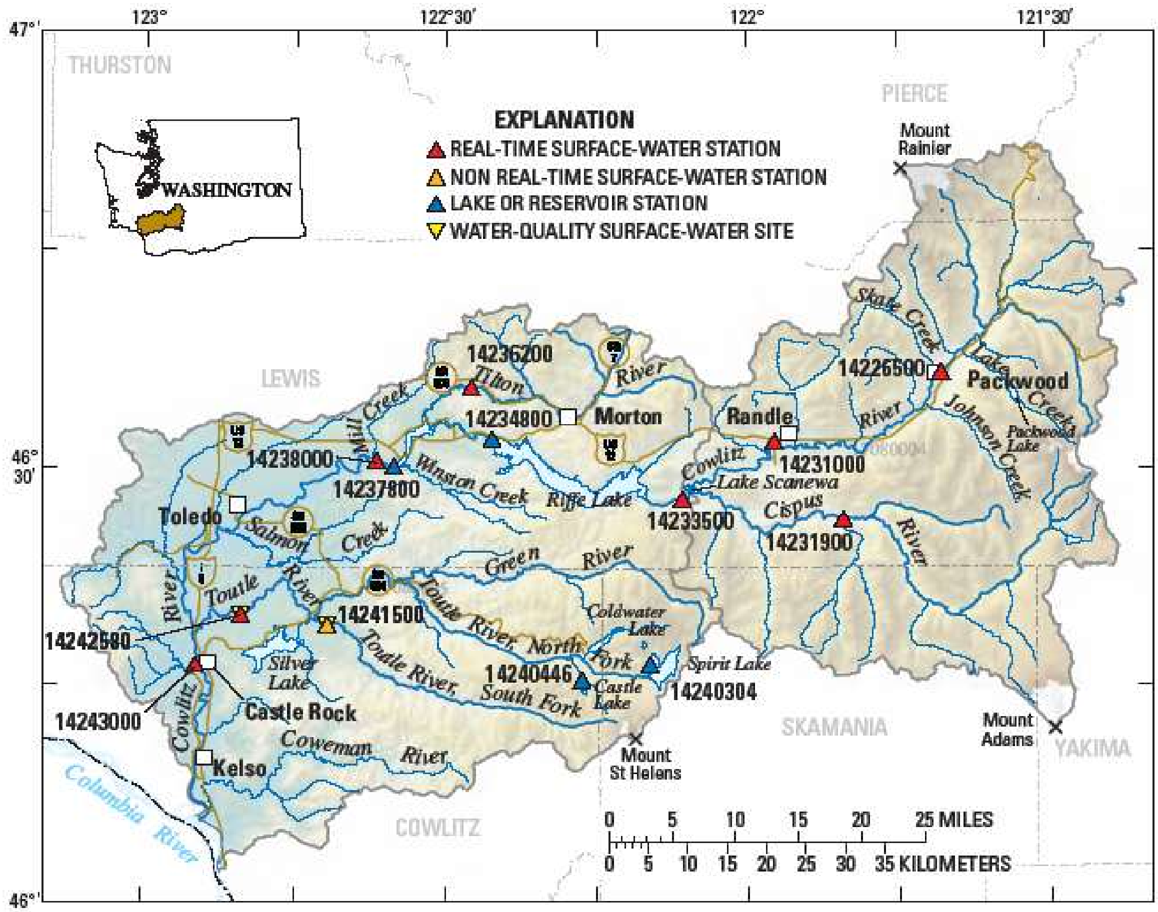


Figure 5. Cowlitz River Gaging Stations (USGS 2007)

2.1.4 Vegetation and Land Use

The natural vegetation of the Lower Cowlitz subbasin was a western hemlock climax forest, which included a significant component of Douglas fir and western red cedar (Franklin & Dyrness 1988). The majority of the forest zone would have been in old-growth conditions, with some areas of early and mid-seral forest due to fires, wind throw, landslides, and volcanic eruptions. The floodplain and riparian zone would likely have been a mix of deciduous forest (cottonwood, alder), shrubland (willows), emergent wetlands and prairies, and coniferous forest (cedar, hemlock).

Currently, the majority of the Lower Cowlitz subbasin is still in forest, albeit in early to mid-seral stages, with the dominant tree species now Douglas fir, big-leaf maple and red alder. Approximately 82% of the subbasin is in commercial forestry land uses (Wade 2000). In the floodplain, the existing vegetation varies widely with urban and industrial development, ornamental landscaping, agricultural/pastureland, dredged material (generally lightly vegetated), former industrial (vacant), deciduous riparian forest, and coniferous forest. In the lower 20 miles, the floodplain and riparian zone is dominated by urban, ornamental landscaping, and dredged material. Some isolated patches of deciduous riparian forest also occur. From RMs 20 to 40, the floodplain is dominated by agricultural/pastureland and residential development. Deciduous riparian forest typically occurs in isolated patches. Above RM 40, the floodplain narrows and becomes more dominated by forest vegetation, both deciduous and coniferous. Patches of herbs and shrubs also occur, as well as ornamental vegetation associated with residential development.

2.1.5 Wetlands

Wetlands in the Lower Cowlitz subbasin have been reduced from historic conditions, particularly in the lower 20 miles. Current wetland mapping (**Figure 6**) shows several areas of remaining wetlands, including: the lower mile of the river associated with the former distributary channels and sloughs; near RMs 12 and 13 where portions of the floodplain were not filled by dredged material; on the left bank near RMs 22-23; near RM 25 and Hill Creek; RMs 30-32 (downstream of Toledo); and RMs 37-41. The primary wetland types are either riverine fringing wetlands or former channels and oxbows. There are also large areas of wetlands in the higher glacial terraces and prairies on both the left and right high ground upstream of I-5. These wetlands may provide significant springwater or groundwater flow into the upper reaches of the Lower Cowlitz River.

2.1.6 Fish Distribution

The information in this section is summarized from the Recovery Plan (LCFRB 2004). The focal species in the Lower Cowlitz subbasin include listed salmon, steelhead, and trout species: Chinook (threatened), chum (threatened), coho (threatened), and winter steelhead (threatened). Spring Chinook were historically abundant upstream of Mayfield Dam and therefore are a species of interest in the Upper Cowlitz subbasin and are part of the overall Lower Columbia Chinook population. Bull trout are not known to occur in the Cowlitz basin. Other species of interest in the Lower Cowlitz subbasin include coastal cutthroat trout and Pacific lamprey. Chinook, coho, and steelhead populations in the Cowlitz subbasin are dominated by hatchery stocks. The Cowlitz Salmon Hatchery and Cowlitz Trout Hatchery supply several million smolts annually to the river.

The mainstem is fully accessible for anadromous fish up to the hatchery barrier dam. An electric barrier is present at the barrier dam to prevent fish from jumping over the dam, but it is not continuously operational and WDFW staff have observed adult steelhead upstream of the barrier dam (J. Henning, WDFW, pers. comm. 2007). All passage is blocked at Mayfield Dam. A trap and haul operation at the barrier dam collects Chinook, steelhead and coho for transport to the upper basin. The salmonids can also access most of the tributaries to the lower river. Fish passage barriers are known to be present at the Mill Creek hydroelectric project and on Blue Creek at the hatchery. Barrier culverts are present on many of the tributary streams including Foster, Leckler, Blue, Monahan, Delameter, and several smaller tributaries (Lewis County Conservation District 2001). **Figure 7** shows the fish distribution in the subbasin.

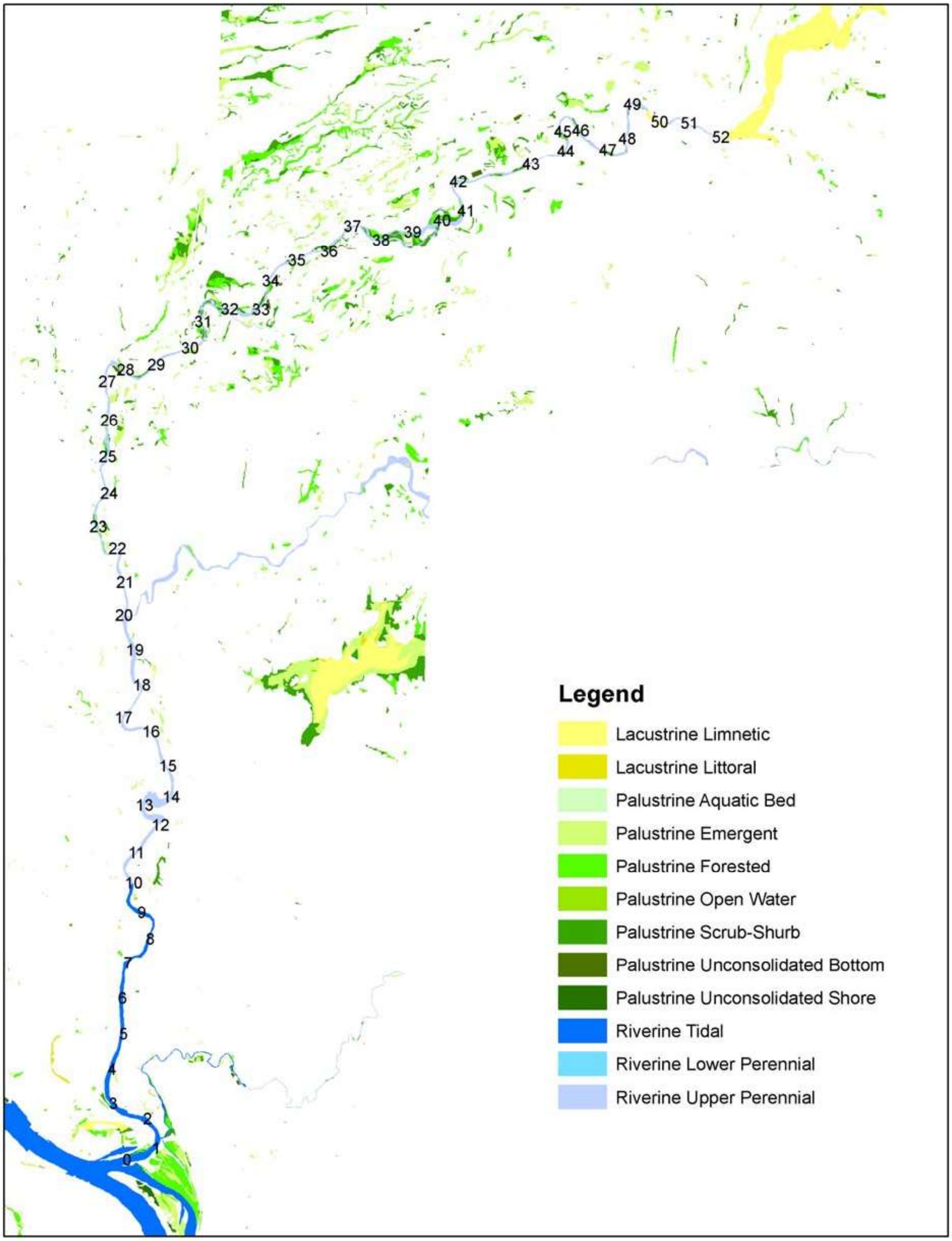


Figure 6. **Wetlands and Waterbodies of the Lower Cowlitz Subbasin** (WDFW 2006). River miles are shown along mainstem Cowlitz River.

The majority of the naturally spawning fall Chinook population spawn between RMs 41 to 49 (approximately 60%), between the Cowlitz Trout Hatchery and the Cowlitz Salmon Hatchery (WDFW unpublished data). The naturally spawning Chinook are primarily first-generation hatchery fish and are attracted back to the hatchery. Suitable spawning habitat is present in the mainstem from approximately RM 25 up to Mayfield Dam at RM 52. Approximately 30% of the natural spawning occurs from the Toutle River confluence (RM 20) to Blue Creek (RM 41). Downstream of the Toutle River confluence, the channel substrate is almost exclusively sand. Fall Chinook also spawn in the Toutle and Coweeman Rivers. Coho and steelhead primarily spawn in the tributaries, including Ostrander, Delameter, Arkansas, Olequa, Lacamas, and Salmon Creeks. Chum salmon are so few that it is unclear where they primarily spawn, but they have been observed in the mainstem Cowlitz and Lacamas, Arkansas, and Ostrander Creeks, as well as the Toutle River.

From observations made during the field reconnaissance of substrate conditions upstream of the Toutle River, it does not appear that a lack of spawning habitat is limiting production in the lower river, although historically, the majority of Chinook spawning and rearing habitat in the basin (80%) was located upstream of Mayfield Dam (Wade 2000). However, channel stability and fine sediments may be reducing the survival of eggs and was considered the most critical limiting factor in the Recovery Plan (LCFRB 2004). The majority of mainstem spawning occurs in the vicinity of the hatchery and the barrier dam (WDFW unpublished data). Superimposition of redds in the vicinity of the hatchery/dam may also reduce survival of eggs. Another factor likely to reduce survival and production is the reduction of off-channel habitats, as compared to historic conditions, and limited habitat diversity and cover in the main channel. Harassment and damage from fishermen in the river may cause pre-spawning mortality and mortality of eggs.

Channel stability and fine sediments were considered the primary limiting factor for coho salmon as well, and a major limiting factor for steelhead (LCFRB 2004). Habitat diversity, such as a lack of off-channel and in-channel rearing habitat were also major limiting factors for coho and steelhead. It is likely that the eruption of Mt. St. Helens and the continuing deposition of sands in the lower 20 miles of the river has significantly reduced chum spawning habitat. Historically, chum may also have spawned in the extensive side channels upstream of Toledo, particularly where groundwater and spring flow from the glacial terraces occurs. The loss of connections to many of these habitats has probably further limited chum production. The lack of tidal rearing habitat is also a major concern for chum salmon.

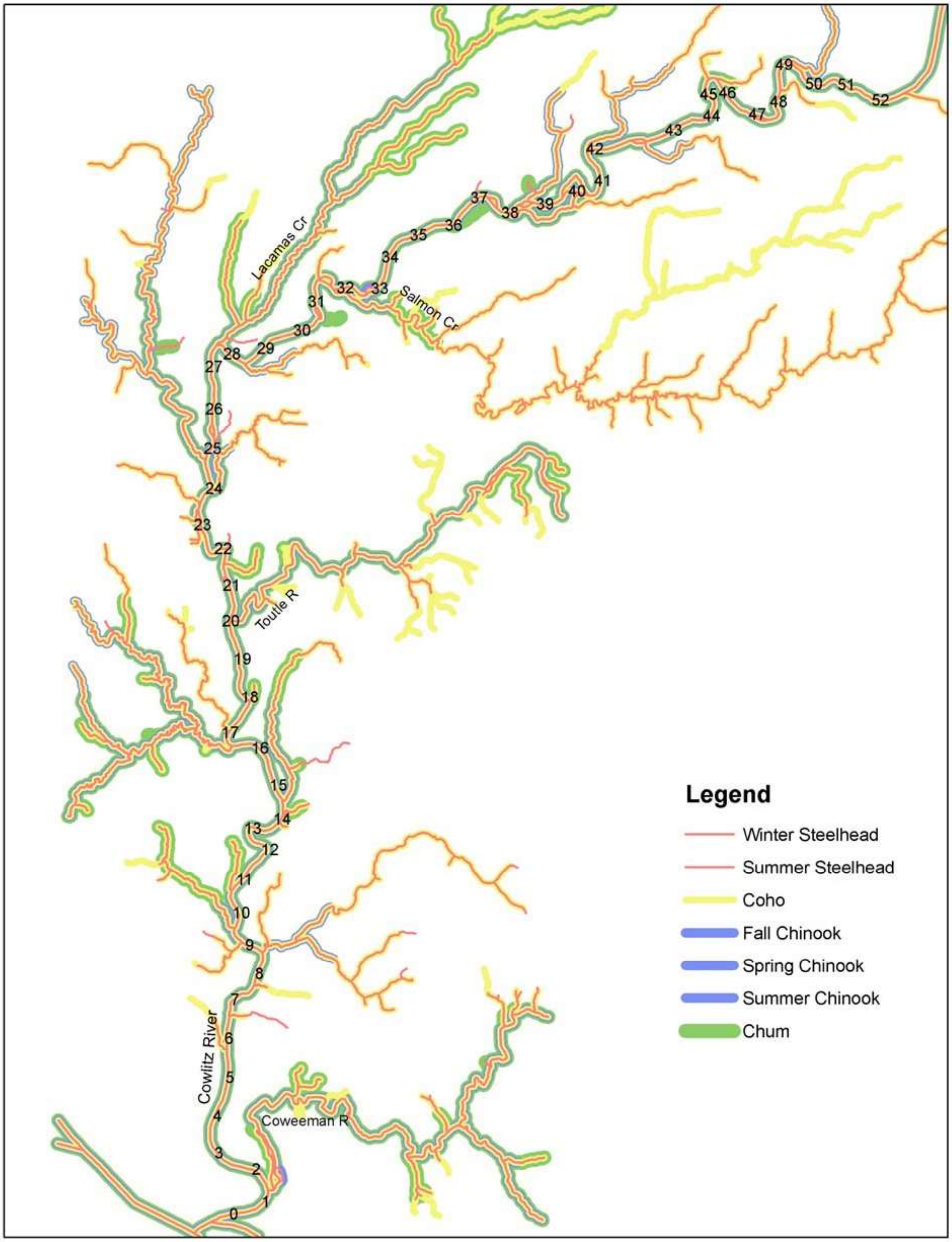


Figure 7. Fish Distribution Map for the Lower Cowlitz Subbasin (WDFW 2006; river miles shown for Cowlitz mainstem)**.**

2.1.7 In-Stream Habitat

The mainstem Lower Cowlitz is a large non-wadable river. Thus, it would not be expected to have the same types and distribution of in-stream habitats as smaller streams. The river in the area downstream from Mayfield Dam enters the broad alluvial floodplain. Historical conditions involved periodic sediment and wood deposition and channel migration leading to active changes in floodplain composition, river location, and more frequent development of off-channel habitat areas. It is likely that high volumes of wood and sediment both contributed to an active historical channel migration zone. Currently, the river and its natural processes are affected by the reduction of wood to the river, reductions in larger peak and channel forming flows, and development and construction of bank stabilization and revetment features limiting natural channel migration activity and reducing the overall potential for development of off-channel floodplain and habitat areas. Sediment transport and deposition has been affected by the construction of dams, and by the excessive supply coming out of the Toutle River.

Currently, the majority of the Lower Cowlitz River subbasin has low quantities of LWD due to past removal actions, lack of recruitment from the riparian zone, and a high transport capacity in the mainstem river. Due to its large size, the Lower Cowlitz may never have been able to retain LWD (Wade 2000) in the main channel. However, bars and side channels likely retained wood at least for some period of time. The 1939 aerial photos show moderate quantities of wood on bars and in small jams. The deltas associated with the Toutle and Coweeman Rivers may have included LWD jams; however, the 1851 General Land Office (GLO) survey maps do not indicate the presence of significant accumulations of wood. Aerial photos from 1939 show small accumulations of wood on gravel bars and channel margins of meander bends. No LWD jams or accumulations are in the main channel, except buried from RM 25 – 27 (Tacoma Power data). Significant timber harvest had occurred in many locations of the subbasin by the late 1930s, as well as removal of wood to facilitate navigation. Currently, there are some small accumulations of wood on bars and in side channels.

The dominant habitat types in the main channel are riffles and glides. Virtually no pools were observed in the main channel during a boat reconnaissance of the river conducted in September 2006 by Tetra Tech and Working Group members.

Habitat diversity and cover along the mainstem could be enhanced by the placement of wood on bars and in side channels and by the restoration of riparian habitats. While LWD would probably not be stable over the long-term in the main channel, it would provide temporary cover and promote deposition and scour on its way downstream. Tacoma Power has agreed to place up to 600 lineal feet of LWD (minimum 10 inches in diameter) near Blue Creek on an annual basis to help enhance mainstem habitat diversity. It may also be possible to construct large scale LWD jams that would be stable over longer time scales, such as have been placed in various large rivers in Washington, such as the Stillaguamish, Green, and Hoh Rivers.

2.1.8 Floodplain Connectivity

The lower 20 miles of the Cowlitz has experienced severe loss of floodplain area and connectivity due to levees, riprap, development and the placement of dredged materials originating from the Mt. St. Helens eruption onto the floodplain. Only RMs 12 -14 downstream of Castle Rock retain areas of connected floodplain habitat. The mainstem Cowlitz between RM 20 and RM 52 has numerous sites with bank revetments that constrain channel meandering, although floodplain connections are present in much of the area (LCFRB 2004). The primary reason for the infrequency of floodplain connections upstream of the Toutle River is the regulation of the river by dam operations. The floodplain is experiencing significant development, which is reducing the opportunities to restore floodplain habitats. Upstream of RM 25, several areas of the floodplain have been mined for gravel and could be opportunities to restore and reconnect the floodplain and off-channel areas to the river.

Key opportunities to restore or enhance floodplain connections are generally upstream of RM 25 and include gravel pit restoration and reconnections, side channel reconnections, removal or setback of revetments, and protection of channel migration zones.

2.2. Reach Conditions

The mainstem Lower Cowlitz River has several distinct geomorphic features and reaches. The geomorphology and channel form of the Lower Cowlitz River is a function of current and historical landform and geologic structural controls and inputs; basin-scale land use and vegetation characteristics; and climatic, hydrologic and sedimentary inputs to the river. The cumulative effects of inputs and responses over time contribute to the current forms and processes occurring along the river, which are ultimately linked to a variety of habitats and functions. Understanding the geomorphologic functions and processes of the study reach is an important step in evaluating potential habitat restoration opportunities for the Lower Cowlitz River.

Within the 52 mile study reach from the confluence to Mayfield Dam there are six distinctive geomorphic reaches or segments that have been delineated as follows:

- Reach 1. River Mile (RM) 0.0 to 5.0 – Cowlitz Mouth to Highway 4 Bridge
- Reach 2. RM 5.0 to 10.0 – Highway 4 Bridge to Leckler Creek
- Reach 3. RM 10.0 to 20.0 – Leckler Creek to Toutle River
- Reach 4. RM 20.0 to 32.0 – Toutle River to Salmon Creek
- Reach 5. RM 32.0 to 42.0 – Salmon Creek to Blue Creek (Cowlitz Hatchery)
- Reach 6. RM 42.0 to 52.0 – Blue Creek to Mayfield Dam

Reach conditions and recommendations are described in detail in Section 4.

3. Methodology of Restoration Site Identification and Prioritization

The overall intent of this project is to build on the Recovery Plan (LCFRB 2004) and Habitat Work Schedule (LCFRB 2007a) by using the limiting factors identified in the basin and develop site specific restoration plans that will address those limiting factors. Because the scope of this study is limited to the mainstem Lower Cowlitz River and its floodplain, not all limiting factors in the subbasin can be addressed.

3.1 Recovery Plan Assessment Process

3.1.1 EDT

The Recovery Plan (LCFRB 2004) identified several limiting factors in the subbasin including: reduced habitat connectivity; modified stream flow/hydrology; water quality; substrate/sediment conditions; reduced habitat diversity; channel instability; reduced riparian function; and reduced floodplain function. The key priority actions and programs that were also identified in the Recovery Plan are:

1. Manage regulated stream flows through the hydropower system;
2. Restore floodplain function, riparian function and stream habitat diversity;
3. Manage growth and development to protect watershed processes and habitat conditions;
4. Address immediate risks with short-term habitat fixes;
5. Manage forest lands to protect and restore watershed processes;
6. Restore passage at culverts and other artificial barriers;
7. Align hatchery priorities consistent with conservation objectives
8. Manage fishery impacts so they do not impede progress toward recovery;
9. Reduce out-of-subbasin impacts so that the benefits of in-basin actions can be realized.

In the Recovery Plan (LCFRB 2004), the Lower Cowlitz mainstem was divided into 10 reaches that were analyzed via the Ecosystem Diagnosis and Treatment (EDT) model to identify which fish species and life stages would benefit most from restoration or protection actions in various reaches. The EDT model was developed by Mobrand Biometrics, Inc. to create an estimate of fish species productivity and abundance in a watershed (or portion of a watershed) based on the quantity and quality of the habitat (Lichatowich, *et al* 1995; Lestelle, *et al*. 2004). The watershed or other area of interest is divided into reaches and physical data on the stream units (riffles, pools, etc.) and ratings for up to 35 environmental quality attributes[2] is entered into the model for each reach. The attributes are then related through peer-reviewed rules for each life history stage of one or more salmonid species to predict the survival and potential productivity and abundance of the species. The model is typically run for historic or reference (template) and existing (patient) conditions. The data for historic conditions is typically derived from historic documents and estimated properly functioning conditions based on the watershed geomorphology. Potential

[2] Environmental quality attributes are divided into four major types: 1) hydrologic characteristics; 2) stream corridor structure; 3) water quality; and 4) biological community. Individual attributes such as habitat type, embeddedness, and fish community richness are rated on a scale of zero to four for quality.

restoration alternatives can also be evaluated by entering data for each attribute that may change as a result of a restoration action.

A new EDT analysis was recently conducted for the Lower Cowlitz River that included additional information about coho and other species and a draft summary was completed in January 2007. This new analysis further subdivided the original 10 reaches into a total of 36 reaches (**Table 1**). These reaches do not match the geomorphic reaches listed previously that are the basis for general discussions in this report, but will be used in the ranking and prioritization of projects. Tier 1 and 2 reaches are the highest priorities for restoration and preservation actions and were the initial focus for this study.

The Lower Columbia Salmon Recovery Six-Year Habitat Work Schedule and Lead Entity Habitat Strategy (hereafter called Work Schedule; LCFRB 2007a) identifies the initial ranking of project types to address the primary limiting factors affecting life stages of the focal salmonid species, as shown in **Table 2**, below. Channel stability, sediment and habitat diversity were considered to be the primary limiting factors for all species in the Recovery Plan (LCFRB 2004). While channel migration is a natural process that creates habitats, the sediment and wood transport capacity may be out of balance due to a lack of LWD and changed hydrologic regime. Because this study cannot specifically address hydrologic and upper watershed or hillslope processes, the primary limiting factor that can be addressed is habitat diversity, which for this study primarily includes off-channel and side channel restoration/creation; floodplain restoration; and riparian restoration. Off-channel and side channel restoration on the lower 20 miles is the highest priority, followed by off-channel and side channel restoration from RMs 20-49 as the second highest priority.

Table 1. Lower Cowlitz Mainstem EDT Reaches (LCFRB 2004; LCFRB 2007a)

Original EDT Reach*	Revised EDT Reach*	River Mileage	Description	Species Reach Potential	Original EDT Tier Ranking	Revised EDT Tier Ranking
LC-1	LC-1	RM 0 – 2.0	Confluence with Columbia to Coweeman River.	Chum – High Coho – Medium Chinook – Low Steelhead – Low	1	2
LC-2		RM 2.0 – 20.27	Coweeman confluence to Toutle River	Chum – Medium Coho – Medium Chinook – Low Steelhead – Low	2	
	LC-2A	RM 2.0 – 6.1	Coweeman confluence to Cowlitz RB Trib 1	Chum – Medium Coho – Medium		3
	LC-2B	RM 6.1 – 6.9	Cowlitz RB Trib 1 to Cowlitz LB Trib 1	Chum – Medium Coho – Medium		3
	LC-2C	RM 6.9 – 8	Cowlitz LB Trib 1 to Cowlitz LB Trib 2	Chum – Medium Coho – Medium		3
	LC-2D	RM 8 – 8.9	Cowlitz LB Trib 2 to Ostrander Creek	Chum – Medium Coho – Medium		3
	LC-2E	RM 8.9 – 9.5	Ostrander Creek to McCorkle Creek	Chum – Medium Coho – Medium		3
	LC-2F	RM 9.5 – 9.9	McCorkle Creek to Leckler Creek	Chum – Medium Coho – Medium		3
	LC-2G	RM 9.9 – 10.9	Leckler Creek to Sandy Bend Creek	Chum – Medium Coho – Medium		3
	LC-2H	RM 10.9 –	Sandy Bend Creek to Cowlitz	Chum – Medium		3

Original EDT Reach*	Revised EDT Reach*	River Mileage	Description	Species Reach Potential	Original EDT Tier Ranking	Revised EDT Tier Ranking
		14	LB Trib 3	Coho – Medium		
	LC-2I	RM 14 – 14.4	Cowlitz LB Trib 3 to Lower Salmon Creek	Chum – Medium Coho – Medium		3
	LC-2J	RM 14.4 – 16.5	Lower Salmon Cr to Arkansas Creek	Chum – Medium Coho – Medium		3
	LC-2K	RM 16.5 – 16.9	Arkansas Creek to Whittle Creek	Chum – Medium Coho – Medium		3
	LC-2L	RM 16.9 – 17.9	Whittle Creek to Cowlitz LB Trib 4	Chum – Medium Coho – Medium		3
	LC-2M	RM 17.9 – 20	Cowlitz LB Trib 4 to Toutle River	Chum – Medium Coho – Medium		3
MC-1		RM 20.27 – 25.15	Toutle confluence to Olequa Creek	Chinook – Medium Chum – Low Coho – Low Steelhead – Low	3	
	MC-1A	RM 20 – 21.5	Toutle confluence to Cowlitz LB Trib 5	Chinook – Medium		3
	MC-1B	RM 21.5 – 23	Cowlitz LB Trib 5 to Cowlitz RB Trib 2	Chinook – Medium		3
	MC-1C	RM 23 – 23.2	Cowlitz RB Trib 2 to Cowlitz RB Trib 3	Chinook – Medium		2
	MC-1D	RM 23.2 – 23.6	Cowlitz RB Trib 3 to Rock Creek	Chinook – Medium		2
	MC-1E	RM 23.6 – 24.2	Rock Creek to Hill Creek	Chinook – Medium		2
	MC-1F	RM 24.2 – 24.9	Hill Creek to Olequa Creek	Chinook – Medium		2
MC-2		RM 25.15 – 28.17	Olequa Creek to Lacamas Creek	Chinook – Medium Chum – Medium Coho – Medium Steelhead – Low	2	
	MC-2A	RM 24.9 – 25.4	Olequa Creek to Cowlitz LB Trib 6	Chinook – Medium Chum – Medium Coho – Medium		2
	MC-2B	RM 25.4 – 27.9	Cowlitz LB Trib 6 to Lacamas Creek	Chinook – Medium Chum – Medium Coho – Medium		3
MC-3		RM 28.17 – 30.60	Lacamas Creek to I-5	Chinook – High Chum – Medium Coho – Low Steelhead – Low	2	
	MC-3A	RM 27.9 to 28.8	Lacamas Creek to Foster Creek	Chinook – High Chum – Medium		3
	MC-3B	RM 28.8 to 30.3	Foster Creek to I-5	Chinook – High Chum – Medium		3
MC-4		RM 30.60 – 32.83	I-5 to Salmon Creek	Chinook – High Chum – Medium Coho – Medium Steelhead – Low	2	
	MC-4A	RM 30.3 – 32.1	I-5 to Cowlitz RB Trib 4	Chinook – High Chum – Medium Coho – Medium		1
	MC-4B	RM 32.1 – 32.5	Cowlitz RB Trib 4 to Salmon Creek	Chinook – High Chum – Medium Coho – Medium		2
MC-5A		RM 32.83	Salmon Creek to Hinkley Road	Chinook – Medium	3	

Original EDT Reach*	Revised EDT Reach*	River Mileage	Description	Species Reach Potential	Original EDT Tier Ranking	Revised EDT Tier Ranking
		– 41.43		Chum – Low Coho – Low Steelhead – Low		
	MC-5A	RM 32.5 – 37.4	Salmon Creek to Cowlitz RB Trib 5	Chinook – Medium Coho – High Steelhead -- Medium		1
	MC-5B	RM 37.4 – 39	Cowlitz RB Trib 5 to Skook Creek	Chinook – Medium Coho – High Steelhead -- Medium		2
	MC-5C	RM 39 – 41.1	Skook Creek to Cowlitz LB Trib 7	Chinook – Medium Coho – High Steelhead -- Medium		2
MC-5B		RM 41.43 – 42.58	Hinkley Road to Blue Creek	Chinook – Medium Coho – High Steelhead – Medium Chum – Low	1	
	MC-5D	RM 41.4 – 42.1	Cowlitz LB Trib 7 to Blue Creek	Chinook – Medium Coho – High Steelhead -- Medium		1
MC-6		RM 42.58 – 50.63	Blue Creek to Mill Creek	Chum – High Steelhead – High Chinook – Low Coho -- Low	2	
	MC-6A	RM 42.1 – 43.6	Blue Creek to Otter Creek	Chum – High Steelhead – High		1
	MC-6B	RM 43.6 – 46.4	Otter Creek to Jones Creek	Chum – High Steelhead – High		2
	MC-6C	RM 46.4 – 46.6	Jones Creek to Lenoue Creek	Chum – High Steelhead – High		2
	MC-6D	RM 46.6 – 49.3	Lenoue Creek to Brights Creek	Chum – High Steelhead – High		2
	MC-6E	RM 49.3 – 50.2	Brights Creek to Mill Creek	Chum – High Steelhead – High		2
MC-7	MC-7	RM 50.2 – 50.5	Mill Creek to Barrier Dam	Chum – High Coho – Medium Steelhead -- High	2	1

* -- LC = Lower Cowlitz, MC = Middle Cowlitz

Table 2. Summary of Primary Limiting Factors for the Life Stages of Focal Salmonid Species (from LCFRB 2004)**.**

Species and Lifestage		*Primary factors*	*Secondary factors*	*Tertiary factors*
Lower Cowlitz Fall Chinook				
most critical	Egg incubation	channel stability, sediment	pathogens	
second	Fry colonization	channel stability, flow, food, habitat diversity, pathogens, predation		
third	Prespawning holding	habitat diversity		
Lower Cowlitz Chum				
most critical	Egg incubation	channel stability, sediment	key habitat	flow, pathogens
second	Prespawning holding	habitat diversity	harassment, pathogens	key habitat, flow
third	Spawning	habitat diversity	flow, pathogens, harassment	key habitat
Lower Cowlitz Coho				
most critical	Egg incubation	channel stability, sediment	key habitat	
second	0-age summer rearing	habitat diversity, temperature	flow, food	channel stability, competition (hatchery), predation, key habitat.
third	0-age winter rearing	habitat diversity	flow	food, channel stability
Lower Cowlitz Winter Steelhead				
most critical	0-age summer rearing	habitat diversity	competition (hatchery), food, pathogens, predation	channel stability
second	Egg incubation	sediment, temperature	channel stability	
third	1-age summer rearing	habitat diversity	competition (hatchery), food, pathogens, predation	channel stability

3.1.2 IWA

The Integrated Watershed Assessment (IWA) is a watershed process screening tool which evaluates watershed process impairments that affect stream habitat conditions. The IWA is a GIS-based assessment that evaluates watershed impairments at the subwatershed scale (3,000 to 12,000 acres). The tool uses landscape conditions (i.e. road density, impervious surfaces, vegetation, soil erodibility, and topography) to identify the level of impairment of 1) riparian function, 2) sediment supply conditions, and 3) hydrology (runoff) conditions. For sediment and hydrology, the level of impairment is determined for local conditions (i.e. within subwatersheds, not including upstream drainage area) and at the watershed level (i.e. integrating the entire drainage area upstream of each subwatershed).

The Lower Cowlitz subbasin, which encompasses a total of 440 square miles, was divided into 40 subwatersheds for an IWA analysis conducted for the Recovery Plan (LCFRB 2004). The IWA results for the Lower Cowlitz subbasin are displayed in **Figure 8**.

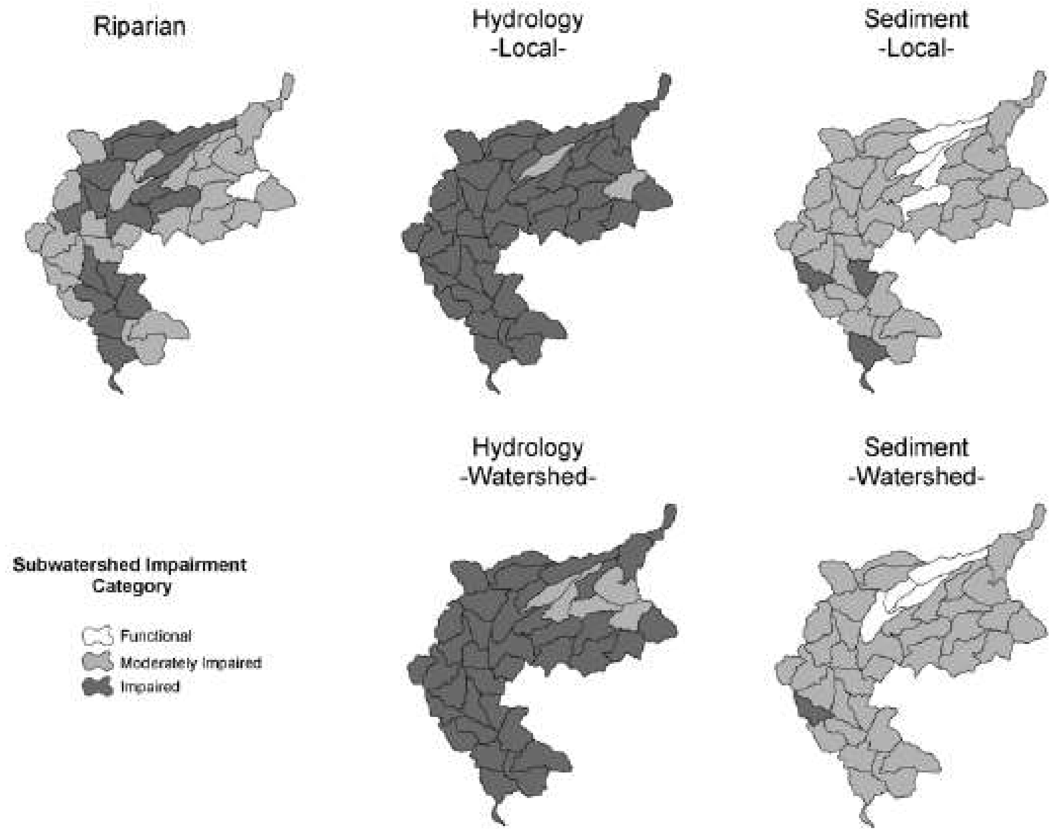


Figure 8. IWA Subwatershed Ratings for the Lower Cowlitz Subbasin

Riparian conditions are rated as moderately impaired (23 subwatersheds) or impaired (16 subwatersheds), with only one subwatershed, Cedar Creek (60201)[3], rated as functional.

Local level hydrologic conditions in the Lower Cowlitz subbasin are impaired in virtually all subwatersheds, with only two moderately impaired subwatersheds on tributaries to the upper mainstem. Watershed level results for hydrologic condition are generally similar, with the exception that hydrologic conditions rated as impaired at the local level in three subwatersheds become moderately impaired at the watershed level, due to the influence of upstream contributing subwatersheds. The lower mainstem of the Cowlitz River has undergone extensive agricultural and residential development. The hydrologic impacts of development include increased magnitude, frequency, and intensity of storm runoff, reduced ground water recharge, and lower stream flows during summer baseflow periods.

Most subwatersheds are rated as moderately impaired for local sediment supply conditions. A few subwatersheds in the lower portion of the subbasin, including the mouth subwatershed, are rated impaired. The remainder are moderately impaired. Locally functional and impaired sediment ratings in two subwatersheds, respectively, become moderately impaired at the

[3] Cedar Creek is a tributary to upper Salmon Creek that enters the Cowlitz River at RM 32.0.

watershed level. This implies that hydrologic and sediment conditions in these subwatersheds are potentially affected by upstream as well as local conditions.

It is important to note that the IWA does not consider the effects of the dams on streamflows within the mainstem Lower Cowlitz subbasin. Given the documented influence of dam operations on mainstem hydrology, the IWA watershed level rating does not adequately portray the level of potential hydrologic impairment in the subbasin.

3.1.3 Six-Year Habitat Work Schedule

The Habitat Work Schedule (LCFRB 2007a) was developed by the to focus the priorities and actions developed in the Recovery Plan (LCFRB 2004) over a six year time frame. The Habitat Work Schedule identifies reach priorities in the subbasin and a list of potential restoration activities. The Habitat Work Schedule is based on a technical assessment and it identifies key priorities, population priorities and viability goals based on the watershed process limitations of the subbasin. In addition, the results of the EDT and Limiting Factors Analysis were incorporated. As a result, a list of eleven prioritized measures was identified in the Lower Cowlitz subbasin. These measures include:

(1) Protect stream corridor structure and function
(2) Protect hillslope processes
(3) Manage regulated stream flows to provide for critical components of the natural flow regime
(4) Create/restore off-channel and side channel habitat
(5) Restore floodplain function and channel migration processes in the mainstem and major tributaries
(6) Restore access to habitat blocked by artificial barriers.
(7) Provide for adequate instream flows during critical periods in tributaries
(8) Restore degraded hillslope processes on forest, agricultural, and developed lands
(9) Restore riparian conditions throughout the basin
(10) Restore degraded water quality with emphasis on temperature impairments
(11) Restore channel structure and stability

The measures that are considered in this study of the lower mainstem and its floodplain include: (4) create/restore off-channel and side channel habitat; (5) restore floodplain function and channel migration processes in the mainstem; (6) restore access to habitats blocked by artificial barriers; (9) restore riparian conditions; and (11) restore channel structure and stability.

3.1.4 Technical Working Group

A Technical Working Group was formed in June 2006 to provide feedback throughout this study on the development of restoration alternatives and the prioritization and ranking process. Participants were invited from the various agencies and stakeholders that participated in the development of the Recovery Plan (LCFRB 2004). Not all invitees participated, but key participants included representatives from the U.S. Army Corps of Engineers, Washington Department of Fish and Wildlife (WDFW), City of Tacoma, Cowlitz Tribe, Cowlitz Game and

Anglers, Lower Columbia Flyfishers, Friends of the Cowlitz, LCFRB, LCFEG, Tetra Tech, and Steward and Associates. The intent was to have Working Group meetings during the course of the study at key points in the process to solicit comments and suggestions. Meetings were held periodically throughout this study to provide feedback on the proposed study plan, assist in the identification and evaluation of potential project sites, and to review prioritization and ranking of projects.

3.2 Restoration Site Identification

Floodplain function, off-channel and side channel restoration, and riparian restoration were identified to provide the most benefits to fish species in the Lower Cowlitz River in the Recovery Plan (LCFRB 2004). The IWA further documented that hydrologic and sediment processes are generally impaired in the lower subbasin. The restoration of floodplain and off-channel habitats may begin to address some of the hydrologic and sediment problems, but the impacts of the Mt. St. Helens eruption, land uses, and the dams will constrain the future functioning of natural processes and must be considered in the development of restoration projects. The identification of restoration sites should focus on locations where restoration can still be functional even within the modified regimes. For example, restoration would be most functional and effective over the long-term in areas with currently active channel migration. Existing side channels can be enhanced to keep them scoured open, or remnant side channels can be restored, but will need to be designed to connect to the mainstem at the new flow regime and include features such as LWD jams to promote continued scour of the openings. By restoring habitats in areas of active channel migration, it is highly likely that the habitats will change over the 20-50 year timeframe, but the channel will form new habitats over the long-term.

In order to identify specific potential restoration sites, a number of steps were taken and are described in the following sections:

3.2.1 Mapping

Base maps were created for the river and floodplain from RM 0 to 52 using aerial photos and topographic mapping. Aerial photos from 1939, 1978, 1990, 1994, 1996, and 2004 were obtained for as much of the lower Cowlitz as available and viewed to identify changes over time to the river and its floodplain. The base maps were developed using the 1990 aerial photos because coverage was available in digital format for the entire area of interest. County parcel maps and topography were overlain on the photos. Additional GIS mapping was obtained from the LCFRB, Cowlitz and Lewis Counties, Washington Department of Fish and Wildlife, National Wetland Inventory, Washington Department of Transportation, and the University of Washington. Potential restoration sites were identified on the base maps. The initial draft of the base maps and project sites were provided at the first Working Group meeting held in July 2006 and feedback was provided on recent development and other conditions that could affect the various sites. The maps were then revised to eliminate some sites that could not support restoration.

3.2.2 Aerial Reconnaissance

An aerial reconnaissance was flown on August 28, 2006 to further identify recent development and vegetation conditions to narrow restoration needs/opportunities down from those identified on the base maps and to identify the types of projects that would be most appropriate at specific sites. The entire lower 52 miles of the Cowlitz River was flown at a low elevation. The trip was documented with video photography. Riverine, floodplain and riparian conditions were inventoried and documented during the flight. Changes to these conditions since the last aerial photos taken were documented on the base maps. Additional features such as gravel and sand bars, side channels, LWD, recent development, and vegetation composition and condition were noted that would help to refine restoration sites or identify new restoration opportunities. Clipped photos from the video were also used to develop project descriptions (see Appendix A).

3.2.3 River Reconnaissance

A boat reconnaissance was then conducted in September 2006 with several members of the Working Group to further define restoration sites and projects and describe existing conditions and constraints. Each site of interest on the mainstem Cowlitz River was visited by boat and foot (where accessible). At each site photographs and field notes were taken to identify specific site features. In some cases, a site map and conceptual drawing of restoration opportunities were drawn.

3.3 Development of Site-Specific Plans

3.3.1 Restoration Approaches

There are several approaches to consider in fish habitat and river restoration that can be used to develop the type and scale of restoration that is appropriate at a specific site.

Conservation and Protection
The most sustainable approach in river restoration is protecting existing river systems, their natural processes and subsequent functioning habitats. This typically involves acquiring and dedicating conservation easements and channel migration zone and floodplain setbacks, especially in critical areas that have extremely valuable habitat benefits, frequent flooding and/or the potential for significant channel migration. This is especially useful in locations at high risk of development or other degradation.

Watershed and Land Use Management
With existing and future growth and development of the human population, it is inevitable that conservation easements and full protection of aquatic and riverine resources are not feasible. Therefore, land use planning and management can be used to prevent further degradation of habitats. While management is not explicitly considered in this report as a site-specific restoration action, it is worthwhile for stakeholders to invest effort in both restoration and management approaches. Some examples include:

- Floodplain, channel migration and critical area zoning and restrictions

- Land use planning and management of resource industries such as mining, forestry and agriculture to provide buffers along waterways and wetlands
- Stormwater management and planning of urbanized and developing areas. Typical types of projects would include regional stormwater facilities or Low Impact Development to limit increases in stormwater and pollutant runoff.

Process Based Restoration

Process based river restoration focuses on restoring physical, biological and chemical processes and the connective linkages that may have been lost due to anthropogenic influences (Kondolf 2006). The underlying approach is based on restoring natural riverine hydrologic and biologic processes and not simply fixing specific symptoms, like an eroding bank. The following are a few examples of process based restoration.

- Riparian plantings along river banks and floodplains to restore natural recruitment of wood to the system.
- Removal of dams and structures that have changed watershed hydrology but are no longer efficiently providing their intended purposes, or cause significant environmental degradation that cannot be mitigated.
- Re-operation of dam water release schedules to account for and simulate natural flows. This can include the quantity of flow, timing, and water quality (i.e. temperature) of flow releases.
- Levee notching, removal or setback to restore floodplain connections and allow habitats to form naturally.
- Gravel and wood augmentation to offset trapping of materials behind a dam. In order to be a functional restoration measure, the scale of wood and gravel loading needs to be similar to the amount of trapping occurring behind the dam(s).
- Fish passage barrier removal or modification.
- Revetment removal to allow natural channel bank erosion and migration processes.

Engineered and Constructed Restoration

Engineered and constructed restoration involves physical manipulation of the river and floodplain to promote, enhance or augment river processes related to fish habitat conditions. Typically, restoration features of this scale and type involve some type of installation of a hydraulic structure or channel manipulation to a desired condition. Engineering analysis and design is needed to support construction. Typically, an engineered and constructed restoration plan can attain results in the short term very efficiently. However there is a higher risk of not being sustainable over the long term, unless the project is designed to accommodate on-going natural processes over the long-term. The following are a few examples of engineered restoration:

- Design and construction of rock or large wood structures to provide in-channel scour and cover.
- Reconnection or reconfiguration of floodplain side channels, backwaters, and wetlands using excavation.
- Bioengineering bank enhancement to reduce impacts from past or future bank stabilization activities.

- Gravel mine restoration that recontours a floodplain on a large scale to recreate natural off-channel habitats.

3.3.2 Restoration Feature Types

Using one or more of the restoration approaches described above (not including watershed and land use management), specific restoration project types were developed that would be suitable on the mainstem Lower Cowlitz River and its floodplain.

Channel Migration Zone Easements
This type of project would involve acquiring properties or conservation easements on properties that are in naturally active channel migration zones that provide multiple benefits to fish habitat, flood and sediment storage. Project sponsors will work with landowners to determine if there is an opportunity for an acquisition or conservation easement. In general, this type of project will involve only minor engineering and construction (such as placement of wood or riparian plantings) and primarily let the river continue to migrate.

Floodplain Restoration and Enhancement
This type of project would involve enhancing or reconnecting existing floodplain areas that may include side channels, backwaters, gravel bars/islands, or wetlands, and that have been disconnected in some manner. Floodplain enhancement can also include placement of large wood (LWD) in the floodplain to provide habitat and cover during high flow events, and planting of riparian vegetation. Floodplain restoration can range from passive to significantly engineered and is a function of adjacent land uses and the risk and the level of disturbance that may have occurred on-site and resulted in the disconnection of the floodplain. For example, simple reconnection of a side channel through notching of a bank or excavation of a bar in an undeveloped area could be relatively passive, whereas removal and setback of a levee adjacent to an urban area would require significant engineering and design to ensure that adjacent previously protected areas did not experience increased flooding as a result of the project.

Riparian Restoration and Non-native Vegetation Removal
These projects are for river bank, side channel, tributary, floodplain, and bar areas that either lack riparian vegetation or have significant non-native vegetation populations. In many cases, riparian plantings and non-native vegetation removal will be part of other project feature types. However, there are instances when it is the only proposed treatment, and will be identified in this manner. Fencing may be included in this type of project if necessary to keep livestock out of a newly restored riparian area. Riparian restoration typically involves planting native tree and shrub species up to the maximum tree height potential immediately adjacent to the mainstem Cowlitz or tributaries (150 feet wide). In some locations, banks may need to be sloped back to provide a suitable area for planting or revetments may need to be modified through wood installations, rock removal and replacement with bioengineered materials and riparian plantings. In some locations, removal of dredged material could create a riparian bench at the appropriate elevation along the river to allow for natural recruitment of wood and other processes.

Side Channel Restoration and Enhancement
This type of project would involve restoring and/or reconnecting side channel features, or enhancing an existing side channel. Side channel enhancement may be part of other project

types. The scale and restoration approach may also vary from project to project. The simplest type of project would involve minor excavation to remove deposited materials to reconnect the side channel. However, a side channel reconnection that is associated with a levee setback and design project near adjacent floodplain infrastructure (farmlands, gravel mines, bridges, houses, pipelines) could require significant engineering and construction work. There are several side channel enhancement projects that are large enough to be stand alone projects and are called out as such in the project list and maps. Restoration can involve restoring historic overflow connections that are currently blocked and enhancement involves placement of LWD and riparian plantings. Other types of side channel enhancement include placement of LWD at the entrances or within side channels to improve habitat complexity and cover or to provide scour to keep the entrance open.

Bar and Island Enhancement
These projects typically involve placement of LWD, side channel enhancements and/or reconnections, and riparian plantings to improve fish habitat conditions in areas that are utilized during a range of flow events, such as high winter flows, to provide cover.

Tributary Enhancement
Tributary enhancement projects focus on the lower end of tributaries and their deltas along the mainstem river. Typically these areas provide a range of habitats for migrating fish. For spawners, the inflow and mixing of cooler water and sediment deposition provides opportunities for spawning near the tributary. For juveniles, the tributary floodplain deltas provide refuge, cover and foraging areas during downstream migration. Typically, alluvial tributary confluence areas are dynamic and complex floodplain environments with active sedimentation and channel dynamics that can provide an array of features including side channels, sloughs, and wetlands. Enhancement features could include placement of LWD, setback of banks to create benches, riparian plantings or levee removals.

Dredged Materials Removal
These projects are specifically related to the removal of dredged materials that were placed in the floodplain of the Toutle and Cowlitz Rivers following the eruption of Mt. St. Helens. In their current state, many of these sites have significant volumes of dredged materials spread across the historical floodplain. These areas have high and oversteepened banks, non-native vegetation and minimal or no floodplain connectivity. There are a variety of strategies that can be applied to these sites. The most engineered approach is to remove all of the material and haul it off site, and restore historic wetlands or side channels and/or plant the floodplain with native vegetation. This action has the potential to incrementally increase floodplain storage. Another approach would be to remove portions of the material to slope the banks back and create a floodplain/riparian bench along the river. Due to the high potential need for future flood engineering along the Lower Cowlitz, this type of project could also be used as mitigation for future flood control projects. Due to the high cost of hauling very large volumes of materials off of a site, most of the projects identified in this study focus on removing only a portion of the material from the site and creating a floodplain/riparian bench along the river.

Gravel Mined Floodplain Restoration

This type of project involves the restoration of gravel mined areas within the floodplain. Restoration of these features includes reconnecting the river and floodplain by removing or notching existing levees and revetments. Depending on the depth and shape of the gravel pits, there may be extensive grading or filling required. In most cases, it will also be necessary to address constraints associated with predator fish species found in the existing warmwater ponds. Creation of flow-through channels will improve water quality, and help salmonids migrate out of the ponds before predators become active in the spring/summer. Also, if cold groundwater upwelling can be incorporated into the project it will tend to reduce suitable habitat for warmwater species. Additional features within the gravel mine restoration projects include pond slope and substrate enhancement (by placement of material to create shallow water zones), placement of LWD and riparian plantings. It will probably be necessary to place protection, such as a levee or berm at the back side of the project area to protect developed areas behind the gravel pits.

3.3.3 Project List

As described in Section 3.2, above, an initial list of potential project sites was developed after the review of the Recovery Plan (LCFRB 2004), aerial photos, and base mapping. This list was first modified based on the feedback from the Working Group and then again after the aerial and boat reconnaissance in the field. The final potential project list is shown in **Table 3**. These sites are shown on the project site maps (**Figures 9-13**) and are identified based on their approximate Rivermile location. Projects identified with a T or C designation are projects on the lower ends of tributaries to the Cowlitz River, submitted by members of the Working Group, or identified in late 2007 for the lower portion of the Toutle River and Olequa Creek. Most of the tributary projects were not visited during the field site reconnaissance. Each project is described in more detail in Appendix A.

Table 3. Potential Restoration Project List

Project ID (RM)	Restoration Project Type	Project Description
0.5R	Riparian restoration	Remove some dredged materials and create riparian and wetland bench
1.0L	Side channel restoration and enhancement	Remove some dredged materials and reconnect side channel, create riparian bench
C3.5R	Tributary enhancement	Reconnect remnant oxbow and restore riparian zone
C4.0B	Tributary enhancement	Place LWD for sediment trapping, cover, and in-stream enhancement upstream of the levees.
3.0L	Riparian restoration	Slope back banks to create riparian bench; remove riprap; revegetate with riparian species
4.5R	Riparian restoration	Set back levee to create riparian bench; remove riprap; revegetate with riparian species
7.3R	Riparian restoration	Remove some dredged materials and create riparian/floodplain bench; construct setback levee if necessary.
8.5R	Riparian restoration	Set back levee and plant riparian/floodplain vegetation on bench
9.0L	Dredged materials removal	Remove some dredged materials and create riparian/floodplain bench.
9.0L-A	Tributary enhancement	Place LWD and vegetate with willows (mouth of Ostrander Creek)
T1	Tributary enhancement	Remove noxious weeds and restore riparian zone along length of Ostrander Creek
9.7R	Bar and island enhancement	Place LWD and ELJ, plant riparian vegetation
T2	Culvert replacement	Replace barrier culvert at Hazel Dell Road on Leckler Creek
9.8L	Riparian restoration	Remove revetment and some dredged material and create riparian and floodplain bench.
10.5L	Riparian restoration	Remove some dredged materials and create riparian/floodplain bench.
11.2L	Bar and island enhancement	Place wood to promote side channel scour and provide cover
12.5L	Side channel restoration and enhancement	Enhance low bar with remnant side channel by placing wood and minor excavation.
12.5R	Riparian restoration	Remove riprap and bioengineer as feasible, remove dredged materials to create riparian/floodplain bench
13.5L	Riparian restoration	Remove some dredged materials and bioengineer recent riprap placement to create riparian/floodplain bench.
14.0L	Side channel restoration and enhancement	Excavate remnant side channel, place LWD
14.5R	Side channel restoration and enhancement	Excavate remnant side channel, place LWD, plant riparian
15.0L	Bar enhancement	Enhance low bar and Sandy Creek and backwater by placing wood and minor excavation.
16.0R	Side channel restoration and enhancement	Create defined boat launch area and restore historic side channel and improve floodplain with plantings and wood
T3	Culvert replacement	Replace fish barrier culvert on Delameter Creek at Delameter Road
T4	Culvert replacement	Fence off stream from livestock and restore riparian below fishways at RM4
T5	Culvert replacement	Replace culvert on Monahan Creek at Delameter Road
T6	Riparian restoration	Remove Japanese knotweed along lower 4 miles of Monahan Creek and revegetate
T7	Channel and riparian restoration	Remove invasive species, revegetate, remeander channel on lower Whittle Creek
16.7L	Bar and island enhancement	Enhance bar with LWD and riparian plantings and promote side channel maintenance
16.8R	Tributary enhancement	Create riparian bench, place LWD and riparian along lower end of Arkansas Creek
17.0L	Riparian restoration	Setback or slope back levees and create riparian bench along Castle Rock
17.0R	Riparian restoration	Setback or slope back levees and create riparian bench along Castle Rock
18.0L	Side channel restoration and enhancement	Reconnect backwater channel and place LWD
18.5L	Dredged materials removal	Remove some dredged materials to create riparian/floodplain bench.
18.8R	Bar and island enhancement	Boat launching area; segregate boat launching from riparian zone and bars; cut chute overflow channels and restore floodplain/riparian habitat
19.8L	Dredged materials removal	Remove some dredged materials to create riparian/floodplain bench.
T0.2R	Dredged materials removal	Remove some dredged materials to create riparian/floodplain bench.
T3.2R	Off-channel restoration and enhancement	Reconnect off-channel ponds behind dredged material, enhance with LWD and riparian restoration
20.2L	Dredged materials removal	Remove some dredged materials to create riparian/floodplain bench.
22.2L	Dredged materials removal	Remove some dredged materials to create riparian/floodplain bench.
23.0L	Off-channel and floodplain restoration	Reconnect wetland to river
23.2R	Bar and island enhancement	Place LWD along side channel and revegetate where appropriate on Hog Island
T8	Culvert replacement	Replace culvert on Rock Creek at West Side Highway
24.0L	Tributary enhancement	Remove water control structure and reconnect Hill Creek; riparian reveg along lower 1000-2000 feet of creek
24.5L	Riparian restoration	Slope back banks and create riparian/floodplain bench.
T9	Tributary enhancement	Restore side channel and riparian zone along lower Olequa Creek, remove invasive species, place LWD
25.0A	Channel migration zone easement	Acquire easements in active channel migration area
25.0B	Side channel restoration and enhancement	Remove car bodies, place LWD and riparian restoration
26.0L	Riparian restoration	Slope back banks to create riparian bench; remove riprap; may need to move road in one area
27.7R	Side channel restoration and enhancement	Place LWD and minor excavation to reconnect side channel
27.7L	Side channel restoration and enhancement	Place wood and create side channel around point; revegetate with native species
28.0L	Gravel mined floodplain restoration	Excavate openings to reconnect gravel mined floodplain,

Project ID (RM)	Restoration Project Type	Project Description
		add LWD, partially fill, regrade shorelines of pond, riparian plantings
T10	Tributary enhancement	Enhance lower portion of Foster Creek and restore riparian to create high quality off-channel site
T11	Culvert replacement	Replace culvert on Foster Creek at I-5
T12	Culvert replacement	Replace culvert on Foster Creek at Jackson Highway
T13	Culvert replacement	Replace culvert on Foster Creek at private drive upstream of Jackson Highway
30.5R	Bar and side channel enhancement	Place log jam at head of side channel
30.7L	Bar and side channel enhancement	Place log jam at head of side channel; minor excavation to reconnect, place LWD and revegetate
31.5R	Bar and side channel enhancement	Enhance existing side channel by placing wood to improve flow and scour, minor excavation and riparian plantings
32.0L	Channel migration zone easement	Acquire easement to allow migration of Cowlitz and Salmon Creek through confluence area, place wood and riparian plantings
32.5R	Side channel restoration and enhancement	Protect existing channels and create new channels through island to take pressure off of private landowner's property. Place wood and riparian plantings
33.0L	Side channel restoration and enhancement	Excavate remnant side channels through gravel islands, place wood and riparian plantings
34.5A	Gravel mined floodplain acquisition	Acquire gravel mined ponds
34.5L	Gravel mined floodplain restoration	Excavate openings to reconnect gravel mined floodplain, add LWD, partially fill, regrade shorelines of pond, riparian plantings. Likely need berm behind ponds to protect properties behind ponds.
36.0R	Side channel restoration and enhancement	Reconnect side channel, riparian vegetation, place LWD
36.5L	Gravel mined floodplain restoration	Excavate openings to reconnect gravel mined floodplain, add LWD, partially fill, regrade shorelines of pond, riparian plantings
37.5L	Side channel restoration and enhancement	Construct culvert or porous revetment entrance to side channel; place wood, riparian restoration along channel, replace culverts, minor excavation as necessary
37.5R	Side channel restoration and enhancement	Excavate to reconnect side channel, place ELJs and wood to promote scour.
T14	Tributary enhancement/riparian restoration	Fence off Skook Creek from livestock and restore riparian upstream of Howe Road
38 - 40 A	Channel migration zone easement	Acquire easements at channel migration zone
40.1 L	Side channel restoration and enhancement	Excavate opening to upper end of Springer channel, place wood to keep scoured open.
41.0L	Riparian restoration	Remove riprap and bioengineer along private properties
41.9R	Bank enhancement	Place LWD and create controlled deposition zone for material eroding from high bank (reduces fine sediment inputs)
42.0R	Tributary enhancement	Remove barrier dams at hatchery, riparian plantings and place wood.
42.5L	Bar and side channel enhancement	Place LWD to provide cover and promote scour of openings
42.7R	Bar and side channel enhancement	Excavate to reconnect side channel and ponds, place ELJs and wood to promote scour.
44.5R	Bar and side channel enhancement	Place LWD to provide cover and promote scour of openings
T15	Culvert replacement	Replace culvert on Jones Creek at Spencer Road
46.5R	Side channel restoration and enhancement	Excavate to reconnect side channel, place ELJs and wood to promote scour.
47.0L	Side channel acquisition	Acquire highest quality side channel and protect.
49.5L	Side channel restoration and enhancement	Excavate to reconnect side channel, place ELJs and wood to promote scour, riparian plantings

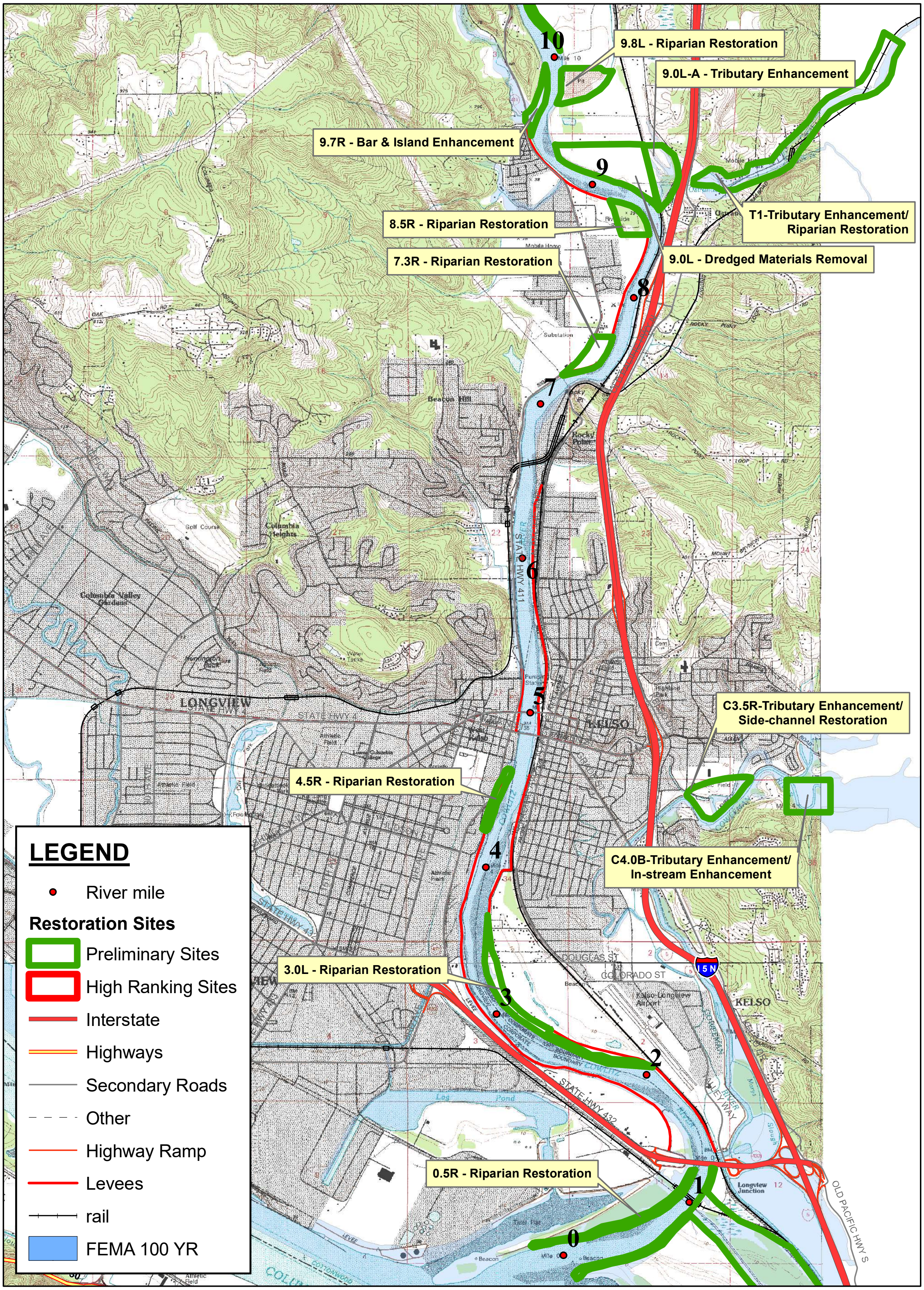


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FIGURE 9.
POTENTIAL RESTORATION PROJECTS
IN THE LOWER COWLITZ RIVER,
RM 0-10

TETRA TECH

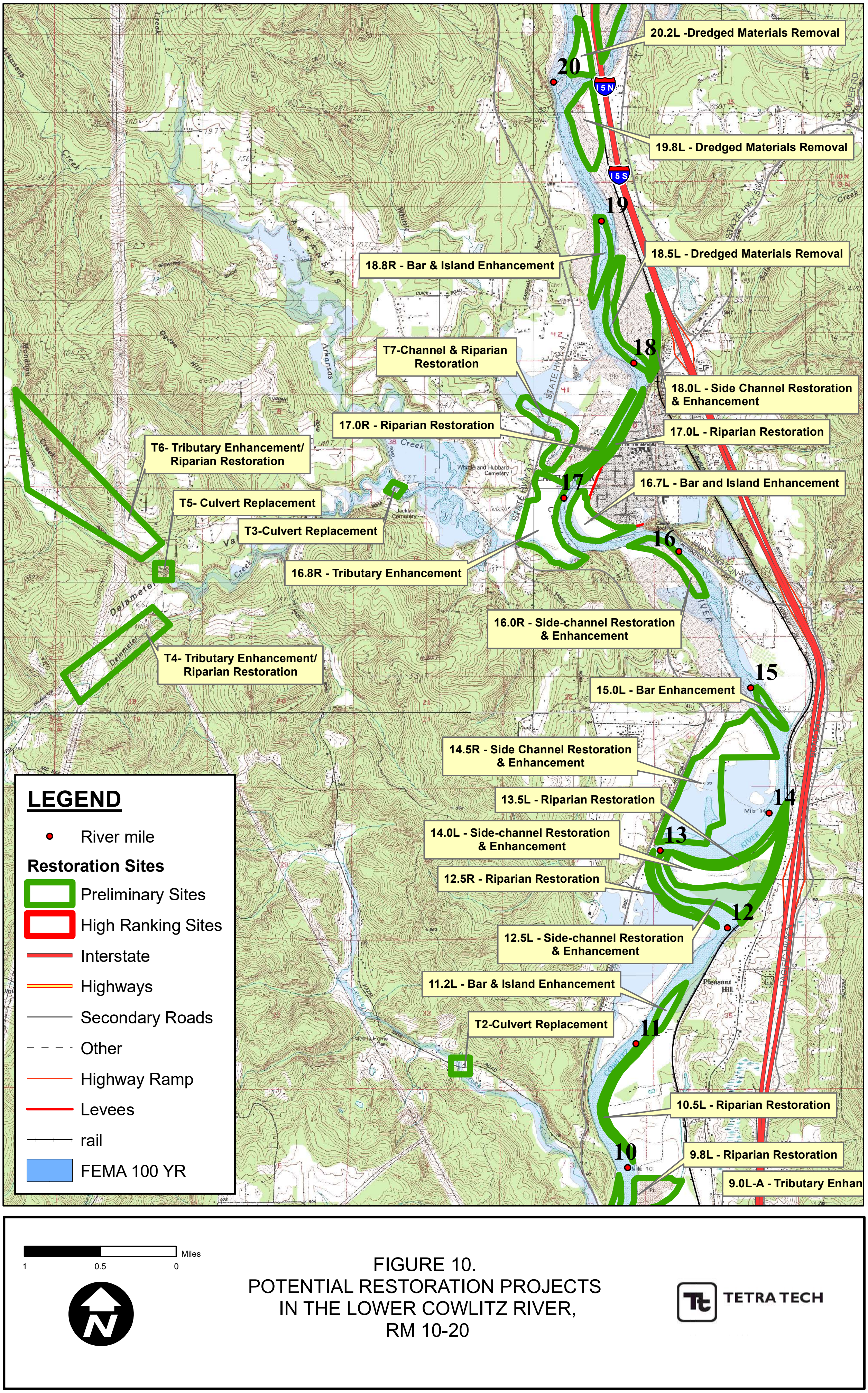

FIGURE 10.
POTENTIAL RESTORATION PROJECTS
IN THE LOWER COWLITZ RIVER,
RM 10-20

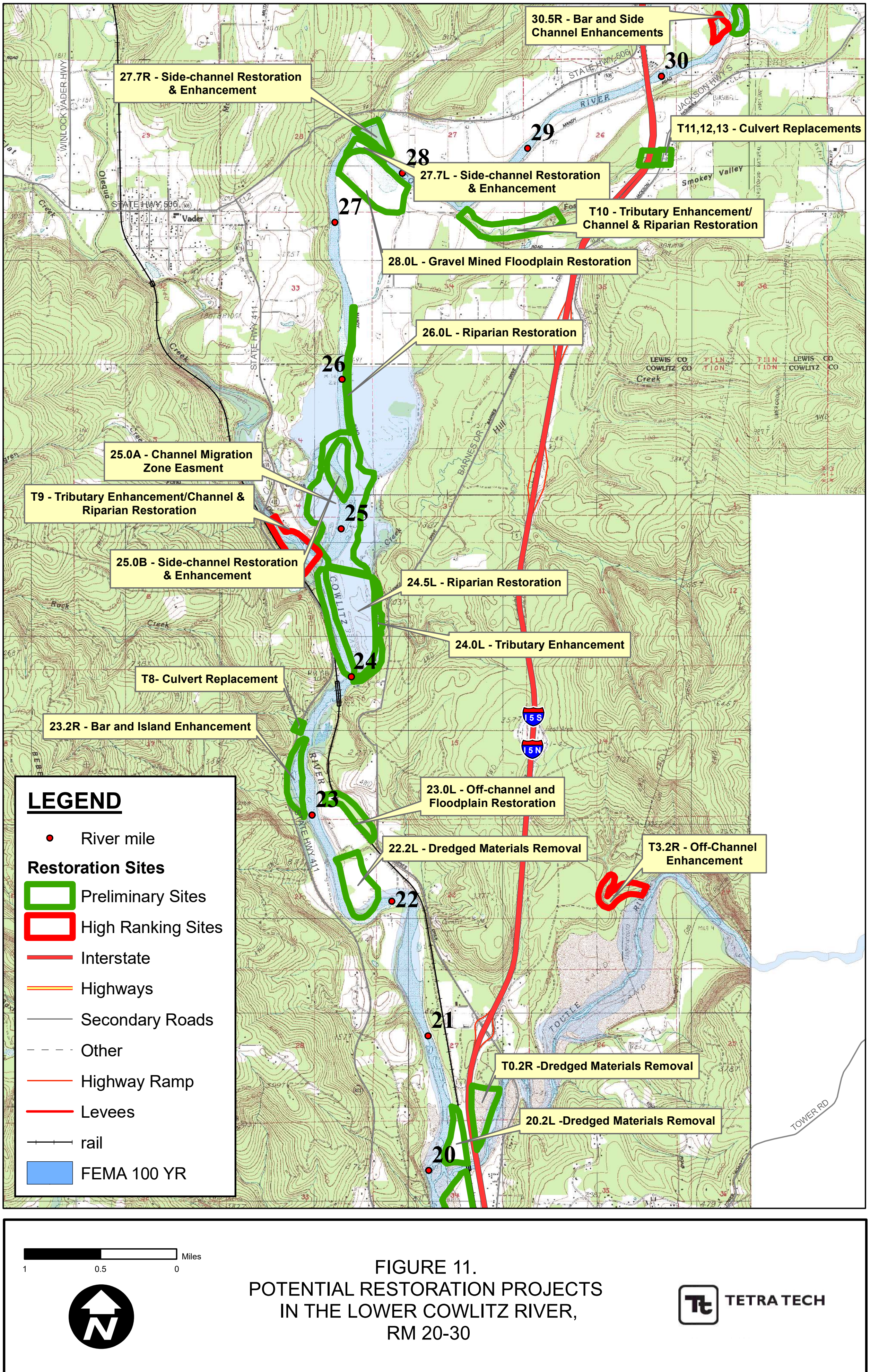

FIGURE 11.
POTENTIAL RESTORATION PROJECTS
IN THE LOWER COWLITZ RIVER,
RM 20-30

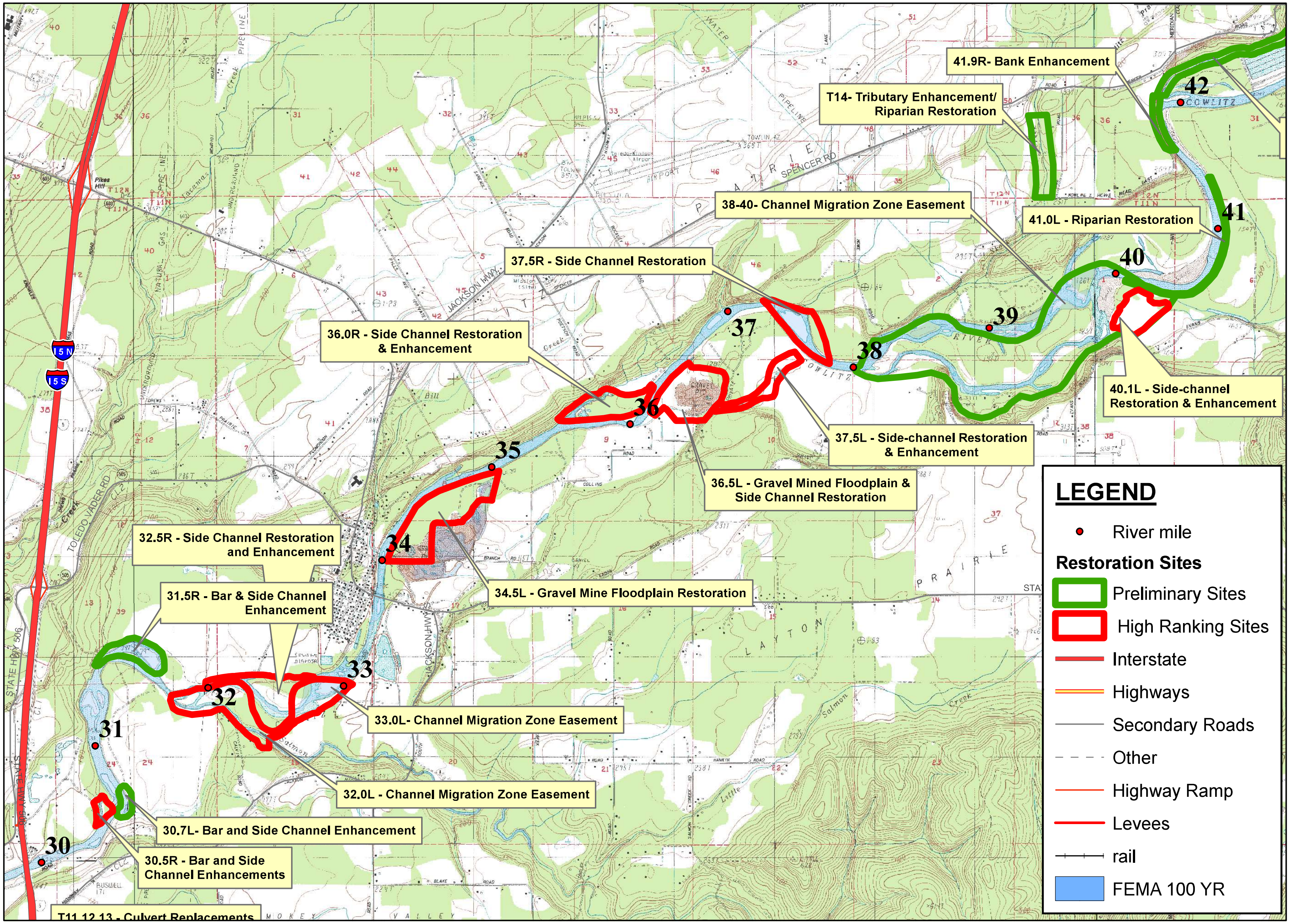

FIGURE 12.
POTENTIAL RESTORATION PROJECTS
IN THE LOWER COWLITZ RIVER,
RM 30-42

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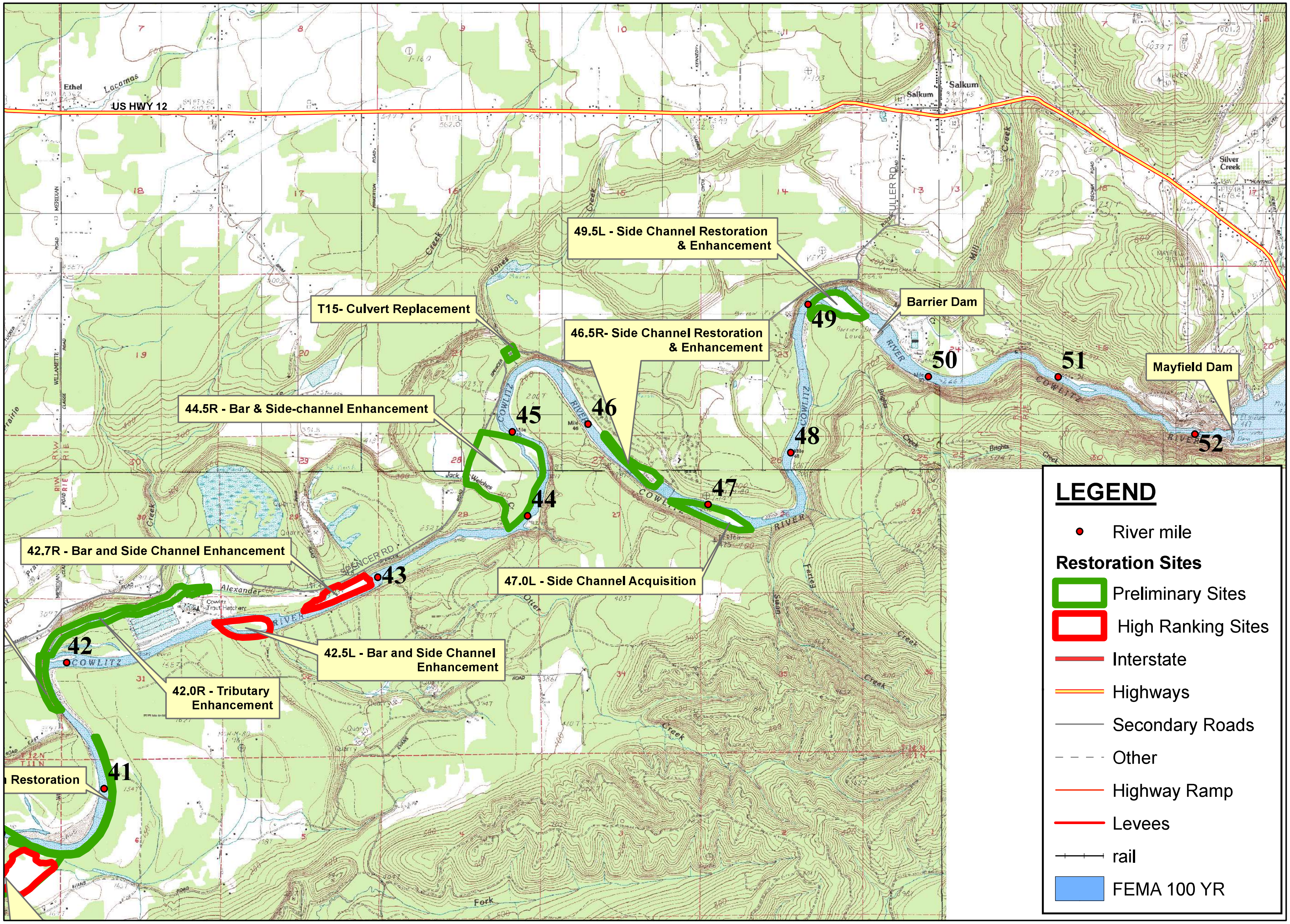

FIGURE 13.
POTENTIAL RESTORATION PROJECTS
IN THE LOWER COWLITZ RIVER,
RM 42-52

TETRA TECH

3.3.4 Project Cost Estimates

Preliminary cost estimates were developed for each project using standard unit costs and estimates of project lengths, widths, and potential depths of excavation required based on the boat reconnaissance. Potential feasibility of construction was evaluated to escalate the costs with a contingency on top of the unit costs. These cost estimates are intended to be at a conceptual level to allow comparisons between projects and do not include costs to acquire easements in most cases. **Table 4** shows the unit costs used in the cost estimates. Appendix B shows the cost estimate spreadsheet that itemizes the quantities of various elements of each project and the narrative on feasibility of construction.

Table 4. Unit Cost Assumptions for Project Ranking.

Feature Type	Unit Costs	Source
1. Riparian plantings	$10,000-15,000 per acre	Evergreen Funding Consultants 2003; Tetra Tech unpublished data
2. Excavate and haul dredged material	$8-10/CY	Tetra Tech unpublished data
3. Bioengineer levee or bank protection	$400/linear foot	Evergreen Funding Consultants 2003; Tetra Tech unpublished data
4. Install piece of LWD	$1000/ea	Tetra Tech unpublished data
5. Import and place soil, substrate, rock	$10/CY	Evergreen Funding Consultants 2003; Tetra Tech unpublished data
6. Install ELJ	$50-100k per structure	Evergreen Funding Consultants 2003; Tetra Tech unpublished data
7. Acquire channel migration easement	$10,000/acre	Evergreen Funding Consultants 2003
8. Fencing	$4-10/linear foot	Evergreen Funding Consultants 2003
9. Noxious weed removal	$5000/acre	Tetra Tech unpublished data

3.3.5 Project Ranking and Prioritization

The ranking and prioritization of the Restoration Project Site List was conducted using a two step method developed by the LCFRB to rank grant applications for the Salmon Recovery Funding Board (SRFB). This method (LCFRB 2007c) is described in detail in Appendix C and the full scoring and ranking spreadsheets are also included. The first step ranks the projects primarily based on their expected benefits to salmonids and consistency with the Recovery Plan (LCFRB 2004). The two key components of the fish benefit evaluation are: 1) the importance of the fish populations, key life history stages, and associated limiting factors targeted by the project; and 2) the extent to which the project will address the targeted limiting factors. Other factors are also considered in this step including other species habitat benefits, the relative costs of each project, and how reasonable that cost is.

The second step of the evaluation considers the certainty of success of a project. This evaluation is primarily concerned with how likely it is that a project will achieve its proposed benefits. Because the projects described in this document are not necessarily at the point where a grant application would be submitted to construct them, not all factors considered by the LCFRB were included in this ranking. The key elements that were included in this certainty of success evaluation are: 1) project scope – is the scope tied directly to the stated goals and objectives and does it account for the causes of the limiting factors in the project reach? 2) project approach – does the project approach utilize proven and accepted technologies and does it account for potential risk of failure? 3) coordination and sequencing – is the project logically sequenced with other habitat projects completed, underway or planned in the subbasin and coordinated with other plans or programs? 4) uncertainties and constraints – does the project account for physical, legal, technical or other uncertainties or constraints such as future development? 5) landowner willingness – is the project proposed for publicly owned lands or privately owned lands and has the landowner been approached to discuss the potential project?

Based on the above evaluation, the final ranking and prioritization is shown in **Table 5**. The methodology for scoring and the scoring spreadsheets are provided in Appendix C. The highest priority projects that were designed to more detail are highlighted in gray and are discussed in Section 5. Projects with known willing landowners (either public or private) are currently ranked highly. This ranking will change over time, as more landowner outreach occurs and some projects with a current low or medium certainty of success could be ranked medium or high.

Table 5. Ranked Project List Using LCFRB Method (LCFRB 2007c).

Project ID	Project Name	Pop/ Reach Score	PAR Score	Raw Benefit Score	Normalized Benefit Score	Cost	Cost/Benefit	Cost Score	Total Benefit Score	Benefit Ranking	Certainty of Success	Overall Priority Grouping
42.5L	Bar and side-channel enhancement	23.5	12.00	35.50	36.00	$150,000	$4,225	15	51.00	H	H	1
37.5R	Side-channel restoration and enhancement	20.5	15.00	35.50	36.00	$350,000	$9,859	14	50.00	H	H	1
T9	Tributary enhancement/side-channel restoration	15	21.00	36.00	36.00	$425,000	$11,806	14	50.00	H	H	1
36.0R	Side-channel restoration and enhancement	20.5	12.00	32.50	33.00	$500,000	$15,385	13	46.00	H	H	1
T9A	Riparian/floodplain acquisition	15	3.00	18.00	18.00	$200,000	$11,111	14	32.00	H	H	1
34.5L	Gravel mined floodplain restoration	20.5	43.92	64.42	65.00	$2,500,000	$38,808	9	74.00	H	M	2
37.5L	Side-channel restoration and enhancement	20.5	24.00	44.50	45.00	$500,000	$11,236	14	59.00	H	M	2
34.5A	Gravel mine acquisition	20.5	24.00	44.50	45.00	$800,000	$17,978	13	58.00	H	M	2
32.0L	Channel migration zone easement	24.5	14.15	38.65	39.00	$450,000	$11,643	13	52.00	H	M	2
T3.2R	Reconnect off-channel ponds	21	9.00	30.00	30.00	$100,000	$3,333	15	45.00	H	M	2
30.5R	Bar and side-channel enhancement	21.5	6.00	27.50	28.00	$175,000	$6,364	15	43.00	H	M	2
30.7L	Bar and side-channel enhancement	21.5	6.00	27.50	28.00	$200,000	$7,273	15	43.00	H	M	2
49.5L	Side-channel restoration and enhancement	21.5	9.00	30.50	31.00	$600,000	$19,672	12	43.00	H	M	2
36.5L	Gravel mined floodplain restoration	20.5	12.15	32.65	33.00	$2,000,000	$61,256	6	39.00	H	M	2
40.1L	Side-channel restoration and enhancement	20.5	49.80	70.30	85.00	$1,000,000	$14,225	13	98.00	M	H	3
42.0R	Tributary enhancement	8	55.05	63.05	64.00	$300,000	$4,758	15	79.00	M	H	3
38-40A	Channel migration zone easement	20.5	44.00	64.50	65.00	$5,000,000	$77,519	6	71.00	M	H	3
T3	Culvert replacement	11	40.2	51.20	52.00	$250,000	$4,883	15	67.00	M	H	3
T2	Culvert replacement	8	24.12	32.12	33.00	$300,000	$9,340	15	48.00	M	H	3
42.7R	Bar and side-channel enhancement	22.5	9.00	31.50	32.00	$300,000	$9,524	15	47.00	M	H	3
47.0L	Side-channel acquisition	22.5	8.00	30.50	31.00	$200,000	$6,557	15	46.00	M	H	3
1.0L	Side-channel restoration and enhancement	19.5	18.60	38.10	39.00	$800,000	$20,997	12	51.00	M	M	4
23.2R	Bar and side-channel enhancement	19.5	15.00	34.50	35.00	$450,000	$13,043	13	48.00	M	M	4
0.5R	Riparian restoration	19.5	16.20	35.70	36.00	$750,000	$21,008	12	48.00	M	M	4
44.5R	Bar and side-channel enhancement	22.5	9.00	31.50	32.00	$150,000	$4,762	15	47.00	M	M	4
46.5R	Side-channel restoration and enhancement	22.5	8.01	30.51	31.00	$400,000	$13,110	13	44.00	M	M	4
24.0L	Tributary enhancement	8	14.40	22.40	23.00	$150,000	$6,696	15	38.00	M	M	4
T1	Riparian restoration/Noxious weed removal	23	179.20	202.20	85.00	$750,000	$3,709	15	100.00	L	M	5
T6	Riparian restoration/Noxious weed removal	15	42.20	57.20	58.00	$750,000	$13,112	13	71.00	L	M	5
C4.0B	Instream enhancement	15.5	31.50	47.00	47.00	$350,000	$7,447	15	62.00	L	M	5
16.0R	Bar and island enhancement	18.5	27.00	45.50	46.00	$500,000	$10,989	14	60.00	L	L	5
14.5R	Side-channel restoration and enhancement	18.5	27.00	45.50	46.00	$750,000	$16,484	12	58.00	L	M	5
9.0L	Dredged materials removal	18.5	28.50	47.00	47.00	$2,000,000	$42,553	8	55.00	L	L	5
14.0L	Side-channel restoration and enhancement	18.5	22.43	40.93	41.00	$750,000	$18,324	12	53.00	L	L	5
25.0B	Side-channel restoration and enhancement	17.5	21.48	38.98	39.00	$500,000	$12,827	13	52.00	M	L	5
33.0B	Channel migration zone easement	20.5	14.70	35.20	36.00	$350,000	$9,943	14	50.00	H	L	5
18.8R	Floodplain restoration	18.5	18.00	36.50	37.00	$500,000	$13,699	13	50.00	L	L	5
31.5R	Bar and side-channel enhancement	24.5	7.47	31.97	32.00	$250,000	$7,820	15	47.00	H	L	5
T5	Culvert replacement	7	24.12	31.12	32.00	$250,000	$8,033	15	47.00	L	H	5
11.2L	Bar and island enhancement	18.5	12.00	30.50	31.00	$250,000	$8,197	15	46.00	L	M	5
3.0L	Riparian restoration	18.5	21.00	39.50	40.00	$3,000,000	$75,949	6	46.00	L	L	5
T8	Culvert replacement	8	24.10	32.10	33.00	$500,000	$15,576	12	45.00	L	H	5
12.5L	Side-channel restoration and enhancement	18.5	12.00	30.50	31.00	$400,000	$13,115	13	44.00	L	M	5
32.5R	Bar and side-channel enhancement	20.5	7.47	27.97	28.00	$300,000	$10,726	15	43.00	H	L	5
15.0L	Bar and island enhancement	18.5	12.00	30.50	31.00	$450,000	$14,754	12	43.00	L	L	5
9.7R	Bar and island enhancement	18.5	9.00	27.50	28.00	$250,000	$9,091	14	42.00	L	L	5
18.0L	Side-channel restoration and enhancement	18.5	9.00	27.50	28.00	$300,000	$10,909	14	42.00	L	L	5
28.0L	Gravel mined floodplain restoration	18.5	14.64	33.14	34.00	$1,500,000	$45,263	8	42.00	L	L	5
C3.5R	Side-channel restoration and enhancement	15.5	12.00	27.50	28.00	$350,000	$12,727	13	41.00	L	H	5
41.9R	Bank enhancement	21.5	6.00	27.50	28.00	$400,000	$14,545	13	41.00	H	L	5
16.7L	Bar and island enhancement	18.5	9.00	27.50	28.00	$525,000	$19,091	12	40.00	L	M	5
27.7R	Side-channel restoration and enhancement	18.5	6.00	24.50	25.00	$250,000	$10,204	14	39.00	L	M	5
23.0L	Off-channel and floodplain restoration	18.5	12.00	30.50	31.00	$1,000,000	$32,787	8	39.00	L	M	5
24.5L	Riparian restoration	19.5	7.50	27.00	27.00	$750,000	$27,778	11	38.00	M	L	5
41.0L	Riparian restoration	22	3.47	24.97	25.00	$400,000	$16,019	12	37.00	H	L	5
7.3R	Riparian restoration	18.5	6.00	24.50	25.00	$400,000	$16,327	12	37.00	L	L	5
10.5L	Riparian restoration	18.5	10.50	29.00	29.00	$1,300,000	$44,828	8	37.00	L	M	5
27.7L	Side-channel restoration and enhancement	18.5	3.90	22.40	23.00	$300,000	$13,393	13	36.00	L	L	5
16.8R	Tributary enhancement	13.0	12.00	25.00	25.00	$650,000	$26,000	11	36.00	H	L	5
9.0L-A	Tributary enhancement	10	10.00	20.00	20.00	$150,000	$7,500	15	35.00	L	L	5
9.8L	Riparian restoration	18.5	6.00	24.50	25.00	$750,000	$30,612	10	35.00	L	L	5
17.0L	Riparian restoration	18.5	3.96	22.46	23.00	$600,000	$26,714	11	34.00	L	M	5
13.5L	Riparian restoration	18.5	6	24.50	25.00	$900,000	$36,735	9	34.00	L	M	5
12.5R	Riparian restoration	18.5	7.00	25.50	26.00	$1,000,000	$39,216	8	34.00	L	M	5
8.5R	Riparian restoration	18.5	6.00	24.50	25.00	$1,000,000	$40,816	9	34.00	L	L	5
26.0L	Riparian restoration	18.5	3.47	21.97	22.00	$750,000	$34,137	11	33.00	L	M	5
T0.2R	Dredged materials removal	21	6.00	27.00	27.00	$2,500,000	$92,593	6	33.00	H	L	5
17.0R	Riparian restoration	18.5	2.48	20.98	21.00	$500,000	$23,832	11	32.00	L	M	5
18.5L	Dredged materials removal	18.5	7.50	26.00	26.00	$2,500,000	$96,154	6	32.00	L	L	5
25.0A	Channel migration zone easement	17.5	5.00	22.50	23.00	$1,000,000	$44,444	8	31.00	M	L	5
22.2L	Dredged materials removal	18.5	4.50	23.00	23.00	$1,500,000	$65,217	7	30.00	L	L	5
4.5R	Riparian restoration	18.5	2.20	20.70	21.00	$900,000	$43,478	8	29.00	L	L	5
19.8L	Dredged materials removal	18.5	9.00	27.50	28.00	$8,500,000	$309,091	1	29.00	L	L	5
T13	Culvert replacement	7	5.4	12.40	13.00	$50,000	$4,032	15	28.00	L	M	5
T14	Riparian restoration	8	5.00	13.00	13.00	$100,000	$7,692	14	27.00	L	L	5
T15	Culvert replacement	7	8.00	15.00	15.00	$250,000	$16,667	12	27.00	L	H	5
20.2L	Floodplain restoration	18.5	3.60	22.10	23.00	$3,000,000	$135,747	3	26.00	L	L	5
T4	Riparian restoration	8	1.45	9.45	10.00	$100,000	$10,582	14	24.00	L	L	5
T10	Stream channel habitat enhancement	8	6.68	14.68	15.00	$350,000	$23,842	9	24.00	L	M	5
T7	Riparian restoration	7	4.74	11.74	12.00	$250,000	$21,295	11	23.00	L	M	5
T12	Culvert replacement	7	5.40	12.40	13.00	$500,000	$40,323	9	22.00	L	H	5
T11	Culvert replacement	7	5.4	12.40	13.00	$1,000,000	$80,645	6	19.00	L	H	5

Projects highlighted in yellow were originally the highest ranked projects before including Spring Chinook from the upper basin.
Projects highlighted in orange have been included in the more detailed designs and costs following the reranking.

4. Results and Recommendations

Based on the field observations, preliminary project development, and scoring and ranking procedures, the following overall results of the analysis of reach conditions and recommendations for restoration are described by reach.

4.1 Reach 1. RM 0.0 to 5.0 - Cowlitz Mouth to Hwy 4 Bridge

4.1.1 Reach 1 Historical to Current Comparison

The lower five miles of the river encompasses the historic Columbia River/Cowlitz River confluence. The mouth of the Cowlitz River and confluence with the Columbia River is an alluvial delta and sedimentary zone. The historical width of the alluvial sedimentary fan or delta at the Cowlitz and Columbia River confluence was approximately 7.5 miles across, as evidenced by geologic mapping and underlying stratigraphy shown in **Figure 14** (WDGER 1987)[4]. The length of the depositional fan extended from the current mouth upstream for approximately 5.0 miles, just upstream from the Highway 4 bridge. This location is where the Cowlitz valley margins become narrow, and are bordered by outcrops and hills composed of continental sediments and deposits of weakly cemented sediments from glacial flood events.

Reach 1 is within the freshwater, tidally influenced zone. Daily tidal fluctuations in river stage occur in this river reach, and play a role in channel and floodplain morphology. The area was likely to have historically been a highly dynamic landscape with active sedimentation, erosion, channel migration and wood deposition from both the Cowlitz and the Columbia River. These processes would contribute to the area having a complex array of floodplain features and relics of dynamic fluvial processes including wetlands, backwater channels and sloughs, multiple distributary and tributary side channels, cutoff ponds and lakes, with abundant variety of riparian trees, grasses, willow and cottonwood forests as are mapped on the original GLO maps shown in **Figure 15** (USBLM 1884). Currently, the channel sinuosity is approximately 1.5, but has not shown active signs of migration since the mid 1800s as shown on the GLO map. Within the main channel, large sand bar features can be seen from recent aerial photography. These features are dynamic structures that are highly mobile and constantly shifting. It is expected that future sediment from the Mt. St. Helens volcanic and lahar sediments will deposit along this reach of the river. This may require actions by the Corps and local flood control districts to protect from adverse flooding from continued sedimentation, which may involve dredging and disposal of spoils (USACE 2002).

Comparisons between the historical GLO map and recent aerial photographs (**Figure 16**) do not show significant changes in the Lower Cowlitz main channel location and position. However, the establishment of industrial and commercial complexes and residential development in the floodplain has significantly modified floodplain features. Many of the historical backwater sloughs and tributaries have been channelized and rerouted to drain the area for development. In particular, as shown in **Figure 16** on the west side of the Cowlitz River, Lake Sacajawea and the Log Pond appear to be remnants of the distributary channels and wetland habitats shown in

[4] Qa = Quaternary alluvium which includes alluvium, volcaniclastic, glacial outburst flood and landslide deposits.

Figure 15. Currently, the industrialized waterfront has limited fish habitat available and water quality issues upstream towards the sewage treatment plant in West Kelso (pH, temperature, fecal coliform, arsenic). To the east side of the Cowlitz, less commercial and industrial development has occurred with the primary human influences on the river being transportation infrastructure (such as the I-5 corridor) and spoils disposal from past dredging operations.

Upstream from the Hwy 432 bridge crossing, the Coweeman River is the primary tributary in this reach of the river. Both the Cowlitz and Coweeman are leveed and confined in place for flood control. The Coweeman travels along the eastern margin of the Cowlitz River valley, with the Cowlitz River remaining in a location similar to the conditions when the GLO mapping occurred.

A number of wetland areas are still present in the delta area of this reach associated with remnant distributary channels and backwaters from the Columbia River (**Figure 17**). However, due to channelization of the river, there are only a few fringing wetland areas remaining on the mainstem. These fringing wetlands are likely formed as a result of sediment deposition within the levees and the growth of wetland vegetation on these low bars. It is likely that these bars and other shoals will be removed to provide flood control within the urban area. The natural processes of sediment deposition, channel migration, and tidal flooding have been disrupted in this reach due to development of the floodplain.

Habitat restoration opportunities in this reach are limited due to the extensive development within the floodplain. Opportunities include reconnection of distributary channels at the confluence with the Columbia River, and restoration of fringing wetlands and riparian zone along the mainstem. Dredged material has been placed in the floodplain below the Coweeman confluence and could be removed to reconnect the floodplain. Any historic spawning habitat in this reach has been buried under the deposition of Mt. St. Helens sediments. The substrate is now entirely sand. There are opportunities for off-channel and in-channel habitat restoration along the lower Coweeman where not constrained by levees or urban development.

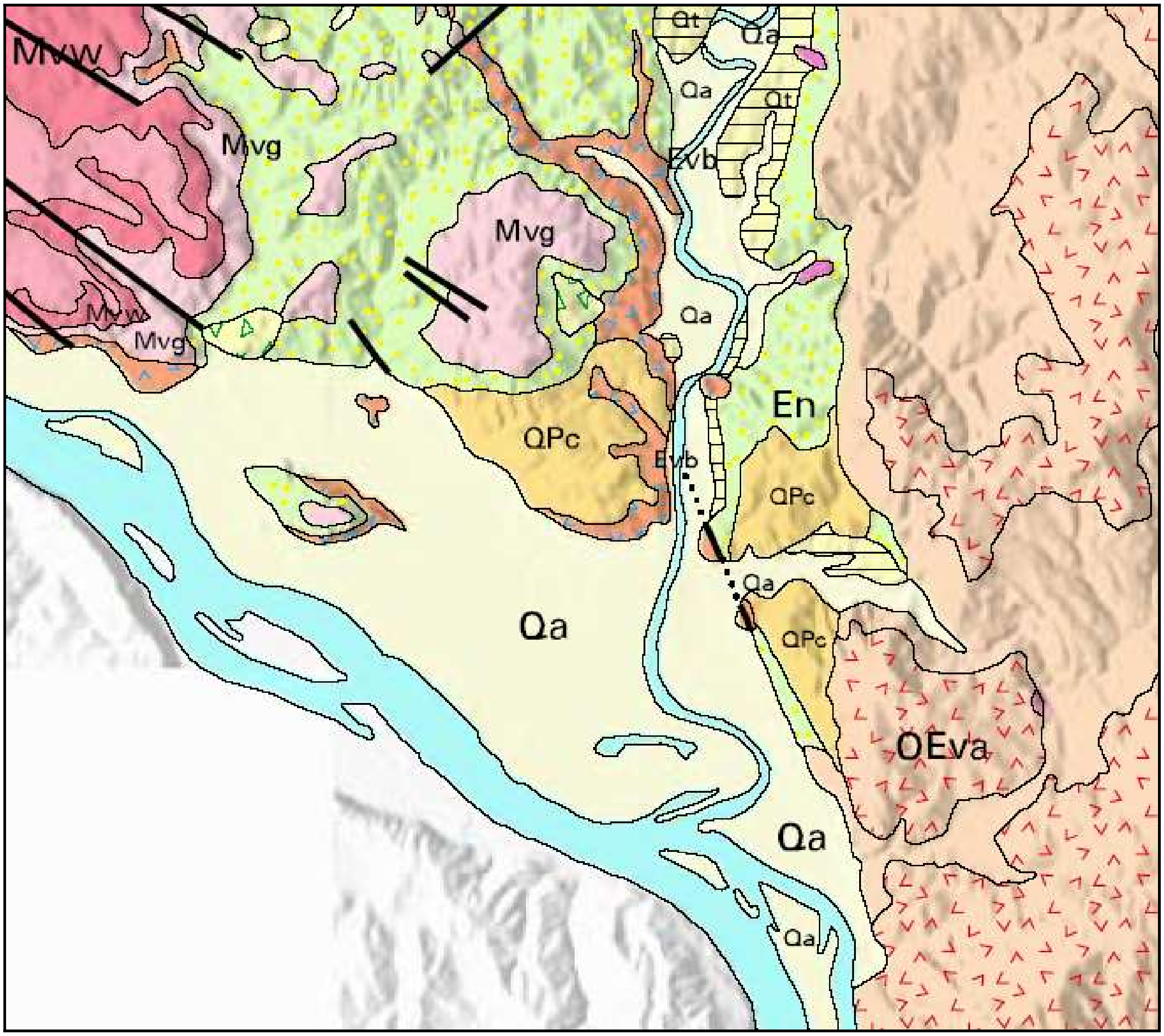

Figure 14. Geologic Map of Cowlitz/Columbia River Confluence to Horseshoe Bend (WDGER 1987)

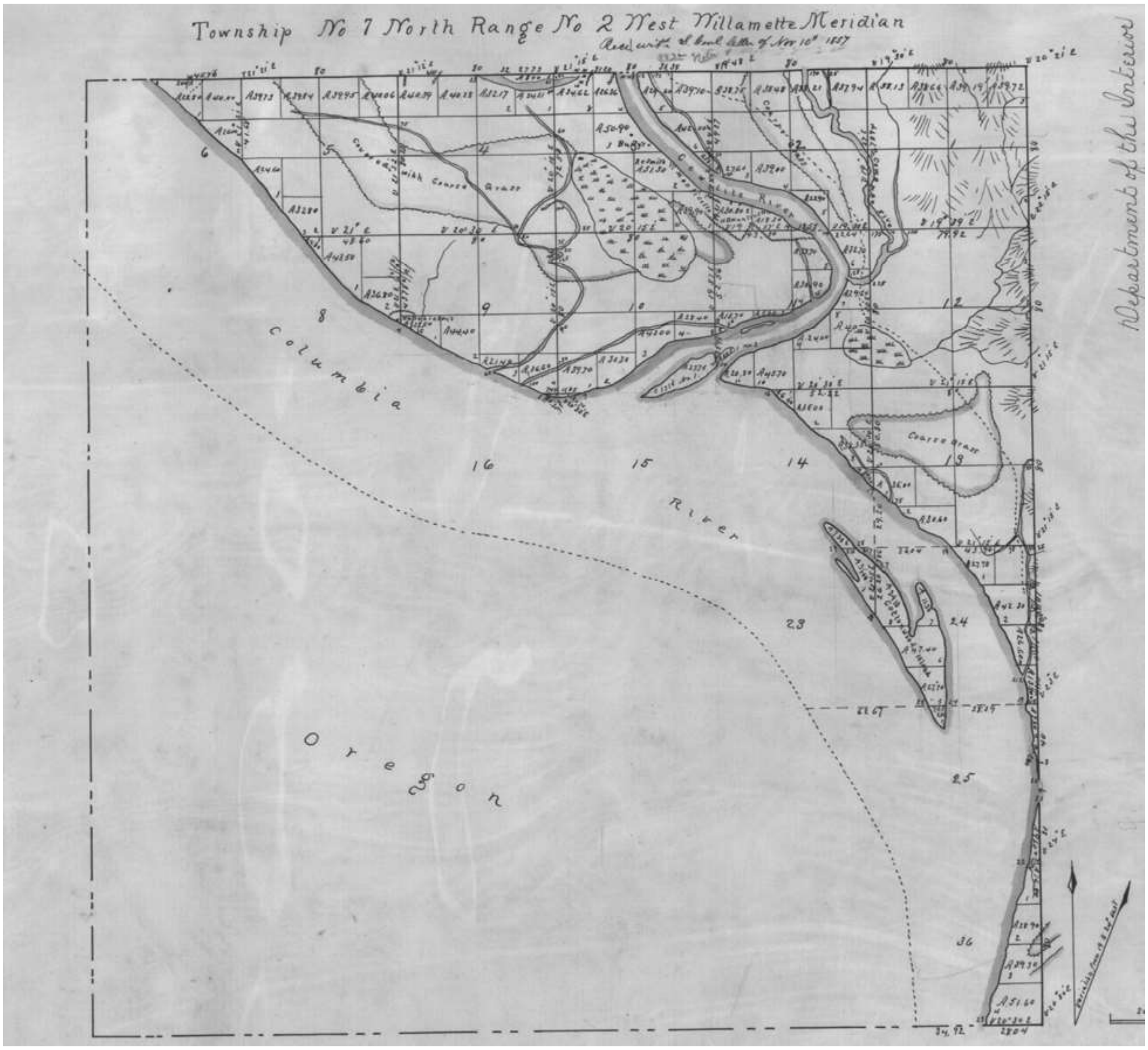

Figure 15. Historical GLO Map of the Cowlitz/Columbia River Confluence (USBLM 1884)

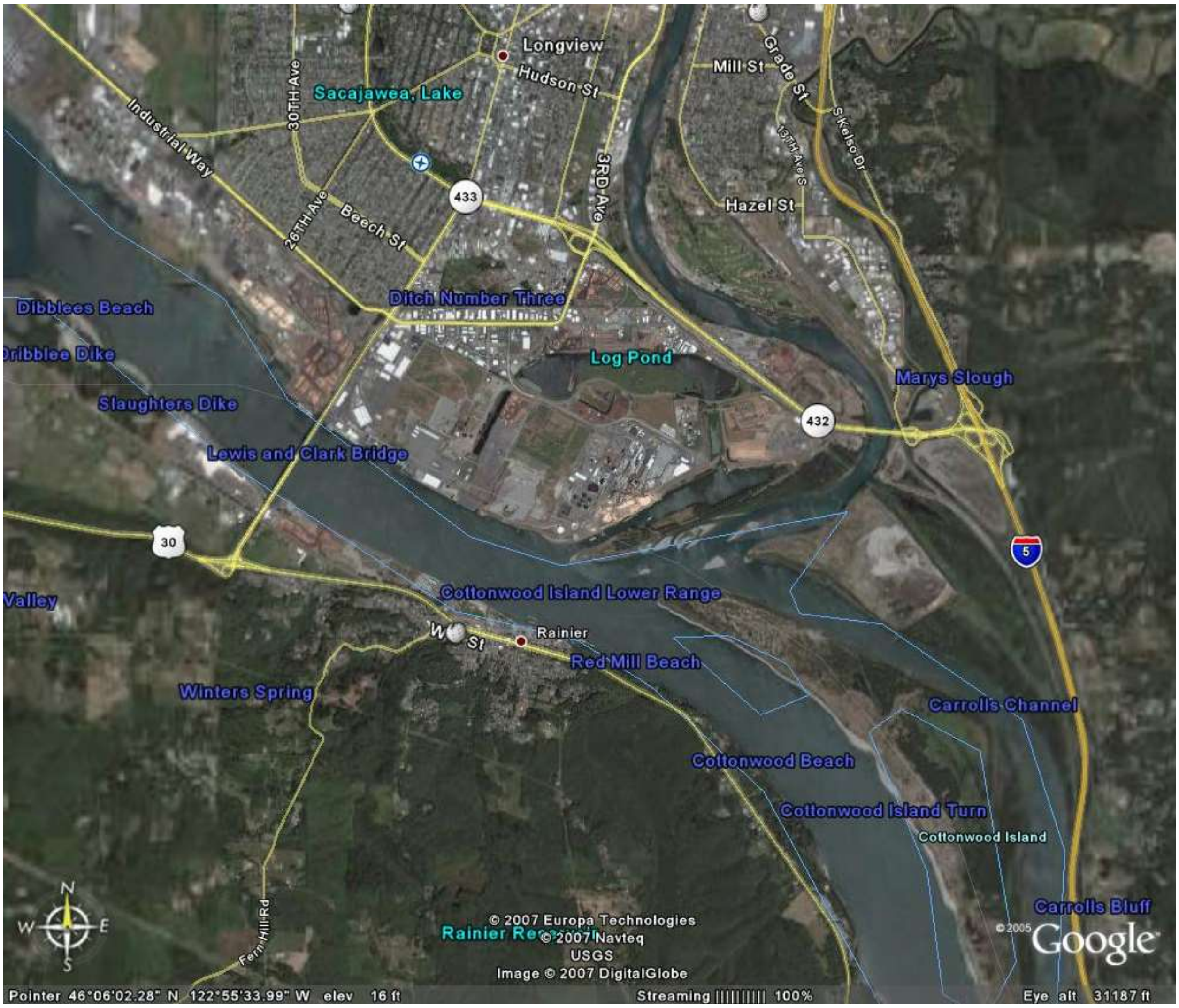

Figure 16. Current Aerial of the Cowlitz/Columbia River Confluence near Kelso, WA (Google Earth 2007)

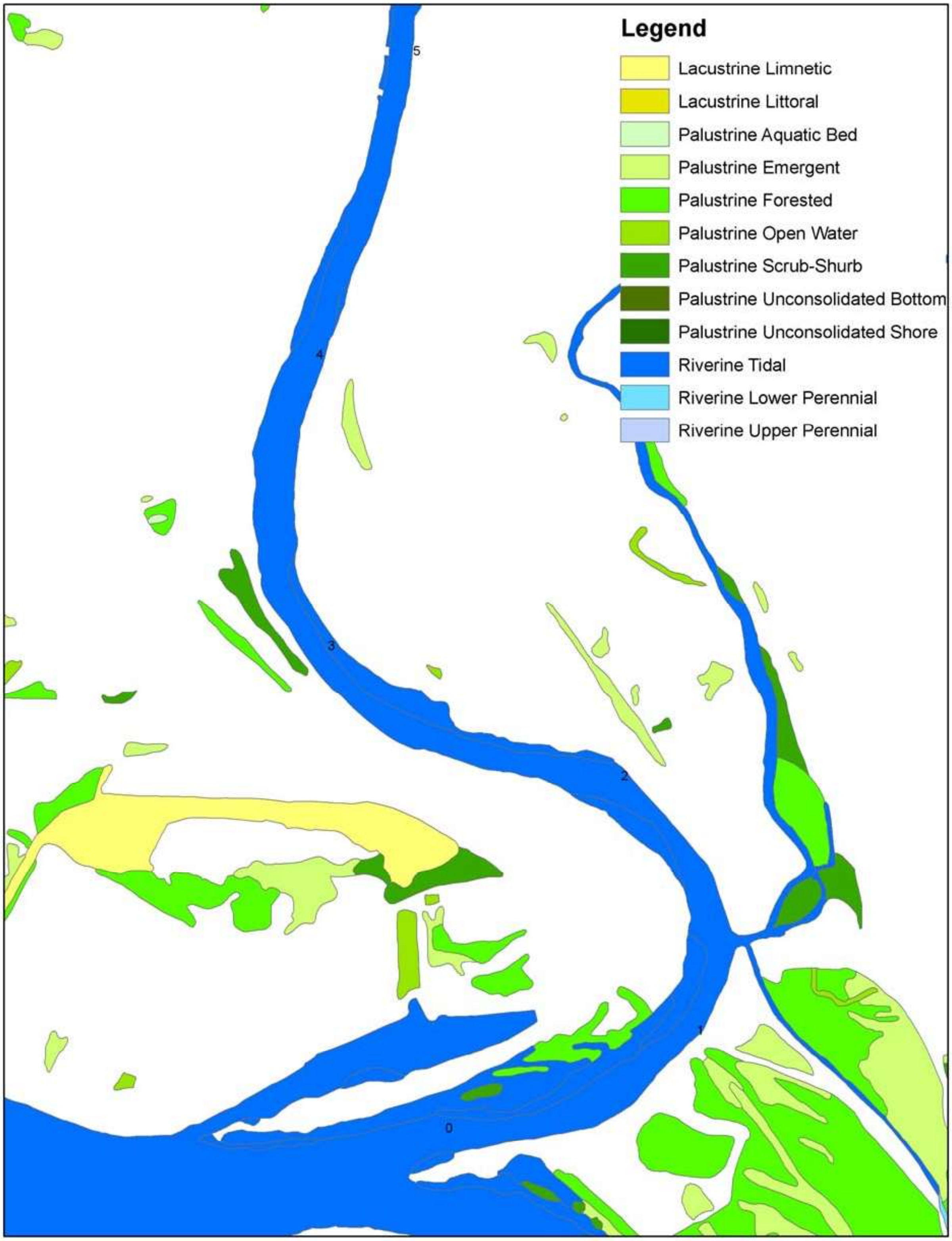

Figure 17. National Wetland Inventory Mapping for Reach 1, RM 0 to 5.0 (WDFW 2006).

4.1.2 Assessment Observations and Results

This reach is surrounded by urban industrial, commercial, and residential land uses and subject to significant on-going sedimentation from material carried downstream from the Toutle River. Because this reach is low gradient and tidally influenced with low or fluctuating velocities, sediment is readily deposited throughout the reach in shifting sandbars and along the shorelines. The deposition of material has increased the potential for flooding in the adjacent developed areas of Kelso and Longview. The Corps is currently studying flood control needs and is currently dredging in this reach. Both the on-going sedimentation and dredging activities significantly reduce the potential to restore in-channel habitat features in this reach, and also limit the effectiveness or longevity of floodplain or off-channel habitat reconnections.

The primary importance of this reach of the river is that it provides shallow water tidal rearing habitat for juvenile salmonids and may provide adult pre-spawning holding habitat. The confluence of the Cowlitz River with the Columbia River was a historically complex zone of distributary channels and tidal sloughs and wetlands. The habitat complexity has largely been eliminated. One distributary/slough channel remains at RM 0.5 on the left bank. This channel is currently connected during high flows in the Columbia or Cowlitz, but is not generally connected during low flows or low tides. There is a lack of tidal marsh habitat. A small area of marsh habitat remains along the right bank below RM 1.0. The substrate is not suitable for spawning habitat, as it is dominated by sand.

4.1.3 EDT/IWA Summary

This reach includes from the original EDT reaches, Lower Cowlitz 1 and a portion of Lower Cowlitz 2, rated as Tier 1 and 2 reaches, respectively. Lower Cowlitz Reach 1 was rated as a Tier 1 reach, likely due to the analysis at the time that this reach historically provided excellent tidal rearing and refuge habitat for all salmonid species in the entire Cowlitz basin as well as a major spawning area for chum salmon. The EDT analysis considered that further degradation of Lower Cowlitz 1 would have a significant negative effect on fall Chinook and chum, and restoration could have a significant benefit for chum. Sediment has a high impact on Chinook and the lack of habitat diversity has a high impact on chum. Restoration of key habitat quantity would have a high positive impact on both Chinook and chum. For Lower Cowlitz 2, both Chinook and chum would be benefitted by restoration actions. Channel stability, habitat diversity, and sediment were considered to have high impacts on Chinook in Lower Cowlitz 2, and habitat diversity has a high impact on chum. Restoration of key habitat quantity would have a high positive effect on chum. However, the reality of the situation in this reach is that the majority of the historic floodplain and off-channel habitat has been developed and distributary channels have either been filled by dredged material or are disconnected due to the high sediment load and deposition. The river channel is highly constrained by levees and there are few opportunities for habitat restoration.

The revised EDT reaches include LC-1 and LC-2A, rated as Tier 2 and 3, respectively. These revised ratings are more accurate with respect to the restoration potential. The small restoration actions that could be undertaken in this reach are unlikely to significantly benefit any of the species. There could be some benefits from restoration of rearing habitats and habitat complexity in Reach 1 and the reach is an important transportation corridor for both juveniles and adults, so the prevention of further degradation would also be important.

4.1.4 Restoration Opportunities and Priorities

The primary opportunities for habitat restoration are for reconnection of the historical wetlands and distributary side channels that are currently inaccessible or filled from dredged material disposal. The loss of distributary channel and slough areas to industrial and commercial uses and placement of dredged material significantly limits the amount of available tidal slough and marsh habitat. The projects identified in this reach include: 1) 0.5R, riparian restoration; 2) 1.0L side channel restoration and enhancement (reconnect distributary channel); 3) 3.0L riparian restoration; and 4) 4.5R riparian restoration. The riparian restoration projects, while feasible, would not likely be highly effective due to the width of the river and the land use constraints (could not provide desired riparian corridor width). The project at RM 1.0L, restoration of tidal channel and marsh habitat would primarily benefit 0-age Chinook and chum that rear extensively in shallow water tidal areas by providing cover and a greater quantity of habitat. The lower Coweeman River is highly channelized between levees and has limited habitat value, but there are opportunities for a couple of projects at RM 3.5 and 4.0 to reconnect a remnant oxbow and enhance in-stream habitat by placement of wood just upstream of where the levees start.

The mainstem projects in Reach 1 do not rank highly overall on the list because they will only provide narrow and isolated habitats within a highly urbanized area. Also, the on-going risk from future sediment deposition and/or dredging activities limits the potential life-time of projects in this reach and their certainty of success. When considering other sources of funding, other than the SRFB, there could be opportunities to construct restoration projects as mitigation for expected future development or flood control actions, or to provide habitat "stepping stones" to facilitate the juvenile and adult salmon transportation corridor function of the river.

The highest ranked restoration action for this reach is the reconnection of the distributary channel and tidal slough and marsh creation at RM 1.0L.

4.2 Reach 2. RM 5.0 to 10.0 – Hwy 4 Bridge to Leckler Creek

4.2.1 Reach 2 Historical to Current Comparison

The five miles of the river between the Highway 4 bridge and Leckler Creek are confined, both geologically and by manmade flood control levees. In the vicinity of northern Kelso, the valley width is approximately 0.5 to 1.0 miles, with an alluvial valley bed and confining lateral geologic structures including quaternary terraced sediments and upper Eocene marine deposits to the east and Eocene era volcanic basalt bedrock to the west. Levees parallel the river throughout the length of this reach between Kelso and Lexington. Within Lexington, the right bank levee (west side of river) follows Westside Drive at the upstream and downstream ends of the levee. Along the middle of the levee, the levee follows the edge of the river, away from Westside Drive, and protects developed areas and Riverside Park from flooding. The floodplain width has been significantly reduced from its historic width of 1.0 mile, to just under 0.3 miles wide. The

Leckler Creek confluence is near the upstream end of the tidal influence area where daily fluctuations in river stage are observed (USACE 2004).

The historical GLO maps indicate that the Cowlitz River occupied a somewhat different location in 1884, further to the west at River Mile 7.2 (**Figure 18**). The map shows the river much further to the west, opposite of Rocky Point. In its current configuration, the river abuts Rocky Point with the areas behind Westside Drive and levees occupied by residential areas of Lexington (**Figure 19**).

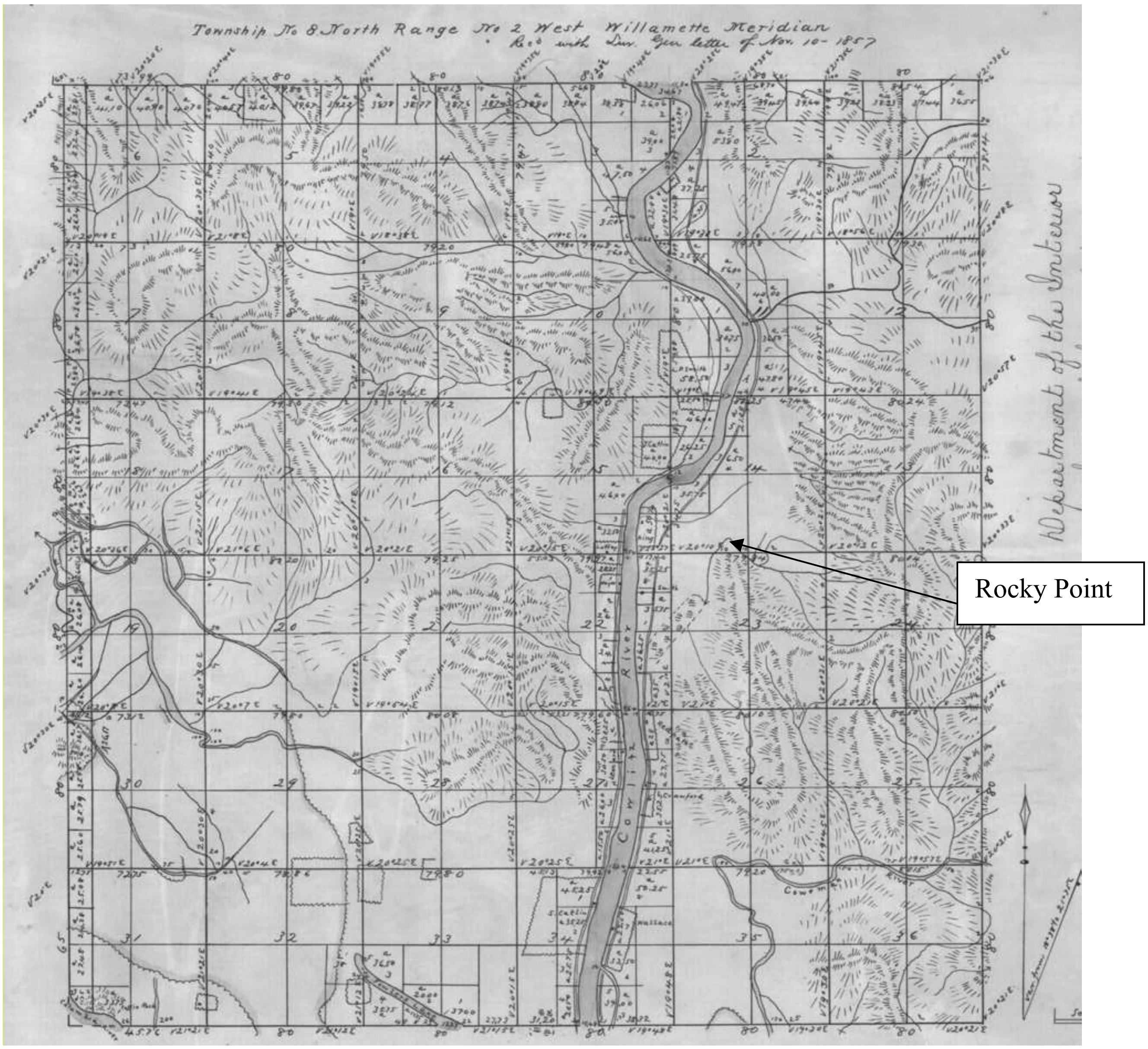

Figure 18. Historical GLO Map of the Cowlitz River near Lexington (USBLM 1884)

Figure 19. Current Aerial of the Cowlitz River near Lexington (Google Earth 2007)

Due to the confinement of the river and development within the floodplain in this reach, there are very few wetlands currently remaining (**Figure 20**). Similar to Reach 1, the majority of the wetlands are associated with low bars deposited along the channel margins within the levees. Also similar to Reach 1, this reach has limited opportunities due to development in the floodplain. The only restoration opportunities are riparian restoration through setting back or modifying existing levees. A small area of floodplain at Riverside Park and an undeveloped dredged material site at RM 7.0 are the only available floodplain areas for restoration. The channel substrate is sand, as a result of deposition of Mt. St. Helens sediments. Restoration of spawning habitat in this reach is unlikely. In-channel structures (i.e. large woody debris) could be placed, but would likely be buried or transported downstream.

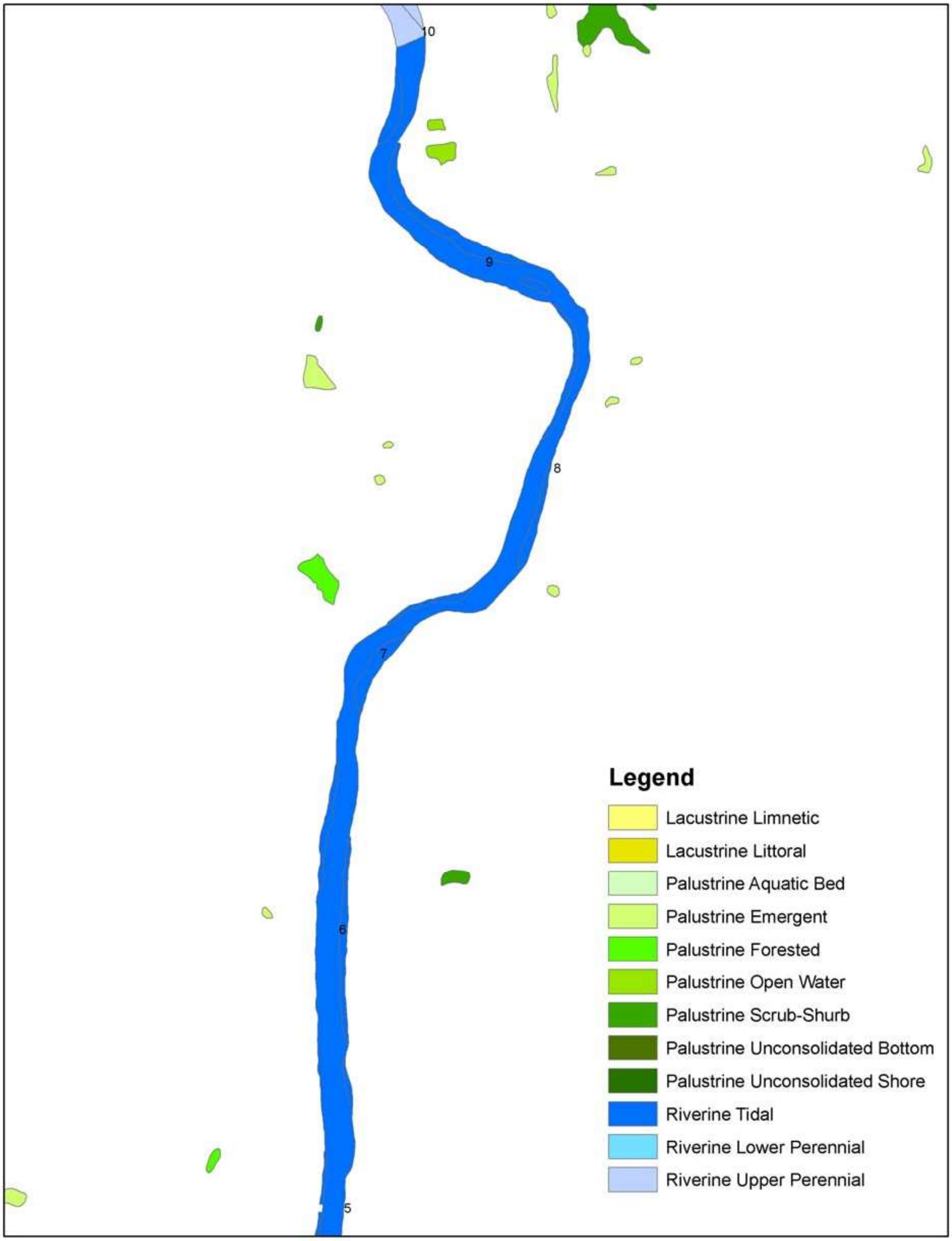

Figure 20. National Wetlands Inventory Mapping for Reach 2, RM 5.0 to 10.0 (WDFW 2006).

4.2.2 Assessment Observations and Results

In this reach, the floodplain is highly developed with commercial and residential development, and levees or bank protection are present in most areas up through Lexington. There are no off-channel or floodplain areas available for restoration below RM 7. There are numerous shoals in this reach and shallow water habitat is plentiful due to the on-going deposition of material from the Toutle River. However, there is essentially no instream or riparian cover, except for some fragmented narrow strips of riparian vegetation. The only restoration options below RM 10 are to set or slope back the levees and create a riparian bench next to the river.

However, this reach of the river provides shallow water tidal rearing habitat for juvenile salmonids and may have historically been used for chum spawning. This reach is also an important transportation corridor for both juvenile and adult salmon.

4.2.3 EDT/IWA Summary

This reach includes from the original EDT reaches, only Lower Cowlitz 2, rated as a Tier 2 reach. For Lower Cowlitz 2, both Chinook and chum would be benefitted by restoration actions. Channel stability, habitat diversity, and sediment were considered to have high impacts on Chinook in Lower Cowlitz 2, and lack of habitat diversity has a high impact on chum. Restoration of key habitat quantity would have a high positive effect on chum. However, the reality of the situation in this reach is that the majority of the historic floodplain and off-channel habitat has been developed. The river channel is highly constrained by levees and there are few opportunities for habitat restoration.

The revised EDT reaches include, Lower Cowlitz 2A through 2F, all rated as Tier 3 reaches. These revised rankings are more accurate with respect to restoration potential. The majority of the floodplain in this reach has either been filled by dredged material or has been developed and is protected by levees or bank armoring. The types of restoration that would be feasible here such as riparian restoration and minor levee setback with floodplain reconnections would not provide significant benefits to fish due to the width of the river and the narrow corridor available. There could be some minor benefits from restoration of refuge habitats and habitat complexity (i.e. placement of wood in the floodplain, and the reach is an important transportation corridor for both juveniles and adults.

4.2.4 Restoration Opportunities and Priorities

The primary opportunities for habitat restoration in this reach are reconnections of the historical floodplains currently inaccessible due to levees or filled from dredged material disposal, and riparian restoration. The projects identified in this reach include: 1) 7.3R, riparian restoration with minor floodplain restoration; 2) 8.5R, riparian restoration and levee setback; 3) 9.0L, dredged materials removal; 4) 9.0L-A; tributary enhancement; 5) 9.7R, bar and island enhancement; and 6) 9.8L, riparian restoration. Because habitat diversity is a major issue in this reach, tributary confluence enhancement (placement of wood) and bar and island enhancement (placement of wood to provide cover and high flow refugia) could provide increased habitat diversity. There is a need to remove noxious weeds and restore the riparian zone along Ostrander Creek.

The mainstem projects in Reach 2 do not rank highly overall on the list because they will only provide narrow and isolated habitats within a highly constrained reach. Also, the on-going risk from future sediment deposition and/or dredging activities limits the potential life-time of projects in this reach and their certainty of success. When considering other sources of funding, other than the SRFB, there could be opportunities to construct restoration projects as mitigation for expected future development or flood control actions, or to provide habitat "stepping stones" to facilitate the adult and juvenile salmonid transportation corridor functions of the river. Restoration of in-stream, riparian and floodplain habitats in Reach 2 would primarily benefit 0-age Chinook and chum that rear extensively in shallow water tidal areas by providing cover and increased habitat diversity/complexity.

The highest ranked project in this reach is T1, riparian restoration along Ostrander Creek. The priority restoration actions for the mainstem in this reach are to reconnect any floodplain areas that are feasible and provide a natural riparian and floodplain zone for refuge and habitat complexity, but overall, this reach has the lowest opportunity and potential benefit from restoration of any of the reaches in the Lower Cowlitz.

4.3 Reach 3. RM 10.0 to 20.0 – Leckler Creek to the Toutle River

4.3.1 Reach 3 Historical to Current Comparison

The floodplain and channel morphology changes as one moves upstream into Reach 3. The valley and historical floodplain are broader than found in the human-confined downstream river segments between Kelso and Lexington. Alluvial deposits and valley width are wider, up to 1.5 miles wide. According to FEMA mapping, some of these floodplains are still within the 100-year floodplain, such as near RMs 11-14; however, much of the floodplain is no longer active due to levee and flood protection measures and several floodplain areas that were filled and raised above the flood elevation due to dredged materials disposal.

The Toutle River is currently the primary sediment source to the Cowlitz River due to the 1980 eruption of Mt. St. Helens and the resulting 3.8 billion cubic yard sediment and debris flow caused by the event (USACE 2002). In response to the volcanic sediment and debris flow, the Corps undertook the Mt. St. Helens Project as authorized by Public Law 99-88 for addressing the flooding and sedimentation problems from the eruption. Several activities were undertaken to protect downstream resources, including construction of the following:

- Sediment Retention Structure (SRS) was constructed on the North Fork Toutle River (constructed 1989) and in the Green River tributary to the Toutle River
- Outlet and diversion tunnel from Spirit Lake to reduce the risk for a debris dam break flood (constructed 1985)
- Fish collection facility on the Toutle River
- Downstream levee improvements on the Kelso, Castle Rock and Lexington levees (1980-1981)

- Dredging operations in the Toutle and Cowlitz River through the year 2035 (last performed 1989)
- McCorkle Creek pump station addition

Dredging operations along the Toutle and Cowlitz Rivers were undertaken subsequent to the debris and sediment avalanche from the 1980 volcanic event. Dredged materials were placed at numerous available undeveloped locations within the Cowlitz River floodplain between the Toutle River and the mouth of the Cowlitz. This fill raised the floodplain up above the 100-year flood elevation in many locations. The majority of the material is sandy and is easily visible due to the sparse vegetation that has been able to recolonize it in the 27 years since the eruption (primarily Scotch broom).

The river channel downstream from the Toutle River confluence exhibits characteristics of high sediment supply and loading to the reach through the development of point and mid channel sand bars. Predictions from the *Mt. St. Helens, Engineering Reanalysis and Design Documentation Report* (USACE 2002) indicate that up to 1.5 feet of channel aggradation may occur in this reach of river. Understanding the role of future sedimentation will be a key element in developing sustainable habitat restoration solutions for this segment of the Lower Cowlitz.

In the Castle Rock area, the town is protected by a flood control levee along the left bank. No other levee systems are identified along the study reach, but there are several bank revetments confining the channel from migrating.

A comparison of the historic 1884 condition (**Figure 21**) to the current conditions of the river channel (**Figures 22-24**), shows the river follows a similar alignment from RM 10-17, up to Castle Rock. A large pond or wetland area is shown in Figure 21 to the east of the river that appears to be fed by the small tributaries from the east. This area is still mapped as floodplain on FEMA maps and is located along the I-5 corridor where two small tributaries enter the Cowlitz River. Upstream of Castle Rock, the historic alignment of the river was somewhat to the east of its current alignment. Anecdotal information from long-term residents indicates the Toutle River now enters the Cowlitz River upstream of where it historically did (D. Becker, pers. comm. 2006).

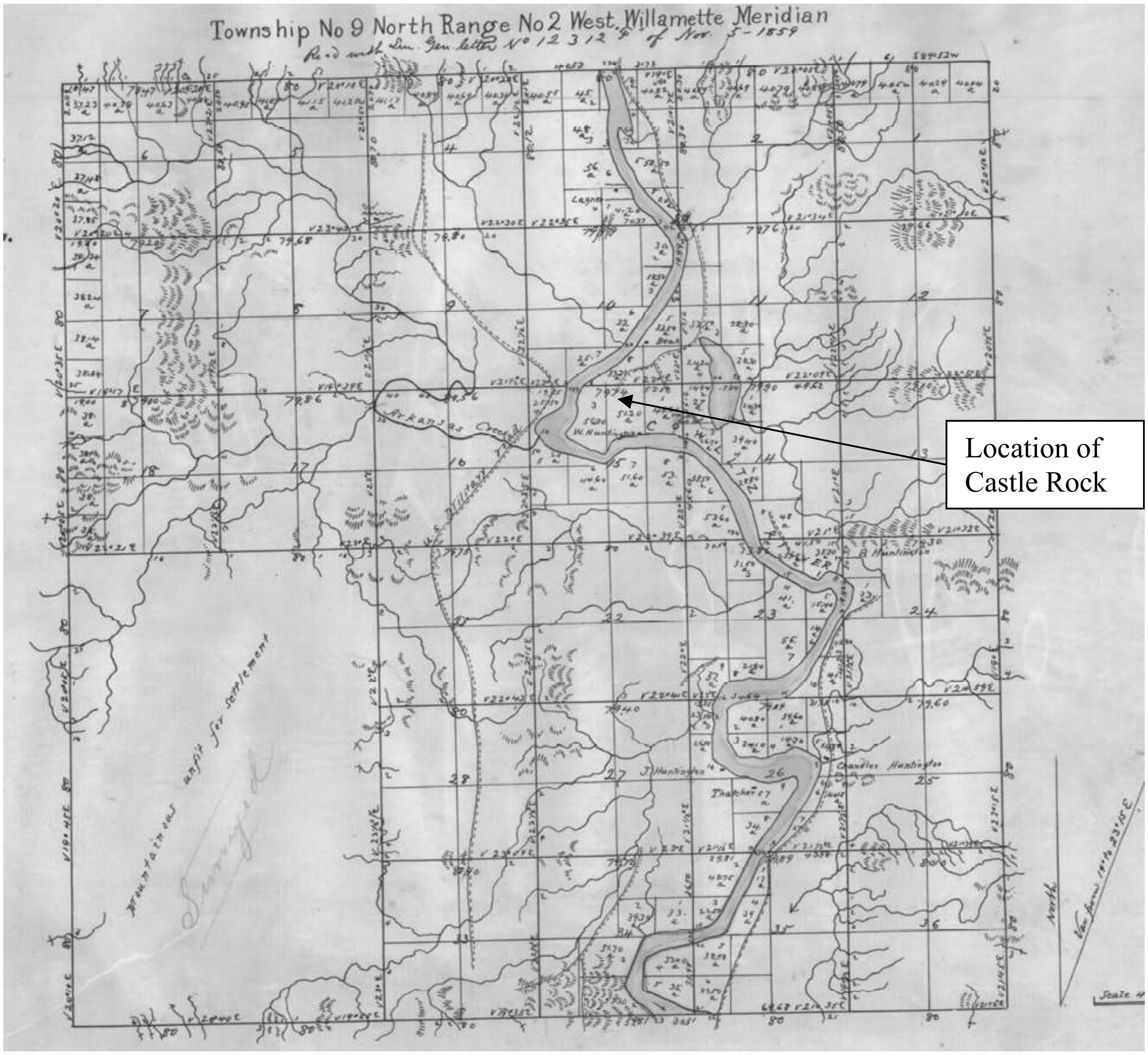

Figure 21. Historical GLO Map of the Cowlitz River near Castle Rock (USBLM 1884).

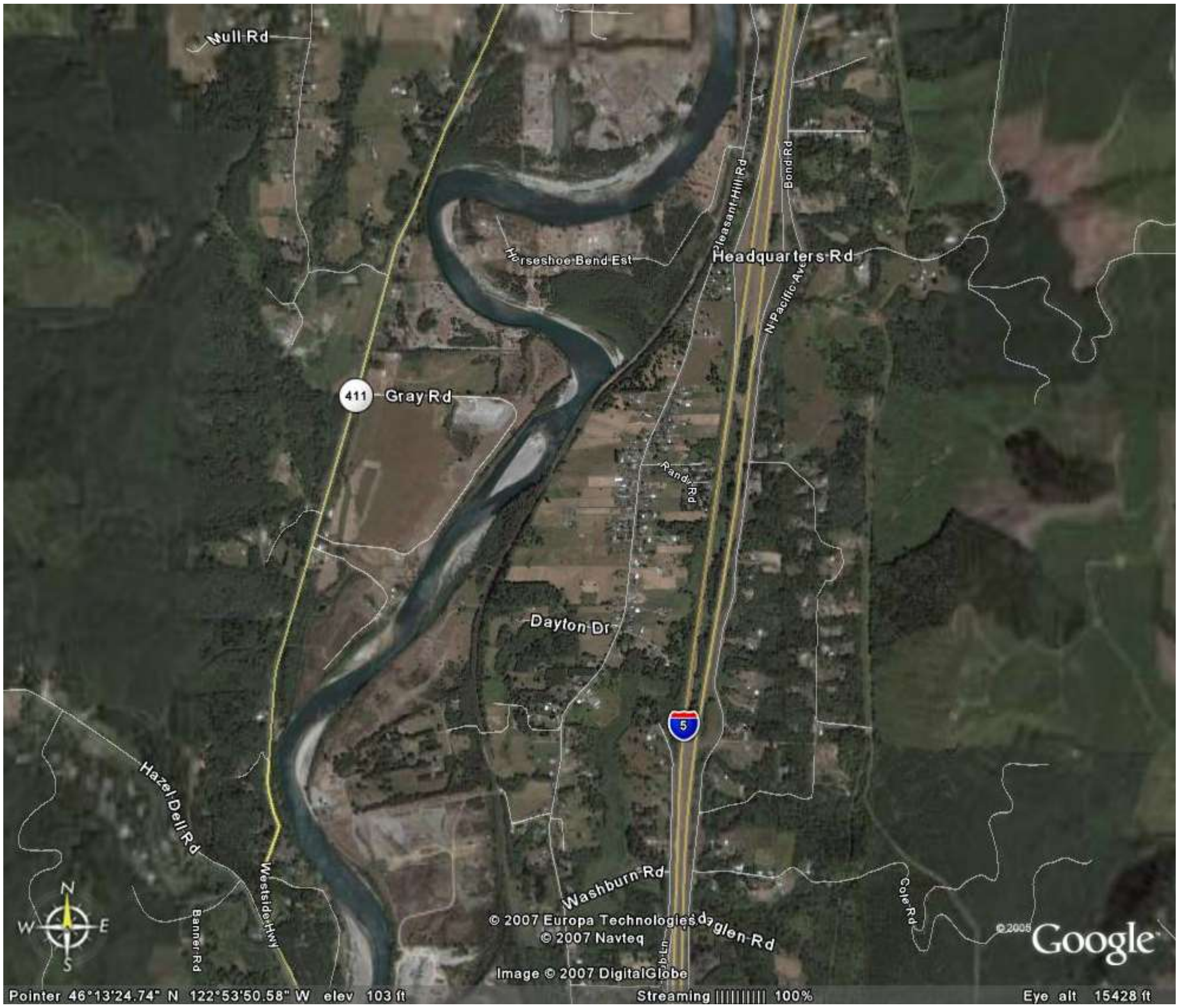

Figure 22. Current Aerial of the Cowlitz River at Horseshoe Bend (Google Earth 2007)

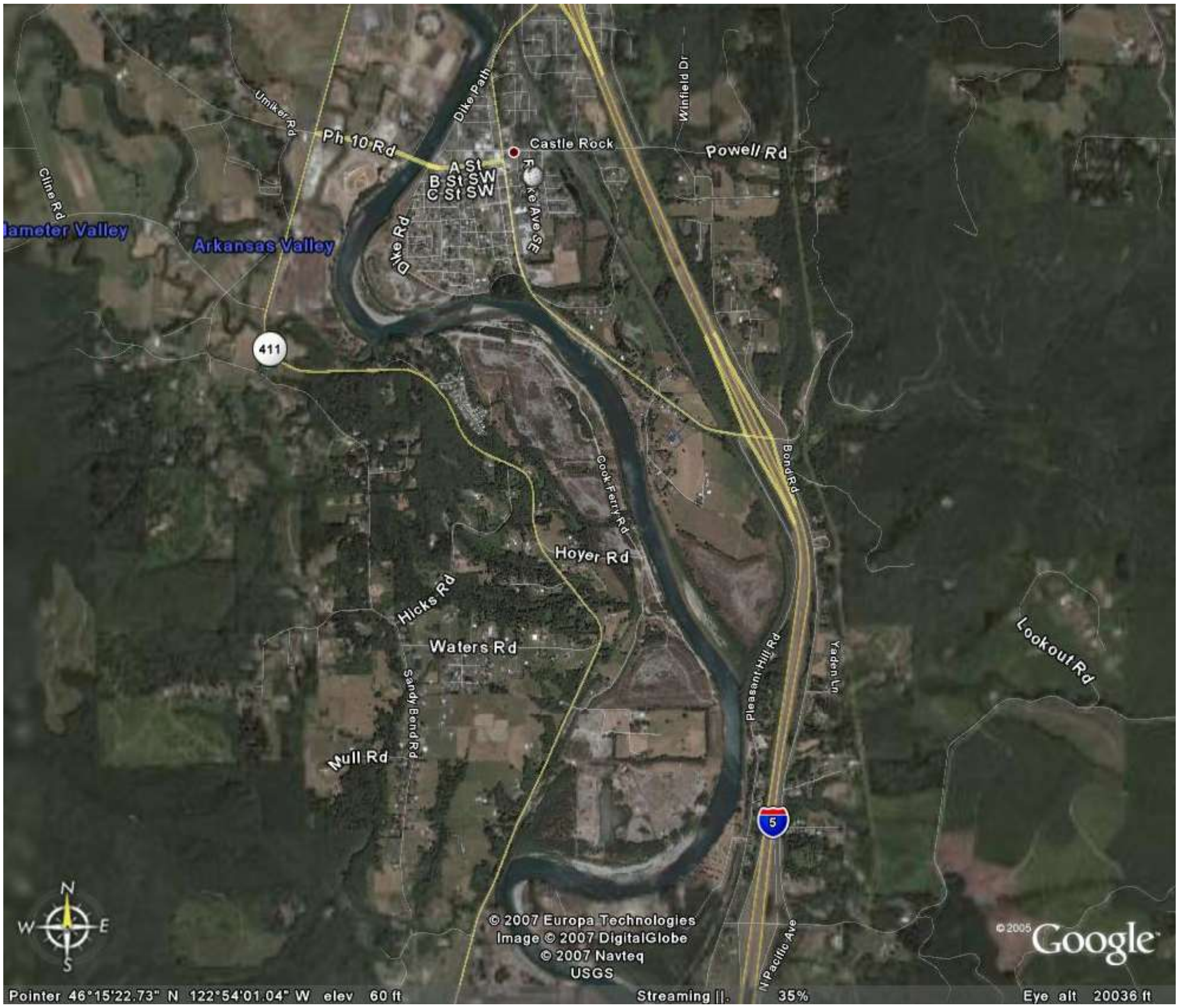

Figure 23. Current Aerial of the Cowlitz River near Castle Rock (Google Earth 2007)

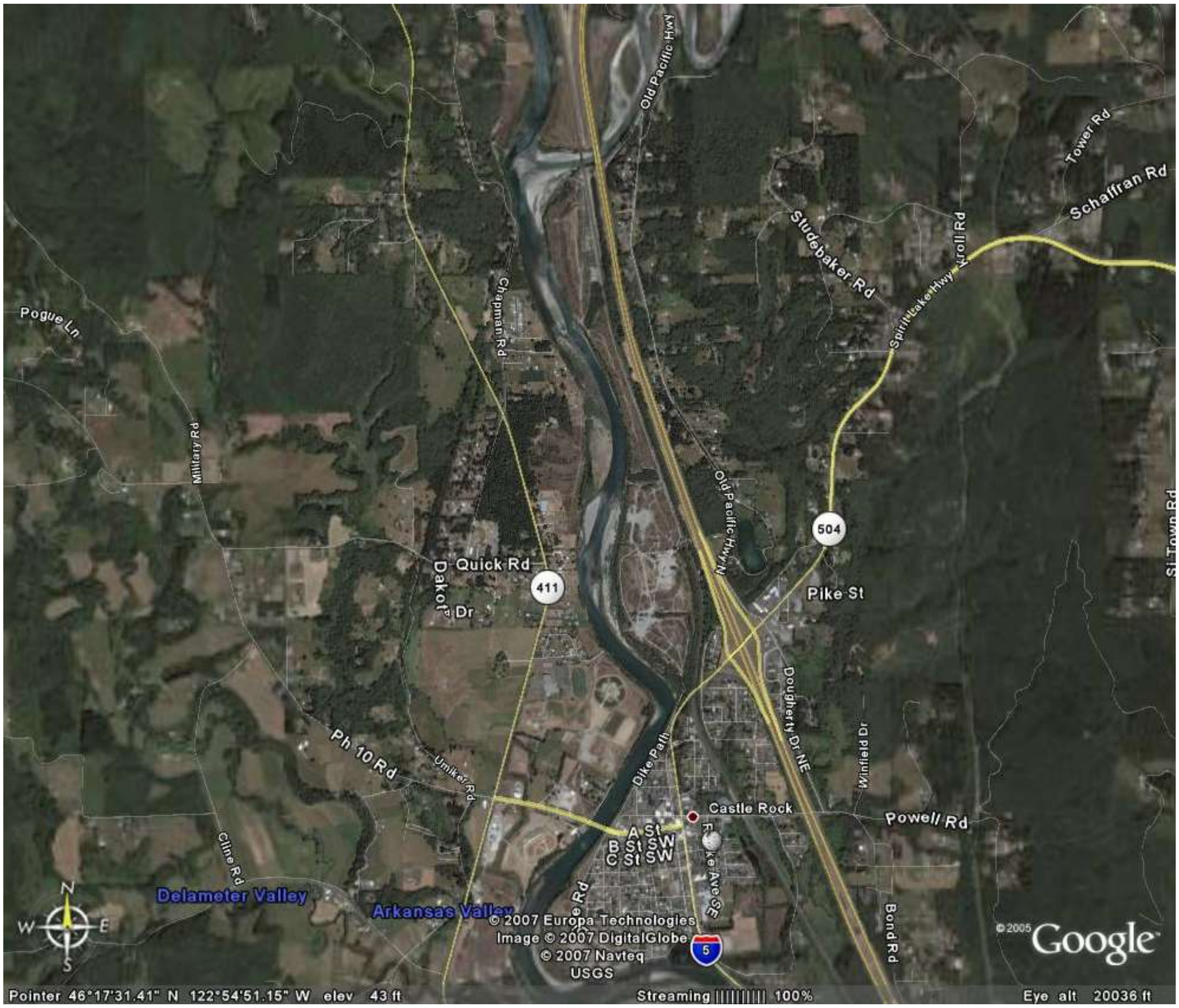

Figure 24. Current Aerial of the Cowlitz River Upstream of Castle Rock (Google Earth 2007)

This reach is much less confined from levees as compared to Reach 2, but is still confined as a result of the placement of dredged materials in the floodplain. The placement of dredged material filled in many hundreds of acres of floodplain and historic wetlands. The remaining wetlands (**Figure 25)** are primarily fringing low bars along the mainstem or are associated with tributaries such as Arkansas Creek or a result of impoundment from the railroad and I-5. Restoration opportunities in this reach are primarily the removal of dredged materials to reconnect the historic floodplain. Other opportunities include improving habitat diversity and access at the mouths of various tributaries that become seasonally blocked due to sediment deposition, restoring historic side channels, enhancing bars by placing wood and riparian plantings, and removing barrier culverts on the major tributaries.

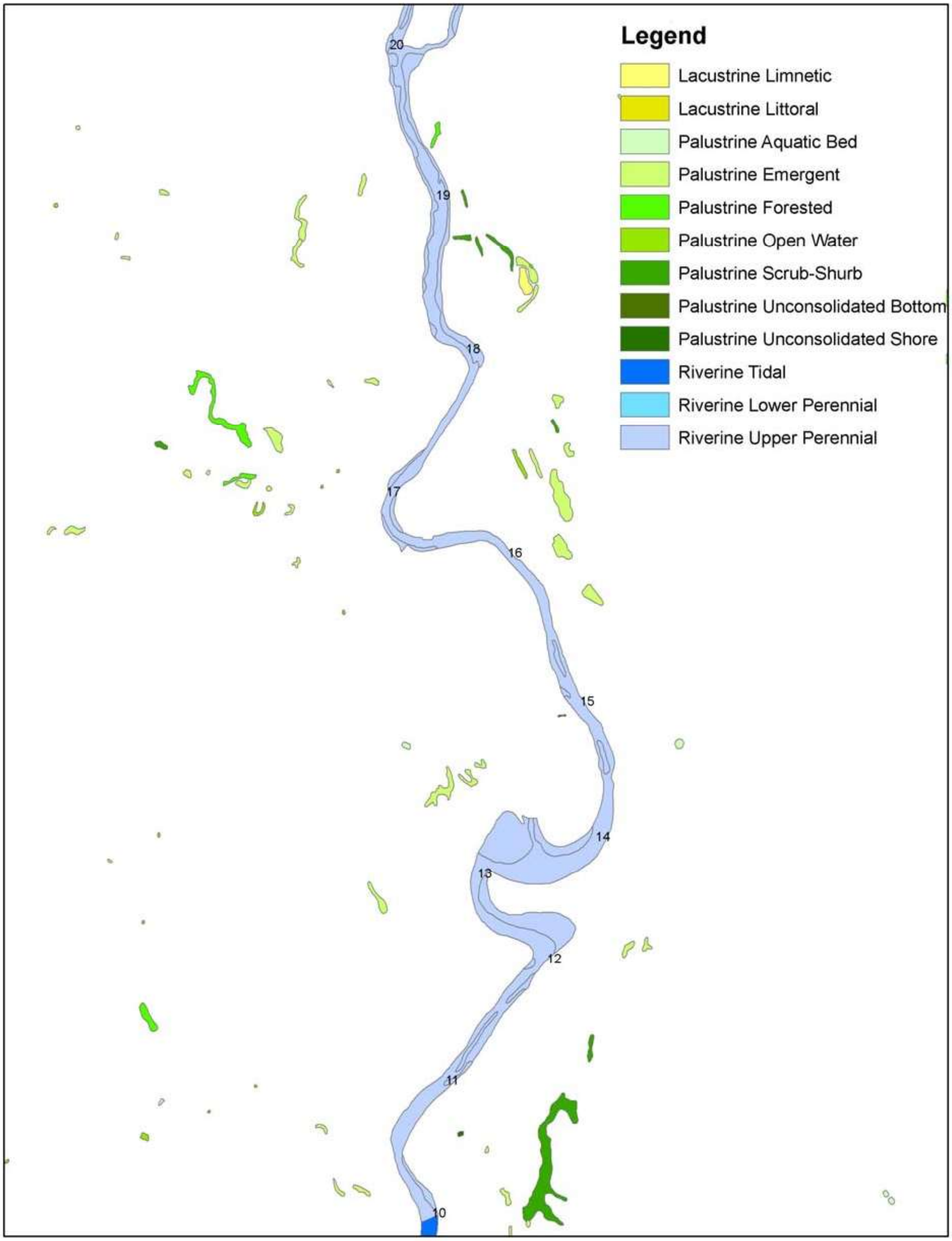

Figure 25. National Wetland Inventory Mapping for Reach 3, RM 10.0 to 20.0 (WDFW 2006).

4.3.2 Assessment Observations and Results

Upstream of RM 10 to the Toutle confluence, almost all former floodplain areas have been filled with dredged material. Historically, there were several long side channels and a large area of floodplain in this reach. The undeveloped dredged material areas could be restored to floodplain by removal of the material back to the floodplain elevation and revegetation. Side channels could also be created through the floodplain in some locations where remnant swales still exist. Potential sites to remove dredged material are located at RMs 10 left bank, 11.5 right bank, 15 left bank, 15-16 right bank, 18-19 left bank, and 19-20 left bank. The dredged material at RM 19 is eroding significantly into the river. There are several small tributaries that have created backwaters behind the dredged material piles and the backwater channel at RM 12.5 is a remnant of an old side channel that formerly started at RM 14. Restoration of this side channel could create a lengthy side channel and reduce the erosion occurring along the upper end of the bend adjacent to residential development. At RM 13-14 right bank there are portions of the original floodplain still remaining (not filled by dredged material) and a remnant contour of a side channel or old main channel that could be reconnected. Tributary deltas could be enhanced by placement of wood and riparian restoration.

One notable area of concern in this reach is a high erosion and meander bend cutoff situation near RM 13.5 left bank, which has recently received riprap bank protection. Review of historic photos indicates that the channel is slowly migrating downstream and eroding the left bank around Horseshoe Bend, which has development and residential properties on the interior side of the meander bend. There is likely need for mitigation for the rock placement that could include reconnection of the side channel at RM 14 to reduce the erosion pressure on the bank.

4.3.3 EDT/IWA Summary

This reach includes from the original EDT reaches, only Lower Cowlitz 2, rated as a Tier 2 reach. For this upper half of Lower Cowlitz 2, both Chinook and chum would be benefitted by restoration actions. Channel stability, habitat diversity, and sediment were considered to have high impacts on Chinook in Lower Cowlitz 2, and lack of habitat diversity has a high impact on chum. Restoration of key habitat quantity would have a high positive effect on chum. However, the reality of the situation in this reach is that the majority of the historic floodplain and off-channel habitat has been filled by dredged material. Restoration actions in this reach will require the removal of dredged material.

This reach includes seven new EDT reaches, Lower Cowlitz 2G through 2M, all rated as Tier 3 reaches. The new designation of these reaches as Tier 3 likely reflects the fact that the very high sediment load from the Toutle River makes any restoration project somewhat risky and the majority of the historic floodplain has been filled by dredged material and the historic side channels have either been filled and developed or are disconnected. The EDT ratings reflect that there is limited restoration opportunity in this reach. However, the potential reconnection of two lengthy side channels in this reach could provide rearing and holding benefits for Chinook, chum, coho, and steelhead, particularly the Toutle River populations.

4.3.4 Restoration Opportunities and Priorities

There are three major types of opportunities for fish habitat enhancement from a geomorphologic perspective. First is the restoration and reconnection of floodplain features in the remaining floodplains (primarily between RM 11 and 15). Second is restoration and enhancement of bar and side channel features in the main channel. And lastly is partial or complete removal of dredged material with riparian and floodplain restoration. Some secondary opportunities include bioengineering of existing revetment areas by placement of wood and vegetation along rock banks or plan for incorporating self mitigating features into anticipated future bank stabilization projects in the reach. The primary constraint on restoration of this reach is the likely risk of continued sediment deposition due to the Toutle River elevated sediment supply. Other constraints are the potential conflicts between floodplain restoration and adjacent development in urbanizing areas near Castle Rock, and the high cost of dredged material removal.

Projects identified in this reach include: 1) 10.5L, riparian restoration and dredged material removal; 2) 11.2L, bar and island enhancement; 3) 12.5L, side channel restoration and enhancement; 4) 12.5R, riparian restoration and dredged material removal; 5) 13.5L, riparian restoration and dredge material removal; 6) 14.0L, side channel restoration and enhancement; 7) 14.5R, side channel restoration and enhancement; 8) 15.0L bar enhancement; 9) 16.0R, side channel restoration and enhancement; 10) 16.7L, bar and island enhancement; 11) 16.8R, tributary enhancement; 12) 17.0L, riparian restoration; 13) 17.0R, riparian restoration; 14) 18.0L, side channel restoration and enhancement; 15) 18.5L, dredged material removal; 16) 18.8R, bar and island enhancement; and 17) 19.8L, dredged material removal. The side channel restoration and enhancement projects rank most highly because they would provide a significant quantity of habitat that would be highly beneficial for 0-age and smolt rearing for all salmonid species and could provide adult holding habitat. However, their certainty of success is low to moderate because the continued high sediment load will make it difficult to keep the side channels scoured open. The placement of wood will promote channel scouring, as well as providing in-stream cover, but may not be able to withstand the extremely high sediment load. It would be highly beneficial to experiment with placement of wood in this reach to determine how feasible some of these projects are. There are several culvert replacements identified for Leckler, Delameter and Monahan Creeks.

The highest priority restoration actions in this reach are to replace barrier culverts on tributaries that open up significant areas of habitat. The next high priority is to restore remnant side channels. These actions would facilitate spawning in the tributaries and rearing, refuge, and holding for juvenile and adult salmon in the mainstem in their transit to and from the upper river and major tributaries such as the Toutle River. However, overall, this reach has somewhat limited restoration opportunity and potential benefit due to the high sediment load.

4.4 Reach 4. RM 20.0 to 32.0 – Toutle River to Salmon Creek

4.4.1 Reach 4 Historical to Current Comparison

The valley composition from the Toutle River to Salmon Creek is generally a broad alluvial floodplain with a gravel bed and then a short section of constricted valley just upstream of the

Toutle River. Between the Toutle River and Olequa Creek, the river and floodplain are flanked by volcanic lahar deposits from Mt. St. Helens eruptions and glacial outwash deposits to the east, and major basalt outcrops and marine sedimentary deposits to the west that form the Olequa Creek drainage. Upstream from Olequa Creek, the floodplain is wider from 0.5 to 1.0 miles in width formed from alluvial deposits bordered by mostly glacial outwash terraces (**Figure 26**).

The historical GLO maps indicate little channel migration and floodplain dynamics between the Toutle River and Olequa Creek (**Figures 27-28**). When compared with recent aerial imagery (**Figures 29-32**) there are minimal indicators of channel migration and floodplain dynamics upstream to the I-5 crossing. The primary historic feature is a large side channel to the east side of the river near RM 28, which is now a large gravel pit and agricultural lands. Upstream of the I-5 crossing to the Salmon Creek confluence, there are current signs of active channel and floodplain dynamics. A large historical wetland complex is shown to the north side of the river at RM 31.5 that is now occupied by farmland and a small gravel mining operation (**Figure 28**).

Currently, in Reach 4, there are a moderate amount of remaining wetlands (**Figure 33**), primarily associated with the floodplain and/or higher elevation glacial outwash terraces. Several of the floodplain areas have been gravel mined and the wetlands are now gravel mined ponds. Only a limited amount of dredged material was placed in this reach, in the lower two miles. The primary restoration opportunities within this reach appear to include bar and side channel enhancement in several locations, protection of channel migration processes such as at the mouth of Olequa Creek and Salmon Creek, restoration and reconnection of gravel mined floodplain areas such as at RM 28. A historic wetland was located near RM 31.5 on the right bank that may have been within the floodplain. Options to restore some of this wetland area should be investigated.

The regulation of river hydrology by the upstream dams have likely had several effects on the river including the reduction of channel migration processes and connections to the floodplain. Peak flows less than the 50-year event are significantly reduced and channel forming flows rarely occur. Constraints on potential projects are primarily related to the ability to achieve frequent floodplain connections and enhancement of side channels in their current alignment because the channel is not likely to significantly migrate except for in a few locations (such as the Salmon Creek confluence). Actions such as placing large wood and engineered log jams at the upstream and downstream ends of side channels will promote scouring of the openings and riparian restoration will contribute to the long-term recruitment of wood to the system.

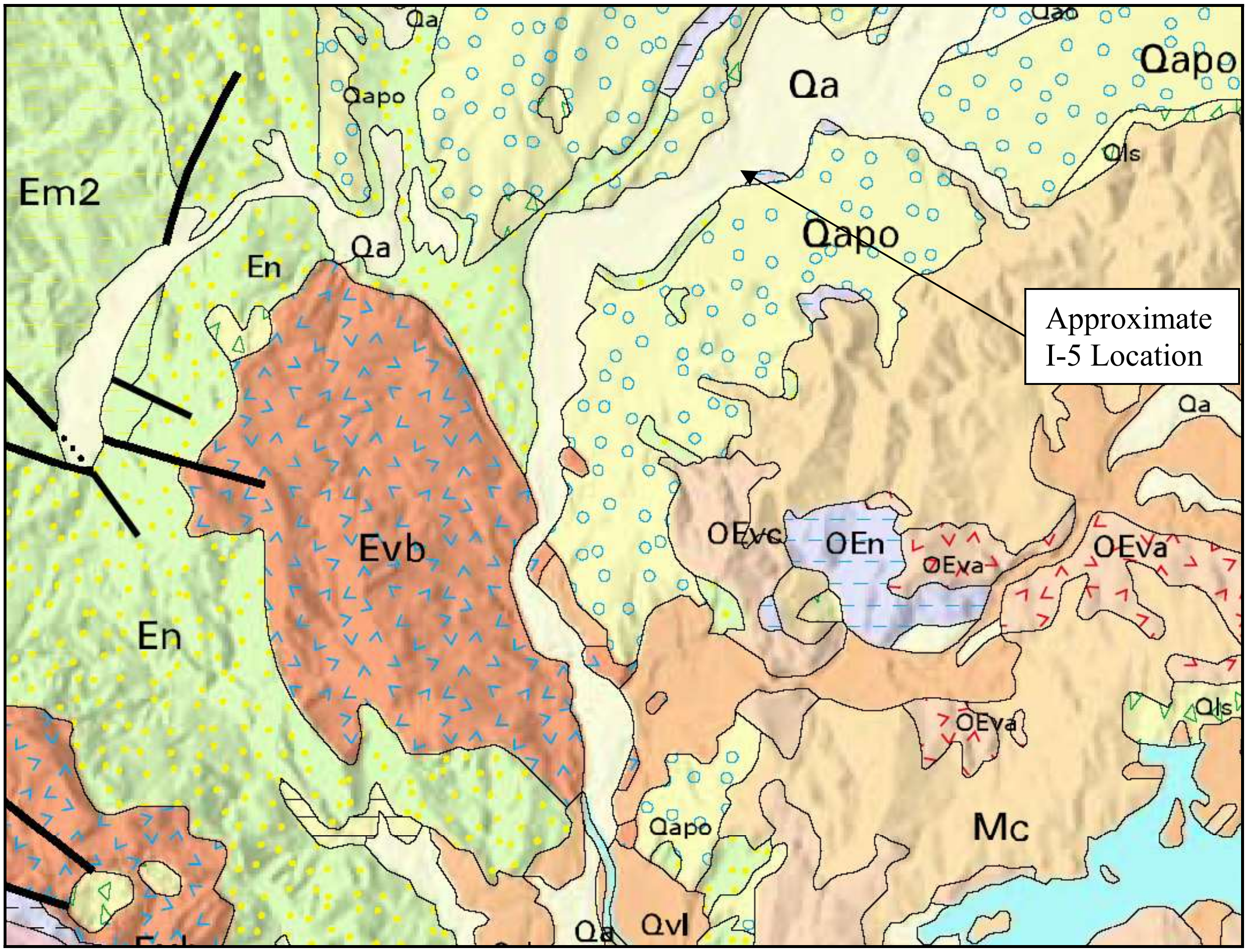

Figure 26. Geologic Map of the Cowlitz River from the Toutle River to Salmon Creek (WDGER 1987)

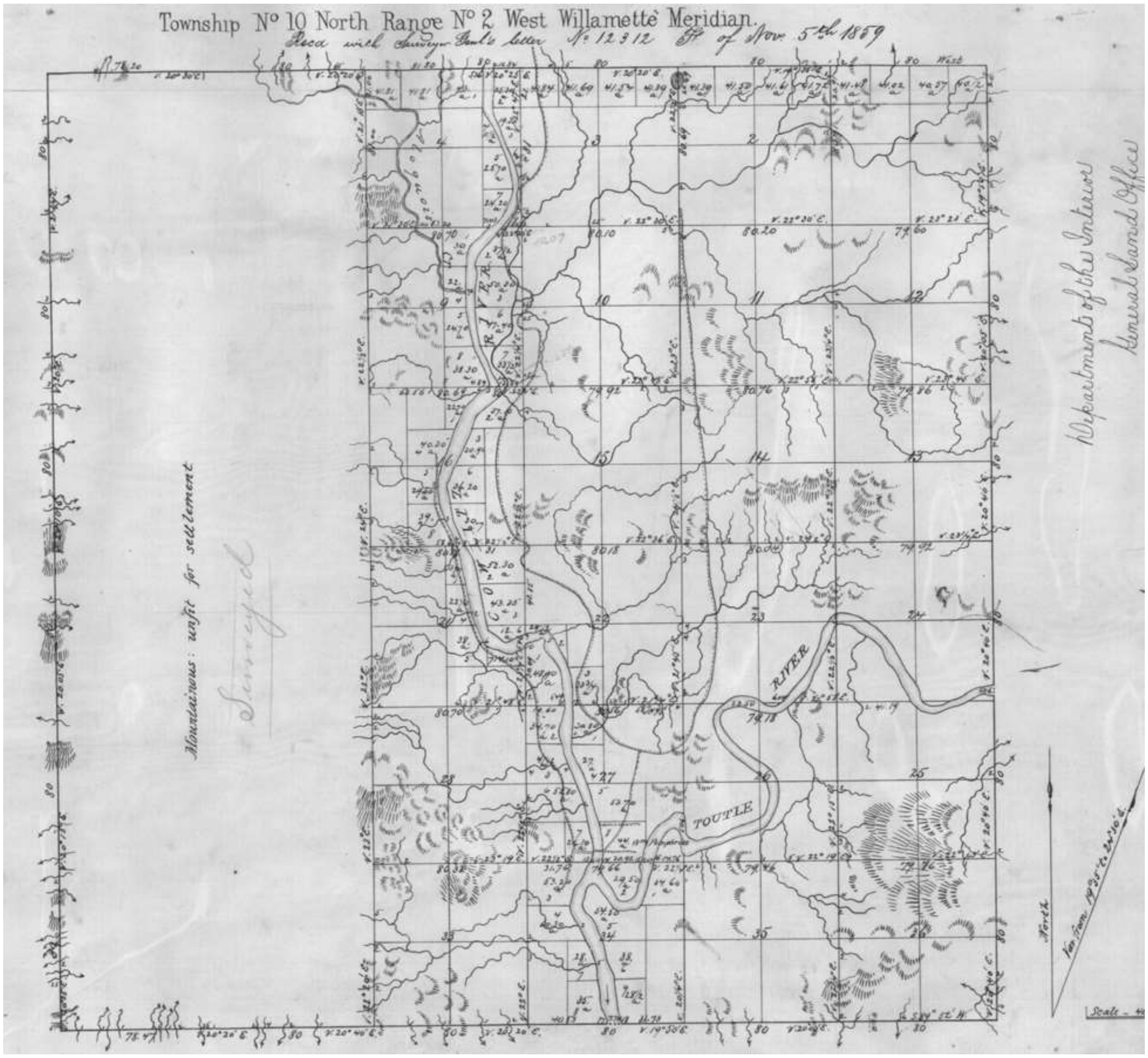

Figure 27. Historical GLO Map of the Cowlitz River from the Toutle River to Olequa Creek (USBLM 1884)

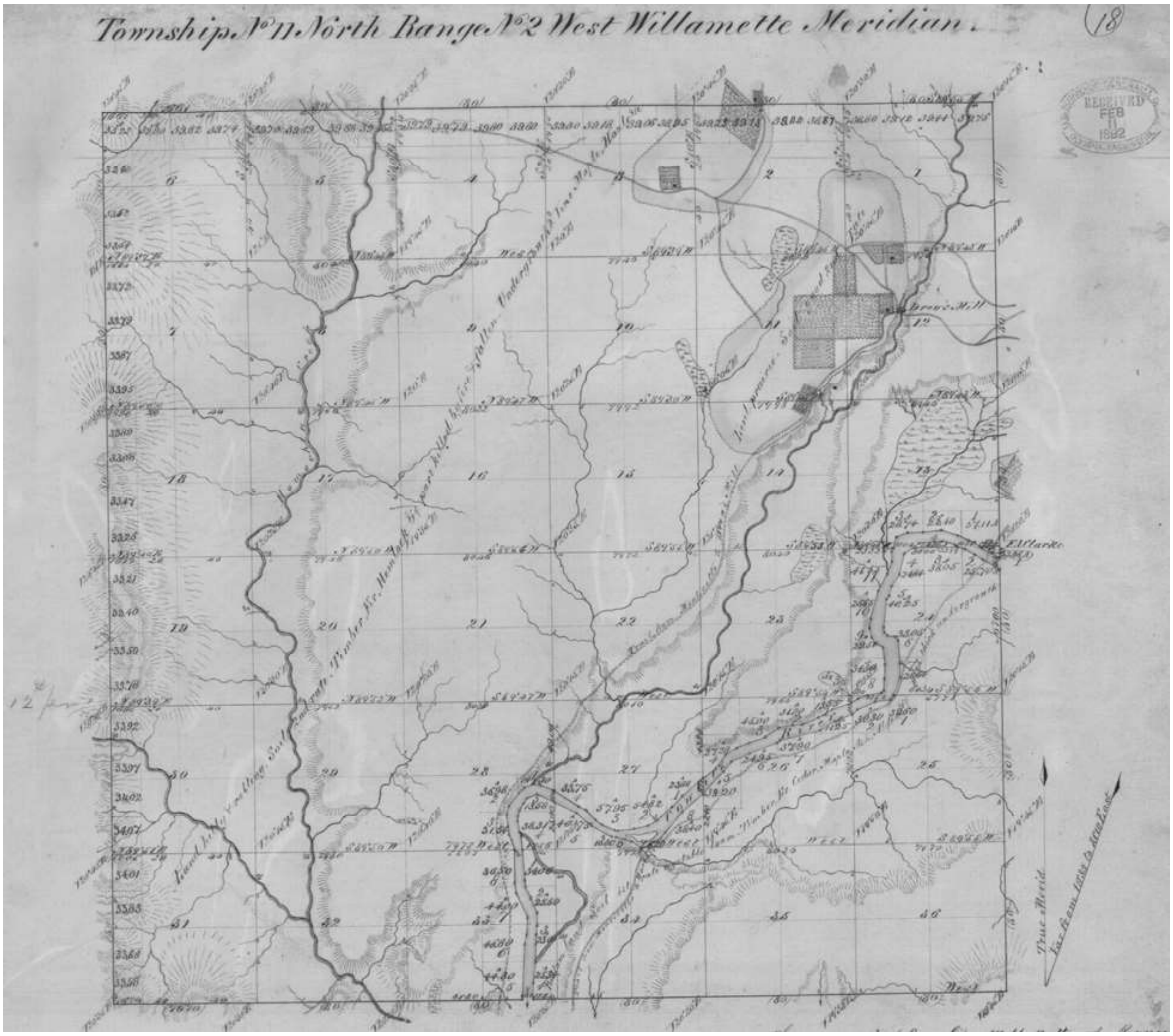

Figure 28. Historical GLO map of the Cowlitz River from Olequa Creek to near Salmon Creek (USBLM 1884)

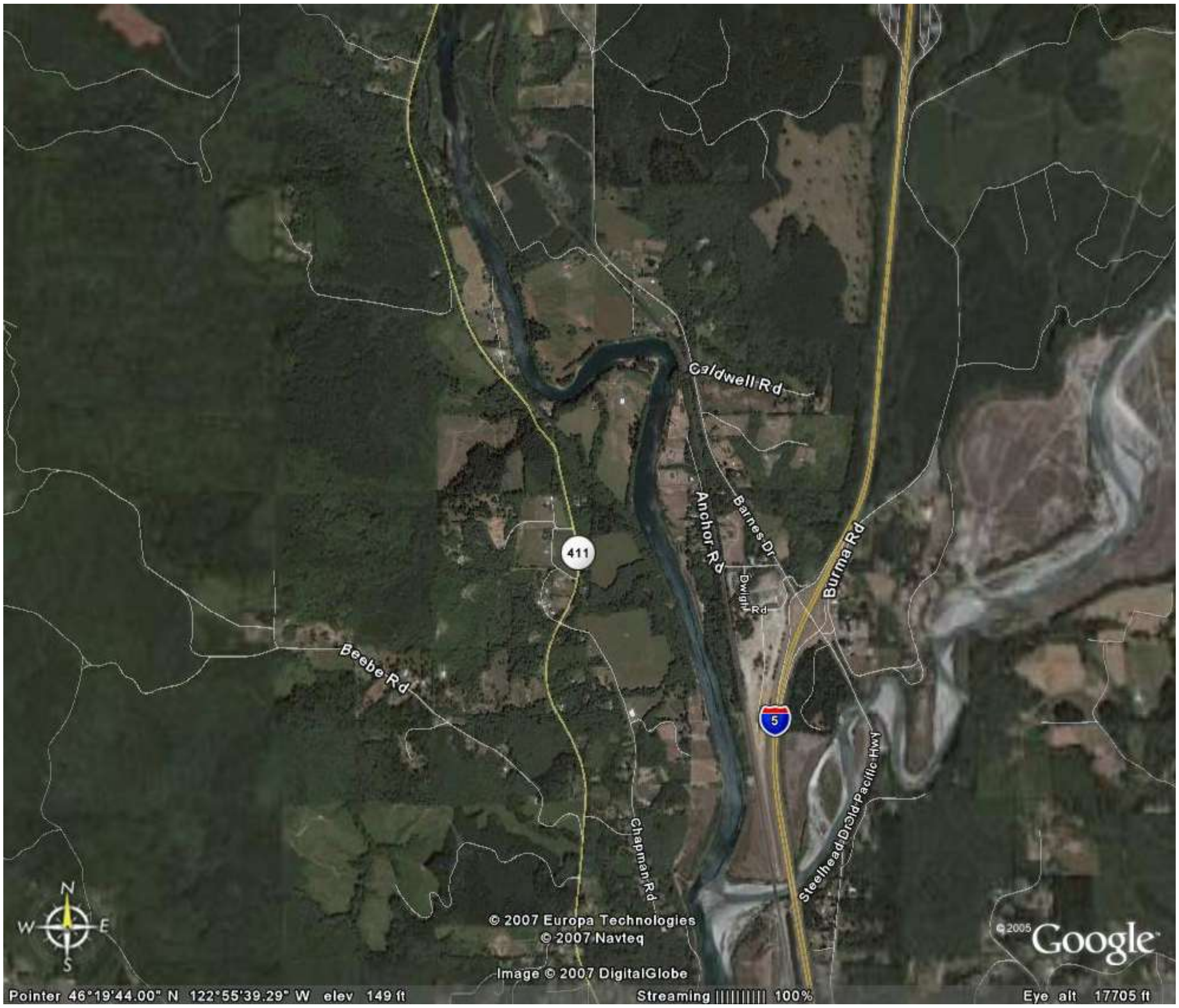

Figure 29. Current Aerial of the Cowlitz River from the Toutle River to Olequa Creek (Google Earth 2007)

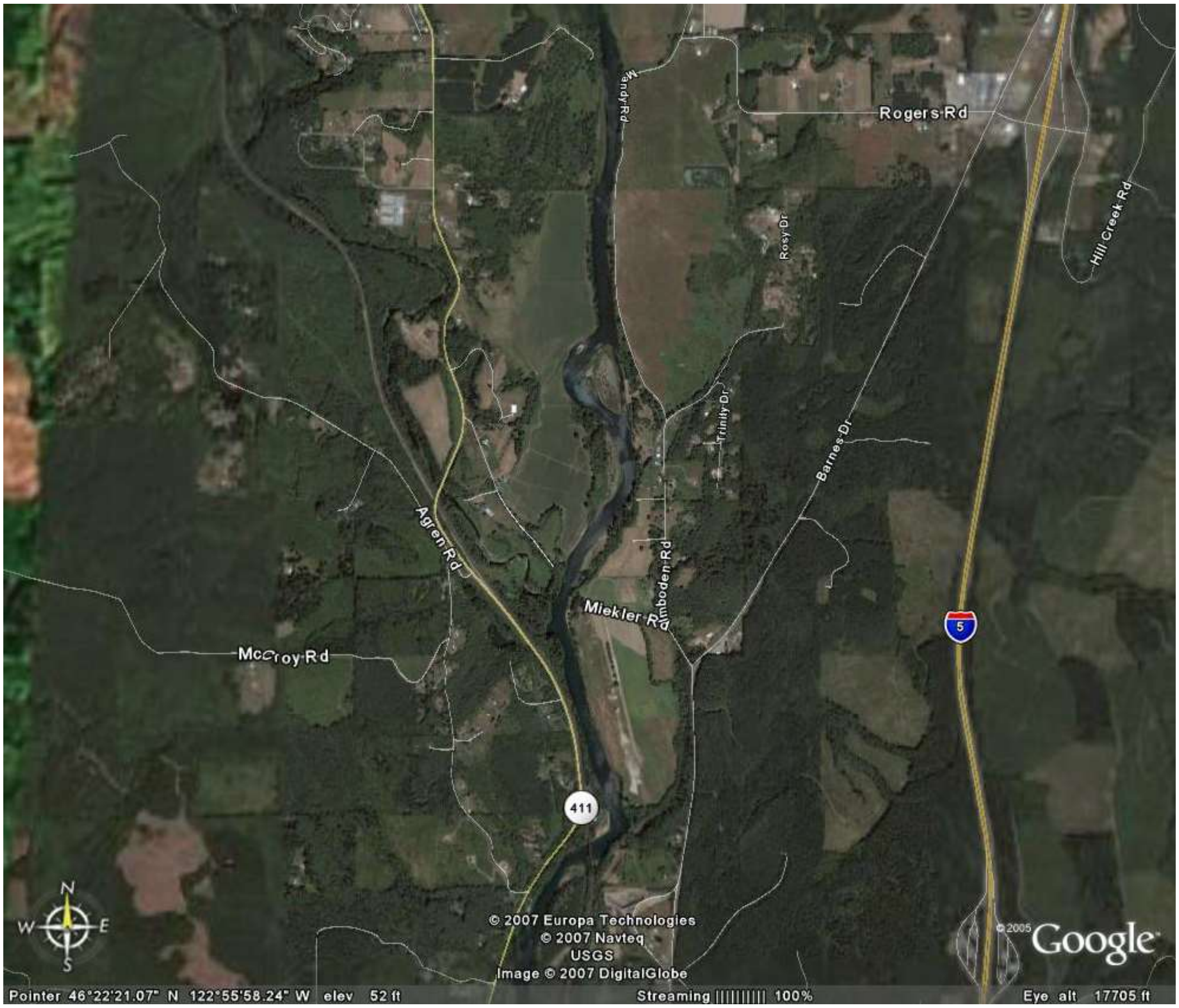

Figure 30. Current Aerial of the Cowlitz River near Olequa Creek (Google Earth, 2007)

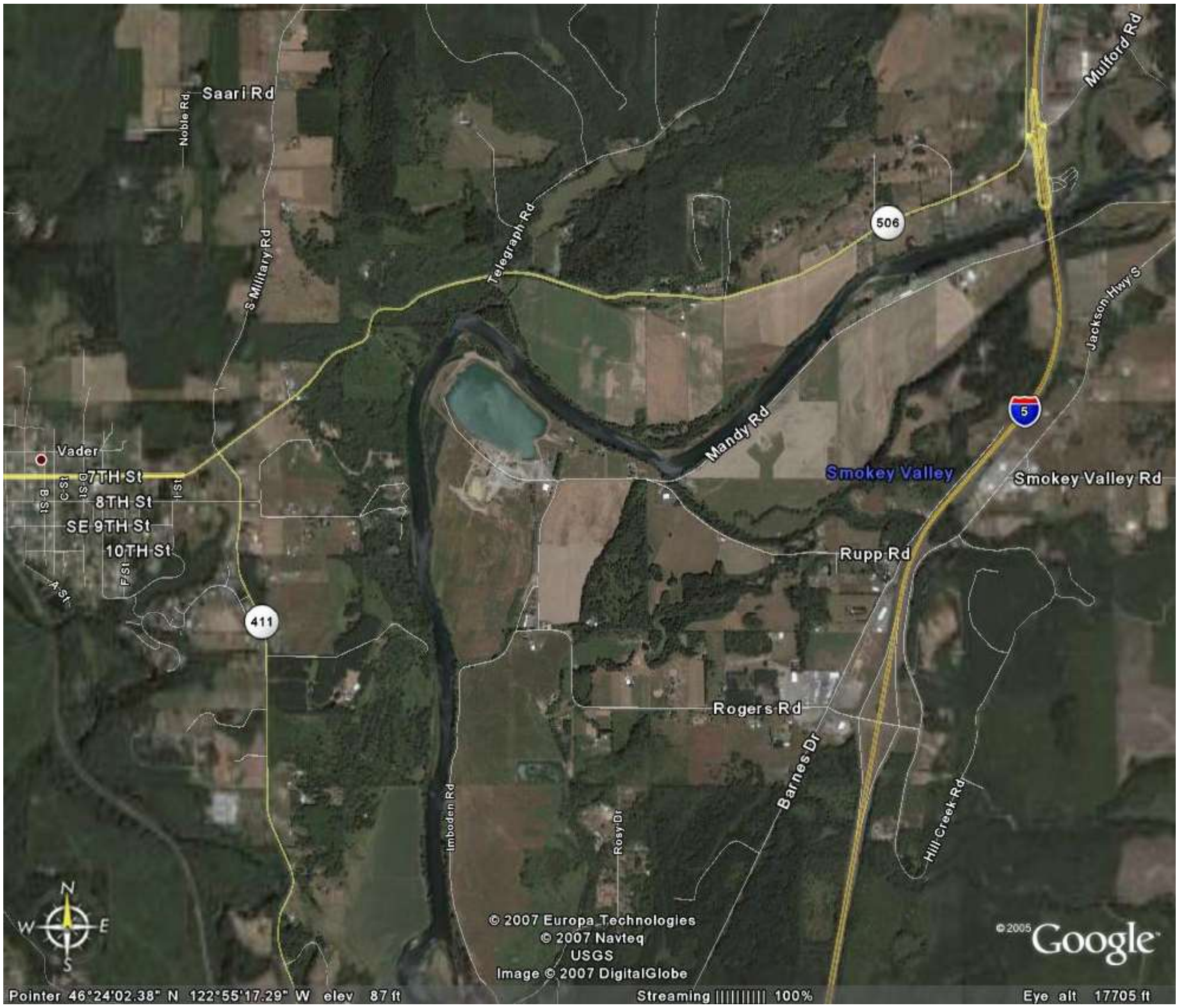

Figure 31. Current Aerial of the Cowlitz River from Olequa Creek to I-5 (Google Earth 2007)

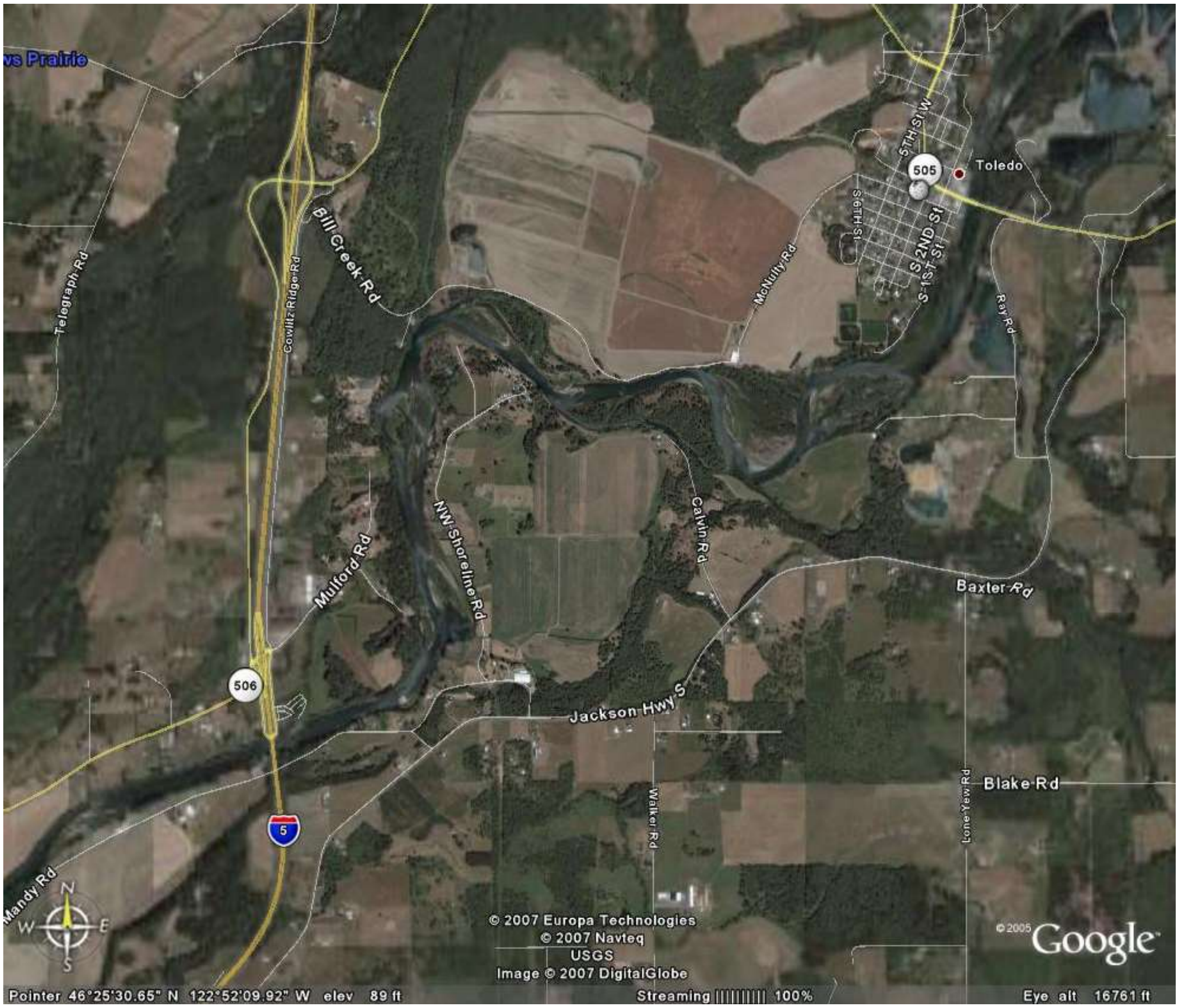

Figure 32. Current Aerial of the Cowlitz River from I-5 to Toledo (Google Earth 2007)

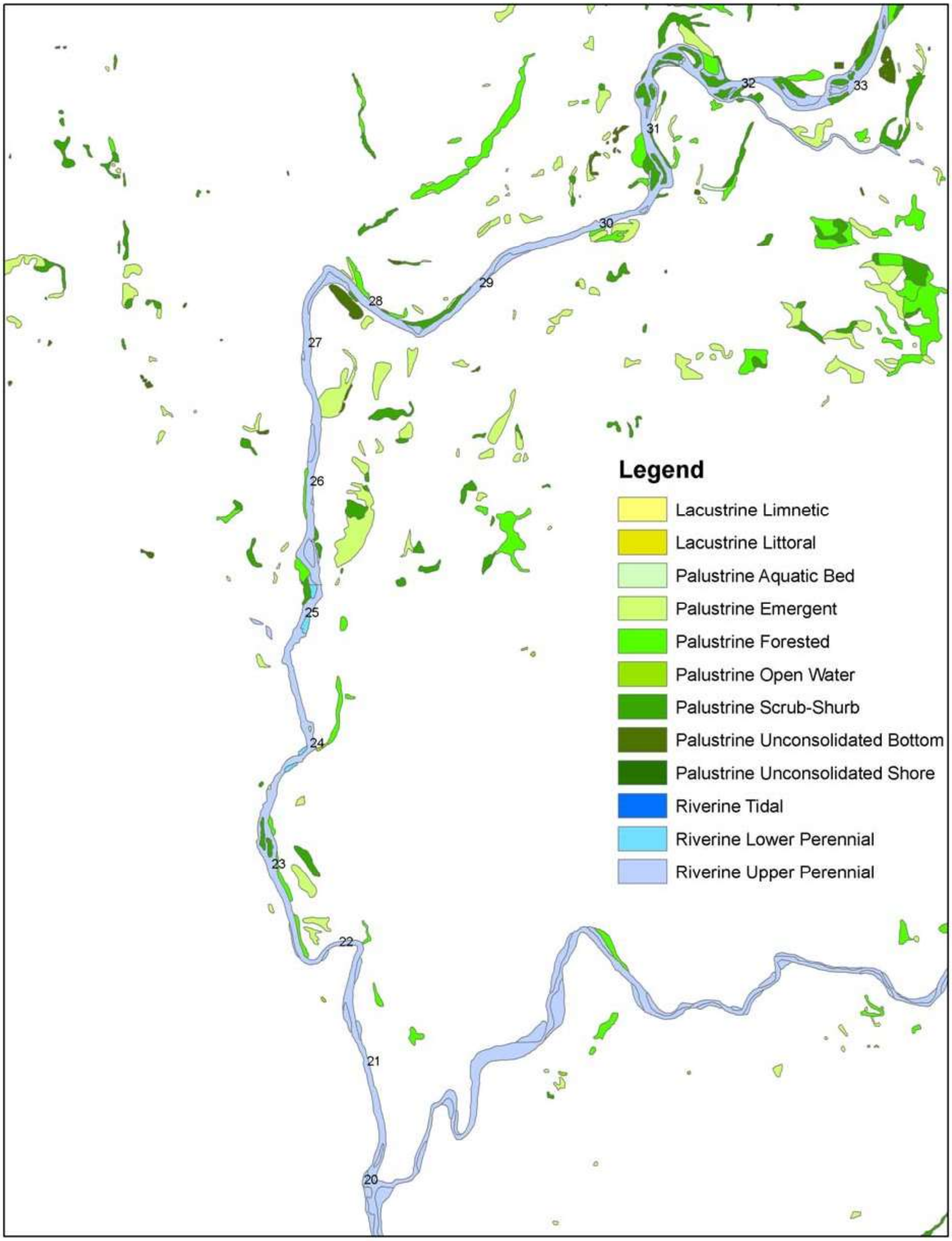

Figure 33. National Wetland Inventory Mapping for Reach 4, RM 20.0 to 32.0 (WDFW 2006).

4.4.2 Assessment Observations and Results

Reach 4 is upstream of the Toutle River and thus the substrate changes to a gravel dominated system. Dredged material was deposited in several sites, up to approximately RM 23, and there are natural high banks in various locations. There have been observations of buried wood in the channel downstream of the I-5 crossing (M. LaRiviere, pers. comm. 2006). Upstream of RM 23 there are some small existing side channels, such as the Hog Island side channel on the right bank at RM 23.2. This is a high quality channel with extensive mussel beds. Restoration of similar side channels would significant increase habitat quantity and quality.

The main channel alignment has been stable in this reach since at least 1939, except for in the vicinity of RM 25 where gravel deposition has caused lateral channel migration. Gravel deposition may have been caused by the constriction of the former bridge crossing. Upstream of RM 25 there are many locations with very limited or no riparian zone with various types of bank protection. There is also a gravel mined floodplain area near RM 28 that could be restored and reconnected to provide off-channel habitat.

There are several existing and former side channels in the vicinity of Salmon Creek. The natural process of channel migration is eroding agricultural lands and residential areas and there is a great risk that rock or other bank protection will be placed to prevent that erosion. A channel migration zone easement such as at the mouth of Salmon Creek would protect the natural process and allow continued formation of habitats. Additionally, some of the pressure on the banks could be relieved by restoring several side channels through the various gravel bars and islands in the center of the channel. The Cowlitz River avulsed into the lower end of Salmon Creek in recent years. There is revetment along the lower end of Salmon Creek and this creek carries a high fine sediment load that may affect egg survival in the Cowlitz downstream.

The lower Toutle River is confined by dredged material piles but has several small tributaries that could be better connected to provide off-channel habitat. Lower Olequa Creek is partially confined due to its historic realignment for the railroad, but still has an accessible floodplain and remnant side channels.

4.4.3 EDT/IWA Summary

This reach includes four reaches from the original EDT reaches, Mid-Cowlitz 1, 2,3, and 4, rated as Tier 3, 2, 2, and 2 reaches, respectively. For Mid-Cowlitz 1, 3, and 4, Chinook would be significantly adversely affected by further degradation, and chum and steelhead would be minorly benefitted by restoration actions. Sediment was considered to have a high impact on Chinook in Mid-Cowlitz 1, 2, and 3, and lack of habitat diversity has a moderate or high impact on Chinook, chum, coho, and steelhead. Restoration of key habitat quantity would have a high positive effect on Chinook in Mid-Cowlitz 1 and a moderate positive effect on Chinook in Mid-Cowlitz 2,3, and 4. This reach historically had several side channels and would benefit from the restoration and reconnection of side channels and floodplain habitats.

This reach includes eleven new EDT reaches, Mid Cowlitz 1A through 1F, Mid Cowlitz 2A through 2B, Mid Cowlitz 3A through 3B, and Mid Cowlitz 4A through 4B. The Tier 1 and 2 reaches include Mid Cowlitz 4A (I-5 to Bill Creek) as Tier 1, and Mid Cowlitz 1C through 2A (Hog Island to Lewis County line) and 4B (immediately downstream of Salmon Creek) as Tier 2 reaches. The remaining reaches are Tier 3s. The revised EDT ratings reflect that there is significant opportunity for restoration and preservation in several areas. The EDT classification generally matches the conditions observed in the field during this assessment in that reach 4A still has a lot of natural channel migration occurring and there is a need to protect and enhance this process, although reach 4B appears to be equally important for the same reason. This reach has significant opportunities for restoration of side channel and floodplain habitats as well as riparian restoration. Hog Island and its side channel is the only high quality side channel in this reach and is very important to protect. Additional side channels could be restored in this area.

4.4.4 Restoration Opportunities and Priorities

The primary opportunities within this reach appear to be associated with side channel enhancement and restoration upstream from RM 23 on the mainstem, and in the lower ends of the Toutle River and Olequa Creek, and reconnecting/restoring the gravel mined floodplain to a flow-through side channel at RM 27.5. The Hog Island side channel at RM 23.2 is the first stable side channel going upstream on the mainstem and providing more side channels as "stepping stones" up the river would provide rearing and holding habitat for both juvenile and adult salmon and could provide spawning habitat. Approximately 8-10% of the fall Chinook in the lower river spawn in this reach (WDFW unpublished data from 2002-2006) and providing more stable habitats such as in side channels could increase spawning in this reach.

Projects identified in this reach include: 1) 20.2L, dredged material removal; 2) 22.2L, dredged material removal; 3) 23.0L, off-channel and floodplain restoration; 4) 23.2R, bar and island enhancement, 5) 24.0L, tributary enhancement; 6) 24.5L, riparian restoration; 7) 25.0A, channel migration zone easement; 8) 25.0B, side channel restoration and enhancement; 9) 30.5R, bar and side channel enhancement; 10) 30.7L, bar and side channel enhancement; 11) 31.5R, bar and side channel enhancement; and 12) 32.0L, channel migration zone easement. The channel migration zone easements and side channel restoration and enhancement projects rank most highly because they would provide a significant quantity of habitat that would be highly beneficial for 0-age and 1-age rearing for all salmonid species and could provide adult holding habitat, and potentially spawning habitat. This reach does not have a high sediment load, but the regulated flows can cause rapid disconnections of side channels and the river cannot really meander freely to form its own habitats in much of this reach, except near the confluence of Salmon Creek and just upstream of I-5. The placement of wood will promote channel scouring, as well as providing in-stream cover. It would be highly beneficial to place wood and restore side channel habitats in this reach. Additionally, the channel migration processes should be protected wherever they continue to occur. The channel migration zone easement at the confluence of Salmon Creek ranked in the top 10 projects in the subbasin.

Restoration of off-channel habitats in the Tier 1 and 2reaches of the lower Toutle River and Olequa Creek would be highly beneficial for fish migrating out of those systems and benefit particularly 0-age and 1-age coho and steelhead.

Overall, this reach has many very good restoration opportunities and potential for benefits. Overall, the projects in the Tier 1 and 2 reaches are ranked very highly.

4.5 Reach 5. RM 32.0 to 42.0 – Salmon Creek to Blue Creek

4.5.1 Reach 5 Historical to Current Comparison

The channel and floodplain from Salmon Creek to the Blue Creek confluence have evidence of active and continuing alluvial channel and floodplain dynamics. This is currently one of the most dynamic reaches in the Lower Cowlitz. However, this section of the river has been significantly modified through the encroachment of agricultural, rural residential and gravel mining development. The encroachment coupled with dam regulation has reduced the width of channel migration and floodplain dynamics. The floodplain is composed of alluvial deposits and is approximately 0.5 to 1.0 mile wide and the valley bottom is bordered by terraced historical glacial outwash deposits (**Figure 34**). Along this reach there are several revetments installed to prevent channel migration and bank erosion, and the river has been channelized in some locations in order to develop gravel mine operations.

The historical GLO maps along the Toledo area show several active floodplain features including riparian wetlands, side channels, backwater areas, and large bar features (**Figure 35**). The historical alignment appears to occupy the current Salmon Creek avulsion area, with a large side channel to the north where the current main channel is aligned. The density of side and backwater channels was much higher than current conditions. Upstream from Toledo on the left side of the valley (south) there were several large side channels and the actual position of the mainstem channel was located on this side of the valley in areas that are now occupied by gravel mine ponds. These dynamic floodplain and channel migration conditions created a diverse array of spawning and rearing habitats for a variety of salmonids. The losses in dynamic floodplains and channel migration areas are primarily along the right bank of the river where the majority of development has occurred from RM 31.5-33.0, RM 34.0-35.0 and RM 36.0-38.0.

Figure 36 shows there is still meandering and extensive gravel bar movement downstream of Toledo and was also observed following high flows in the fall of 2006 and 2007. **Figure 37** shows the location of several gravel mined floodplains that could be restored and reconnected. **Figure 38** shows the large meander bends near RM 38-40 that are undeveloped and historically had multiple channels. Protection of this channel migration zone would protect a significant quantity of habitat.

The Toledo area historically experienced a great deal of channel migration. Prior to the 1930's the Cowlitz River was a multiple thread channel in the Toledo area (Collins 1996). Post 1937, the river was channelized and the floodplain was mined, primarily in two locations on the left side of the river, upstream from the current Hwy 505 crossing at RM 34.5 and across from Massey Bar boat launch at RM 36.0. A third, smaller, gravel mine operation is located on the right bank of the river at RM 31.5. This mine and surrounding agricultural areas are located within the large floodplain wetland complex discussed in GLO map review. Rock and other features have been placed in several areas to prevent channel migration or to cut off side channels.

The Washington Department of Natural Resources (DNR) is responsible for regulating and permitting gravel mining operations in Washington State. A case study review of the Toledo gravel mines was performed (Norman 1998) that documented the floodplain avulsions of the Toledo mining ponds during the November 1995 and February 1996 floods. During these flood events, the Cowlitz River overtopped and eroded revetment and levee structures protecting the gravel mine pond areas upstream from Toledo. The mines were located in channels historically occupied by the mainstem Cowlitz as observed on GLO maps and historical aerial photographs. The primary avulsion mechanism in these events was overtopping of the revetments and scouring of the river down into the deep gravel ponds.

The failure of the Kirkendoll revetment/levee at RM 37.5 on the left bank completely inundated the mining operations and stranded local residences at the point area north of the overflow channel in the RM 36.0-38.0 area. The avulsion flow pathway reconnected with the Cowlitz more than 1 mile downstream across from the present day Massey Bar boat ramp. It was estimated that 1/4 of the Cowlitz flood flowed through the avulsion, and that major reoccupation of the channel may have occurred if re-construction of the revetment and emergency operations had not occurred (Norman 1998).

Downstream at RM 34.5, a series of relict gravel mine ponds also experienced a minor avulsion in the upper two ponds. Subsequent to the avulsion event the upper berm/revetment was rebuilt, but the downstream flow path was allowed to remain open for fish passage into the ponds. These ponds have historically housed fish rearing operations, but are known to have warmwater fish and likely predation issues. Gravel pit restoration is most successful when the ponds are partially refilled or regraded to provide extensive shallow water habitats and cover and allow frequent connections with the river to improve water quality and reduce or eliminate habitats for warmwater fish species (Norman 1998).

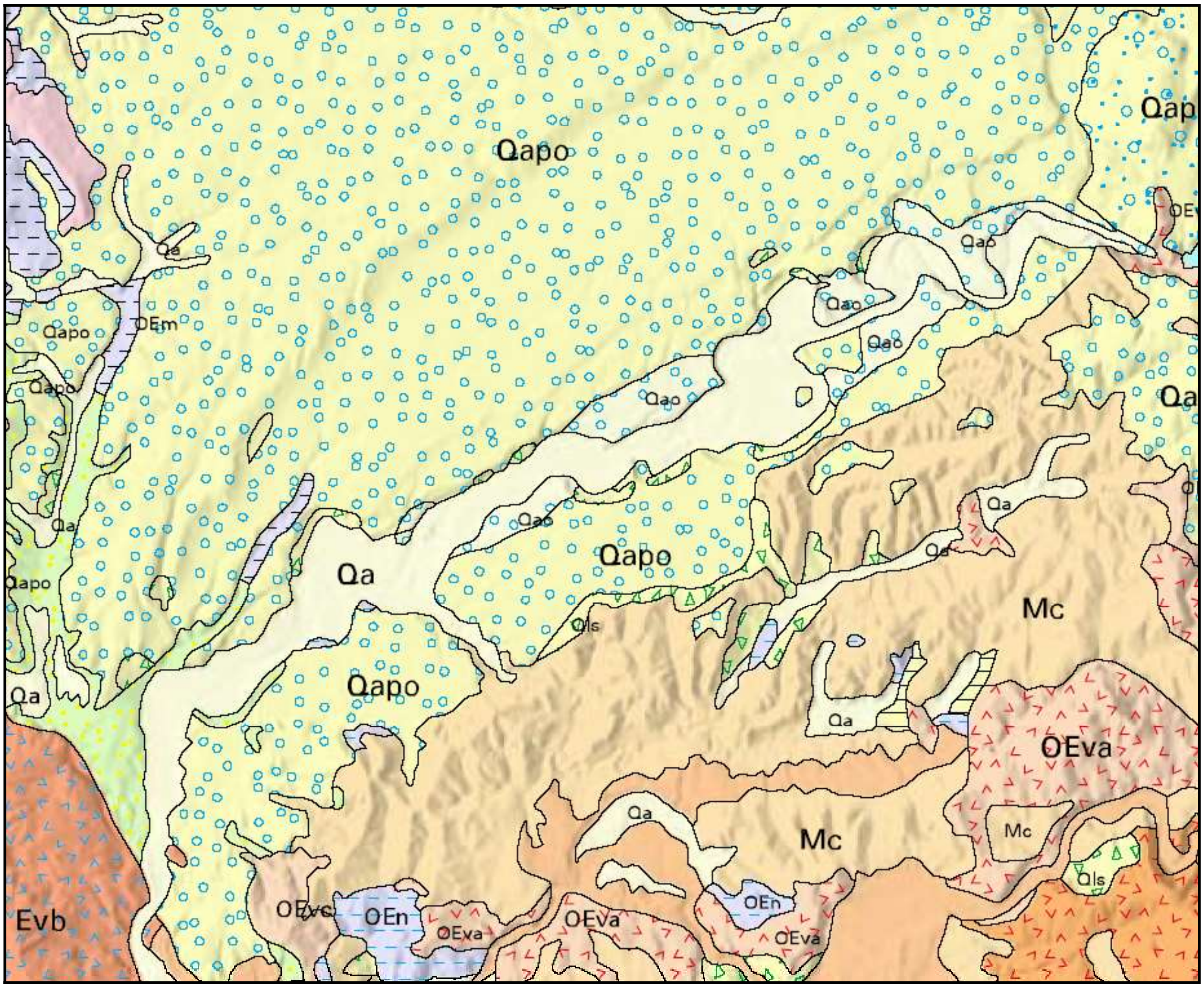

Figure 34. Geologic Map of the Cowlitz River from Vader to Mayfield Dam (WDGER 1987).

Figure 35. Historical GLO map of the Cowlitz River near Toledo

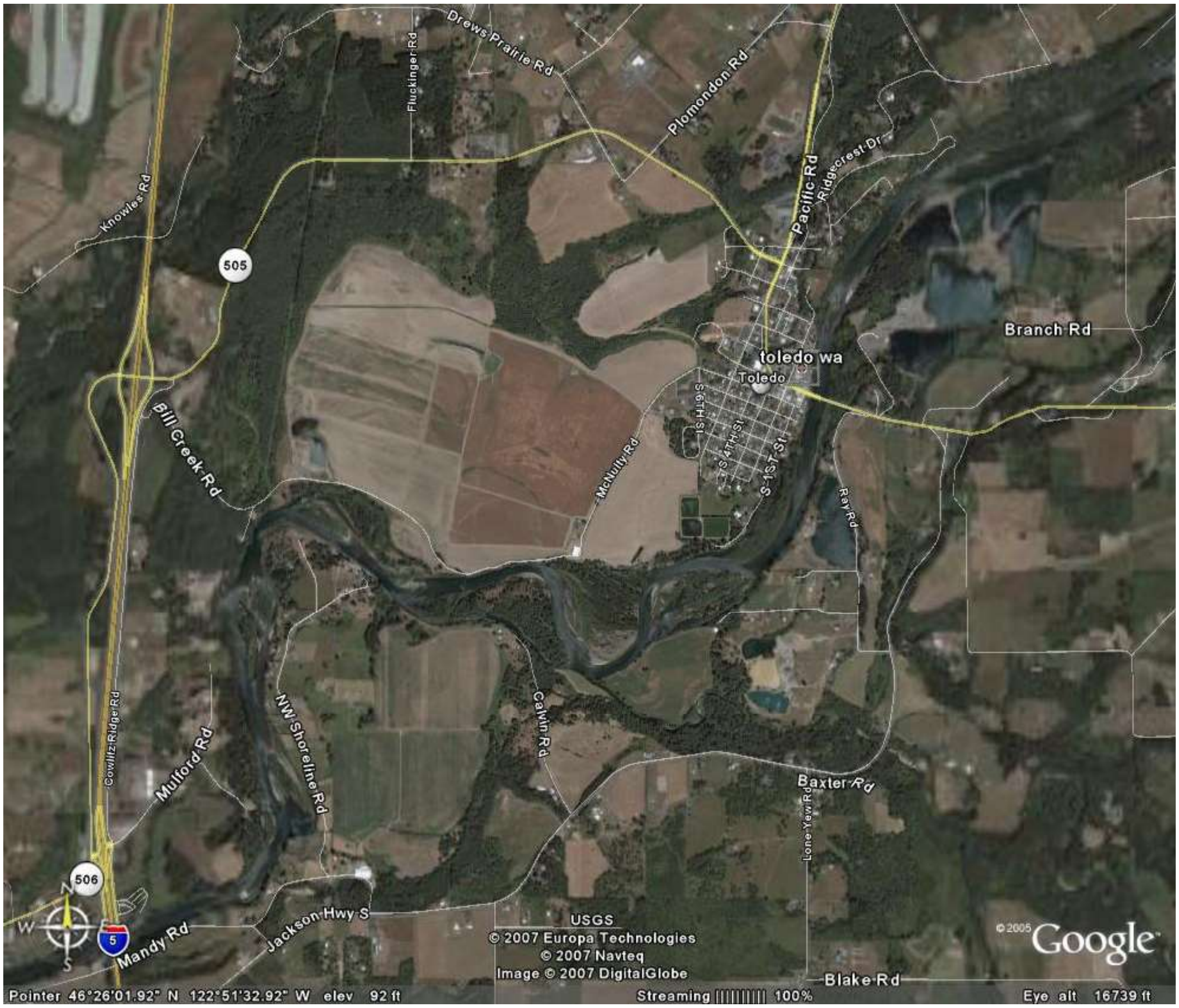

Figure 36. Current Aerial of the Cowlitz River near Toledo (Google Earth 2007)

Figure 37. Current Aerial of the Cowlitz River Upstream of Toledo (Google Earth 2007)

Figure 38. Current Aerial of the Cowlitz River near Blue Creek (Google Earth 2007)

Currently, there are extensive wetland areas on the glacial terraces above the floodplain of the Lower Cowlitz in Reach 5 (**Figure 39**). There are also several wetlands associated with remnant side channels and gravel mined floodplains. The extensive groundwater flowing from the terraces to the north of the river into Reach 5 could be used to promote chum spawning habitat in side channels and other off-channel habitats.

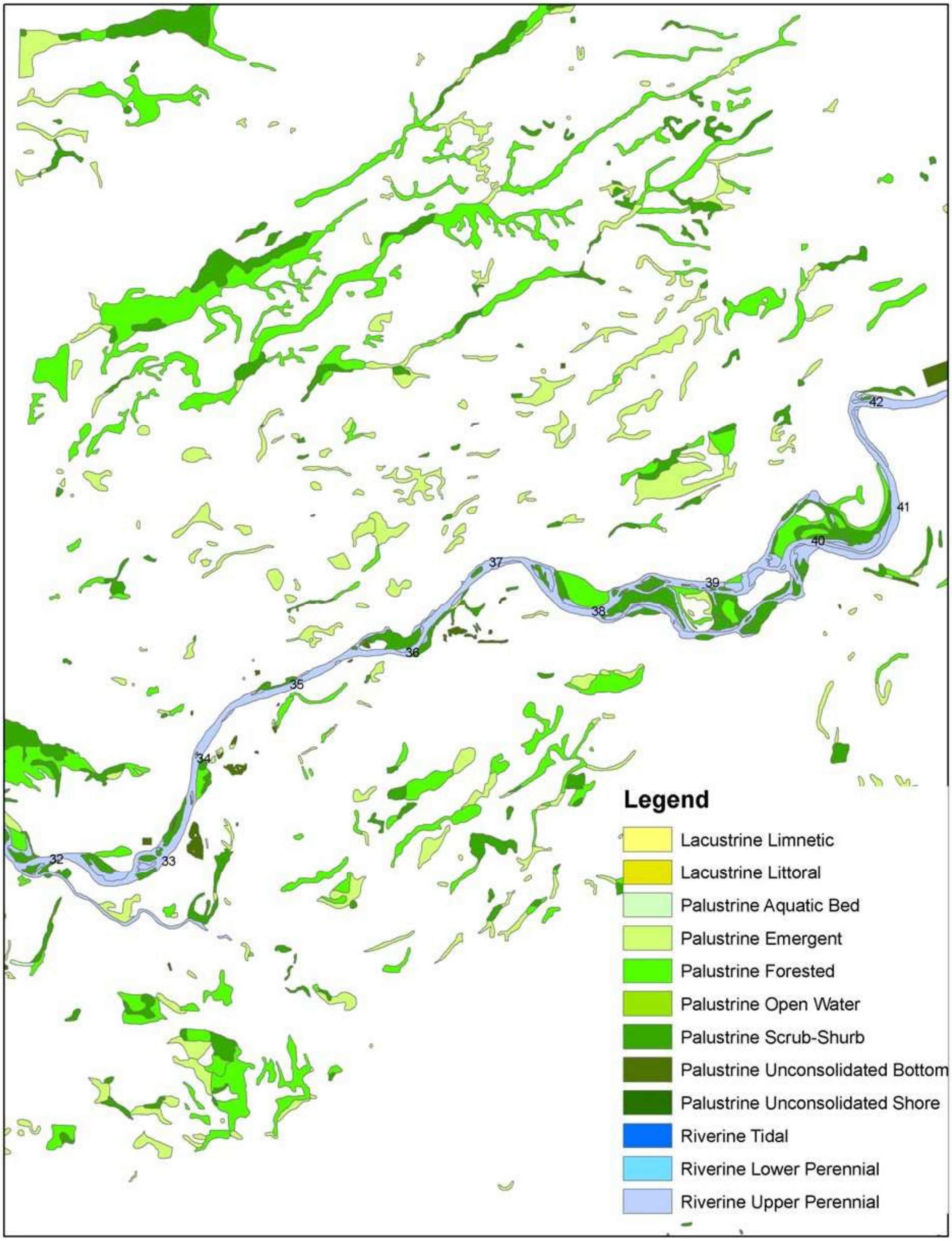

Figure 39. National Wetland Inventory Mapping for Reach 5, RM 32.0 to 42.0.

4.5.2 Assessment Observations and Results

This reach historically had extensive gravel bars and side channels and still has the most area of existing and remnant side channel habitat of any reach. This reach provides the most opportunities for both protection and restoration of side channel and floodplain habitat in the lower Cowlitz River. Particularly from RM 38 to 40 there are extensive partially connected side channels that could be restored very cost effectively and provide very long stretches of stable habitat.

From the mouth of Salmon Creek up to the Toledo bridge, there are several side channels that could be enhanced with LWD or reconnected. There are several areas with limited riparian vegetation that could be revegetated to provide more bank stability in a natural way and bank protection that could be removed and bioengineered. From RM 34 to 35, there is an extensive gravel mined floodplain along the left bank that could be restored and reconnected to provide off-channel rearing habitat. At RM 36 right bank, is the Mission boat launch and potential for reconnection of side channels that have extensive springflows off of the terrace above them. On the left bank at RM 36.5 is a gravel mined pond at the outlet of a former side channel. The side channel could be reconnected via a controlled inlet upstream at RM 37.5 left bank and restored all the way through and connected to the gravel pond with multiple outlets. There is a remnant side channel on the right bank at RM 37.5 that could be reconnected. The riprap bank along RM 37 to 38 could be bioengineered with wood and riparian vegetation. From RM 38 to 40 is an extensive channel migration zone with remnant and existing side channels. This area would be best maintained by easements or purchases for protection and enhanced with the addition of LWD, minor excavation, and riparian revegetation. RM 41 to 42, downstream of Blue Creek is confined between a high bluff on the right bank and extensive residential development and bank protection on the left bank; there is limited opportunity in this area.

There are also several limitations for restoration in this reach. First, the majority of the property is privately owned and existing bank armoring is protecting residences, agricultural lands and other uses. Restoration designs need to ensure that these structures continue to have protection, and that the restoration project does not increase the potential for avulsion, unless an easement has been acquired to allow for migration/avulsions. Another challenge with restoration of the gravel mined floodplain areas is the size and depth of the gravel ponds. Very large ponds would require significant amounts of excavation, grading and fill to meet desired habitat and water quality conditions, which could be very expensive. Due to the scale of these projects, a phased approach will likely be necessary.

4.5.3 EDT/IWA Summary

Reach 5 includes two original EDT reaches, Mid-Cowlitz 5A and 5B, rated as Tiers 3 and 1, respectively. The EDT analysis estimated that Chinook would experience only minimal effects from either further degradation or restoration in these reaches; chum and coho would experience minor benefits from restoration, whereas steelhead would experience significant benefits from habitat restoration in Reach 5B. The lack of habitat diversity and key habitat quantity has a moderate or high impact on chum, coho, and steelhead. This reach historically had numerous side channels and would benefit from the restoration and reconnection of side channels and floodplain habitats. The original rating of Mid-Cowlitz 5A as a Tier 3 reach is completely contrary to the conditions observed in the field, in that from Salmon Creek to Hinkley Road is the reach with the most restoration opportunity in the entire lower river, and particularly to address key habitat quantity and habitat diversity/complexity.

Reach 5 includes four new EDT reaches, Mid Cowlitz 5A through 5D, all rated as Tier 1 and 2 reaches. Reaches 5A and 5D are Tier 1 and reaches 5B and 5C are Tier 2. Approximately 20% of the fall Chinook spawning in the lower river occurs in these reaches (WDFW unpublished data). The revised EDT ratings reflect that this entire reach is a high priority for restoration and protection. The EDT classification partially matches the conditions observed in the field during this assessment. Reach 5D immediately below Blue Creek still does not seem to warrant a Tier 1 rating due to its confinement between a high bluff and residential development, uniform habitat, and a lack of opportunity for restoration. This high tier ranking may be reflective of the fact that the Blue Creek Hatchery is present immediately upstream and large numbers of hatchery fish are present in Reach 5D. Reaches 5A through 5C all appear to warrant a Tier 1 designation; all 3 reaches have extensive natural channel migration occurring and significant opportunities for restoration of side channel and floodplain habitats. There are a number of springs or spring-fed tributaries that enter the river in this reach and restoration actions could provide chum spawning habitat. There is a moderate risk of further degradation from bank armoring, particularly in the vicinity of Toledo.

4.5.4 Restoration Opportunities and Priorities

The primary opportunity for fish habitat restoration in the Toledo reach is to preserve currently functioning and dynamic sections of the river and floodplain. The areas of interest occur at RM 32 to 34 upstream of the Salmon Creek confluence and RM 38 to 40. The Salmon Creek confluence has shown recent active channel migration with a recent avulsion and reoccupation of the historical channel on the left side of the valley shown in the historical GLO maps, and significant movement of the main channel in the winter of 2006-2007 due to new gravel bar deposition. Restoration of several side channels through the extensive bars and islands up to the Toledo bridge would help relieve hydraulic pressure on the privately owned lands and reduce the need for likely future bank armoring. Placement of LWD to promote scour of the channels, provide cover and to divert flows away from existing structures would also be beneficial.

Projects identified in this reach include: 1) 32.5R, side channel restoration and enhancement; 2) 33.0L, side channel restoration and enhancement; 3) 34.5A, gravel mined floodplain acquisition; 4) 34.5B, gravel mined floodplain restoration; 5) 36.0R, side channel restoration and enhancement; 6) 36.5L, gravel mined floodplain restoration; 7) 37.5L, side channel restoration and enhancement; 8) 37.5R, side channel restoration and enhancement; 9) 38-40A, channel migration zone easement; 10) 40.0L, side channel restoration and enhancement; 11) 41.0 riparian restoration; and 12) 41.9R, bank enhancement. Five of these projects rank in the top 6 projects for the entire subbasin, including channel migration zone easement, side channel restoration and enhancement, and gravel mined floodplain restoration, because they would provide a significant quantity of habitat that would be highly beneficial for 0-age and 1-age rearing for all salmonid species and could provide adult holding and spawning habitat. This reach has modified hydrology, but the placement of wood will promote channel scouring, as well as providing in-stream cover. It would be highly beneficial to place wood and reconnect side channels in this reach.

The upper channel migration zone at RM 38.0-40.0 is one of the most notably dynamic and functioning channel and floodplain areas in the Lower Cowlitz. Future development and encroachment within this area would be highly detrimental to these processes which provide excellent conditions for salmon spawning and rearing habitats. This area presents a singular and extremely important opportunity for acquiring conservation easements and protecting natural floodplain areas and channel migration zones. Minor excavation to reconnect the Springer channel could be conducted at RM 40 (project 40.0L).

The highest priority restoration actions in this reach are to enhance and restore side channels and channel migration zones. Overall, this reach has the best opportunities for both habitat protection and restoration in the Lower Cowlitz River, and most of the highest priority projects are in this reach.

4.6 Reach 6. RM 42.0 to 52.0 – Blue Creek to Mayfield Dam

4.6.1 Reach 6 Historical to Current Comparison

The Blue Creek to Mayfield Dam reach of the Lower Cowlitz changes in floodplain composition and channel dynamics. The valley's glacial outwash terraces encroach upon the river and limit the alluvial floodplains to "pocket" areas that are a maximum of 1 mile in width on only one bank or the other. Between these pocket floodplains, the width of the floodplain is very narrow typically no more than ¼ mile wide. Within this reach, the Cowlitz Trout Hatchery occupies the downstream most floodplain area near the Blue Creek confluence. Upstream, the floodplain is relatively open near Jack Welches Creek, and the uppermost pocket floodplain is near the Cowlitz River Salmon Hatchery and Barrier Dam. The Barrier Dam blocks most fish passage and fish are typically collected here for transport to the upper Cowlitz subbasin. The channel upstream of the Barrier Dam is generally confined between high banks and restoration opportunities are limited. No restoration project sites were identified upstream of the Barrier Dam.

The GLO maps of this river reach (**Figure 40**) are less descriptive with respect to riverine and floodplain conditions. No features are mapped south of the river. No large wetland complexes or dynamic floodplain features are identified on the historical maps.

The main opportunities for salmon habitat restoration are protection and enhancement of existing high quality side channel and bar areas in the Blue Creek to Barrier Dam area. There are several large bar features that have existing or historical side channel areas. Existing side channels and backwater areas can benefit from the placement of large wood to provide better scour at the openings and reconnection of historical side channels would also enhance habitat conditions. The main limitations associated with the side channel enhancement projects are access, the need to minimize any disturbance-related adverse effects to existing high quality habitats, and a placement technique that keeps wood relatively stable. Using helicopters for installing large wood may be feasible.

Another opportunity within this reach is a potential channel migration zone easement and restoration in the area near Jack Welches Creek on the right side of the river near RM 44 (**Figure 41**). It appears this area may still be within the active floodplain and channel migration zone. However, it does not appear that the Blue Creek to Barrier Dam reach of the river is at risk for development and degradation in the immediate future. Therefore, large scale conservation purchases are not likely to be worth the cost. Focusing efforts on the mainstem and side channels is likely the best strategy for this section of river.

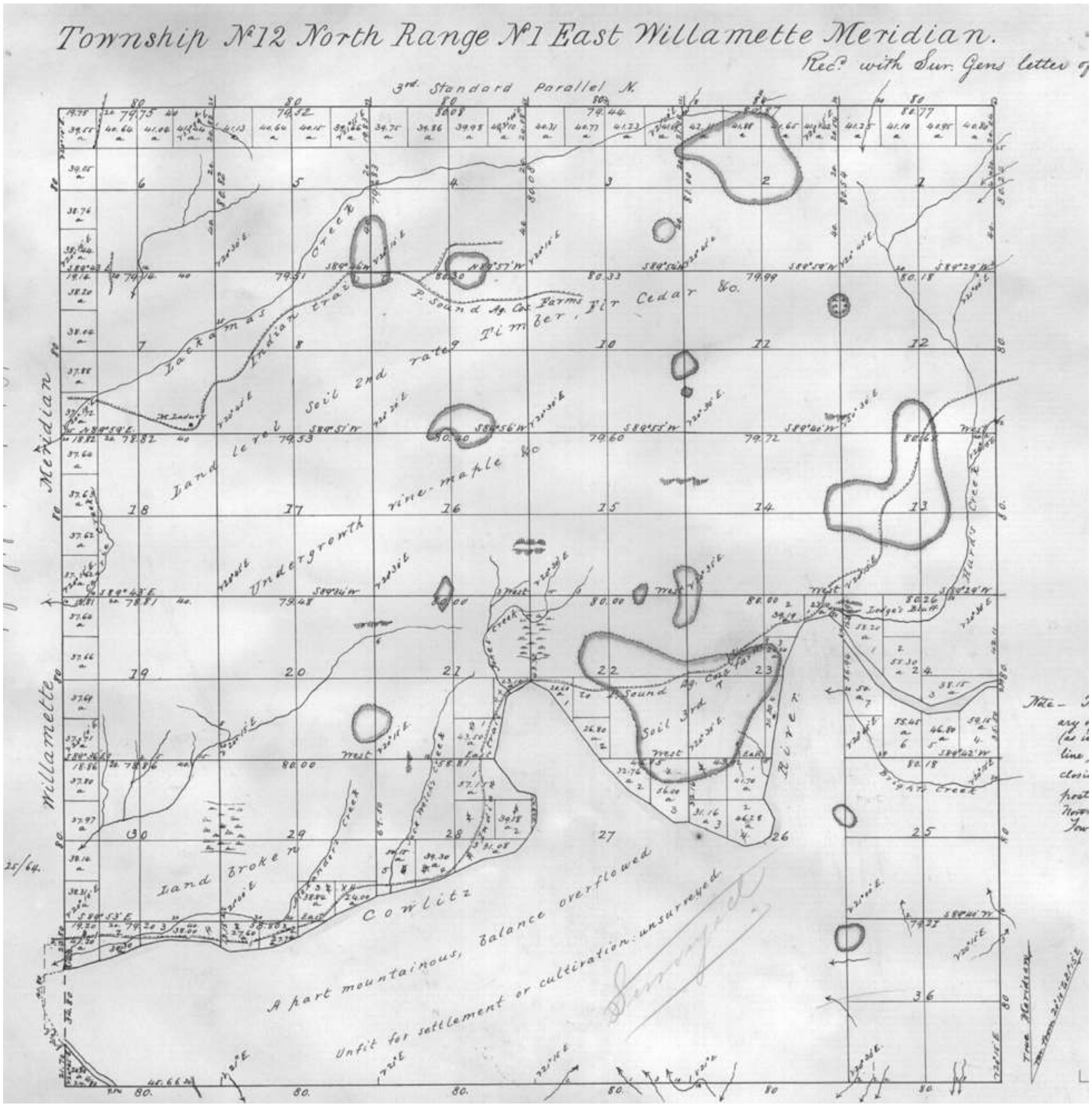

Figure 40. Historical GLO Map of the Cowlitz River from Blue Creek to the Barrier Dam (USBLM 1884).

Figure 41. Current Aerial of the Cowlitz River Upstream of Blue Creek (Google Earth 2007)

There are several large wetlands to the north of the Cowlitz River in this reach (**Figure 42**), but looking at the topography, they do not appear to be in the floodplain. There are likely to be groundwater flows into the river in this reach.

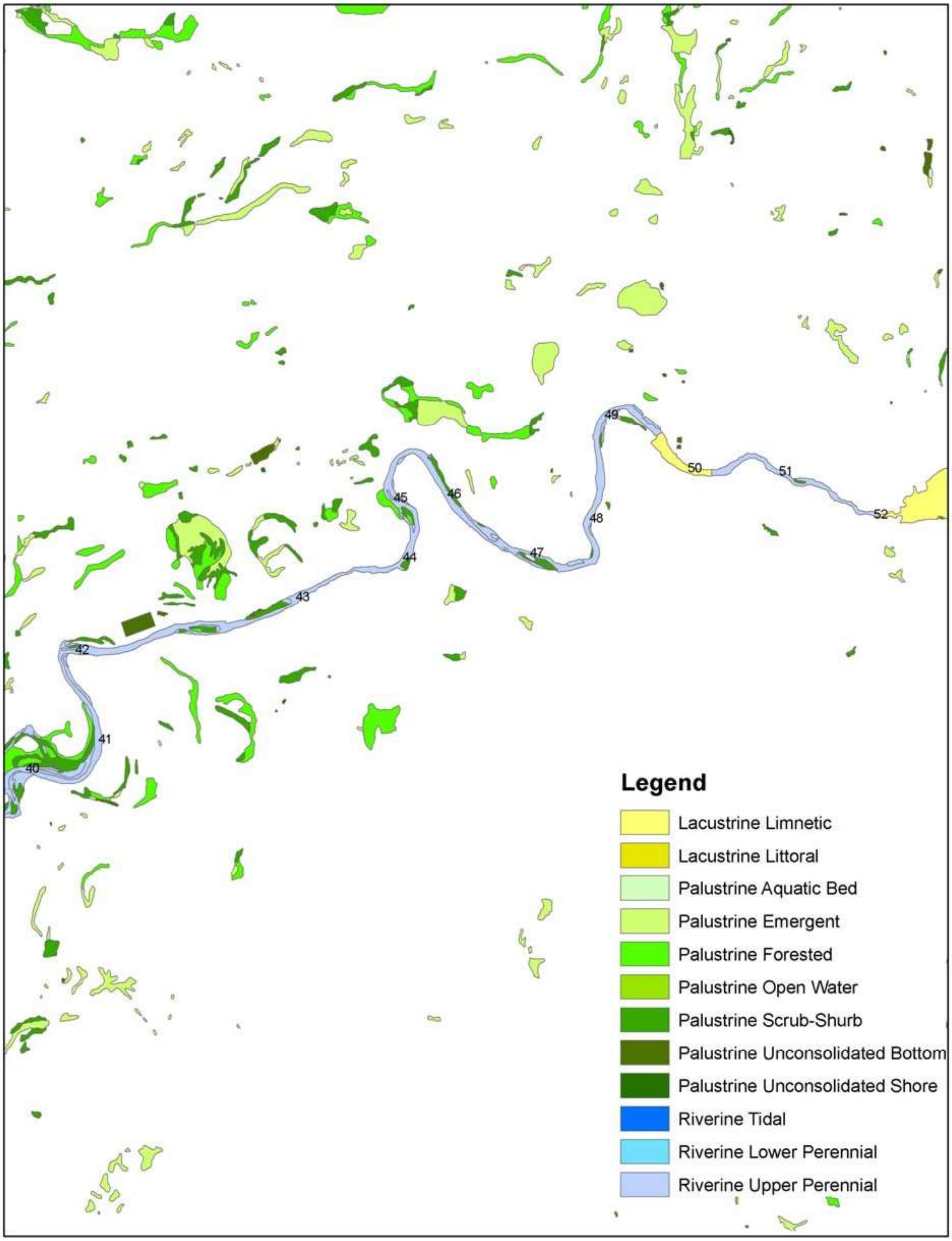

Figure 42. National Wetland Inventory Mapping for Reach 6, RM 42.0 to 52.0 (WDFW 2006).

4.6.2 Assessment Observations and Results

This reach is more confined than Reach 5. Riparian conditions are good in many locations, except immediately adjacent to the hatchery and boat launch. There are several existing side channels at RMs 42.5 left bank, 44.5 right bank, and 47.0 left bank. These side channels are some of the primary areas for Chinook spawning in the lower river. In general, these side channels provide existing high quality spawning habitat and are in proximity to the hatchery. Some of these side channels have been proposed for protection by the City of Tacoma. The channels could be enhanced for rearing habitat by the placement of wood for cover and to create scour at the openings to ensure they will remain connected at lower flows. Removal of non-native vegetation and riparian plantings would also improve habitat conditions. Side channel habitats could be restored and reconnected at RM 42.7 right bank, and 46.5 right bank.

A backwater channel is located on the left bank at RM 49.5. The top end was filled and blocked off during the construction of the Barrier Dam. This channel could be restored to be a flow-through side channel by creating one or more connections downstream of the barrier dam. A connection from above the barrier dam could be created via a culvert. Removal of non-native species and revegetation with native riparian species and placement of LWD would also enhance this channel.

4.6.3 EDT/IWA Summary

Reach 6 includes two original EDT reaches, Mid-Cowlitz 6 and a portion of Mid-Cowlitz 7, rated as Tier 2 reaches. The EDT analysis estimated that Chinook and chum would experience only minor effects from either further degradation or restoration in these reaches; whereas steelhead would experience significant benefits from habitat restoration. Channel stability and the lack of habitat diversity have moderate or high impact on Chinook, chum, and steelhead. Restoration of key habitat quantity would have high positive effects on steelhead. This reach historically had numerous side channels and would benefit from the restoration and enhancement of side channels.

This reach includes six EDT reaches, Mid Cowlitz Reaches 6A through 6E and 7, rated as Tier 1 and 2 reaches. Approximately 70% of the fall Chinook spawning in the lower river occurs in these reaches (WDFW unpublished data). These reaches are fairly stable due to the controlled flows from the dams, and there are several high quality side channels. The EDT classification generally matches the conditions observed in the field during this assessment in that there is high potential for preservation of good habitats, but the restoration opportunities are more limited. There could be benefits from restoration of disconnected side channels and from providing LWD to promote scour to keep the existing side channels open. Placement of LWD could also enhance stability of spawning gravels. There is a minor need for riparian restoration in Reach 6 near the hatcheries and Barrier Dam.

4.6.4 Restoration Opportunities and Priorities

The main opportunities for salmon habitat restoration are protection and enhancement of side channel and bar areas. The main limitations associated with the side channel enhancement projects are access, the ability to utilize a low impact construction and placement technique that keeps wood relatively stable. Helicopter loads of large wood and construction equipment may be a viable solution for installing large wood as part of the side channel enhancement projects.

Another opportunity within this reach is the potential floodplain conservation and restoration in the area near Jack Welches Creek on the right side of the river. Upon initial examination, the area may still be within the active floodplain and channel migration zone. If true, the expected future channel and floodplain dynamics would provide beneficial habitat as the river migrates and provides new active floodplain habitats.

Projects identified in this reach include: 1) 42.0R, tributary enhancement; 2) 42.5L, bar and side channel enhancement; 3) 42.7R, bar and side channel enhancement; 4) 44.5R, bar and side channel enhancement; 5) 46.5R, side channel restoration and enhancement; 6) 47.0L, side channel acquisition; and 7) 49.5L, side channel restoration and enhancement. These projects generally rank in the top 20 projects for the entire subbasin, because they would provide a significant quantity of habitat that would be highly beneficial for Chinook and steelhead spawning, and 0-age and 1-age rearing for all salmonid species. This reach has modified hydrology, but the placement of wood will promote channel scouring, as well as providing in-stream cover. It would be highly beneficial to place wood and reconnect side channels in this reach.

Overall, this reach is a high priority for habitat protection, with a few side channel enhancement or restoration opportunities. It does not appear that the Blue Creek to Barrier Dam reach of the river is at risk for development and encroachment.

5. Concept Designs and Cost Estimates

Concept designs and revised cost estimates were prepared for the following 15 high priority projects.

- RM 30.5 R – Bar and Side Channel Enhancement
- RM 32.0L – Channel Migration Zone Easement and Restoration
- RM 32.5R – Channel Migration Zone Easement and Restoration
- RM 33.0L – Channel Migration Zone Easement and Restoration
- RM 34.5L – Gravel Mined Floodplain Restoration
- RM 36.0L – Side Channel Restoration
- RM 36.5L – Gravel Mined Floodplain Restoration
- RM 37.5L – Side Channel Restoration and Enhancement
- RM 37.5R – Side Channel Restoration and Bar Enhancement
- RM 40.1L – Side Channel Restoration and Enhancement
- RM 42.0R – Tributary Enhancement
- RM 42.5L – Bar and Side Channel Enhancement
- RM 42.7R - Side Channel Restoration and Bar Enhancement
- T3.2R – Off-channel Reconnection and Enhancement
- T9 – Tributary Enhancement

5.1 Concept Design Overview

The concept design process involved laying out potential project features and construction activities on a project plan sheet using GIS to develop estimates for quantities. Types of features and construction activities that would provide fish habitat restoration for the various types of restoration designs (i.e. gravel mined floodplains and side channels) at the selected sites include large wood debris, engineered log jam construction, excavations for side channel and pond reconnections, and riparian plantings. The following section of the report provides a brief summary of the concept designs and cost estimates for the 15 high priority projects.

RM 30.5R – Bar and Side Channel Enhancement
This project site is an existing bar and side channel just upstream of I-5 and is shown in **Figure 43.** The plan for the project is to place large wood at the entrance to the side channel to promote scouring to keep the channel open more effectively and provide additional cover. Additional large wood would be placed on the bar and in the channel to increase habitat complexity. Riparian plantings would occur as necessary to buffer the side channel from adjacent development.

RM 32.0L – Channel Migration Zone Easement and Restoration
This project is associated with the Salmon Creek channel migration zone area and is shown in **Figure 44**. The plan for the project is to acquire channel migration conservation easements and allow the river to naturally migrate, avulse and change positions across the floodplain areas shown in the project plan layout. Additional activities would include placement of anchored large wood debris along Salmon Creek and other small side channels in the area, as well as

riparian plantings in the cleared area in the southeast corner of the project area. Recently, it was observed from two field visits in the fall of 2006 and spring of 2007, that winter 2006 flooding had significantly changed the Salmon Creek confluence area with the Lower Cowlitz. It is this type of channel dynamics and floodplain redevelopment that the project is designed to conserve.

RM 32.5R – Channel Migration Zone Easement and Restoration

This project is along the mainstem of the Lower Cowlitz upstream of the Salmon Creek confluence and is shown in **Figure 44**. The site has had significant channel migration from high flows in the fall of 2006 and also in 2007 and the main flow is currently flowing along the northern portion of the channel (historically a smaller side channel) along the agricultural property to the north. This property has been cleared to the edge of the channel and is in jeopardy of significant erosion and continued channel migration. The intent for the project is to work with local landowners to install engineered log jam structures (barb jams rather than riprap or rock protection) to deflect flows away from the bank, plant a riparian buffer, construct flood overflow side channels across the island, and install anchored large wood debris along the overflow side channels.

RM 33.0L – Channel Migration Zone Easement and Restoration

This project is along the mainstem of the Lower Cowlitz also upstream of the Salmon Creek confluence and is shown in **Figure 45**. The site was recently abandoned by the major channel avulsion and is now a backwater area, where the mainstem flow of the Cowlitz River shifted to the north. The downstream section of the project site is an agricultural property and has been cleared with bank stabilization measures to protect from recent historical channel migration and erosion. The eastern portion of the project is a series of backwater and side channel features that are relicts from previous channel migration.

The intent for the project is to work with local landowners to install engineered log jam structures (barb jams rather than riprap or rock protection) to deflect flows from the bank and plant a riparian buffer along the western portion of the project site. The activities on the eastern portion of the site will include construction and excavation of side channel reconnections, backwater excavation, and engineered log jam construction to provide habitat along this dynamic floodplain area of the Cowlitz River.

RM 34.5L – Gravel Mined Floodplain Restoration

The project is upstream of the Toledo Bridge crossing on SR-505, where a large area of floodplain has been mined for gravel and is shown in **Figure 46**. The site had an avulsion occur in the 1995/1996 flood events, where flows breached the embankment into two of the existing ponds. In total there currently are six ponds, which are no longer being actively dredged or reclaimed. The intent for the project is to reconnect the three ponds closest to the river by excavating breaches to allow flows to access the site during a variety of seasons and flow conditions. Other sections of the high bank will be removed, and the material from the breaching and removal work will be used to provide shallow shoreline areas to improve fish habitat. Other restoration activities will include installation of anchored large wood debris, and several acres of riparian plantings. A final element of the project will be to construct a berm or other type of protection to protect the remaining three ponds from future avulsions.

RM 36.0R – Side Channel Restoration

This project is located just downstream from the Mission boat launch and is shown in **Figure 47**. The intent of the project is to reconnect a side channel along the bar area by constructing two engineered log jams at the head of the bar to keep the channel inlet scoured open, and then excavate a side channel downstream to an existing backwater. In addition, a new backwater or overflow feature would be excavated along the central portion of the bar and a connection made to an existing pond. The final element of this design is to install several anchored pieces of large wood debris as habitat structures.

RM 36.5L – Gravel Mined Floodplain Restoration

This project is located upstream from the Mission boat launch and is shown in **Figure 48**. The intent for this site is to reconnect the current side channel and the 5 gravel mined ponds at the site. This would involve breaching the berms between the river and the relict side channel, and also breaching of the berms between the 5 ponds. The breach spoils materials will be used to reshape the shoreline of the ponds to improve fish habitat conditions. Also, breaching will create several riparian island areas. Other restoration elements for this project include installation of numerous pieces of anchored large wood debris, and approximately 40 acres of riparian plantings. The most beneficial restoration concept would be to combine this project with the side channel restoration/reconnection at RM 37.5L.

RM 37.5L – Side Channel Restoration and Enhancement

This project is located at the Kirkendoll revetment/levee and the IFA nursery and ultimately connects to the gravel mined floodplain at RM 36.5L, and is shown in **Figure 49**. The intent for this site is to allow a controlled reconnection to the side channel at the upstream end via culverts in the revetment or a porous revetment. The opening would be sized to allow only a specified amount of flow during normal flows to enhance the side channel habitat for off-channel rearing and refuge and potentially spawning, but not flood the properties behind the revetment. During flood events, the entire site is flooded, and the river made a major avulsion into this site during the 1996 floods. Fish currently can access the side channel from the downstream end, but the habitat quality is generally low. The culverts at Collins Road and the nursery access roadway would be replaced to allow unhindered access to the channel and large woody debris would be placed in the channel, along with riparian restoration and excavate a better connection at the downstream end. The intent is to work with the landowner to identify a feasible restoration plan that will work with the existing land uses. The most beneficial restoration concept would be to combined this project with the gravel mined floodplain restoration at RM 36.5L.

RM 37.5R – Side Channel Restoration and Bar Enhancement

This project is located across the Cowlitz River from the Kirkendoll levee and is shown in **Figure 50**. The plan for this site is to access the point bar area and install 3 engineered log jams (1 barb and 2 bar apex jams) to promote flow diversion and scouring to the historical side channel area. In addition, the side channel and adjacent backwater area would be excavated to promote flow through the channels for a variety of seasonal conditions. The final element of the design includes installation of numerous pieces of anchored large wood debris along both the side channel and backwater area as habitat structures.

RM 40.1L – Side Channel Restoration

This project is located at the historical inlet to the Springer Channel and is shown in **Figure 51**. This restoration opportunity will reconnect several thousand feet of the currently disconnected Springer side channel. The plan is to construct 2 engineered log jams (barbs) to promote flow diversion and scour at the opening to the historical side channel area. In addition, the historical inlet to the Springer Channel and an adjacent backwater area will be excavated to promote flow and increase the length and area of side channel and backwater habitats. Other restoration elements include installation of numerous pieces of anchored large wood debris and planting nearly 25 acres of riparian forest areas on currently cleared areas. Another element of the project is the removal of several makeshift crossings in downstream areas of the side channel.

RM 42.0R – Tributary Enhancement

This project is located on the lower mile of Blue Creek that joins the Cowlitz River at RM 42.0 and is shown in **Figure 52**. This restoration opportunity will provide fish passage into the upper reaches of Blue Creek and enhance the lower channel that has been degraded as a result of the adjacent hatchery facility and fishing access. The plan is to remove two low head diversion dams that divert flows into the hatchery (the hatchery has a new intake and outfall in the Cowlitz River). The channel will be enhanced by the placement of LWD along the lower 2,600 feet of the channel as well as planting of riparian species along the south bank to provide an adequate riparian buffer from the hatchery.

RM 42.5L – Bar and Side Channel Enhancement

This project is located just upstream of the Cowlitz Trout Hatchery and is known at the Otter Creek side channel. This project layout is shown in **Figure 53**. The intent of this project concept is to enhance an existing good quality bar and side channel by placing LWD to promote scour at the opening and provide riparian restoration as necessary on the island (primarily removal of non-native species and plantings of native trees/shrubs).

RM 42.7R – Side Channel Restoration and Bar Enhancement

This project is located near Brim road and is called Brim Bar and is shown in **Figure 54**. This restoration opportunity will reconnect a remnant side channel and enhance the existing conditions of the bar area. The plan is to construct an engineered log jam (bar apex jam) at the head of the island to promote flow diversion into the side channel area. The side channel will be excavated and will connect the upstream inlet at the head of the island to the backwater ponds located at the tail of the bar. Numerous pieces of anchored large wood debris will be placed along the side channel and pond area. The bar would then be planted with 10 acres of riparian vegetation. A final element of this project site is to evaluate the potential realignment of Alexander Creek into its likely confluence with the Cowlitz through the backwater ponds on the bar to improve water quality.

T3.2R – Off-Channel Reconnection and Enhancement

This project is located on the lower Toutle River near RM 3.2 on the right bank and is shown in **Figure 55**. The intent of this project concept is to reconnect off-channel ponds located behind dredged material spoils to provide off-channel rearing habitat along the lower Toutle River. Fish access will be enhanced by ensuring the pipeline crossing is passable and, if necessary, placing large wood to promote scour at the. Off-channel habitat will be enhanced by the placement of wood and plantings as needed.

<u>T9 – Tributary Enhancement</u>

This project is located on the lower end of Olequa Creek and is shown in **Figure 56**. The intent of this project concept is to restore a side-channel and the riparian zone/floodplain along the lower ½ mile of Olequa Creek, on both banks. There is currently a channel connected at high flows, but there is also a remnant channel along the left bank. The remnant channel could be reconnected for high flow refuge and rearing and the bar and existing channel could be enhanced by placement of wood. Actions include placement of wood to promote scour at the entrance and exit of the side channel and on the bar to provide cover. Removal of noxious weeds (knotweed) and riparian plantings on both banks would also occur. The Cowlitz Tribe currently owns most of the right bank and a willing landowners owns the left bank.

5.2 Concept Design Cost Summary

Preliminary costs for each of the eight selected projects were developed based on the concept design layouts. These costs used assumptions based on available project data from similar types of restoration in the states of Washington and Oregon, and expertise based on several years of restoration planning, design and construction experience from the project team. All quantities were estimated using project layouts in GIS using the software's measurement tools, and 2003 aerial photography as background for project feature layouts. These costs are considered preliminary, should be used for planning purposes only, and should be revised through a more detailed design and construction contracting phases of work. **Table 6** is a summary of the preliminary project costs for the priority sites. The following assumptions were used in developing the cost estimates:

- Real estate acquisition or easements were assumed to range between $5,000 and $10,000 per acre as a one time payment (fee simple).

- Site preparation, erosion and stormwater control, access road construction and maintenance, equipment mobilization and demobilization were assumed to be $20,000 for all projects.

- Side channel excavation, levee breaching, and shoreline grading were assumed to be $3.09 per cubic yard as published in RS Means, Site Work and Landscape Cost Data (2005).

- Engineered log jam construction used the designer's experience with numerous log jams installed on the Green River in Washington using large wood debris anchored with a series of driven piles in the shapes of barb and bar apex jams. Barb jams were assumed to be $25,000 per jam and larger bar apex jams assumed to be $50,000 per jam. This includes all necessary materials including piles, large wood debris, and chain anchoring systems, as well as installation using standard pile driving, backhoe and log loader equipment.

- Placement of anchored large wood debris assumes a cost range of $2,000 (land-based operations) to $2,500 (helicopter based operations) per log based on the designer's experience at purchasing, transport and installation of pieces of large wood debris, which includes economies of scale.

- Riparian vegetation planting areas were assumed to be $10,000 per acre which includes seeding, mulching and hand plantings of 1-5 gallon sized trees and shrubs and/or willow stakes.

- Culvert removal and disposal assumed a project cost of $10,000 per structure. Culvert replacements costs can be highly variable and the estimated costs range from $50,000 to $100,000 for replacement of structures up to 6 feet in diameter in rural forested areas.

Some of the priority project costs include estimates of engineering design (12%), permitting (2%) and administration (3%) as percentages of construction cost estimate to evaluate the complete project costs. More cost details are provided in each of the plan layout figures.

Table 6. Summary of Project Costs

Project	Description	Cost
30.5R	Bar and Side Channel Enhancement	$147,100
32.0L	Channel Migration Zone Easement and Restoration	$ 620,000
32.5R	Channel Migration Zone Easement and Restoration	$ 800,900
33.0L	Channel Migration Zone Easement and Restoration	$ 576,800
34.5L	Gravel Mined Floodplain Restoration	$ 1,808,600
36.0R	Side Channel Restoration	$ 296,800
36.5L	Gravel Mined Floodplain Restoration	$ 1,239,300
37.5L	Side Channel Restoration and Enhancement	$539,000
37.5R	Side Channel Restoration and Bar Enhancement	$ 470,800
40.1L	Side Channel Restoration	$ 1,304,500
42.0R	Tributary Enhancement	$362,700
42.5L	Side Channel Enhancement	$251,800
42.7R	Side Channel Restoration and Bar Enhancement	$ 494,700
T3.2R	Off-Channel Restoration and Enhancement	$449,400
T9	Tributary Enhancement	$438,000

6. Conclusions

The assessment of potential habitat restoration projects conducted in this study identified the majority of floodplain, off-channel and side channel, channel migration, and stream channel habitat restoration that can possibly be done on the Lower Cowlitz River mainstem. Fish passage barriers within the floodplain of the Lower Cowlitz were also identified. Riparian restoration measures were identified in many locations; however, additional riparian restoration actions could be identified based on individual landowner interest. This assessment did not address water quality, instream flows, flow management, or watershed conditions and hillslope processes.

The projects identified in this assessment will address critical limiting factors for salmonids in the Lower Cowlitz basin, including habitat diversity, key habitats, and channel stability. Restoration of floodplain and off-channel and side channel habitats, placement of wood and log jams, and riparian restoration will significantly improve habitat diversity in the mainstem and restore many of the key habitats that historically existed and provided spawning, rearing, and refuge. This will improve egg incubation, fry colonization, 0-age summer and winter rearing, 1-age summer rearing, prespawning holding, migration, and slightly improve spawning habitats. However, channel stability will still be influenced by the hydrologic regime, sediment sources and transport, and the potential for future channel confinement. The control of the hydrologic regime on the mainstem Cowlitz is unlikely to significantly change for some time in the future. The restoration projects have been identified and developed to function within a controlled hydrologic regime. However, for the long term, natural channel migration processes and sediment erosion and deposition patterns will be affected by the hydrologic regime. Restoration of the scale of historic habitats and habitat forming processes that once existed is not currently feasible. There are also on-going risks of channel confinement in many areas. Protection of key locations has been identified in Reaches 4 and 5.

Implementation of the projects identified in this assessment will likely take many years and should be accomplished in a phased approach, to restore the highest priority sites first (particularly those that are already within public ownership) and then move down the list from high to moderate to lower fish benefit. Projects that are currently identified as having a low certainty of success may in the future change to have a moderate or high certainty of success as efforts to work with landowners and other stakeholders proceed. Currently, many of the projects are identified with a low certainty of success simply because it is not known if a landowner or other stakeholder might be interested in a restoration project.

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