

**Site and Reach Assessment
South Fork Newaukum River
At SR 508, Milepost 5.75**



**Work Order MT0100
Chronic Environmental Deficiencies (CED) Program**

**Rob Schanz, Hydrologist
WSDOT Environmental Services
Hydrology Program**

July 2009



Washington State Department of Transportation
Environmental and Engineering Service Center
Environmental Services Office

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Table of Contents

Figures.....	iii
Tables	iii
Summary.....	iv
Introduction.....	1
Site Assessment.....	2
Maintenance History.....	2
Site Layout and Channel Geometry	2
Bank Soil Profile.....	4
Streambed Profile and Sediments	5
Local Hydraulics, Shear Stress and Erosion Potential.....	5
Riparian Habitat	6
Large Woody Debris.....	6
Aquatic Habitat	8
Reach Assessment	9
Watershed Conditions and Land Cover	9
Geology and Soils.....	9
Hydrology	10
Historical Channel Migration	11
General Channel Profile and Sediment Transport	11
Riparian Conditions	12
Fish Utilization and Habitat Availability	12
Evaluation of Treatment Alternatives	14
Mechanisms and Causes of Failure.....	14
Project Objectives	14
First-Cut Screening of Treatment Alternatives.....	14
Alternative 1 - Engineered Log Jam	15
Alternative 2 - Log Toe with Soil Reinforcement	16
Alternative 3 - Rock Toe with Soil Reinforcement	18
Alternative 4 – Roughened Log Cribwall Anchored with Piles	19
Recommended Alternative.....	20
References.....	23

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Figures

Figure 1. Project Location Map.....	1
Figure 2. 2006 Aerial Photo with 1999 and 2003 Banklines at the Project Site.	2
Figure 3. Channel Cross Section in the Pool at the Center of the Site.....	3
Figure 4. Channel Cross Section at the Downstream Riffle.....	3
Figure 5. Photo of the Eroding Bank Soil Profile.	4
Figure 6. River Bed Profile at the Project Site.....	5
Figure 7. Large Woody Debris at the Project Site.	7
Figure 8. Raft of Woody Debris Protecting Bank, January 2006.....	8
Figure 9. Surficial Geology at the Project Site.	10
Figure 10. Channel Alignments shown in Historical Aerial Photos.	12
Figure 11. Proposed Location of the Engineered Log Jam (Alternative 1).....	16
Figure 12. Typical Section of the Alternative 2 Log Toe Treatment.....	17
Figure 13. Extent of Toe Treatments (Alternatives 2 and 3).	17
Figure 14. Plan View of the Roughened Log Cribwall.	21
Figure 15. Section View of the Roughened Log Cribwall	21
Figure 16. Location of the Roughened Log Cribwall.	22

Tables

Table 1. Pros and Cons of Treatment Alternatives.	v
Table 2. Flow Statistics for the South Fork Newaukum River.	11
Table 3. Salmonid Stock Status in the South Fork Newaukum Basin.	13

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Summary

This report analyzes bank erosion problems at State Route (SR) 508 at Milepost (MP) 5.75 along the South Fork Newaukum River. The site is located on the outside of a river bend that has migrated within 20 feet of the road shoulder. WSDOT has needed several Hydraulic Project Approvals (HPAs) to reposition logs that were directing the river's flow against the bank. WSDOT has also cabled trees along the bank so they deflect flow and roughen the bank when they fall into the river.

The mechanism of failure is erosion at the toe of the bank, caused by high shear stresses on the outside of the river bend. The erosion has progressed to a point where there is little vegetative structure or erosion resistance remaining in the steep cut bank. This erosion is driven by reach-scale meander extension that causes the river to migrate toward the road with a high degree of curvature.

Table 1 summarizes pros and cons and relative costs for the alternatives we analyzed in detail. If no action is taken, the river will eventually undermine the road shoulder and trigger an emergency repair. At this point there will be fewer options for bank stabilization, resulting in greater cost and habitat mitigation requirements.

We recommend a roughened log cribwall (Alternative 4) as the preferred solution. Log or rock toe treatments (Alternatives 2 and 3) would leave only six feet of buffer between the road shoulder and the top of the bank. An Engineered Log Jam (Alternative 1) would divert flow away from the bank but would not fully protect the downstream segments without additional treatment.

The cribwall would rebuild a terraced riparian area outward from the existing eroding bank, replacing bank that was lost in recent years. Logs would be wedged among two alternating rows of piles, and would be buried by a mix of large rock, quarry spalls, and woody slash. Soil would be incorporated into the upper layers so that the top of the terrace could be planted with riparian trees and shrubs.

Road runoff and pasture drainage is currently being routed into a ditch that discharges into the elbow of the eroding bend. This saturates and weakens the bank structure and will compromise the integrity of the repair if it is not controlled. We recommended directing this runoff into a pipe that would then be incorporated into the log matrix and discharged onto logs and rock on the face of the bank treatment.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Table 1. Pros and Cons of Treatment Alternatives.

Alternative	Pros	Cons
<p><u>No Action</u> <i>Minimal construction cost until failure occurs.</i></p>	<p>Lowest construction costs and impacts until failure occurs.</p>	<p>Road will eventually be threatened, requiring emergency repair and mitigation.</p> <p>Fewer options for future repairs as buffer between the road and bank shrinks.</p>
<p>1. <u>Engineered Log Jam</u> <i>High cost.</i></p>	<p>Diverts flow away from the upstream end of the eroding bank.</p> <p>Increases pool and cover habitat.</p>	<p>Would need to be combined with other treatment to protect downstream bank segments from secondary currents that form in the bend.</p> <p>Short term impacts to mostly pool habitat. Supplemental treatment to downstream banks would impact riffle habitat.</p>
<p>2. <u>Log Toe with Soil Reinforcement</u> <i>Moderate cost.</i> Recommended solution if costs for Alternative 4 are prohibitive</p>	<p>Protects toe along entire eroding segment of bank.</p> <p>Increases cover habitat.</p>	<p>Leaves only six feet of buffer between the road shoulder and the top of the bank.</p> <p>Short term impacts to pool and riffle habitat.</p>
<p>3. <u>Rock Toe with Soil Reinforcement.</u> <i>Moderate cost</i></p>	<p>Easier construction and less excavation into the bank than required for log treatments.</p>	<p>Leaves only six feet of buffer between the road shoulder and the top of the bank.</p> <p>Provides less roughness, velocity reduction, and cover habitat than log treatments.</p>
<p>4. <u>Roughened Log Cribwall.</u> <i>High Cost (about \$1700 per linear foot on the SR 530 Sauk River project)</i> Recommended Solution</p>	<p>Stabilizes and protects the entire bank.</p> <p>Maintains the existing buffer and adds 10 feet of buffer between the road and the top of bank.</p> <p>Increases cover habitat.</p>	<p>Short term impacts to pool and riffle habitat.</p> <p>Higher cost than log or rock toe treatments.</p>

Site and Reach Assessment, South Fork Newaukum River at SR 508 MP 5.75

Introduction

This report analyzes bank erosion problems at SR 508 at Milepost (MP) 5.75, on the South Fork Newaukum River near River Mile 17 (Figure 1). The river is migrating towards the highway, and has cut into a steep bank that is now within 20 feet of the road shoulder. Additional erosion could occur rapidly during a major flood, and could undermine the road shoulder. This report analyzes site and reach conditions to identify the root causes of this erosion, and evaluates alternative solutions.

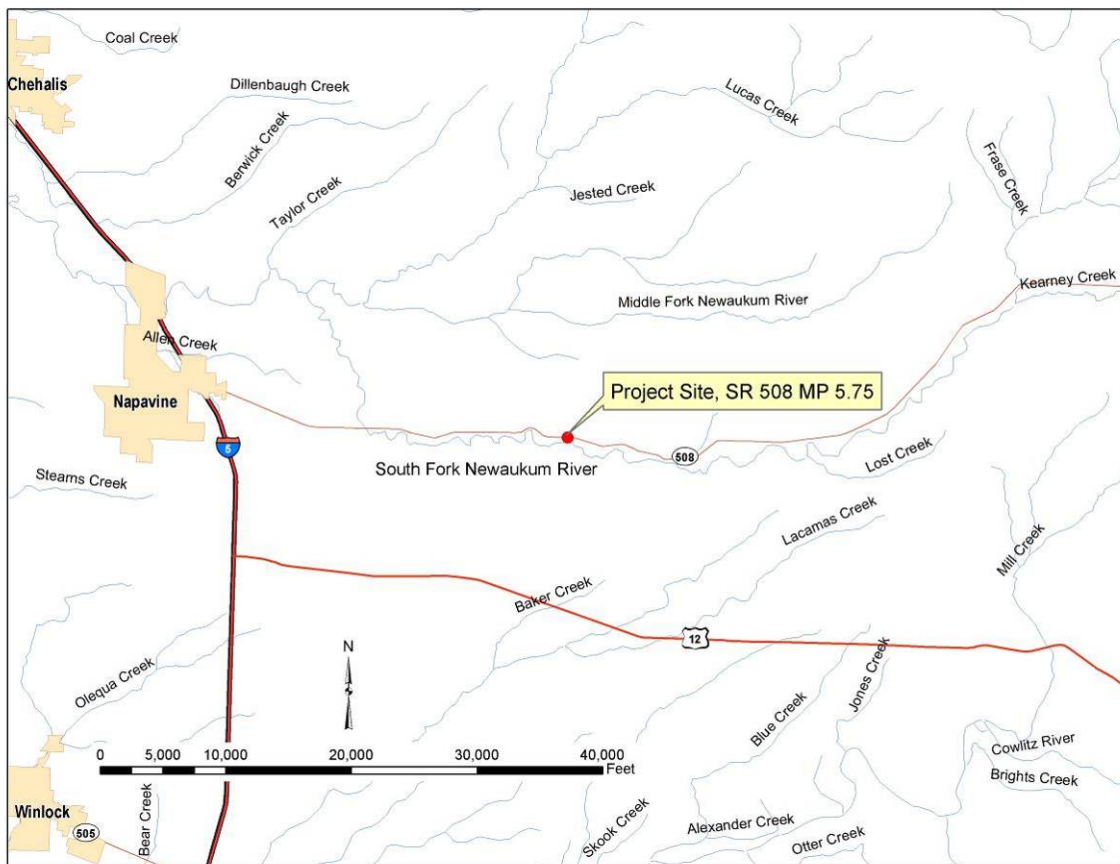


Figure 1. Project Location Map.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Site Assessment

Maintenance History

Over the last decade the South Fork Newaukum has migrated towards SR 508, raising concerns that the river could undermine the road prism. By March 2003 the river had come within 20 feet of the road, cutting a 10-foot high vertical bank and eliminating most trees from a 130-foot section of bank. WSDOT has responded to this threat by monitoring and manipulating woody debris to limit erosion. Trees periodically fall into the river and lodge with the rootwad directing flow against the bank. WSDOT obtained HPAs in March and December 2003 to turn and move these trees against the bank, with rootwads facing upstream to divert flow away from the bank. WSDOT has also cabled riparian trees on the shore so they will remain on-site and protect the bank when they fall into the river.

WSDOT has marked riparian trees at the site and periodically monitors their location. Since 2003 the rate of erosion has slowed, although several riparian trees have been lost. A tree tagged as #4 in the forest at the upstream end of the site fell in the river in the winter of 2007, and is now lodged within a log cluster just offshore. Tree #3 was the last one remaining in the center of the site, and was lost in the winter of 2006. Tree #2 at the downstream end of the site was severely undercut by 2004, but still remains in place.

Site Layout and Channel Geometry

Figure 2 shows an aerial photo of the river at the project site. The project site sits within a meander bend with a radius of curvature of about 185 feet. The stream approaches the bend in a relatively straight channel that takes an almost 90-degree turn before running parallel to SR 508. Bank erosion is concentrated against the outside of this bend, and has formed a deep scallop at the point where the river begins to turn against SR 508.

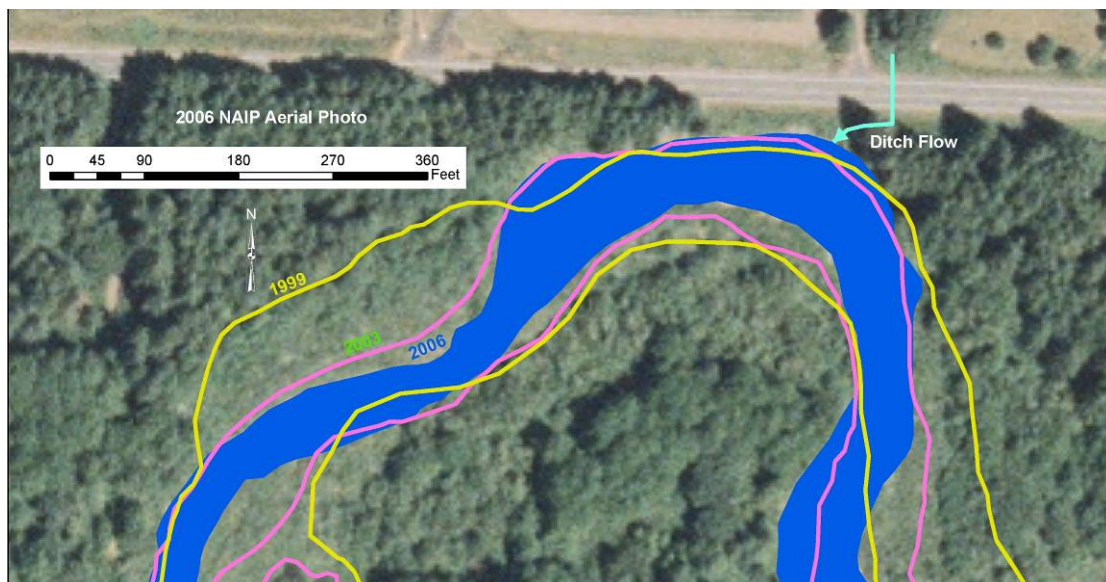


Figure 2. 2006 Aerial Photo with 1999 and 2003 Banklines at the Project Site.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Road runoff and pasture drainage is currently being routed into a ditch that discharges into the elbow of the eroding bend. This saturates and weakens the bank structure at the point where erosive forces are highest.

Figures 3 and 4 show channel cross sections surveyed in September 2008. The eroded bank is nearly vertical, and drops into a scour hole that runs along the toe of the bank. The channel bed slopes upward from this hole to a gravel point bar on the inside of the meander bend. On the left bank this gravel point bar slopes steeply up to a low bench of canary grass and willows.

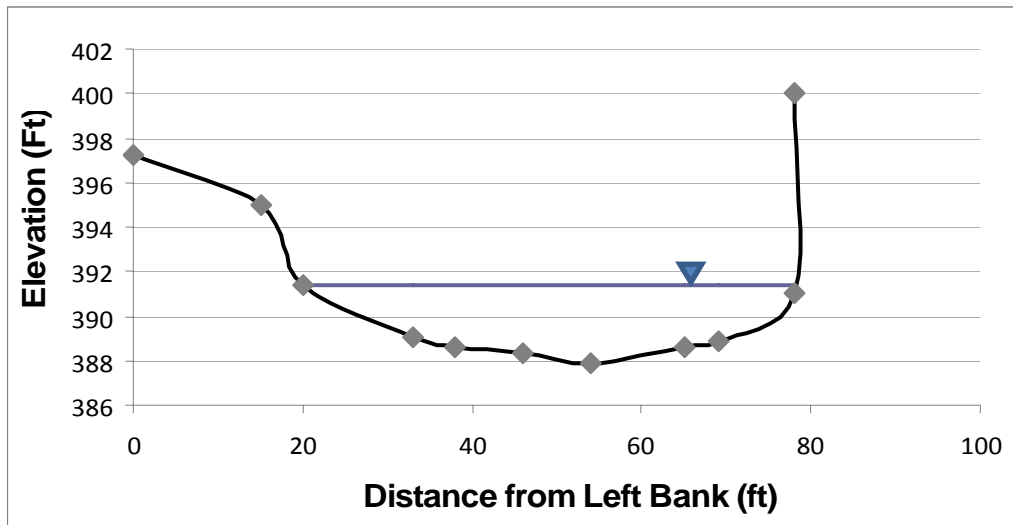


Figure 3. Channel Cross Section in the Pool at the Center of the Site.

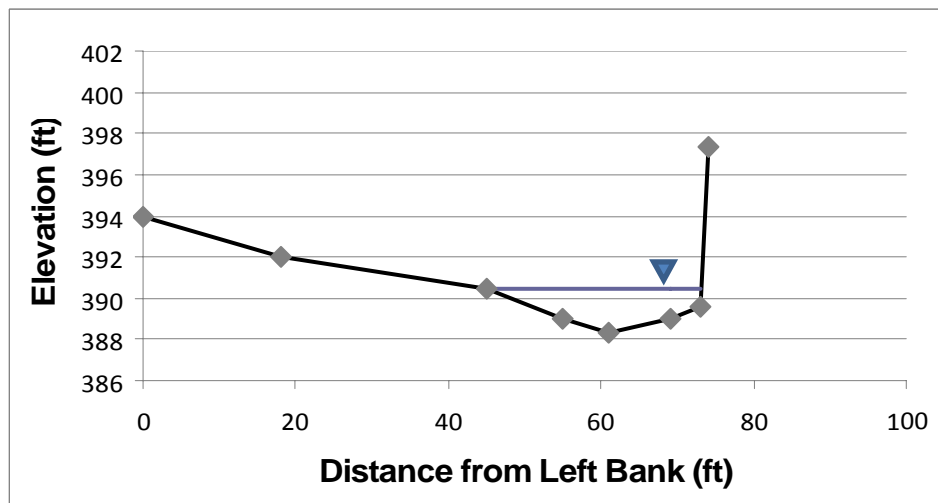


Figure 4. Channel Cross Section at the Downstream Riffle.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

The channel is 60 to 100 feet wide at the top of the bank. At the sharpest point in the bend the channel is 94 feet wide at the top of bank and has a radius of curvature of about 185 feet. The ratio of the radius of curvature to the channel width is therefore less than 2:1. This indicates the bend may be too sharp for diversion structures like barbs and groins, because of high potential for secondary currents that could erode between the structures. (FHWA, 2001).

Bank Soil Profile

The eroding bank consists of a nine- to 11-foot vertical scarp of fine-grained alluvium (Figure 5). Driller's logs for nearby wells indicate this alluvium has some clay content, and is therefore sufficiently cohesive to maintain a vertical slope when eroded (Washington State Department of Ecology, 2008). Soils at the site are mapped by the USDA (1979) as Newberg fine sandy loam.

A layer of rounded gravel embedded in a matrix of fine sediment is periodically exposed along the base of the bank. This is probably a relic of historical river bed deposits that were buried as the river migrated across the valley floor. In some locations a layer of reddish sandy soil marks the transition between the overlying fine-grained alluvium and the buried gravel. No bedrock is exposed at the site, although boulders of marine siltstone transported from upstream are scattered along the toe of the eroded bank.



Figure 5. Photo of the Eroding Bank Soil Profile.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Streambed Profile and Sediments

Figure 6 shows the profile of the river bed thalweg as it passes the erosion site. The river approaches the erosion site through a series of riffles spaced 200 to 300 feet apart. The last of these riffles marks the upstream boundary of the eroded bank, and is made up of coarse gravels to large cobble. The bed slopes at about 0.69 percent between the riffles that bracket the erosion site.

As the river turns along the eroding bank it enters a long deep pool. The inlet of the pool contains coarse gravels and cobbles that are mixed with sand and occasionally buried in sandbars. In the center section of the pool streambed materials transition from one- to three-inch gravels on the point bar to fine silts and sands in scour holes. In the deepest part of the pool the sediment is mucky and covered with aquatic plants.

The pool tails out into a riffle with three-inch gravel mixed with six to 12-inch cobbles and few fines. More riffles continue downstream, interspersed with deep scour holes along eroded sections of the bank and around large woody debris.

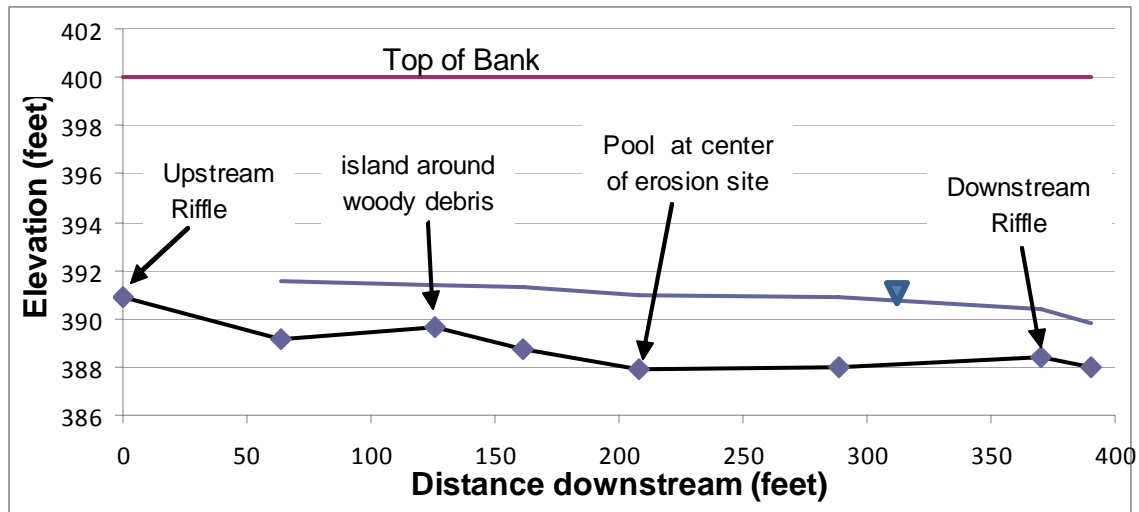


Figure 6. River Bed Profile at the Project Site.

Local Hydraulics, Shear Stress and Erosion Potential

We used a limited set of field cross sections to develop a preliminary HEC-RAS hydraulic model of the eroding channel segment. This preliminary model is not sufficiently accurate for design or floodplain mapping (primarily because the boundary condition is not far enough downstream), and is used here only to characterize general flow and shear trends.

At the two-year flood level (2913 cfs) the water surface just overtops the lower segments of the right bank. This flow generates average velocities ranging from four to six feet per second (fps). The mean bed shear stress is typically about 1.4 lbs/ft². This shear stress would mobilize a median particle size of about four inches (equivalent to a small cobble).

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

This corresponds well with particle sizes observed in riffles ranging from coarse gravel to large cobbles.

Flow around the outside of the bend generates about 1.6 lbs/ft² of shear stress along the toe of the right bank. This is more than enough shear to erode a sparsely-vegetated bank of fine-grained alluvial soils (WDFW, 2003).

Riparian Habitat

Bank erosion has eliminated all trees from a 130-foot segment of the right bank, leaving behind a thicket of snowberry, Himalayan blackberry, and annual grasses. This open segment is bracketed upstream and downstream by dense stands of evenly-spaced Douglas Firs that are 12-24 inches in diameter at breast height (DBH). The river is eroding into these stands and has exposed the roots of several bankside trees. WSDOT cabled some of these trees so they would lodge next to the eroding bank as they fell. Many of these trees have also been girdled and stripped of bark by beaver, and are likely to die soon (particularly downstream of the erosion site). Bankside trees have few large branches that hang over the channel.

Mature riparian vegetation is sparse on the inside of the meander bend on the left bank. The point bar opposite the erosion site is covered by canary grass that transitions to a dense willow and alder forest on the high part of the bar. None of these trees are large enough to provide significant shade or cover over the channel.

Large Woody Debris

Trees eroded from the site contribute to log clusters that form along the eroding bank and across downstream riffles. WSDOT has enhanced the retention of wood along the base of the bank by cabling trees to the shore. When trees lodge parallel to the bank they help prevent erosion, but at times they fall perpendicular across the river and vector flow against the bank.

During our September 2008 site visit we observed a log cluster consisting of eight key pieces mixed with smaller debris in the sharp bend at the upstream end of the erosion site (Figure 7). Flow splits around this cluster, directing some of the river's energy against the bank. Key pieces were 18-24 inches in DBH, with rootwads intact. One was still cabled to a tree on the bank, and probably fell in after January 2006. A low island of mucky sediment has developed along the downstream face of this jam, where three key pieces intersect.



Figure 7. Large Woody Debris at the Project Site.

Rootwads and log clusters can also be seen on low floodplain areas on both banks downstream of the erosion site. At the downstream end of the site a cluster of three pieces of large woody debris marks the transition between the vertical eroded scarp and a vegetated sloping bank. These logs lie on the bank parallel to the river, with rootwads facing upstream.

We briefly inspected the site during a January 2006 flood event. A log cabled by WSDOT to divert river energy away from the road had recruited a significant amount of woody debris that floated as a dense raft in the eddy at the upstream end of the eroded bank (Figure 8). The tagged tree on the photo is now one of the trees we observed in the September 2008 log cluster.



Figure 8. Raft of Woody Debris Protecting Bank, January 2006.

Aquatic Habitat

Pool tailouts at the tops of riffles contain substrate and flow conditions suitable for salmonid spawning. Scour holes along the toe of the eroded bank and around woody debris provide pool habitat and cover for fish. WDFW databases show that this reach of the river provides spawning habitat for fall and spring Chinook, coho, and winter steelhead. In September 2008 we observed numerous juvenile salmon around large woody debris and vegetation.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Reach Assessment

This section describes reach- and watershed-scale processes that could influence erosion at the site, focusing on the South Fork Newaukum from River Mile 16 to 18.

Watershed Conditions and Land Cover

The South Fork Newaukum River begins at Newaukum Lake in the Cascade foothills. It combines with the North and Middle Forks about 17.4 miles downstream to form the mainstem Newaukum River. The Newaukum River eventually flows into the Chehalis River near Chehalis, and is within the Upper Chehalis Water Resources Inventory Area (WRIA 23).

Elevations range from about 400 feet at the site to 3800 feet NAVD in the headwaters. Headwater areas are covered by privately owned industrial forest. Most of the project reach flows through agricultural land and low-density rural development. The unincorporated town of Onalaska lies just upstream of this reach.

Geology and Soils

Figure 9 shows the surficial geology in the area, based on 100K Department of Natural Resources (DNR) mapping. The South Fork Newaukum flows through the center of a 3400-foot wide plain of alluvial flood deposits. Logs for nearby wells indicate that this alluvium consists of red or yellow clay mixed with sand and gravel (Washington State Department of Ecology, 2008). The alluvium is typically 16-35 feet thick, and is underlain by thick deposits of dense blue clay. Only one well encountered bedrock, at a depth of 258 feet.

The valley floor alluvium is bounded to the north and south by terraces of alpine glacial outwash from the Logan Hill and Hayden Creek formations. The outwash is underlain by Miocene sedimentary rock. This rock is exposed along the riverbank about three miles upstream at the MP 7.3 repair site, where geotechnical reports describe a layer of very weak, highly weathered sandy siltstone. We noted several boulders of this material along the toe of the eroded bank at MP 5.75, but these were likely carried to the site by the river from upstream exposures.

The erosion site and other areas between SR 508 and the river are covered by Newberg fine sandy loam soils (USDA, 1979). These floodplain soils are typically very deep with moderately rapid permeability. Coarse alluvial soils found in active floodplains dissected by channels cover low areas on the left bank. Cloquato silt loam and Chehalis silty clay soils cover other adjacent floodplains and valley floor pastures.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

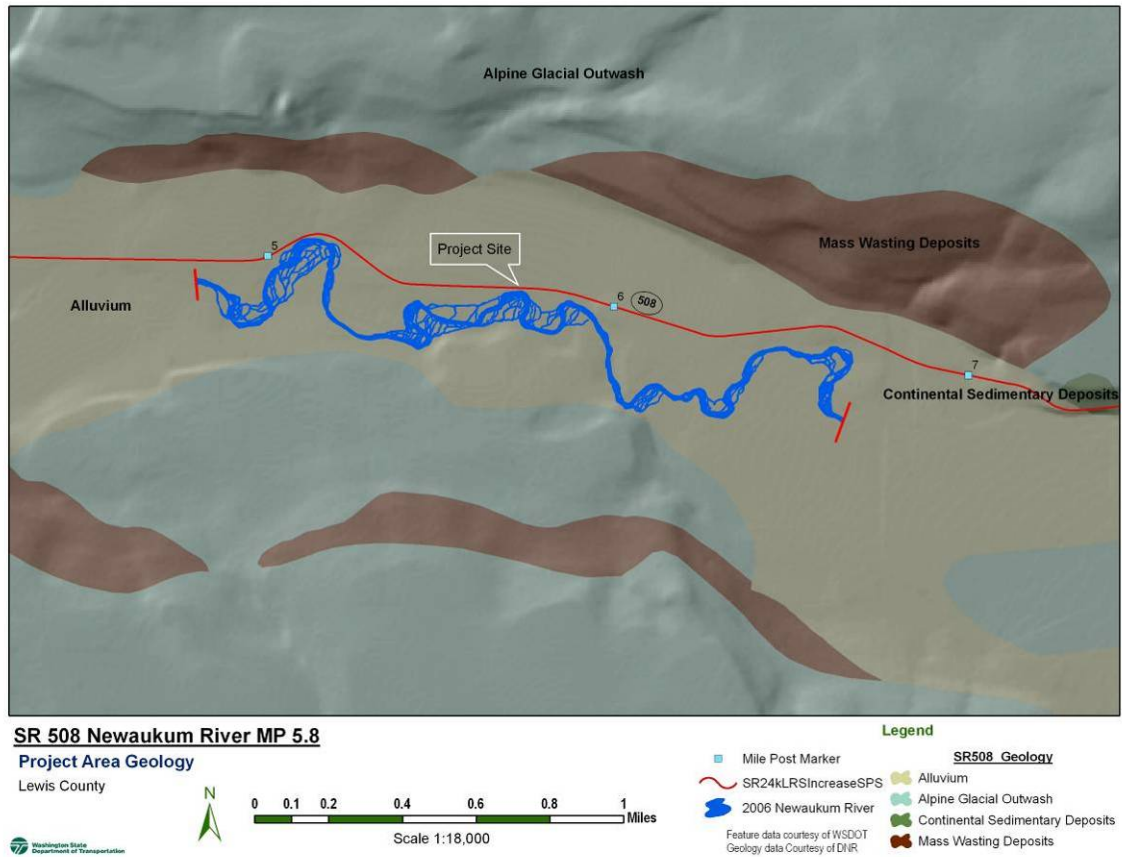


Figure 9. Surficial Geology at the Project Site.

Hydrology

The South Fork Newaukum basin receives 63 inches of mean annual precipitation and drains 55.6 square miles at the project site (USGS Streamstats, 2006). The watershed generally does not maintain a persistent snow pack, and flood events are driven by winter rainstorms. Rain-on-snow contributed to major floods in February 1996, December 2007, and January 2009. There are no major dams upstream that regulate river flows.

The USGS operates a stream gage at Jorgenson Road upstream of the project site (USGS, 2006). The river drains 42.4 square miles at the gage. Table 2 summarizes peak flows at the USGS gage and at the project site, estimated from flow statistics and drainage area relationships derived by Sumioka et al. (1998).

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Table 2. Flow Statistics for the South Fork Newaukum River.

Event	Peak Flow at USGS Gage 12024000	Estimated Peak Flow at the project site (cfs)*
2-year	2270	2913
10-year	3470	4453
25-year	4020	5158
50-year	4410	5659
100-year	4790	6146

- Region 1: Estimated flow = USGS Gage Flow x $(55.6 \text{ mi}^2 / 42.4 \text{ mi}^2)^{0.92}$

Historical Channel Migration

Figure 10 compares channel alignments shown in aerial photographs from 1944, 1981, 1993, 1999, 2003, and 2006. The 1944 photo shows a relatively straight channel that is distant from SR 508. By 1981 the river had developed meander bends that were extending northward towards SR 508, coming within 20 feet of the highway by 2003. Meander migration occurred primarily by north-south extension of bends, with little downstream translation.

In 2006 the river flowed through a well-developed series of meanders with an average belt width of about 514 feet. The channel top of bank width ranges greater than 100 feet in eroded bends, but averages about 85 feet in the reach. The ratio of the meander belt width to channel width is therefore about 6:1. Mature meander bends tend to have a belt width ratio near 6:1, so it is likely that the rate of meander extension will slow in the near future.

General Channel Profile and Sediment Transport

The two-mile reach centered on the project site slopes at about 0.4 percent, according to 10-meter DEM data. This reach typically contains a meandering gravel and cobble bed flowing through sequences of riffles and pools. The nearest bedrock exposure on the bed is located about three miles upstream, where the river has migrated against a glacial terrace underlain by marine sedimentary rock. The river does not interact with any major landslides or alluvial fans within the project reach that would contribute large sediment loads. Most of the sediment in this reach is therefore derived from the steep headwaters and upstream eroding banks. There is no evidence that the river bed is aggrading or degrading.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

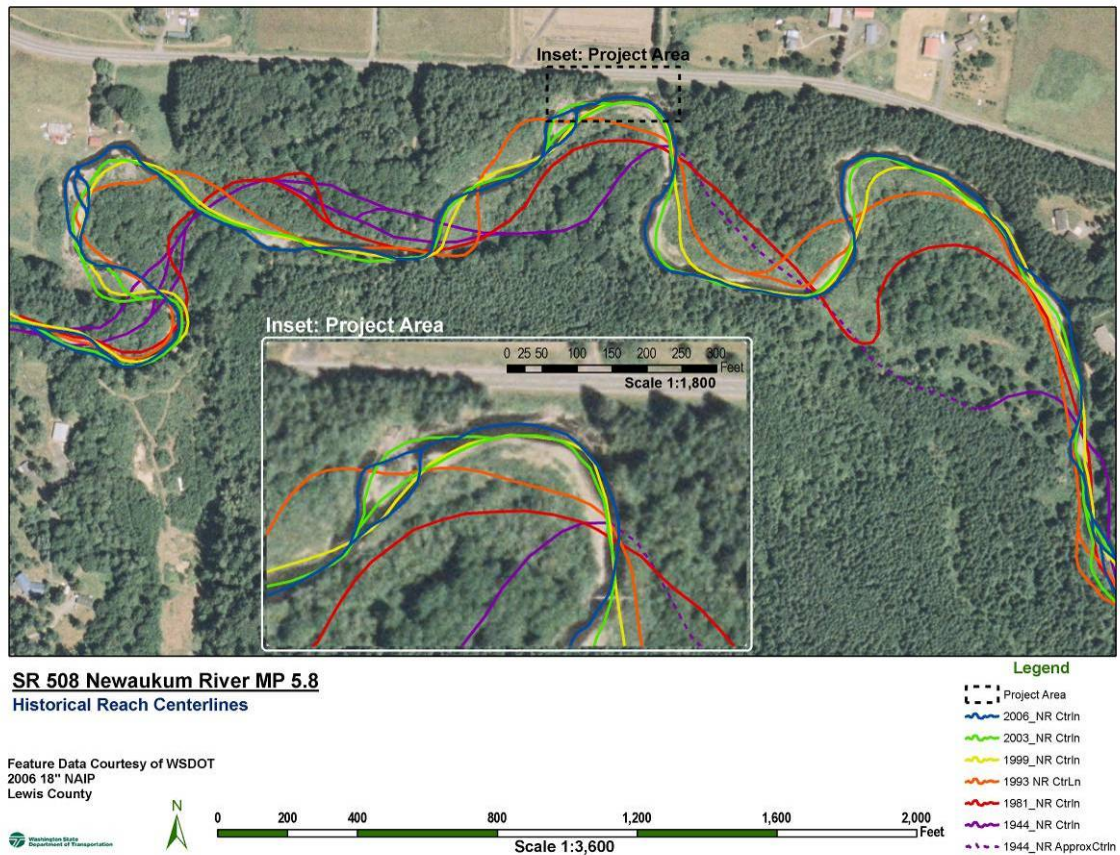


Figure 10. Channel Alignments shown in Historical Aerial Photos.

Riparian Conditions

The WRIA 23 Limiting Factors Analysis rated riparian conditions as “good” in the two-mile reach that centers on the project site (Washington State Conservation Commission, 2001). This reach has some of the highest quality riparian habitat in the lower South Fork Newaukum valley. Most downstream reaches have poor riparian conditions, while upstream reaches vary from fair to poor.

Surveys conducted in the 1990s show 32 percent of riparian areas along the lower South Fork Newaukum as unforested (Washington State Conservation Commission, 2001). Hardwood forests cover 55 percent of riparian areas, and early- to mid-seral coniferous forest covers 13 percent. Four percent of surveyed stream banks were altered by riprap (Envirovision, 2000).

Fish Utilization and Habitat Availability

The South Fork Newaukum River provides spawning habitat for coho salmon, winter steelhead, Chinook salmon, and cutthroat trout (Table 3). None of these are listed in the Chehalis Basin as threatened or endangered under the Endangered Species Act (WSDOT, 2008a). The U.S. Fish and Wildlife Service lists coastal cutthroat trout as a Federal species of concern.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

The Limiting Factors Analysis for the Chehalis basin WRIAs 22 and 23 identified the Newaukum as a priority subbasin for salmon recovery (Washington State Conservation Commission, 2001). A variety of factors combine to limit salmon production in the basin, including high water temperatures, riparian degradation, low levels of large woody debris, excess sediment delivery from landslides and erosion, channel incision, and loss of side- and off-channel rearing habitat. Bank erosion, livestock access, high road densities, and historic gravel mining have all contributed to sedimentation.

The Chehalis Basin Level I Assessment summarized habitat conditions in the South Fork Newaukum based on 1993 surveys and a 1999 watershed analysis (Envirovision, 2000). These surveys identified loss of streamside vegetation from livestock damage, bank erosion, and land clearing activities as a major source of habitat problems. Road erosion and landslides have lead to fine sediment deposition and pool filling.

Table 3. Salmonid Stock Status in the South Fork Newaukum Basin.

Source: WSDOT (2008a) and WSDOT (2008b)

Species	Stock	Primary Utilization	SASI Status	ESA Status
Coho (<i>Oncorhynchus kisutch</i>)	Chehalis	Spawning	Healthy	Not Warranted
Winter steelhead (<i>O. mykiss</i>)	Skookum-chuck/ Newaukum	Spawning	Healthy	Not Warranted
Coastal cutthroat trout (<i>O. clarki clarki</i>)		Unknown	Not rated	Species of Concern
Fall and spring Chinook (<i>O. tshawytscha</i>)	Chehalis	Spawning	Healthy	Not Warranted

Evaluation of Treatment Alternatives

This section summarizes the mechanisms and causes of failure, and analyzes treatment alternatives. Tables 1 summarize pros and cons and relative costs associated with each alternative.

Mechanisms and Causes of Failure

Bank erosion is typically influenced by a combination of site-based mechanisms and reach-scale processes. At this site the mechanism of failure is toe erosion along a bend. Flow curvature in the bend increases shear stresses along the toe of the bank, causing it to erode and slump into the river. The erosion has progressed to a point where there is little vegetative structure remaining in the steeply cut bank. Without roots and other vegetative structure, the alluvial soils have little resistance to erosion.

Road runoff and pasture drainage is being routed into a ditch that discharges into the elbow of the eroding bend. This saturates and weakens the bank structure at the point where erosive forces are highest.

Erosion at the site is influenced by reach-scale meander extension. This has caused the meander bend to migrate towards the road, and increases the degree of curvature and related shear stresses.

Project Objectives

To the extent practicable, treatment alternatives should:

- Stabilize the eroding bank and reduce the risk to SR 508 by addressing site- and reach-scale mechanisms and causes of failure.
- Minimize upstream and downstream progression of erosion.
- Minimize impacts to aquatic and riparian habitat.
- Avoid increases in flood risks to adjacent infrastructure and properties.
- Avoid increases in erosion that would threaten adjacent structures and properties.

First-Cut Screening of Treatment Alternatives

We used screening matrices from the Integrated Streambank Protection Guidelines (WDFW, 2003) to identify treatments that could address the mechanisms and causes of failure and meet project objectives. Treatments rated as good for toe erosion in bends with reduced vegetative structure include groins, buried groins, barbs, engineered log jams, roughness trees, log toes, roughened rock toes, soil reinforcement, and bank reshaping with plantings. All of these can also be suitable in reaches where meanders are migrating towards infrastructure. The matrices rate log cribwalls as only “Fair” in banks with reduced vegetative structure, but we chose to analyze a roughened version of this treatment because it is often a good solution when there is limited room between the road and a steep eroding bank.

Several of these alternatives were eliminated from further consideration based on specific site limitations. Groins and barbs are generally not recommended in tight bends where they would fill in existing scour holes and increase erosive energy downstream. In this

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

case the ratio of the radius of curvature to the channel width is less than 2:1, indicating a significant risk that secondary currents would develop that would create erosion hot spots between barbs, groins, or buried groins.

Roughness trees are typically placed with less anchoring than engineered log structures, and are not appropriate where flow energy is high or where infrastructure is threatened. According to ISPG, “this technique is a relatively passive approach to bank protection and should only be implemented where some degree of uncertainty in outcome is acceptable.” Because of the high consequences of failure in this situation, we eliminated roughness trees from further consideration.

Bank reshaping with plantings was also not considered further because of the height of the bank and the limited space between the river and SR 508. This would require a slope steeper than 2:1, and would therefore need the structural reinforcement provided by other alternatives.

Soil reinforcement would require a rock or log toe to provide a foundation and resist the high shear stresses that occur along the toe of the eroding bank. This alternative is therefore evaluated as a component of the roughened rock and log toe treatments, where it would reinforce the upper bank.

The remaining alternatives (Engineered Log Jam, Log Toe with Soil Reinforcement, Rock Toe with Soil Reinforcement, and Roughened Log Cribwall) are analyzed in more detail below and summarized in Table 1.

Alternative 1 - Engineered Log Jam

Description: An interlocking array of large woody debris would be placed in the erosion scallop at the point where the river first bends parallel to the road, at the upstream end of the erosion site (Figure 11). A footer log would be placed across the bend, roughly parallel to the bank. Key members that are partially embedded into the bank would then cross the top of the footer log, with roots facing out into the channel. The entire structure would be backfilled with rock and soil, and the bank above the last layer of logs would be graded and planted with native riparian plants.

The structure could make use of existing logs in the river, plus larger trees along the bank that have already been damaged by beaver.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75



Figure 11. Proposed Location of the Engineered Log Jam (Alternative 1).

Performance and Risk: This structure would deflect flow away from the upstream end of the erosion site, and limit further progression towards the road. It would also provide substantial roughness and flow resistance that would slow velocities and reduce shear stresses.

This would reduce but not eliminate the risk of erosion along downstream portions of the eroded bank. An additional treatment would still be needed for these sections. The high degree of channel curvature creates secondary currents that could erode banks downstream of the structure. A log and rock key would also be needed on the upstream end to minimize the risk of flanking if the channel migrates towards the back side of the structure.

Habitat impacts: This structure would provide cover and pool habitat for salmon, and improve habitat conditions at the site.

There would be short-term impacts to existing pool habitat during construction, since this would require excavation into the banks and streambed to anchor the footer and bank logs. Sediment and water control would be needed during construction.

Alternative 2 - Log Toe with Soil Reinforcement

Description: The toe of the eroding bank would be armored with layers of interlocking 18-inch minimum DBH logs, covering the lower four feet of bank where shear stresses are highest (Figure 12). The structure would begin with a footer log placed parallel to the channel with its top level to the streambed. A layer of perpendicular logs would be placed on top of this log with rootwads extending out into the channel. A third layer of logs would be placed parallel to the bank on top of the perpendicular rootwads. Spaces be-

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

tween the logs would be backfilled with rock, soil, and smaller woody debris (slash). The upper bank above the logs would then be stabilized with soil lifts reinforced with geotextile fabrics at a 2:1 slope. Brush layers of willow and dogwood cuttings would be placed between lifts, along with plantings of native riparian species.

The structure would extend from an embedded key at the upstream end of the bend to the downstream end of the vertical unvegetated bank (Figure 13). This downstream point marks a transition to a sloping bank protected by vegetation and large woody debris, and is therefore a logical end point for engineered bank protection.

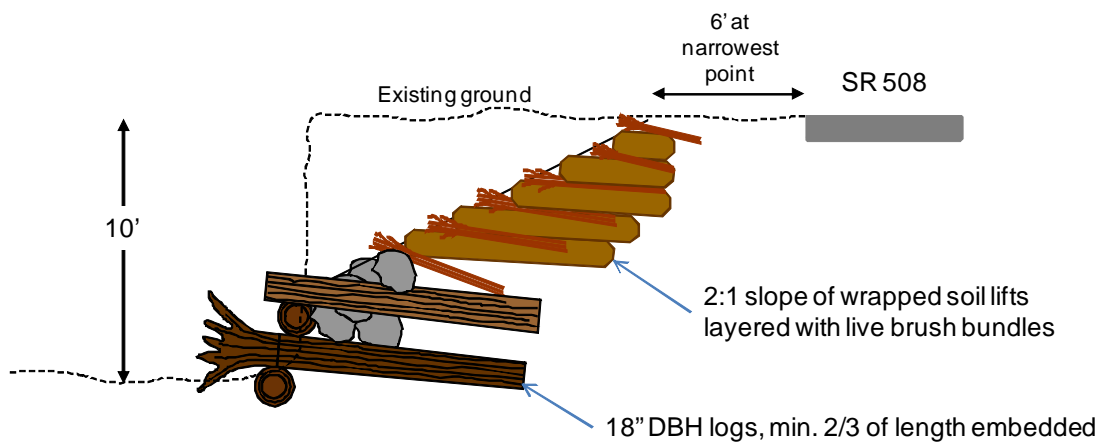


Figure 12. Typical Section of the Alternative 2 Log Toe Treatment.



Figure 13. Extent of Toe Treatments (Alternatives 2 and 3).

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Performance and Risk: This treatment would armor the toe of the slope and resist shear stresses. The logs would also provide roughness and flow resistance that would reduce velocities and shear stresses along the bank. Unlike the log jam treatment it would not deflect the river away from the bank. However, it would protect the entire segment of bank that is at risk.

The 2:1 slope on the upper restored bank would reduce the buffer between the road shoulder and the top of bank to only six feet at the narrowest point.

The primary risk for this structure would be flanking at the upstream end. This would be minimized with a rock key embedded into the bank at the upstream end of the treatment. Because the structure would intrude less into the river the risk of flanking is lower than for the log jam alternative.

Scour could also undermine the structure if it is not properly designed. This will be minimized by providing a buried footer log and rock foundation.

Habitat impacts: The footer logs and rootwads would provide cover and scour holes for salmon, and would substantially increase the complexity of the existing smooth vertical bank.

There would be short-term impacts to pool and riffle habitat during construction, since this would require excavation into the banks and streambed to anchor the footer and bank logs. Sediment and water control would be needed during construction.

Alternative 3 - Rock Toe with Soil Reinforcement

Description: A roughened rock toe would be placed on the eroding section of the bank in the same location as proposed for the Alternative 2 Log Toe (Figure 13). This treatment would use substantially larger rock than normally used for riprap, and the rock would be placed strategically so that large boulders would project out from the bank to maximize roughness. Occasional rootwads could be embedded into the structure to increase habitat values. The upper bank above the rock toe would be stabilized with a series of reinforced soil lifts and plantings, similar to those described for the Log Toe.

Performance and Risk: This alternative would function similarly to the log toe, but would provide less roughness. Construction would be easier than for the log alternatives, since there would be no need for excavation of trenches into the bank. A rock key would be needed at the upstream end to minimize flanking risks. The foundation of the structure would have to be buried below scour depth or include a launchable toe to minimize scour risks.

Habitat impacts: The roughness of the rock structure would provide resting habitat and have less impact than a conventional riprap treatment. It would not provide as much cover or pool habitat as log structures. Placement of the rock could eliminate some pool habitat along the toe of the slope.

Placement of the rock foundation would require excavation in the streambank and bed, and would cause short-term construction impacts to pool and riffle habitat. Sediment and water control would be needed.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Alternative 4 – Roughened Log Cribwall Anchored with Piles

Description: This treatment would rebuild a terraced riparian area outward from the existing eroding bank, replacing bank that was lost in recent years. Two alternating rows of steel piles would be driven into the streambed offshore of the bank (Figures 14 and 15). Footer logs would then be wedged parallel to the stream between the two rows of piles. Cross logs would be placed on top of the footer logs on the upstream side of each pile, with rootwads facing out into the stream and angled upstream. Additional layers of parallel and cross logs would be placed above this and backfilled with a mix of large rock, quarry spalls and woody slash to build about 10 feet of floodplain terrace. Soil would be incorporated into the upper layers so that the top of the terrace could be planted with riparian trees and shrubs.

The cribwall would cover the 225-foot segment of bank that is closest to the road (Figure 16). A downstream 100-foot segment would be covered with the Alternative 1 Log Toe treatment to provide a transition to existing vegetated sections of bank.

Rootwads and footers along the toe of the bank would need to be at least 18 inches in DBH to function as large woody debris, but logs along the upper bank could be as small as 12 inches. Many could be salvaged from trees that will have to be removed during construction (especially those that have already been damaged by beaver) and existing logs that lie along the toe of the bank. Additional trees from off-site will probably be needed to complete the structure.

Performance and Risk: This structure would preserve the entire existing buffer between SR 508 and the top of the bank, and add about 10 feet of additional riparian buffer. Roughness would be provided by using logs with rootwads for the key pieces embedded into the toe of the bank.

The structure will need to resist drag and buoyant forces generated on logs by the river. Drag forces will be resisted by wedging logs among piles, which prevent the logs from being turned out of the bank. Buoyant forces will be resisted by providing an adequate cover of rock and soil to weight the logs down.

The primary risk for this structure would be flanking at the upstream end. This would be minimized with a rock key embedded into the bank at the upstream end of the treatment.

Habitat impacts: The footer logs and rootwads would provide cover and scour holes for salmon, and would substantially increase the complexity of the existing smooth vertical bank. The terrace at the top of the structure allows for planting that will restore riparian vegetation to a stretch of bank currently devoid of large trees.

There would be substantial short-term impacts to pool and riffle habitat during construction, since this would require installation of piles, logs, rock, and soil onto the streambed offshore of the existing bank. Sediment and water control would be needed during construction.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

Recommended Alternative

Table 1 summarizes pros and cons and relative costs for the alternatives we analyzed in detail. If no action is taken, the river will eventually move towards the road and trigger an emergency repair. At this point there would be fewer options for bank stabilization, resulting in greater cost and habitat mitigation requirements.

The Roughened Log Cribwall (Alternative 4) best meets the project objectives but will also cost the most. If costs for this alternative are prohibitive or piles cannot be driven at the site, we recommend the Alternative 2, Log Toe Treatment. The primary problem with Alternative 2 is that it will require cutting the existing bank back to support the upper 2:1 slope, leaving only six feet of buffer between the edge of pavement and the new top of bank. It therefore entails more risk of failure and future road damage.

Logs in either alternative will be anchored by the weight of overlying soil and rock. Buoyancy calculations should be performed during design to ensure that burial provides adequate anchoring. Geotechnical investigation will be needed to determine if piles can be driven at the site.

Road runoff and pasture drainage is currently being routed into a ditch that discharges into the elbow of the eroding bend. This saturates and weakens the bank structure and will compromise the integrity of the repair if it is not controlled. We recommended directing this runoff into a pipe that discharges onto rock armor on the face of the bank treatment.

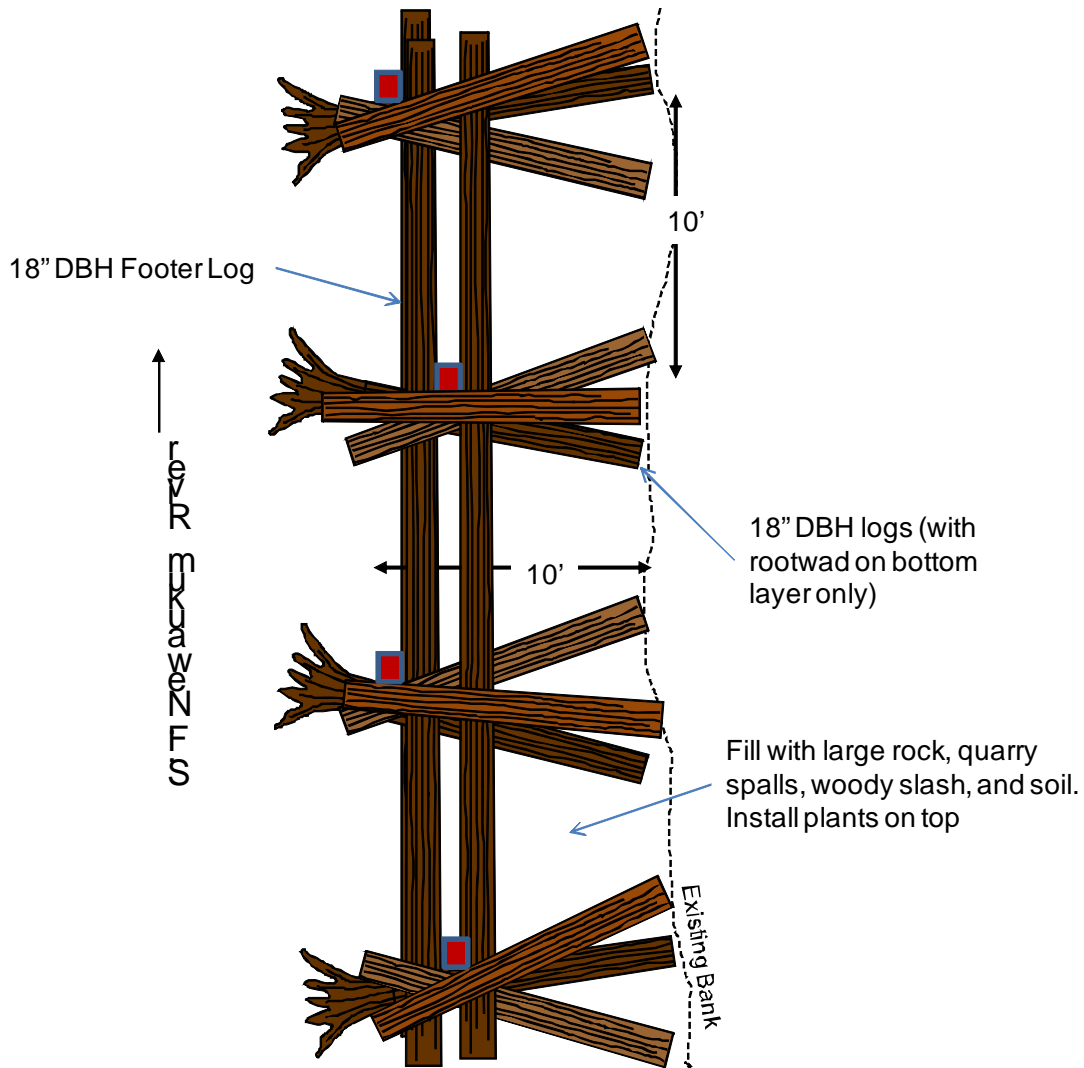


Figure 14. Plan View of the Roughened Log Cribwall.

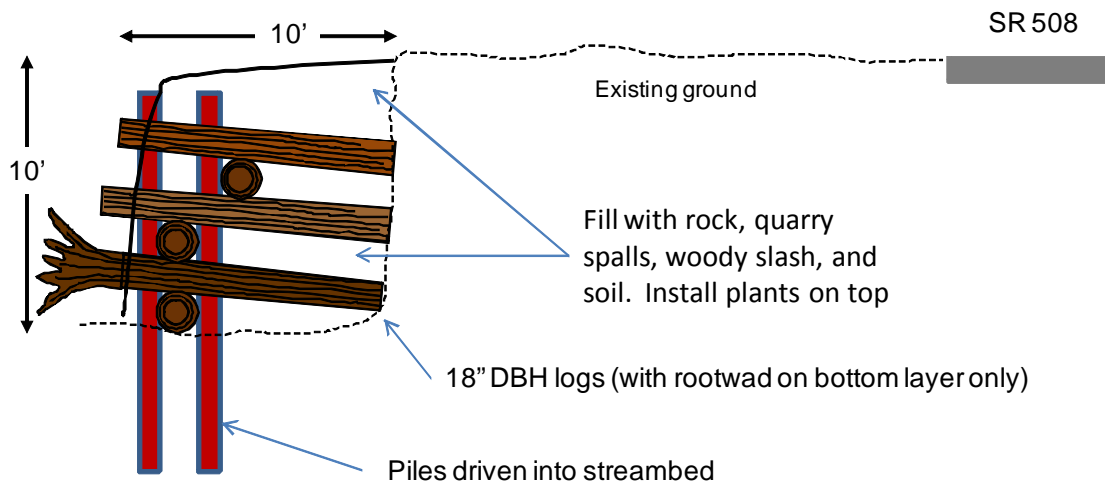


Figure 15. Section View of the Roughened Log Cribwall

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75



Figure 16. Location of the Roughened Log Cribwall.

Site and Reach Assessment, South Fork Newaukum at SR 508 MP 5.75

References

- Envirovision, 2000. Chehalis Basin Level I Assessment. Prepared for the Chehalis Basin Partnership and Grays Harbor County.
- Federal Highways Administration (FHWA), 2001. Stream Stability at Highway Structures. Hydraulic Engineering Circular No. 20.
- NOAA Fisheries, 2006. Endangered Species Act Status of West Coast Salmon and Steelhead. <http://www.nwr.noaa.gov/ESA-Salmon-Listings/Salmon-Populations/>, Accessed May 2006.
- Sumioka, S.S., D.L. Kresch, and K.D. Kasnick, 1998. Magnitude and Frequency of Floods in Washington. USGS Water Resources Investigation Report 97-4277. Tacoma, Washington.
- U.S. Department of Agriculture (USDA), Soil Conservation Service, 1979. Soil Survey of Lewis County, Washington.
- U.S. Geological Survey, 2008. Streamstats in Washington website. <http://water.usgs.gov/osw/streamstats/Washington.html>. Accessed September 2008.
- Washington State Conservation Commission, 2001. Salmon and Steelhead Habitat Limiting Factors, Chehalis Basin and Nearby Drainages, WRIAs 22 and 23.
- Washington State Department of Ecology. 2006. On-Line Well Log Database, <http://apps.ecy.wa.gov/welllog/>. Accessed August 2006.
- Washington State Department of Fish and Wildlife (WDFW), 2003. Integrated Stream-bank Protection Guidelines.
- Washington State Department of Transportation, 2000. SR 508 Onalaska Slide Preliminary Recommendations. Memorandum from T.M. Allen and D.V. Jenkins, OSC Geotechnical Services Branch, to Ron Pollock, SW Region. January 14, 2000.
- Washington State Department of Transportation, 2008a. Environmental Services Office, Biology website, ESA Consultation and Biological Assessments. <http://www.wsdot.wa.gov/Environment/Biology/BA#SpeciesList>, accessed October 20, 2008.
- Washington State Department of Transportation, 2008b. Geodata Catalog, GIS Coverages of Fish Species of Interest, derived from the WDFW Washington Lakes and Rivers Information System (WLRIS).
- Weigle, J.M. and Foxworthy, B.L., 1962. Geology and Groundwater Resources of West-Central Lewis County. Washington State Division of Water Resources, Water Resources Bulletin 17.