BASIS OF DESIGN

CLARKS CREEK CHANNEL AND BANK STABILIZATION

Puyallup Tribe of Indians
3009 E. Portland Ave.
Tacoma, Washington 98404
253-573-7800

Natural Systems Design
1900 N. Northlake Way, Suite 211
Seattle, WA 98103

This document summarizes the rationale for the design and construction methods selected to meet the goal of sediment reduction for the Clarks Creek Channel and Bank Stabilization Project. The primary goal of this project is to stabilize and trap sediment within the project area. Stabilizing and trapping sediment will help reach the TMDL goals for Clarks Creek which include Sediment and Dissolved Oxygen (WSDOE, 2014) as well as Fecal Coliform (WSDOE, 2009). This document builds on the Existing Conditions and Geomorphic and Hydraulic Assessment prepared by Natural Systems Design, Inc (NSD) for the Clarks Creek Channel and Bank Stabilization Project. The Sediment Reduction Action Plan (Brown & Caldwell, 2013) is the planning document that identified and prioritized projects to reduce sediment (based on planning-level approximations of tons/yr) in the Clarks Creek watershed. Therefore, we have included a relative approximation of sediment source reduction (tons/yr) to discuss the Clarks Creek Channel and Bank Stabilization design within the framework of the Sediment Reduction Action Plan numbers.

Sediment Source Reduction

Historical (Baseline) Sediment Production

The Puyallup Tribe has coordinated the Clarks Creek Channel and Bank Stabilization Project in effort to rehabilitate a degraded part of the watershed upstream of the WDFW fish hatchery and Maplewood Springs. The project area covers two channel segments identified by Brown and Caldwell (2013) in the recently completed Sediment Reduction Action Plan for the Clarks Creek watershed. Natural System Design, Inc. (NSD) has developed design plans for two sites identified in the plan: Upper Clarks Creek downstream from 23rd Ave SW (Pr05), and the Upper Clarks Creek Tributary (Pr06). Natural System Design, Inc. (NSD) is developing design plans for channel and bank stabilization at both sites. The purpose of this section is to summarize estimates of the sediment source reduction associated with proposed actions for Pr05 and Pr06.

The prevailing mechanism of sediment production under existing conditions is channel incision caused by an excess in sediment transport capacity due to human impacts including removal of riparian forest and impairment to wood recruitment processes, in combination with increases in runoff associated with development and land use impacts in the upper watershed. Subsequently, incision has destabilized adjacent hillslope areas resulting in episodic pulses of sediment that are temporarily stored in the channel and remobilized by high flows that transport the material downstream and out of the project reach.

Baseline sediment production rates are quantified by the volumetric estimates from Brown and Caldwell (2013) representing the total volume of eroded material associated with channel incision and widening (Table 1).

Table 1. Baseline (historical) sediment production from in-channel sources in project areas Pr05 and Pr06 (Brown and Caldwell, 2013).

	MAINSTEM (PR05)	TRIBUTARY (PR06)
Reach Length (feet)	1,300	600
Total Eroded Material (CY)	4,600	3,300
Sediment Production Rate (CY/yr)	48	35
Sediment Production Rate (Tons/yr)	64	47

Sediment Source Reduction

Sediment source reduction is targeted through both stabilization & prevention of erosion as well as storage within the channel for mobilized sediment. The design approaches stabilization and storage for multiple areas, mechanisms, and time scales. Stabilized area will start with the as-built condition and increase over time as root mass establishes. Sediment storage will start immediately within the channel as well as over time as slopes continue to reset.

Channel Bed, Streambank, and Hillslope Stabilization

Channel Bed Stabilization

Project actions aim to reduce sediment production from the project areas by increasing stability of the channel bed and banks. Large woody matrix structures will be installed to provide roughness elements that increase flow resistance and create storage areas to trap sediment in the channel. A coarse layer of cobble within and downstream of the woody matrices will dissipate energy and armor the channel bed in the steepest channel segments where flow exits the woody matrices. Bed logs between woody matrices will further partition shear stress and reduce sediment transport capacity.

Streambank and Hillslope Stabilization

While stabilizing the channel bed is important to preventing further incision and headcut progression, the current sediment supply is dominated by slope failures recruiting large volumes of glacial sediments (silt, sand, and gravel) to the system in episodic pulses (Brown and Caldwell, 2013). As such, a key element of the design plan involves stabilization of the over-steepened streambanks and adjacent hillslope areas through installation of timber frame structures (double layer of coir, plants, with log framing & ground anchors) and revegetation of disturbed areas to increase root cohesion and hold sediment in place. Vegetation is to be installed along the edges of large woody matrices and toe structures, within timber frame structures, and throughout the riparian corridor within 50’ of the channel centerline.

Channel Bed, Streambank, and Hillslope Stabilization Source Reduction Estimates

The projected sediment source reduction associated with project actions is estimated using a ratio of the surface area treated through stabilization measures relative to the surface area of eroding bed/bank areas delineated through field assessment (Table 2). Mainstem treatment areas (Pr05) delineated in design plans account for 98% of the eroding channel area and 39% of the eroding bank/hillslope area. The collective area treated by bed and bank stabilization measures accounts for 62% of the eroding source areas in Pr05. Reducing the historical average production rate by the relative surface area of stabilization treatments yields an estimated source reduction of 40 tons/year and a future sediment production rate of 24 tons/year.

Tributary treatment areas (Pr06) delineated in design plans account for 85% and 78% of the eroding channel and bank areas respectively. The collective area treated by bed and bank stabilization measures accounts for 80% of the eroding source areas in Pr06. Reducing the historical average production rate by the relative surface area of stabilization treatments yields an estimated source reduction of 38 tons/year and a future sediment production rate of 9 tons/year.

Table 2. Summary of sediment source stabilization estimates for Upper Clarks Creek (Pr05) and the Upper Clarks Creek Tributary (Pr06) sites.

	MAINSTEM (PR05)	TRIBUTARY (PR06)
Eroding Source Areas		
Channel Bed (SY)	1,730	480
Bank/Slope (SY)	2,710	1,760
Total (SY)	4,440	2,240
Stabilization Treatment Areas		
Channel Bed (% Eroded Area)	98%	85%
Bank/Slope (% Eroded Area)	39%	78%
Total (% Eroded Area)	62%	80%
Historical Sediment Production Rate (Tons/year)	64	47
Source Reduction by Stabilization Treatments (Tons/year)	40	38
As-built Sediment Production Rate (Tons/year)	24	9

In-Project Area Storage

Channel areas upstream of large woody matrix structures and brush matrasses will provide sediment storage areas within the two project sites and reduce sediment output to downstream reaches. Similarly, toe structures will provide storage areas to capture incoming sediment from upslope eroding areas along the valley margin. The collective sediment storage capacity created by project elements at each site was calculated in AutoCAD Civil3d and summarized below in Table 3.

Our estimates of sediment reduction assume 60-80% trap efficiency, on average, at each structure. Applying this trap efficiency to the incoming post-project sediment production rate yields an estimated in-project storage of 14 to 19 tons per year in the mainstem (Pr05) and 5 to 7 tons per year in the tributary channel (Pr06). Assuming a sediment bulk density of 1.34 Tons/CY, we estimate the volume of in-project sediment storage as 10 to 14 CY/year in the mainstem site (Pr05) and 4 to 5 CY/year in the tributary channel (Pr06). Over time, we assume the in-project storage rates (within/upstream of large woody matrices) to decline with reducing storage capacity. Dividing the total in channel storage capacity by these estimated sediment storage rates yields an estimated timeline of net deposition as 95-135 years in the mainstem site (Pr05) and 49-61 years in the tributary channel (Pr06). Beyond these timelines, storage areas are assumed to be at capacity and the net sediment supply to downstream channel reaches will increase slightly in the absence of additional roughness elements to create additional storage areas.

Table 3. In-project sediment storage capacity derived in AutoCAD Civil3d.

	MAINSTEM (PR05)	TRIBUTARY (PR06)
Large Woody Matrices (CY)	1,290	237
Toe Structures (CY)	45	N/A
Brush Mattresses (CY)	N/A	7
Total (CY)	1,335	244

Cumulative Stabilization and Storage Sediment Source Reduction Estimates

Combining the in-project storage with the sediment source stabilization reduction estimates associated with stabilization treatments yields a collective source reduction estimate (Table 4).

Table 4. Summary of sediment source reduction estimates.

	MAINSTEM (PR05)	TRIBUTARY (PR06)
Historical Sediment Production (Tons/yr)	64	47
Reduction from Stabilization Treatments (Tons/yr)	40	38
Reduction from In-Project Storage (Tons/yr)	11-14	4-6
Total Cumulative Sediment Source Reduction (Tons/yr)	**51-54**	**42-44**
Projected Future Sediment Production (Tons/yr)	**10-13**	**4-6**
Total Cumulative Sediment Source Reduction (%)	**80-84**	**89-94**

Design and Construction

The design and construction methods selected for the Clarks Creek Channel and Bank Stabilization all factored in the goal to stabilize and trap sediment within the project area (Pr05 and Pr06).

Design

Planting

Plants (trees, shrubs, and ground covers) will be installed into wood structures within the channel, along the banks, as well as throughout a 100' wide riparian corridor. The plants are essential for long-term stabilization of the banks and slope. The wood structures will help create a stable soil substrate for the plant roots to establish and provide long-term stabilization as well as enhancing future in-channel wood recruitment to further aggrade sediment. The plant roots help to stabilize soils, reduce soil moisture through evapotranspiration, and smooth the hydrograph as water is intercepted by the canopy cover, understory vegetation, leaf litter, and roots.

Within the channel, plants will be installed on the banks/ slope within timber frame structures where the ground surface slope is gentle enough to hold plants. Much of the reaches' banks are too steep and incised to provide a stable surface for planting into existing soil. In these areas, burlap sacks filled with soil amendments will be installed along structures to create a stable, consolidated substrate to plant into. These burlap sacks are double-bagged with topsoil in the inner sack and an outer sack of mulch to help provide nutrients, retain moisture, and retain a stable substrate for plants to grow. The burlap sacks will be placed 50/50 on the slash structures and the existing soil. The structures will help stabilize the existing soil and provide a stable base for the plants' to establish root structure in the adjacent soil and slash as it aggrades and traps sediment and detritus from leaves, etc.

Bare root plants were selected for ease of transport and reduction of impact to existing plants and slopes during delivery in this tightly constrained site with steep, unstable slopes. Bare root plants have also shown long-term success in moist environments and are a lower cost, allowing for increased density of planting. Bare root plants will be installed in the winter, post structure construction. Therefore, the design was developed to enable the majority of the material to be delivered with one mobilization during the summer structure construction. Therefore, the topsoil, burlap sacks, & mulch will be delivered & installed at the time of structure construction. Then several months later when bare roots are installed there will be a lower impact to the site, a lower cost to mobilize, and easier delivery of the bare root plants. Fertilizer tablets will be installed with the bare root plants to enhance nutrient availability.

The exception to bare roots are for sword ferns supplied in 1 gallon pots and for the plants used in construction access path and staging restoration. The construction access & staging area will be an easy area to access for plant delivery. Contractor will be required to de-compact the top layer of soil & then install plants and mulch on bare soils.

Timber Frame Structures

The objective of the timber frame structure design is to stabilize sediment in-place using plants, wood, biodegradable erosion control fabric, and ground anchors in areas of actively eroding sediment and slumps at grades steeper than 1:1. The fabric and wood will stabilize sediment immediately and create a stable substrate for the installed plants as well as any volunteer plants to take root to provide long-term soil stabilization.

Large Woody Matrices

The large woody matrices are channel-spanning porous woody check dams that are intended to slow velocities and aggrade sediment within the channel bed. They have a log frame that is stabilized by log posts driven into the ground. The log frames are filled with a dense matrix of slash. The layering of the logs as well as the density and sizing of slash is designed to create a non-linear path for water to seep through the matrix, preventing piping and evacuation of slash.

In order to prevent structure failure due to end-running or down-cutting , a layer of cobble is placed on the bed and banks. The ends of the horizontally-placed logs are embedded into the banks. The slash is surficially integrated with the adjacent bank and slopes to create a continuous density across the structure cross-section. The burlap planting sacks are placed overlapping the slash or cobble and adjacent banks/slope to establish root mass that will further stabilize the banks over time.

Adaptive management for these structures may be needed to ensure that erosion does not occur along the perimeter of the structures. This may include addition of coir logs or additional slash to fill any voiding that may occur.

Toe Structures

The toe structures are designed to trap sediment sloughing from near-vertical eroded banks. They are placed at the toe of the near-vertical slope with a log frame stabilized by log posts and filled with slash. The edges have burlap planting sacks to help establish root mass.

Bed Logs

Bed logs will be installed along the channel bed in the mainstem of Clarks Creek (P105) in the channel segments between the large woody matrices. The bed logs are intended to stabilize the existing channel bed and create surface roughness to slow velocities and lower shear stress.

Cobble

In addition to cobble installed as part of the large woody matrix structures, cobble will be placed on the channel bed between the two large woody matrix structures upstream and downstream of the 12’ headcut in the upper mainstem channel to stabilize that segment of the channel.

Brush Mattresses

The brush mattresses are made up of small wood stakes, coir, and slash that are installed along the entire bed and bank cross-section to slow water and aggrade sediment in the upstream-most incised part of the Tributary (Pr06).

Construction and Access

Skyline and Machine Access Restrictions

There is an existing abandoned railroad grade that will be used as the primary machine access route for the project. In order to minimize impact to the steep, unstable slopes along Clarks Creek and Clarks Tributary, skyline delivery will be used to deliver all materials to the channel. A machine access route will be permitted into both the mainstem and tributary for structure installation, however no material delivery will be allowed along this route to reduce the number of trips in and out of the channel. The machine access width and associated permissible equipment track width is restricted to the width of the surveyed channel bed. There are also restrictions for maximum ground pressure (in PSI) and a requirement for vegetable-based biodegradable hydraulic fluids used for equipment entering the channel.

Temporary Erosion and Sediment Control

The contractor will be required to install 2' of machine-compacted slash along the entire length and width of the tributary. No driving on bare soil in the tributary will be permitted due to the softness of the soils. The soil in the mainstem is relatively stable and dry, so driving will be permitted on bare soil, but there will be 2' of machine-compacted slash placed on bare soils between structures in the mainstem to help with erosion control from construction activities.

All bare soils caused by construction activities will be covered with mulch for areas less than 1:1 and covered with biodegradable erosion control fabric for areas steeper than 1:1 to provide temporary erosion control. The construction access routes will be covered with mulch and planted post-construction.

Contractor will also be required to de-water all active work areas onsite.

Hand Methods

The area upstream of the 12' headcut on the mainstem and the area downstream of an existing natural large woody matrix of the tributary will not allow machine access and will be installed using hand methods. The large woody matrix structures in these segments of the channel have a modified design that does not include log posts and includes crossing 5' rebar anchor pins driven into the channel bed.

REFERENCES

Brown & Caldwell, 2013. Clarks Creek Sediment Reduction Action Plan. Prepared for Puyallup Tribe of Indians, Puyallup, Washington. March, 2013.

Natural Systems Design, Inc. Existing Conditions for Upper Clarks Creek Channel and Bank Stabilization Project. Prepared for the Puyallup Tribe of Indians. February, 2015.

Natural Systems Design, Inc. Geomorphic and Hydraulic Assessment for the Clarks Creek Channel and Bank Stabilization Project. Prepared for the Puyallup Tribe of Indians. May, 2015.

Washington State Department of Ecology, 2009. Clarks Creek Watershed Fecal Coliform Bacteria Total Maximum Daily Load: Water Quality Implementation Plan. Publication No. 09-10-081. December, 2009.

Washington State Department of Ecology, 2014. Clarks Creek Dissolved Oxygen and Sediment Total Maximum Daily Load: Water Quality Improvement and Implementation Plan. Publication No. 14-10-030. December, 2014.