Seattle City Light

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VIA ELECTRONIC FILING

October 23, 2023

KIMBERLY D. BOSE
SECRETARY
FEDERAL ENERGY REGULATORY COMMISSION
888 FIRST STREET NE
WASHINGTON, D.C. 20426

Re: Updated *Newhalem Dam Decommissioning Geomorphology Considerations,* Newhalem Creek Hydroelectric Project (P-2705-037)

Dear Secretary Bose,

Seattle City Light (City Light) is filing an updated *Newhalem Dam Decommissioning Geomorphology Considerations* ("Geomorphology Report") under P-2705-037 for the proposed surrender and decommissioning of the Newhalem Creek Hydroelectric Project. This filing is in accordance with City Light's response to the Federal Energy Regulatory Commission's (FERC) Additional Information Request (AIR) filed on December 12, 2022, in which City Light provided that the Geomorphology Report would be distributed to intervening Parties (Parties) within 2 weeks for their review. City Light's AIR response further provided that the updated report would be filed with FERC after addressing the Parties' comments. This filing contains the updated Geomorphology Report, revised based on all comments received from the Parties after the Geomorphology Report's distribution on December 23, 2022.

In addition to the updated Geomorphology Report, this filing provides a summary of the Parties' comments and their resolution in Attachment B, including the consultation log; a revised report dated June 2023 showing highlighted tracked changes in response to the National Park Service's (NPS) comments from May 11; and a highlighted tracked change version of the report currently being filed in response to the NPS' comments on July 17, 2023 and August 23, 2023.

If you have any questions, please feel free to contact me at (206) 386-4571, or the Decommissioning Project Manager, Shelly Adams, at (425) 891-1765. City Light looks forward to continued engagement with FERC and other parties to surrender the license and decommission the Project facility.

Sincerely,

Chris Townsend (Oct 24, 2023 07:46 PDT)

Chris Townsend
Director Natural Resources & Hydro Licensing
Seattle City Light

Attachment

Cc: Diana Shannon, FERC
Mark Ivy, FERC

NEWHALEM DAM DECOMMISSIONING GEOMORPHOLOGY CONSIDERATIONS

NEWHALEM CREEK HYDROELECTRIC PROJECT FERC NO. 2705

Prepared by:
Kathy Vanderwal Dubé
Watershed GeoDynamics

October 2023

List of Acronyms and Abbreviations

BAGS	Bedload Assessment in Gravel-bedded Streams
City Light	Seattle City Light
cfs	cubic feet per second
CM	creek mile
FERC	Federal Energy Regulatory Commission
ft	feet
LiDAR	Light Detection and Ranging
mm	millimeter
MW	megawatt
NPS	National Park Service
Project	Newhalem Creek Hydroelectric Project
RLNRA	Ross Lake National Recreation Area
USGS	U.S. Geological Survey

Table of Contents

List of Figures

List of Tables

List of Attachments

1.0 INTRODUCTION

1.1 Project Description

Seattle City Light (City Light) is licensed by the Federal Energy Regulatory Commission (FERC) to operate and maintain the Newhalem Creek Hydroelectric Project, FERC No. 2705 (Project). The Project is located on Newhalem Creek in northern Washington State in the Cascade Mountains of the upper Skagit River watershed. Newhalem Creek is a tributary to the Skagit River and enters the south side of the river at mile 93.3 (Figure 1.1-1).

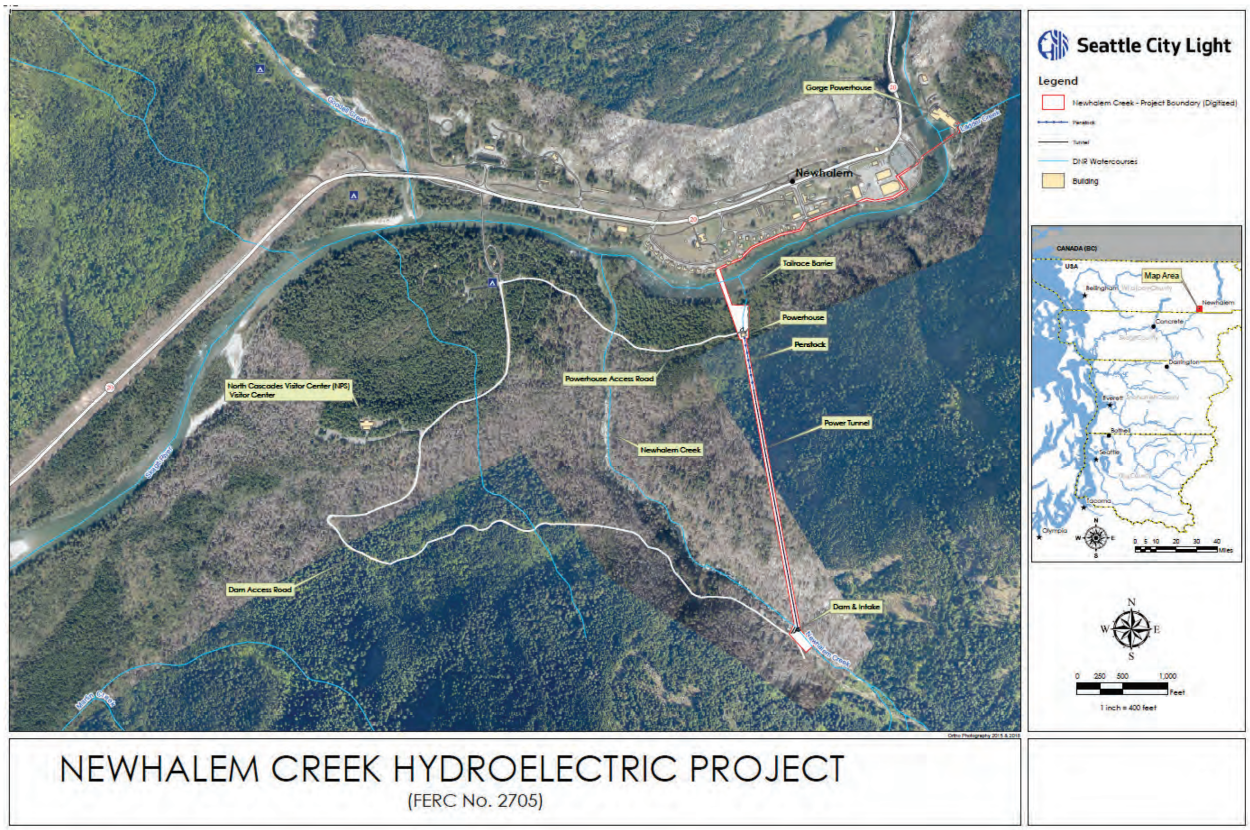


Figure 1.1-1. Newhalem Creek Project location map

The Project began operations in 1921 to supply power to the town of Newhalem and to construct Gorge Dam and Powerhouse, the latter of which are part of the Skagit River Hydroelectric Project (FERC No. 553). The Project has an authorized installed capacity of 2.2 megawatts (MW). The current Project license expires on January 31, 2027. City Light filed a Notice of Intent with FERC on April 28, 2021, to surrender the license and submitted an Application for Surrender of License for the Project on January 28, 2022.

The Project occupies 6.4 acres of federal lands within the Ross Lake National Recreation Area (RLNRA), which is managed by the National Park Service (NPS) as part of the North Cascades National Park Complex. The Project's diversion structure is located at Creek Mile (CM) 1.0, above a 100-foot waterfall, and impounds very little water (0.1-acre/0.6 acre-ft). Newhalem Creek flows

are diverted into a power tunnel and penstock that lead to the powerhouse. These flows bypass an approximately 1-mile reach of Newhalem Creek. There is a U.S. Geological Survey (USGS) stream gage just upstream of the diversion.

1.2 Proposed Action and Report Purpose

As part of decommissioning the Project, City Light is proposing to remove the diversion structure and associated facilities. The current proposal is to remove concrete at the current diversion location and grade to elevation 1,009 feet (Skagit Project datum, approximately equivalent to 1,015 feet [ft, NAVD88 datum]) at the downstream end of the existing spillway. The new streambed base level at this location would be approximately 10 ft lower than the top of the existing diversion structure. The purpose of this report is to evaluate potential geomorphic effects of removing the diversion structure on Newhalem Creek. Two primary geomorphic effects identified include:

- Potential for headcutting and incision upstream of the diversion location after diversion is removed due to change in base level of stream,
- Transport of sediment currently stored in and upstream of the impoundment into downstream reaches of Newhalem Creek and the Skagit River (including potential effects on turbidity levels in Newhalem Creek).

The report also evaluates concerns and questions raised during the decommissioning proceeding and after review of the initial drafts of this report. The consultation record is presented in Attachment B.

This report relies on existing maps, reports, hydrologic data, and topographic (Light Detection and Ranging [LiDAR]) information; observations made during four 1-day field visits to the Project; surficial and sub-surface grain size sampling; and cross sections surveyed during the field visits.

2.0 METHODS

2.1 Field Data

Observations of site conditions and stream characteristics were made during a site visit on June 14, 2021, with a follow-up geomorphic assessment on October 14, 2022. Substrate pebble counts were made and a stream cross section was surveyed during a site visit on September 8, 2021. Repeat surficial pebble counts and sub-surface sampling was conducted on September 12, 2022, to assess changes in substrate following a 4,920[1] cubic-foot-per-second (cfs) peak flow in November 2021. Streamflow at the Newhalem gage (USGS 12178100) was 499 cfs during the June 2021 site visit, 28 cfs during the September 2021 site visit, 25 cfs during the September 2022 visit, and 15 during the October 2022 geomorphic assessment.

2.1.1 Surface Grain Size Sampling

Surficial Wolman pebble counts were made at four locations upstream of the Newhalem Creek diversion dam in 2021 and repeated in 2022 (Figure 2.1-1; Wolman 1954). A minimum of 100 pebbles were selected approximately every foot across the channel at two locations (at the USGS gage site and approximately 500 ft upstream from the dam) and in a grid pattern in deposits just upstream from the diversion and at the head of a point bar approximately 1,000 ft upstream from the diversion. Each particle was passed through a gravelometer to measure the equivalent particle size class in half phi increments (e.g., < 2 millimeters [mm], 2–4 mm, 4–8 mm, 8–16 mm, 16–32 mm, etc..... up to the 512 mm size class). The gravelometer provides the same results as sieving a sample. Pebble count data were entered into a spreadsheet for computation of particle size statistics and graphing of the grain size distribution.

2.1.2 Sub-surface Grain Size Sampling

Bulk samples of the material below the surface armor layer were collected at two of the pebble count locations in September 2022 following the method of Church et al. (1987; bulk sample locations shown on Figure 2.1-1). To do this, the surface armor layer was removed and then a pit was excavated until either the practical sampling limit of 440 pounds or a volume sufficient that the largest particles in the deposit made up no more than one percent of the sample weight was obtained (the 1 percent criteria). The bulk sample material was field sieved to separate material at the 32 mm size. Material larger than 32 mm was divided into half-phi grainsize classes using a gravelometer, and the weight of each class was measured in the field. A 30- to 45-pound sub-sample of the material smaller than 32 mm was retained for grainsize analysis following American Society for Testing and Materials standards, and was performed by Materials Testing & Consulting, Inc. Field and lab grainsize distributions for each bulk sample were then combined based on the split ratio of the material; water weight was assumed to be evenly distributed through the <32 mm fraction.

[1] Note: all flow data was obtained from the USGS website (https://waterdata.usgs.gov/monitoring-location/12178100/). Recent data (2021–2022) is provisional.

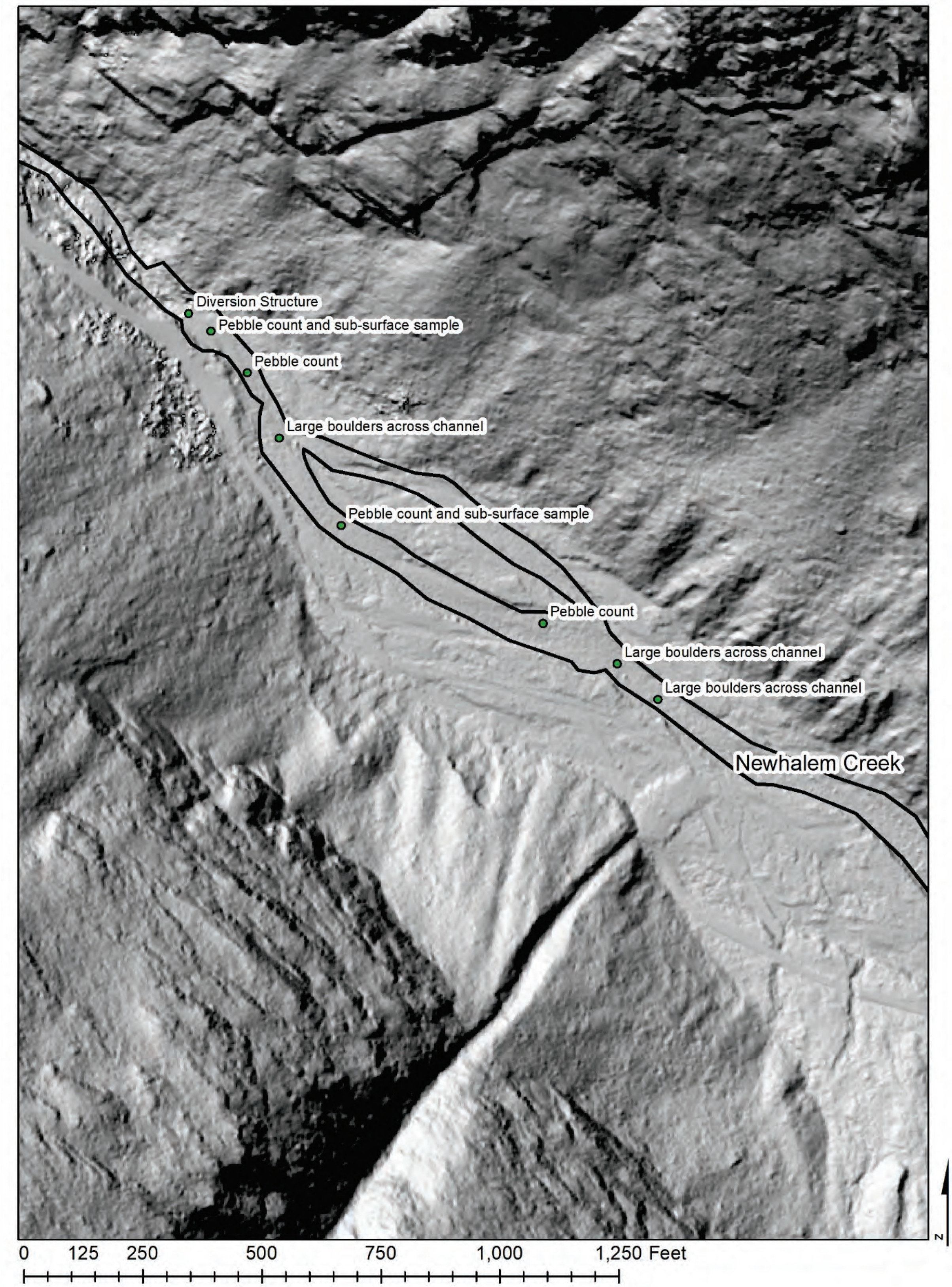


Figure 2.1-1. Newhalem Creek sediment sampling locations

Since the practical sampling limit of 440 pounds determined for this study was below the recommended 1 percent criteria (Church et. al, 1987), the hybrid method of Rice and Haschenburger (2004) was applied to characterize the coarse tail of the bulk grainsize distribution, consistent with Skagit Hydroelectric Project relicensing methodology. This method assumes that the surface and subsurface material come from the same source grainsize population and that the surface armor layer formed through selective horizontal removal of fine sediment (winnowing). This implies that the ratio of the weight of a specified match fraction (between the surface and subsurface samples) and each larger grainsize fraction in the surface material can be used to determine the distribution of the coarser material more reliably than would be possible with only the undersized sample. Selection of the match fraction was determined by identifying the largest grainsize fraction meeting the 1 percent sample size criteria. In other words, the match fraction was chosen for the largest grainsize where the cumulative weight of the sample through that size class (smallest to largest) was greater than the 1 percent criteria for material of that size. For our 440-pound samples, the match fraction was 64–91 mm.

2.1.3 Cross Section Survey

A cross section at the USGS gage site was surveyed using a tape, laser level, and survey rod in September 2021. The concrete platform at the Project intake was used as a known elevation to allow correlation of the survey data with LiDAR data to extend the cross section across the valley on each side of the transect. The transect and USGS gage records (stage: discharge) were used for sediment transport analysis.

2.1.4 Geomorphic Stream Assessment

On October 14, 2022, a team of two geomorphologists completed a geomorphic assessment of the channel by walking the stream from the existing weir upstream approximately 0.5 mile. Stationing along the channel was determined by measurement with a long fiberglass tape up to 1,500 ft above the weir and by pacing, calibrated to landmarks visible in the LiDAR data, between station 1,500 and 2,661 ft. Individual geomorphic units were identified as belonging to one of the following classes: pool, glide, riffle, pocket water, step pool, plane bed or cascade. These followed the same definitions as previous work completed for the Skagit River Hydroelectric Project (FERC Project No. 553) relicensing except that step pool morphologies were distinguished from pocket water morphologies. The differentiation is that pocket water consists of disorganized features with a generally planar bed geometry but very high relative roughness (boulders protruding through the free surface), while step pool morphologies have organized the boulders into step features that create added “jammed state” stability (e.g., Church and Zimmermann, 2007; Zimmermann et al., 2010).

In each geomorphic unit, dominant and subdominant bed material were visually determined. The dominant bed material was the grain size class (Table 2.1-1) visually determined to make up the largest portion of the bed surface, and the sub-dominant was the grain size class visually determined to make up the second largest portion of the bed surface. The presence of other geomorphically important grainsize classes (for example finer gravel pocket deposits that may be important spawning habitat or boulders that might be controlling the channel gradient or roughness) were also noted.

Table 2.1-1. Bed material size ranges used in geomorphic assessment notes

Size Range	Grain size (abbreviation in notes)
2–8 mm	Fine Pebbles (fP)
8–22 mm	Fine Gravel (fG)
22–64 mm	Gravel (G)
64–128 mm	Cobble (C)
128–360 mm	Large Cobble (LgC)
>360 mm	Boulder (B)

The width and general cross section shape of each geomorphic unit were measured at a characteristic location. Bankfull width was measured using a fiberglass long tape and bankfull depth was measured to the nearest 0.5 ft with a level rod. In addition, the total height of the bank (e.g., from bank toe to the top of a terrace that lies above the bankfull elevation) and width of the bank (horizontal distance from bank toe to the elevation of the top of bank) were measured with a level rod, so that the bank angle could be determined. Tailout and maximum depths of pool, glides, and step pool features were measured so that residual pool depths could be calculated. The characteristics of the bank materials were noted for each bank, with a description of the stratigraphy including dominant grainsizes, angularity of the material, and interpreted type of material (alluvial or colluvial).

2.2 Data Analysis

Mean daily and annual instantaneous peak flows for the period of record were obtained from the USGS NWIS website for the Newhalem Creek near Newhalem, WA, gage (USGS 12178100). Annual peak flows were entered into a spreadsheet for log-Pearson Frequency Analysis using the Bulletin 17B methods.

LiDAR data and aerial imagery from 2015, 2018, and 2022 were used to map channel position and produce stream profiles and gradients. A 1920 survey map (Figure 2.2-1) was used to estimate pre-Project streambed elevation and gradients by direct measurement from the map and geo-rectifying the map in ArcMap 10.8.1. Note that scale, vertical datum differences, and geo-rectifying challenges introduces some error into calculations using old maps, so the resulting 1920 profile should be considered an estimate.

The Bedload Assessment in Gravel-bedded Streams (BAGS) spreadsheet transport tool (https://www.fs.fed.us/biology/nsaec/products-tools.html) was used to analyze hydraulic characteristics, potential sediment transport/deposition areas and headcutting in the Newhalem Creek intake area based on the surveyed cross section, pebble count data, and local and reach-averaged stream gradients measured from LiDAR data.

Figure 2.2-1. Scanned 1920 Newhalem Creek map (source: Seattle City Light archives)

3.0 GEOMORPHIC SETTING AND EXISTING CONDITIONS

The Newhalem Creek Project is in the North Cascades of Washington state, a geomorphically active, geologically diverse, and climatically cool and wet area with high mountain peaks and steep valley walls and canyons.

3.1 Geology and Landforms

The North Cascades is a complex mosaic of geologic terranes that were formed as the Pacific Ocean plate and the North American continental plate collided, breaking off pieces of volcanic island arcs, deep ocean sediments, ocean floor, continental rocks, and subcrustal mantle over the past 400 million years (Haugerud and Tabor 2009). These terranes were then uplifted, thrust on top of each other, eroded, or buried to further complicate the geology and form the high peaks of the North Cascades. Newhalem Creek is within the Metamorphic Core Domain of the North Cascades and is underlain by the Skagit Gneiss (labeled TKbg(s) and TKog(s) on Figure 3.1-1). The Skagit Gneiss has a high level of metamorphism and is resistant to weathering and erosion, forming the steep stream canyon with numerous waterfalls downstream from the Newhalem diversion structure. While resistant to erosion, the steep valleys formed in the rocks of the Metamorphic Core are also subject to rockfalls, landslides, and avalanches as evidenced by the mass movements along the western slopes downstream from the diversion (the active rockfall/mass wasting area on the access road is one of these unstable areas).

During the Quaternary Period, starting about 2.6 million years ago, continental and alpine glaciers covered much of the area in the Project vicinity, with several major advances of thick continental ice from the north and smaller alpine glaciers originating from mountain peaks. The most recent continental glacial advance, culminating approximately 15,000 years ago, resulted in many of the surficial geologic features and deposits in the Newhalem Creek vicinity. Following melting of the glaciers, surficial processes further re-shaped the landscape resulting in development of alluvium (river deposits), terraces, and alluvial fans. Surficial geology around Project includes Quaternary and Holocene glacial and stream deposits (Qad and Qa), alluvial fan/debris cone deposits (Qaf), and colluvium derived from local soils and underlying geologic units.

Landforms have been mapped by the NPS for areas within RLNRA (Riedel et al. 2012). Landform mapping provides information on surficial geologic features and processes by grouping areas of the landscape into units formed by discrete geologic processes. Landforms include features that are depositional in nature (e.g., moraines, alluvial fans) or erosional (horns, bedrock benches). Mapped landforms are shown on Figure 3.1-1 and include the steep valley walls surrounding the Newhalem Creek valley, the floodplain features in the lower gradient area upstream from the diversion, the bedrock canyon downstream from the diversion, and the alluvial fan near the confluence with the Skagit River that has cut into the moraines and terraces in the Skagit River valley. Note that several debris cones control floodplain width at the diversion structure and in the valley upstream from the diversion; these debris cones control the confined/unconfined reaches of the stream and limit channel movement across the floodplain as well as providing extremely large (up to 12-foot diameter) boulders that were noted at several locations in the channel.

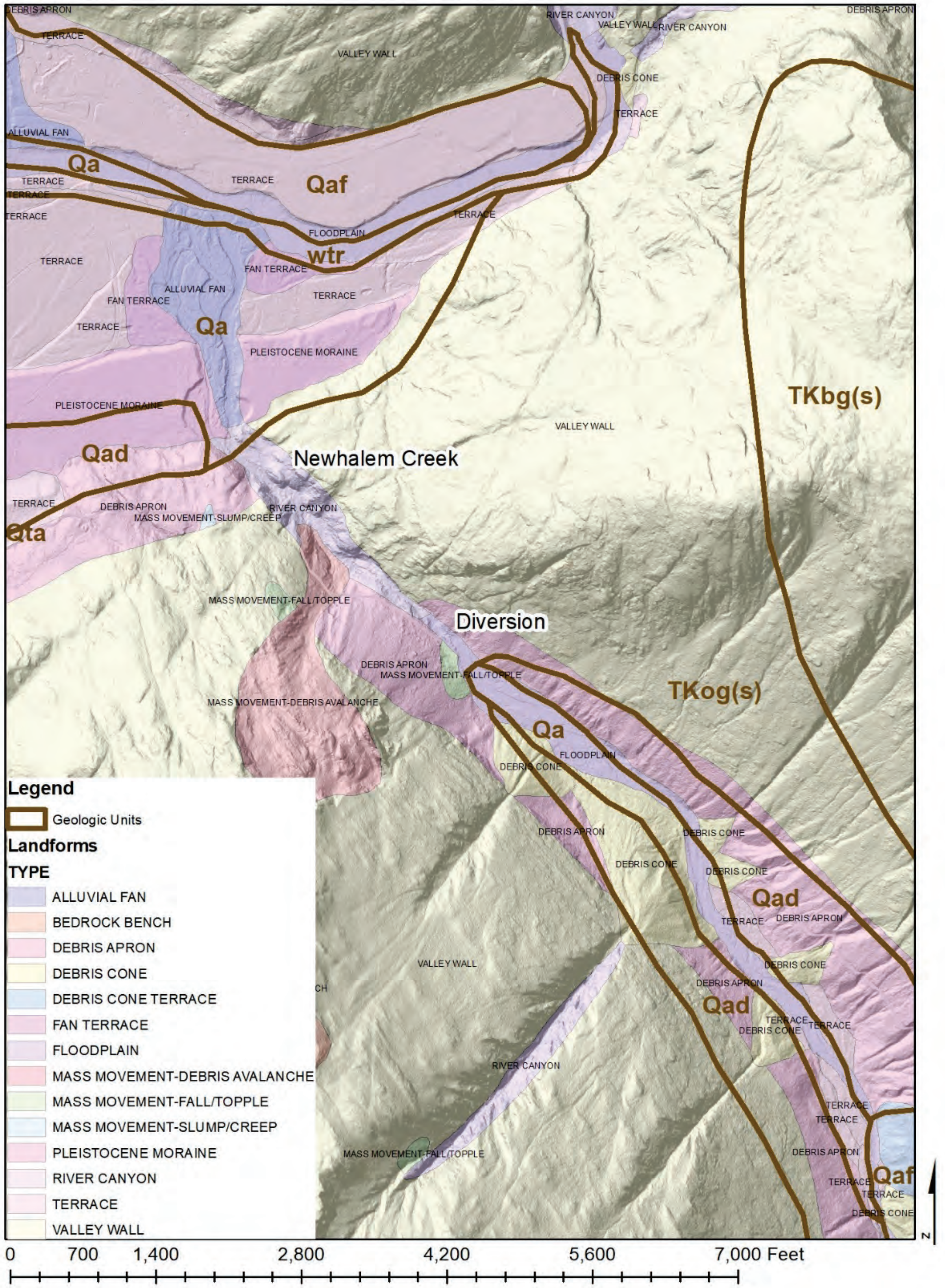


Figure 3.1-1. Geologic units and landforms in the Newhalem Project vicinity

3.2 Newhalem Creek Hydrology

Newhalem Creek has a drainage area of 26.9 square miles at the Project intake. Mean daily flows typically range from a low of 20 to 30 cfs in September to peaks of 1,000 to 3,000–4,000 cfs during rain, rain-on-snow, and snowmelt from November through late June (Figure 3.2-1).

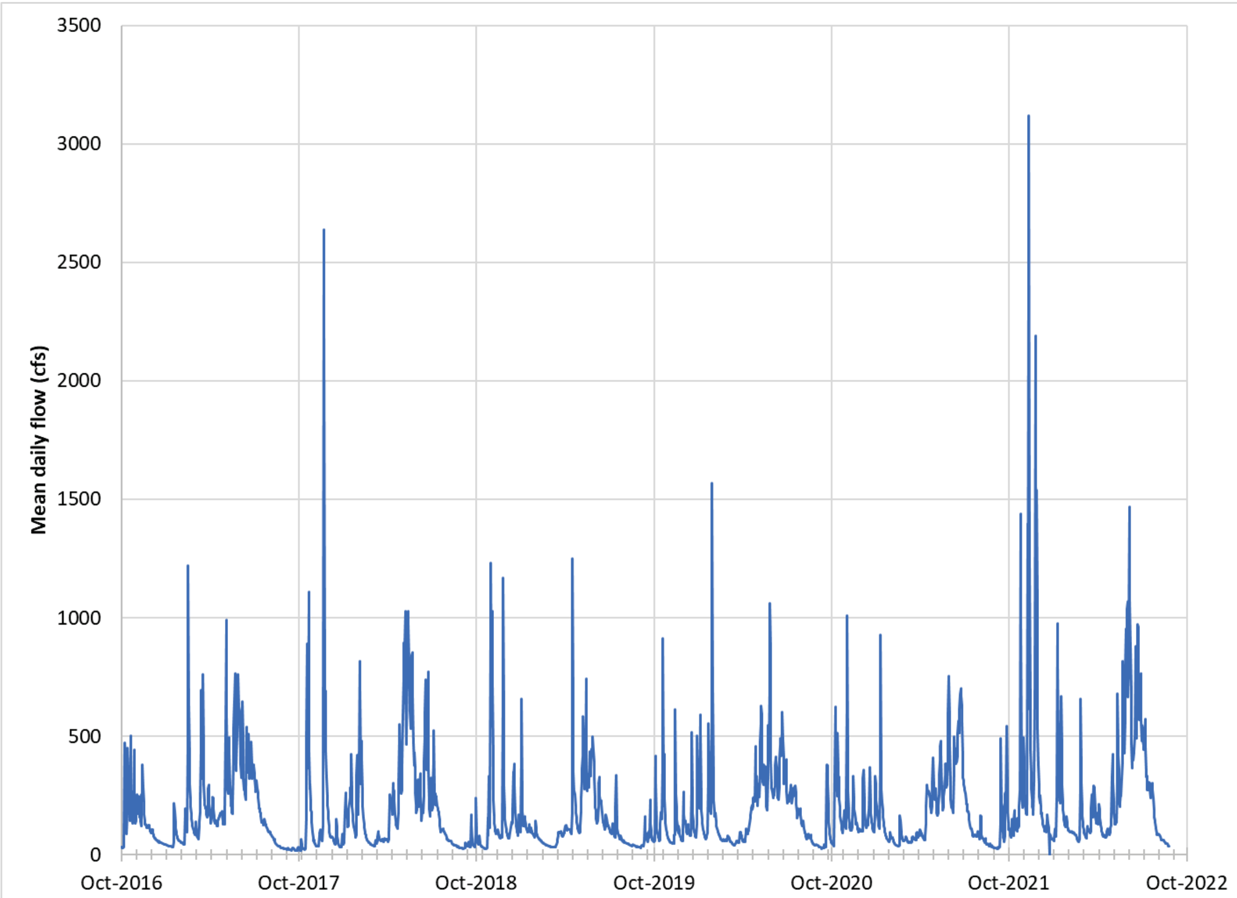


Figure 3.2-1. Daily flow at Newhalem Creek Gage (USGS 12178100) Water Years 2017–2022

The majority of bedload transport and geomorphic "work" is done during high flows when stream energy is high enough to disrupt the coarser armor layer on the bed of the stream and transport gravel/cobble/boulder downstream. Annual instantaneous peak flows recorded at the Newhalem gage range from less than 1,000 cfs to nearly 9,000 cfs (Figure 3.2-2). The highest peak flows occur during the November to February timeframe as a result of rain-on-snow events (Figure 3.2-3). Smaller magnitude peak flows between October and March are the result of rainfall events; peaks during May–July are driven by snowmelt from the higher elevations in the watershed.

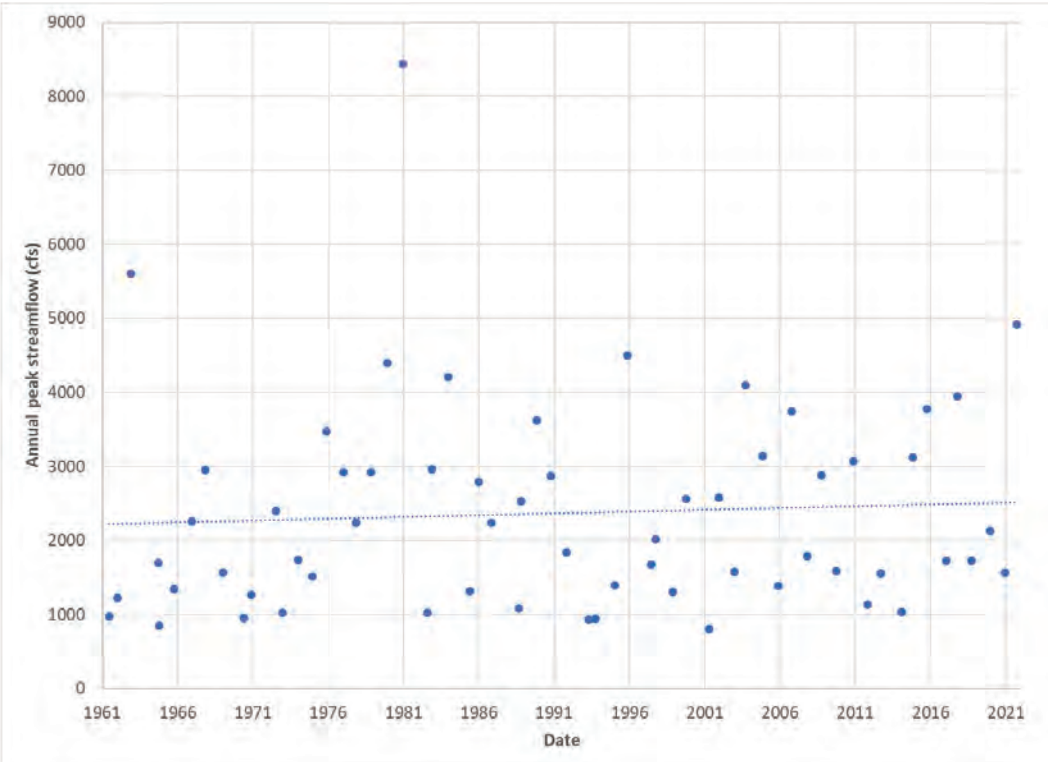


Figure 3.2-2. Annual peak streamflow at Newhalem Creek gage (USGS 12178100; 1961–2022)

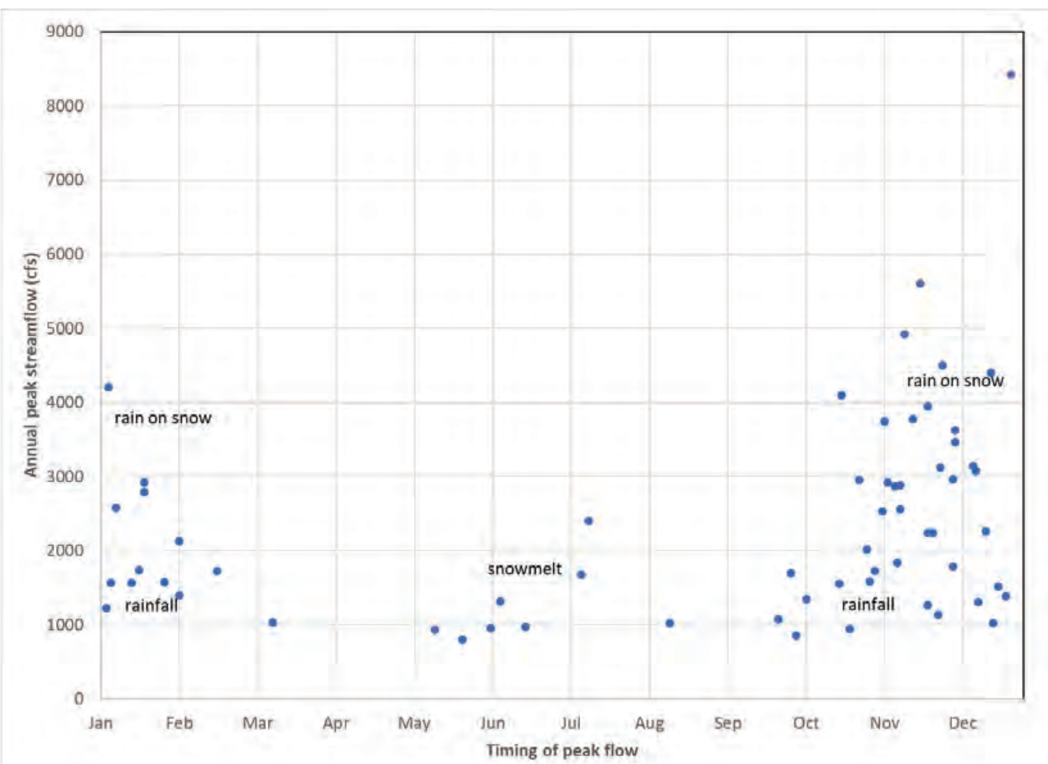


Figure 3.2-3. Timing and cause of peak streamflow at Newhalem Creek gage (USGS 12178100; 1961–2022)

Computed peak flow recurrence intervals for the period of record (1961–2022) at the diversion dam range from 884 cfs for the 1.05-year recurrence interval to 7,840 cfs for the 100-year event (Table 3.2-1). Note that the highest peak flow recorded at the gage (8,430 cfs on 12/26/80) was an extreme event and was higher than the computed 100-year recurrence interval flow. Peak flow recurrence intervals are statistically-based computations and take into account the probability of a given flow occurring based on the entire period of record. The 1.25- to 2-year recurrence interval event is often considered to be the formative discharge for stream channel shape and bedload transport and often corresponds to the bankfull discharge in alluvial streams.

Table 3.2-1. Peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2022)

Recurrence interval (years)	Annual percent chance	Peak discharge (cfs)	95% Confidence upper limit (cfs)	95% Confidence lower limit (cfs)
100	1	7,840	10,200	6,400
50	2	6,600	8,370	5,490
25	4	5,470	6,740	4,640
10	10	4,120	4,890	3,590
5	20	3,190	3,680	2,830
2	50	2,010	2,240	1,790
1.25	80	1,300	1,470	1,130
1.05	95	884	1,030	731

3.2.1 Potential Future Changes to Peak Flows

Estimates of potential changes to future peak flows in the Skagit River watershed have been made by researchers at Seattle University (Ranoa and Lee 2021). They used the 1960–2005 peak flows as a base and projected how streamflow and water availability may change in the future for three different time ranges (2000–2049; 2025–2074; and 2050–2099) at 20 sites within the Skagit River basin under low and high greenhouse gas emission scenarios (Representative Concentration Pathways [RCPs] 4.5 and 8.5, respectively). The Newhalem to Marblemount area gages were predicted to change from -5 percent to +90 percent for various peak flow recurrence/future time range scenarios, with greater changes predicted for more frequent peak flows and under the high greenhouse gas emissions scenarios (Figure 3.2-4 and Figure 3.2-5).

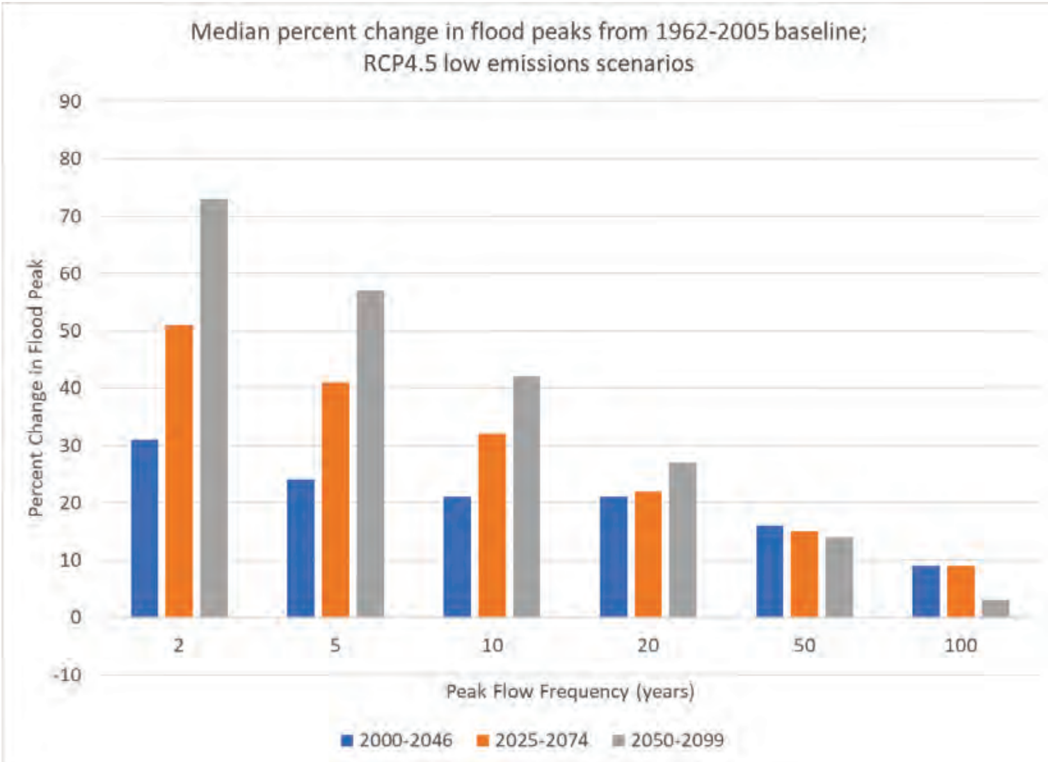


Figure 3.2-4. Median predicted percent change in flood peaks at the Newhalem Creek gage from 1962–2005 baseline, RCP 4.5.

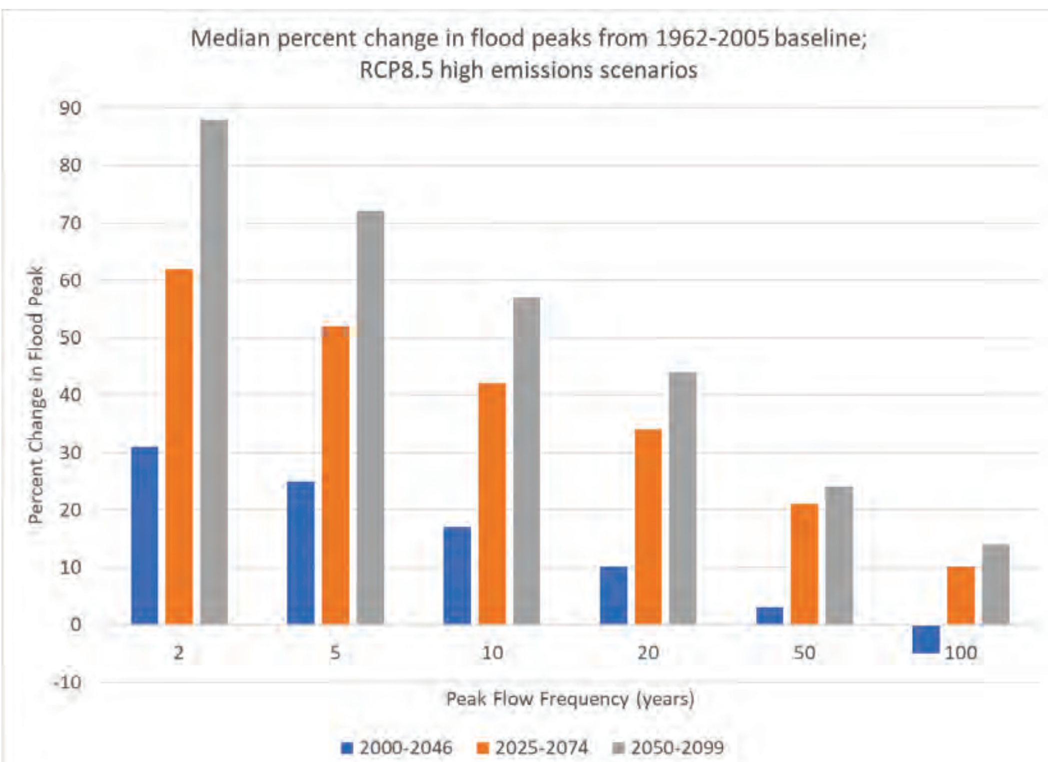


Figure 3.2-5. Median predicted percent change in flood peaks at the Newhalem Creek gage from 1962–2005 baseline, RCP 8.5.

The calculated peak flow recurrence for the Newhalem Creek USGS gage for the 1961–2005 and 2000–2022 time ranges as well as predicted future peak flows for the three time ranges and RCP 4.5 scenarios based on Ranoa and Lee (2021) are shown in Figure 3.2-6 and Table 3.2-2. Predicted flows under the RCP 8.5 scenarios are shown in Figure 3.2-7 and Table 3.2-3. The 2000–2022 actual peak flows at the Newhalem gage were used to calculate the 2-year and 5-year recurrence interval peak flows and are shown on Figure 3.2-6 and Figure 3.2-7 for comparison with the estimated future flow scenarios (note that the 2000–2022 timeframe is not sufficient to feel confident in longer-interval peak flow calculations). The computed 2000–2022 2-year and 5-year peak flow events, shown as orange triangles on the graphs, are very similar to the baseflow period (1960–2005) peak flows and do not show evidence that substantial increases in peak flow magnitudes for these frequent floods have occurred to date at the Newhalem gage.

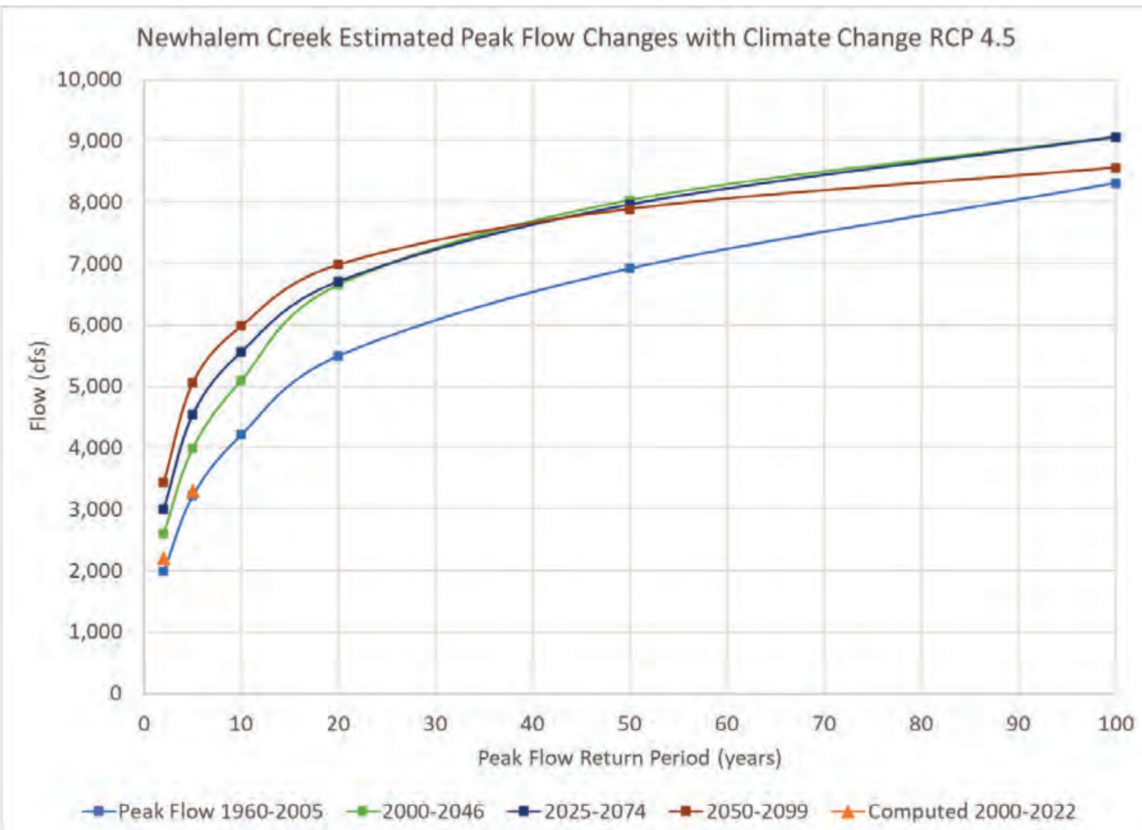


Figure 3.2-6. Estimated changes in peak flows at the Newhalem Creek gage (RCP 4.5)

Table 3.2-2. Calculated peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2005) and predicted future climate change peaks under RCP 4.5.

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
100	1	8,310	n/a	9,140	9,140	8,810
50	2	6,920	n/a	7,960	8,100	8,100
10	10	4,220	n/a	5,150	5,740	6,120

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
5	20	3,220	3,300	4,030	4,570	5,150
2	50	1,990	2,210	2,610	3,000	3,440

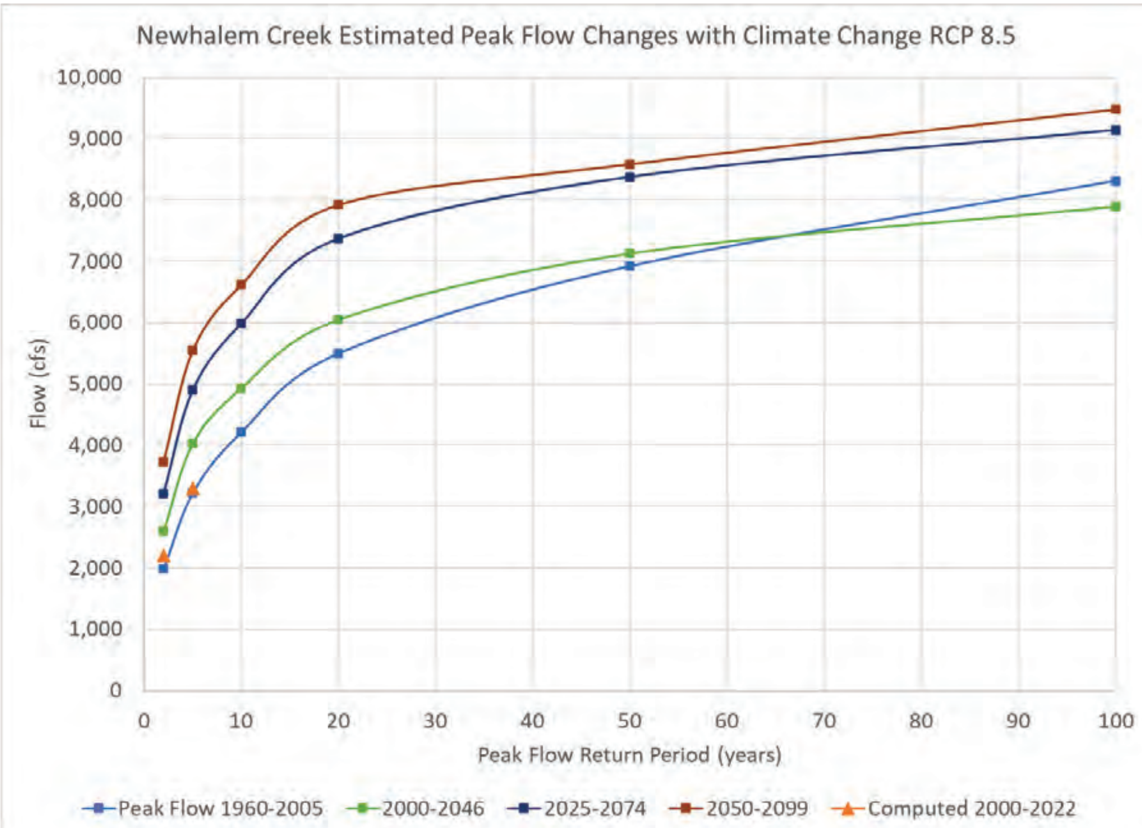


Figure 3.2-7. Estimated changes in peak flows at the Newhalem Creek gage (RCP 8.5)

Table 3.2-3. Calculated peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2005) and predicted future climate change peaks under RCP 8.5.

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
100	1	8,310	n/a	7,890	8,970	9,720
50	2	6,920	n/a	7,060	8,230	8,790
10	10	4,220	n/a	4,980	5,990	6,750
5	20	3,220	3,300	4,030	4,930	5,600
2	50	1,990	2,210	2,610	3,260	3,760

3.3 Newhalem Creek Existing Geomorphic Characteristics

Newhalem Creek has several distinct geomorphic reaches between the confluence with the Skagit River and the valley upstream from the diversion dam that influence how the stream processes water and sediment moving through the system and ultimately affects instream habitat characteristics (Figure 3.3-1, Figure 3.3-2).

Upstream from the diversion structure the stream has a relatively consistent gradient (2–3 percent) with a cobble/boulder/gravel bed, bankfull channel width of approximately 75 ft, and valley widths of 500 ft in relatively unconfined reaches and 150–200 ft in areas where the stream is confined by debris cone deposits coming off the valley walls. There is a confining debris cone approximately 0.25 mile upstream from the diversion and another, larger cone approximately 0.5 mile upstream from the diversion. These two features limit channel movement across the valley.

The Newhalem Creek bed 500 ft upstream from the diversion consists of cobble, boulders, and gravel that span the width of the Creek.

At and downstream from the diversion, the stream enters a very high gradient (10–25 percent) bedrock canyon with numerous waterfalls. This area was not visited but based on observations just downstream from the diversion it is likely that substrate is bedrock with patches of cobble/gravel/boulder. This reach is a transport reach – sediment supplied from upstream areas moves relatively quickly through the reach into the downstream alluvial fan.

Downstream from the canyon reach Newhalem Creek encounters the Skagit River valley terraces and forms an alluvial fan with numerous relict channels. The stream averages 5 percent gradient with gradients decreasing closer to the Skagit confluence and has cut through the higher Skagit valley terraces. Alluvial fans are geomorphically active areas where the stream deposits the largest sized material near the top of the fan and finer-grained sediment near the distal (downstream) portion of the fan as the stream gradient/power drops. Observations at the Powerhouse Road crossing show a boulder/cobble bed with what appear to be lag boulders (moss-covered boulders indicating infrequent transport) interspersed with fresh gravel/cobble material.

The Newhalem Creek alluvial fan appears to be forcing the Skagit River to the North; the Skagit River narrows and has a locally higher gradient at the confluence with the creek. Gravel and cobble material transported from Newhalem Creek provides a source of spawning-sized material to the Skagit River.

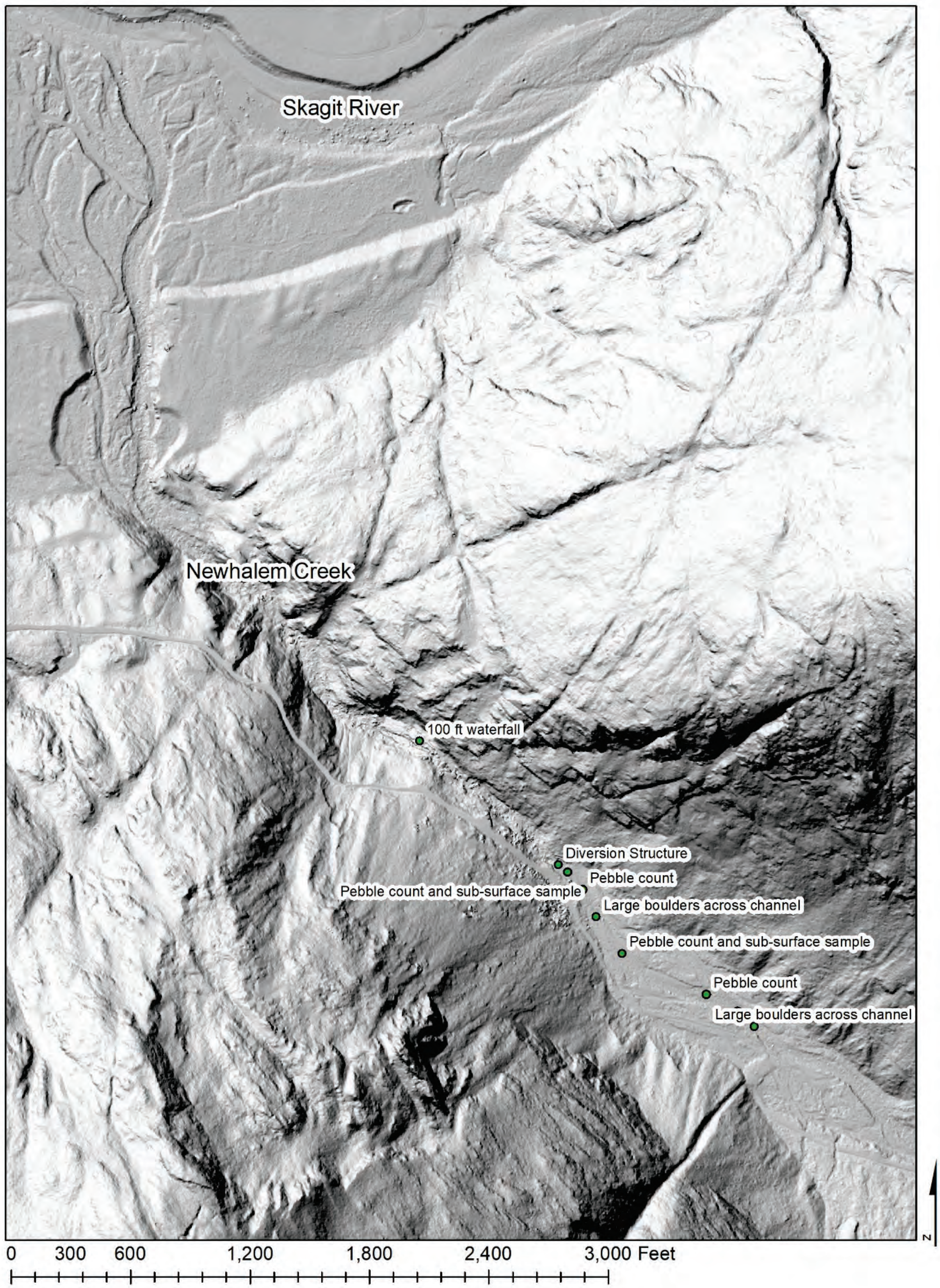


Figure 3.3-1. Topography of Newhalem Creek and Skagit River in Project area (2022 LiDAR hillshade)

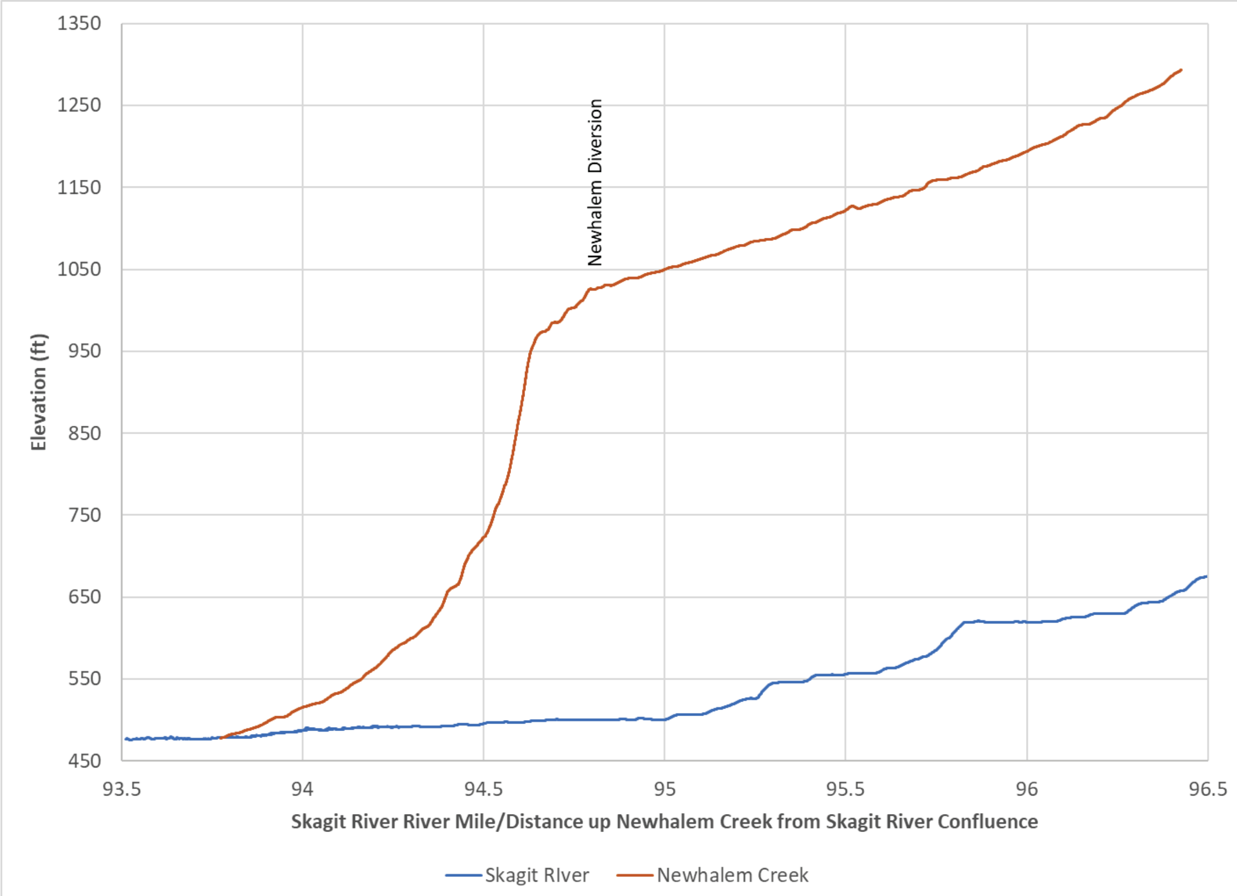


Figure 3.3-2. Longitudinal profile of Newhalem Creek and Skagit River

3.3.1 Geomorphic Assessment of Newhalem Creek Upstream from Project Diversion Structure

Upstream from the Project diversion structure, Newhalem Creek is a high gradient stream. The 0.5-mile-long reach upstream of the intake has an average 2.2 percent slope gradient and includes a mix of pocket water (32 percent of reach length), pools (16 percent), glides (14 percent), step pools (13 percent), plane bed (11 percent), cascades (8 percent) and riffles (6 percent). Bankfull width ranges from 48 to 162 ft (average 70 ft) and bankfull depths ranged from 2 to 6 ft (average 3 ft, Figure 3.3-3). Bank heights ranged from 0.5 to 12 ft (average 5 ft) and varied considerably based on channel incision into the adjacent terraces, with left bank heights generally higher than right bank heights because of higher left bank terrace/fan features (Figure 3.3-4). Bank material was primarily boulder/cobble/gravel alluvium with some landslide debris.

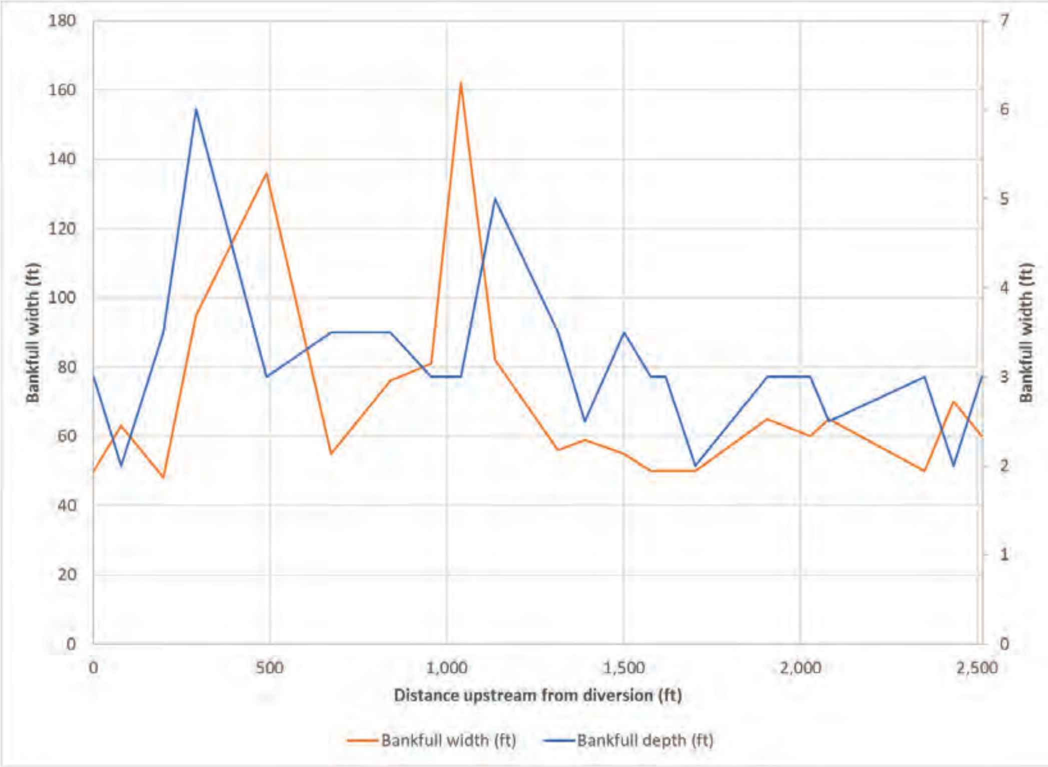


Figure 3.3-3. Bankfull width and depth upstream from Project diversion structure.

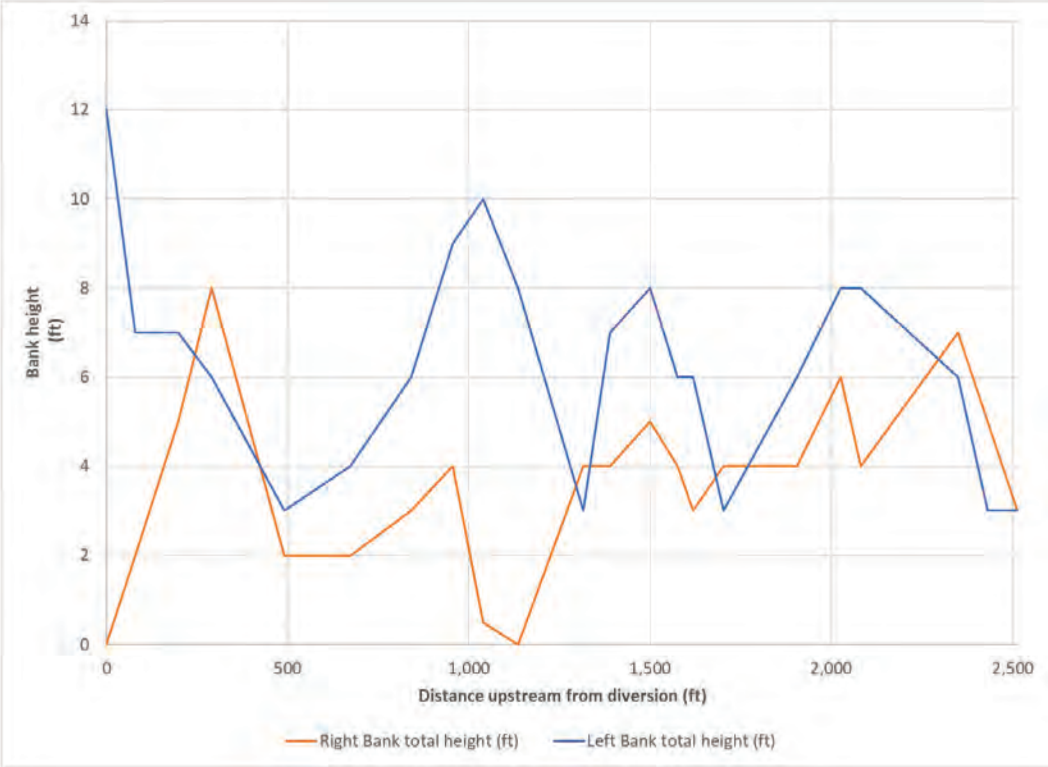


Figure 3.3-4. Bank heights upstream from Project diversion structure (right and left designations looking downstream).

Large, channel-shaping boulders (4- to 15-foot diameter) and large woody debris were also assessed during the field visit to help determine locations where boulders or large wood deposits will control the adjustment of the channel to removal of the Project diversion dam and associated structures. Numerous large boulders are located along the banks or across the channel between 227 and 440 ft upstream from the Project diversion structure, likely as the result of a large ancient slope failure from the left bank hillside. At 320 ft upstream from the diversion structure (station 320), several 6- to 12-foot-diameter boulders are located under the current stream channel and are forming a grade control, resulting in a cascade upstream from this location. Between 1,251 and 1,390 ft upstream from the diversion structure other groups of 5- to 7-foot-diameter boulders across the channel are forming a grade control. These boulders are large enough that they are not mobile under peak flows and appear to be forming persistent grade controls.

Large wood pieces and jams were noted during the geomorphic assessment, but most were along the banks and did not appear to be substantially impacting channel hydraulics except for several pieces of wood that were forming a pool between 702 and 730 ft upstream from the intake.

Details of the geomorphic unit assessment are included in Attachment A.

3.4 Grain Size Data

Pebble counts in Newhalem Creek upstream of the diversion in 2021 and 2022 show surficial substrate is composed of cobble, boulder, and gravel material (Figure 3.4-1 and Figure 3.4-2, Table 3.4-1 and Table 3.4-2). Median (D_{50}) grain sizes ranged from 106 to123 mm in 2021 and 89 to 238 mm in 2022 following an approximate 20-year return interval peak flow event in November 2021.

Sub-surface samples collected at two locations show that sub-armor material is, as expected, finer that the surface armor layer, with median grain sizes from 39 to 61 mm (Table 3.4-3, Figure 3.4-3). There was very little (less than 0.5 percent) silt/clay material in the sub-surface samples so high turbidity levels are not expected during streambed disturbing activities.

Boulder sized particles (larger than 512 mm diameter) were observed to have been transported into the intake area from upstream as a result of the November 2021 peak flow (provisional peak of 4,920 cfs). The grain size information was used to evaluate bed mobility, headcutting potential, and expected turbidity levels.

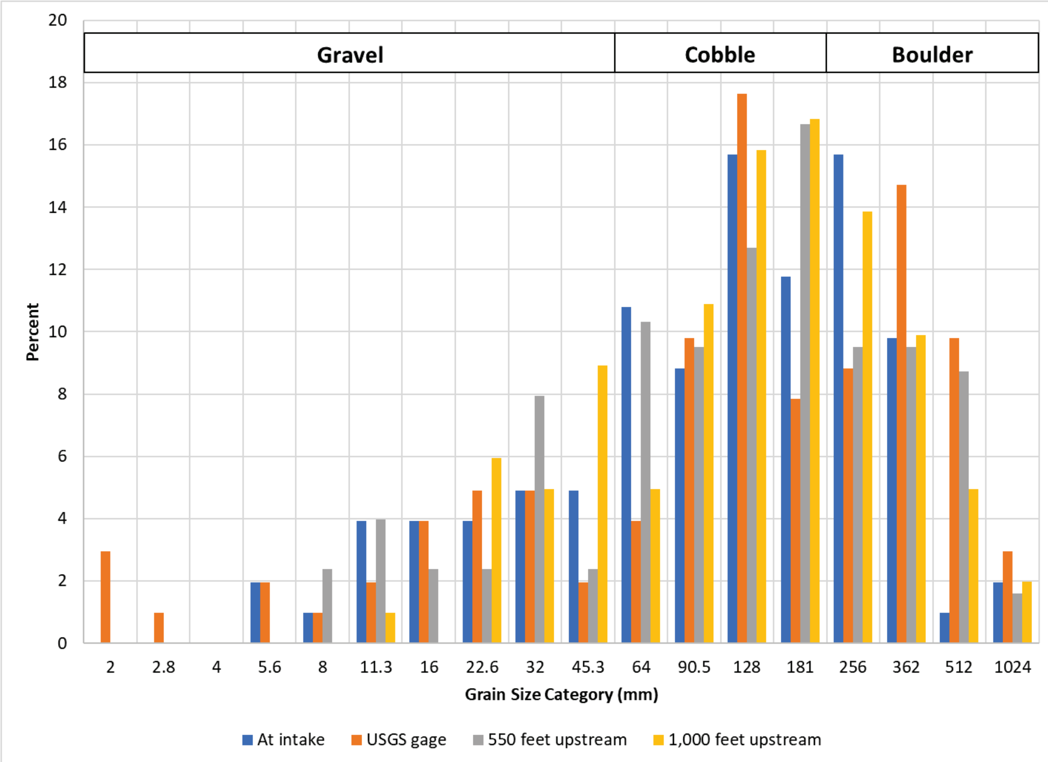


Figure 3.4-1. **Grain size distribution of substrate upstream from Newhalem Creek diversion structure, 2021.**

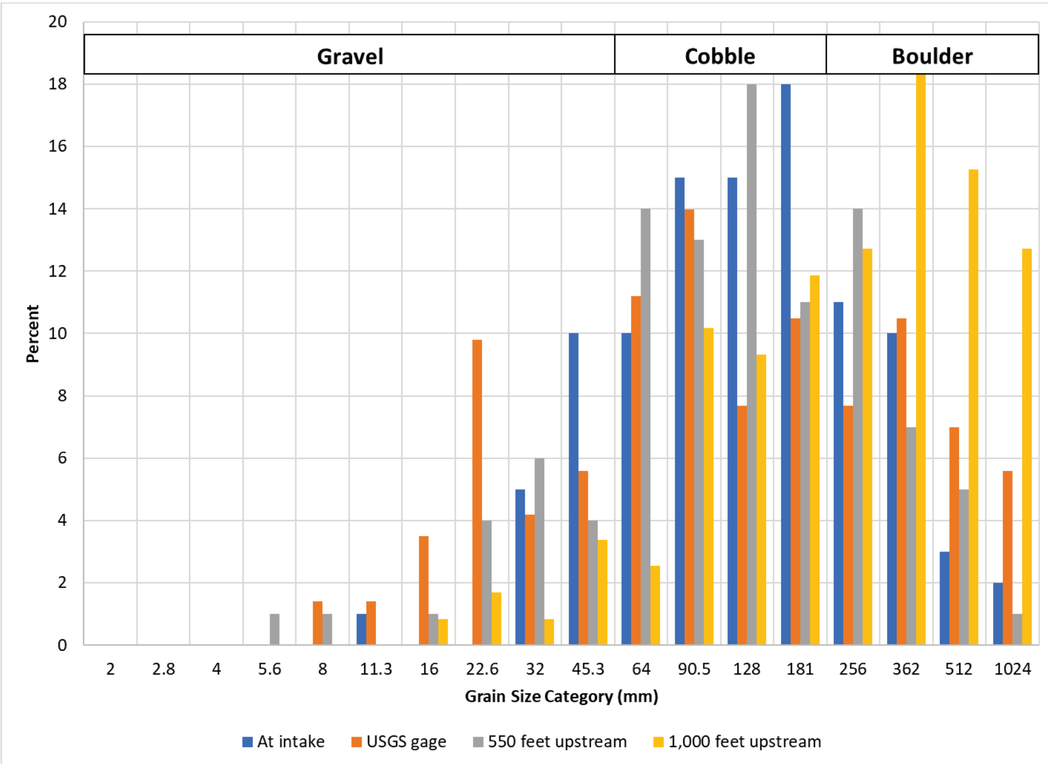


Figure 3.4-2. **Grain size distribution of substrate upstream from Newhalem Creek diversion structure, 2022.**

Table 3.4-1. Surficial grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2021).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	25	106	242	25%	47%	28%
USGS gage (180 ft upstream from diversion)	21	117	341	25%	39%	36%
550 ft upstream from diversion	29	118	312	21%	49%	29%
1,000 ft upstream from diversion	40	123	265	21%	49%	31%
AVERAGE	**29**	**116**	**290**	**23**%	**46**%	**31**%

Table 3.4-2. Surficial grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2022).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	45	115	250	16%	58%	26%
USGS gage (180 ft upstream from diversion)	23	89	329	26%	43%	31%
550 ft upstream from diversion	84	238	482	17%	56%	27%
1,000 ft upstream from diversion	42	105	241	7%	34%	59%
AVERAGE	**49**	**137**	**326**	**16%**	**48%**	**36%**

Table 3.4-3. Sub-surface grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2022).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Silt/clay	Percent Sand	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	3.5	39	164	0.5%	9%	53%	30%	8%
550 ft upstream from diversion	3.6	61	202	0.5%	12%	39%	40%	9%
AVERAGE	**4**	**50**	**183**	**0.5%**	**11%**	**46%**	**35%**	**9%**

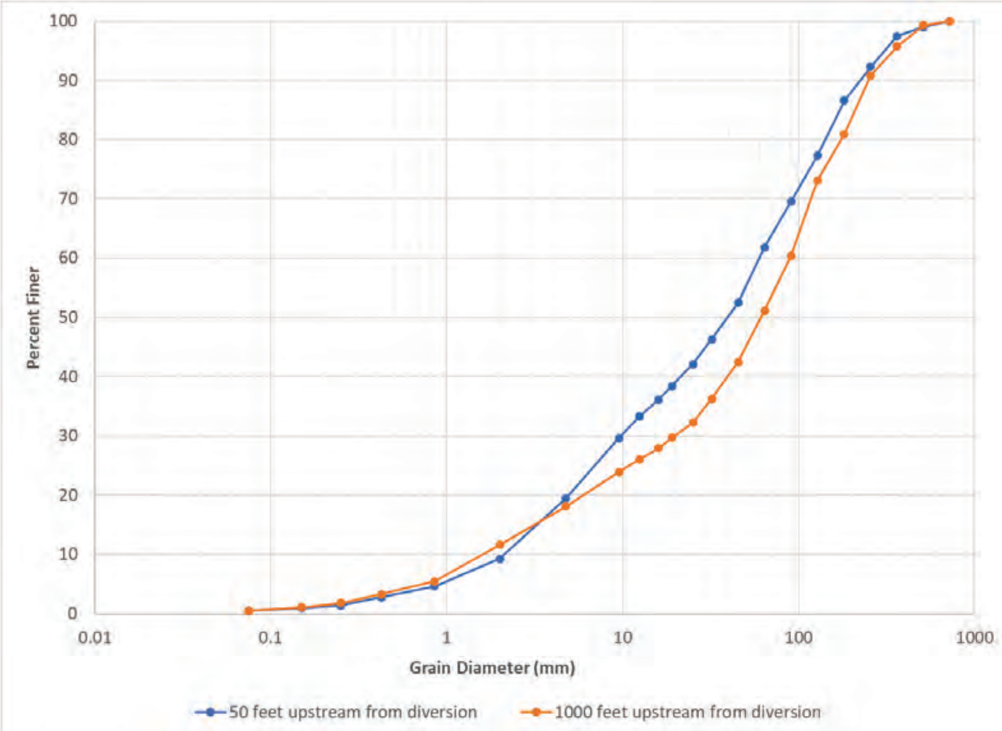


Figure 3.4-3. Grain size distribution of sub-surface samples upstream from Newhalem Creek diversion structure, 2022.

3.5 Existing Effects of Newhalem Project on Newhalem Creek Geomorphology

The Newhalem Project started operation over 100 years ago; the primary geomorphic effects on the Newhalem Creek have been:

- Diversion structure (8–10 ft tall) that provides a grade control for the stream (note that the original dam was replaced with the current structure in 1969);
- A small impoundment that retains some portion of the bedload transported from upstream reaches; and
- Diversion of water through the intake and out of Newhalem Creek when the Project was operating.

Over the 100 years since the Project began operating, Newhalem Creek has re-adjusted its profile upstream from the diversion structure to the new base level provided by the diversion dam. The small impoundment retains at least some portion of the bedload coming from the watershed upstream from the diversion. City Light reports that while the Project was operating, an average of 200–400 cubic yards of material were removed from the impoundment and placed in the channel downstream from the diversion dam on an annual basis to keep the area near the intake clear of sediment for Project operations. This provides a minimum estimate of the annual bedload transport volume in the stream. Since the removed sediment was placed downstream from the dam and the impoundment is very small, the Project did not cause a major net change in sediment supply to downstream reaches of Newhalem Creek.

4.0 DISCUSSION

The primary geomorphic effect associated with decommissioning the Newhalem Project will be the response of the streambed to removal of the diversion structure. Current plans are to remove the diversion structure to the underlying bedrock at an elevation of 1015 ft NAVD88 (approx. 1009 ft Project datum), 10 ft below the top of the existing diversion. This will lower the base level of Newhalem Creek at the diversion location and the stream will adjust to the new base level.

4.1 Potential Future Geomorphic Effects

Potential geomorphic effects of diversion removal include:

- Higher local stream gradient will increase sediment transport capacity immediately upstream from the diversion location in the short term (see Section 4.1.1).
- Existing sediment in the impoundment area will be transported downstream (see Section 4.2, particularly 4.2.2).
- As the channel adjusts to the lower base level over the longer term, the streambed upstream from the (removed) diversion structure will be lower than under existing conditions (see Section 4.1.1).
- There will be increases in turbidity immediately following diversion/cofferdam removal and during subsequent peak flow events that disrupt the armor layer; these are expected to be small and short-term increases (see Section 4.2.1).

Site conditions will minimize the amount of geomorphic change. The channel under and immediately downstream from the diversion is a high gradient (9 percent), boulder/bedrock channel. The bedrock provides a limit to the depth of channel incision at the diversion site and the high gradient channel downstream from the diversion site will quickly transport sediment from the impoundment to the alluvial fan and Skagit River.

4.1.1 Changes to Stream Profile Upstream of Diversion Structure

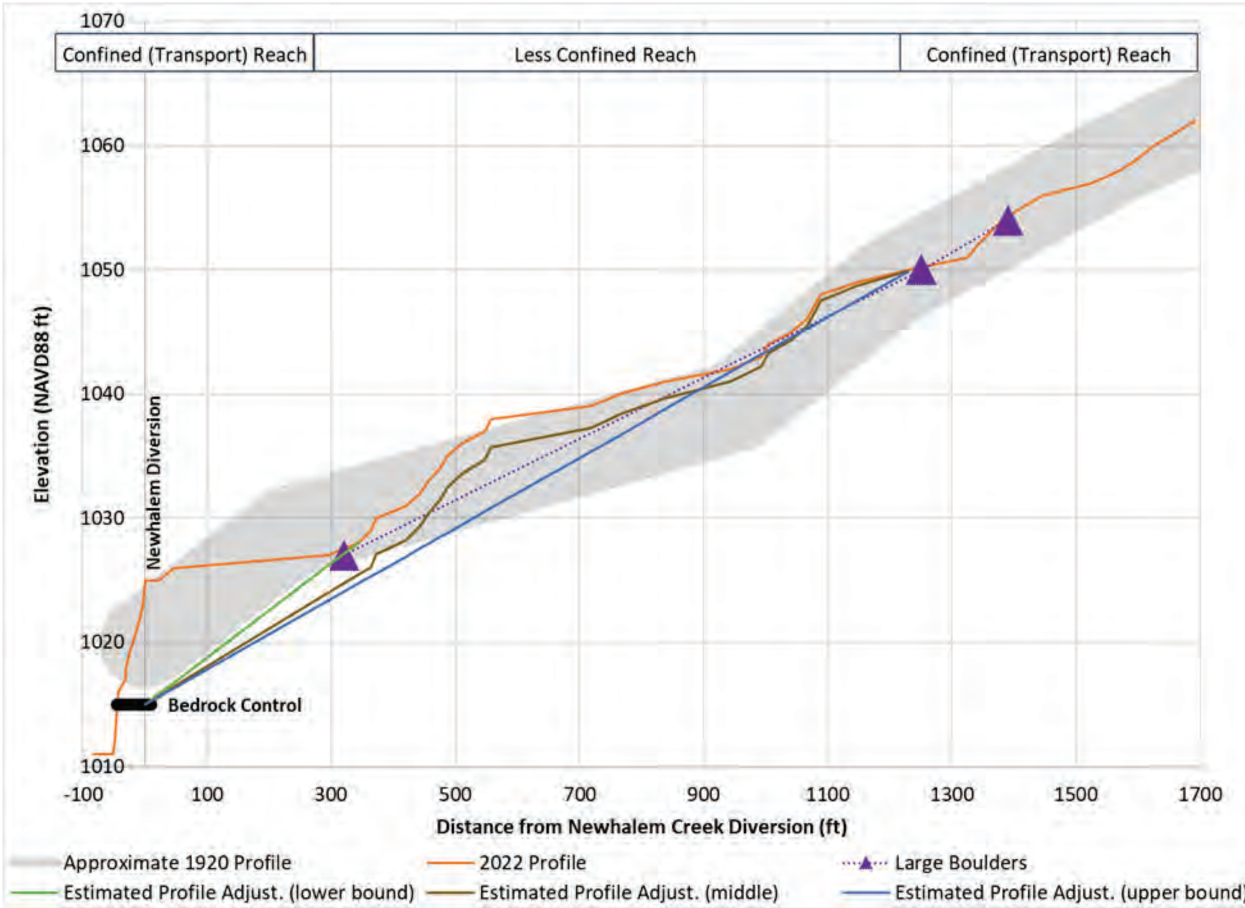
Removal of the diversion structure will result in adjustment of the bed of Newhalem Creek to the new base level. An approximate 1920 longitudinal profile (from Figure 2.2-1 above) and 2022 longitudinal profile (from LiDAR data) upstream from the diversion structure were plotted to compare approximate pre-Project and current stream profiles (Figure 4.1-1). There is uncertainty in horizontal location and vertical datum on the 1920 map, so the 1920 stream profile is shown as a wide band and should be considered approximate. The location of large, immobile (5- to 12-foot diameter) boulders from the field inventory were also plotted. These data were used to estimate the potential amount of channel downcutting that could take place following removal of the diversion structure.

Note that the 2022 stream profile includes several “steps,” in the 1,200-foot reach just upstream from the diversion/intake pool. A major step is located approximately 550 ft upstream from the diversion and is likely controlled by the large boulders at station 320 ft. This step is visible in the field as a steep cobble/boulder riffle located at the downstream end of a split high flow channel/island area. Several very large (10- to 12-foot diameter) boulders were observed under the existing channel at station 320 ft. These large boulders appear to have originated from an ancient,

large landslide on the west bank of the river and are not mobile, providing a stable grade control at this location. Two additional sets of large channel-spanning boulders were mapped at 1,251 and 1,390 ft upstream from the diversion. These are also at the toe of a landslide deposit. Steps are also apparent in the 1920 stream profile, suggesting that this type of stepped profile is a naturally occurring feature of the Newhalem Creek channel in this location.

Three bounding estimates of the amount of potential channel lowering shown in Figure 4.1-1 were made based on the following assumptions:

- Lower bounding estimate – assumes the 8- to 12-foot-diameter boulders 320 ft upstream from the existing diversion will be a grade control; the channel downstream from this location would lower to the green line in Figure 4.1-1.
- Middle bounding estimate: Assumes Newhalem Creek erodes into the right bank at the location of the 8- to 12-foot-diameter boulders (320 ft upstream from the existing diversion) and there are smaller boulders in the new channel location that allow some downcutting at this location. The stream continues to adjust the profile, but instead of a straight line (like the upper bounding estimate described below), the stream adjusts to a new profile with a similar shape as the existing profile. The brown line in Figure 4.1-1 shows a hypothetical new profile using these assumptions.
- Upper bounding estimate: Assumes the stream erodes toward the right bank and around the boulders at Station 320, there are no boulders in the right bank to form a grade control and the stream continues to adjust upstream to the location of the 5-foot angular boulders distributed across the stream 1,251 ft upstream from the diversion. In this scenario, the streambed adjusts to a straight-line profile from the bedrock under the diversion structure to the boulders at station 1,251, shown as the blue line in Figure 4.1-1. This straight line future channel condition is not likely given the character of Newhalem Creek, but it is provided as an upper bounding estimate.



Elevation is NAVD88

Figure 4.1-1. Longitudinal profile of Newhalem Creek upstream from diversion structure with potential profile adjustments.

Potential future change in channel bed elevation following diversion removal was determined by subtracting the 2022 bed elevation from the estimated lower, middle, and upper bounding profile lines. Bed lowering would be greatest just upstream from the removed diversion and at the top of the "steps" in the 2022 profile, with a maximum of 10 ft of bed lowering at the diversion structure (Figure 4.1-2). Estimated bed lowering would extend upstream at varying depths, from the diversion dam for 320 ft (lower estimate, green line) or 1,251 ft (middle and higher estimate, brown dotted and blue dashed lines respectively).

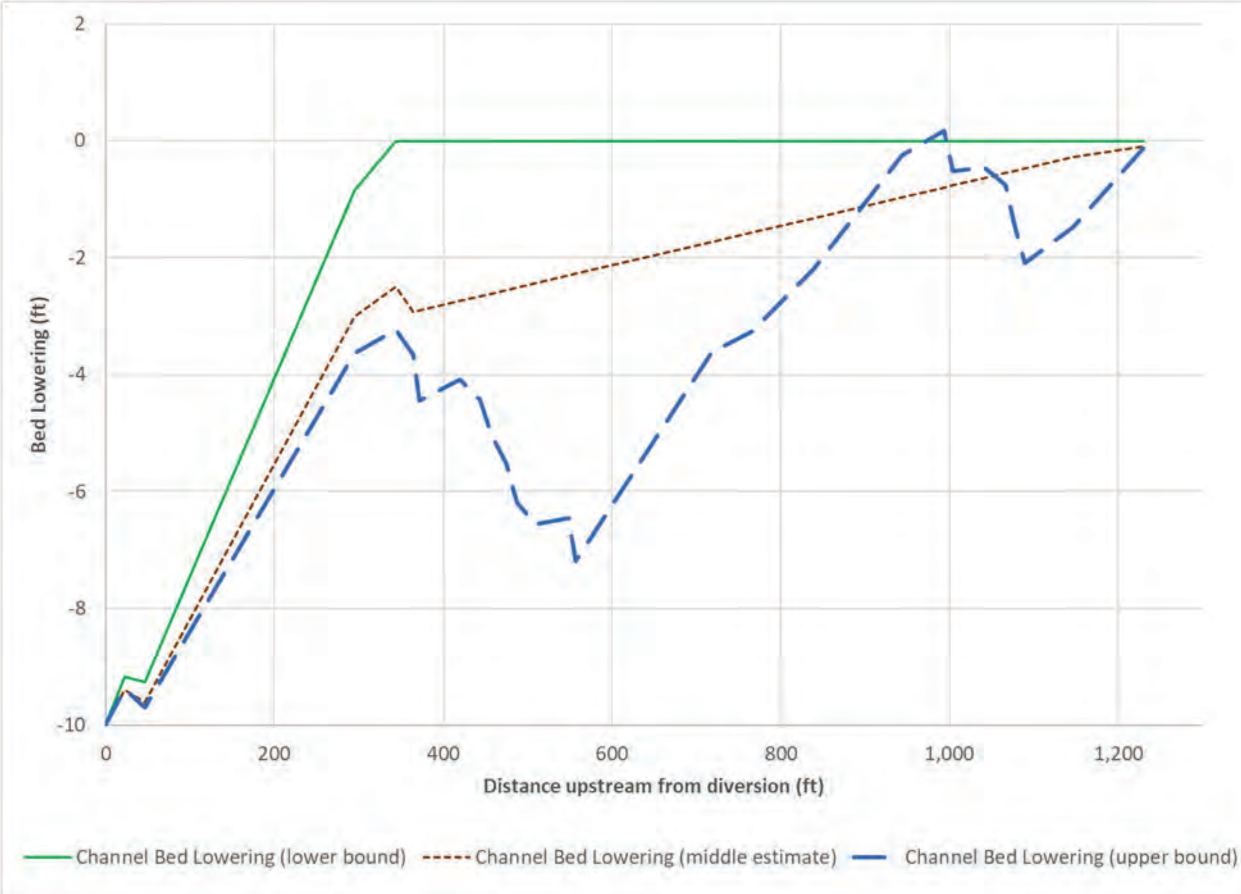


Figure 4.1-2. Estimated depth of bed lowering following removal of diversion structure for three channel adjustment scenarios.

The total volume of sediment that may be transported out of the adjustment area was calculated based on change in bed elevation and an average channel width of 70 ft (average bankfull width). Total potential volume of sediment transported is 4,400 cubic yards (lower bounding estimate), 9,000 cubic yards (middle estimate), or 12,900 cubic yards (upper bound estimate). These volumes can be compared to the estimated existing sediment load of Newhalem Creek made as part of the Skagit River Hydroelectric Project relicensing studies (Seattle City Light 2023). Estimates of coarse-grained sediment yield from Newhalem Creek were made using three different methods for the relicensing studies, as summarized below:

1. Based on the volume of gravel/cobble/boulder material removed from the Newhalem Creek diversion structure during past cleanout procedures, a minimum of 500–1,000 cubic yards/year of coarse-grained sediment is transported to the Newhalem Creek diversion structure. This is an absolute minimum annual volume because once the diversion pool fills with sediment any additional bedload would be transported over the diversion structure; during high flow years the volume of sediment movement would be much higher. Therefore, the average annual long-term bedload supply is higher than this amount.

2. Based on grain size sampling within Newhalem Creek and channel dimensions, an average of 2,000 cubic yards/year of bedload was estimated to move past the diversion using the relationships described in DeVries (2000). This is a more realistic volume of the average annual bedload movement rate near the diversion structure.

3. Based on a regional sediment yield equation, an estimated 10,000–15,000 cubic yards/year of gravel and cobble are supplied into the Skagit River from the Newhalem Creek watershed. This estimate takes into account very high flow events.

There is a wide range in the estimated average annual bedload supply volumes, but given even a lower-end estimate of 2,000 cubic yards/year under current conditions, the estimated volume of additional bed sediment that may be eroded following diversion removal is at most 6.5 times the average annual bedload supply rate (assuming the upper bound estimate of sediment is eroded following dam removal) and may be as little as 2.2 times the average annual amount of bedload sediment (assuming the lower bound estimate of sediment is eroded following dam removal).

If the amount of sediment eroded under existing conditions is closer to the higher end estimates from the regional sediment yield equation, the total amount of sediment transported downstream from dam removal would be equal to or less than the average yearly amount of bedload moving through Newhalem Creek under current conditions.

Under potential future bed lowering scenarios, the re-adjustment to the new base level would likely take place relatively slowly due to the coarse nature of the streambed (cobble/boulder/gravel). However, bedload transport is an episodic process and pulses of material will move through the system as high flows mobilize the material. If very high flows occur immediately after diversion structure removal, more sediment will be moved than if lower peak flows occur in the years following removal. These same high flows that mobilize the material will have the energy to transport it downstream; note that the stream gradient in the canyon/waterfall reach and alluvial fan (average 5 percent) are higher than gradients in the reach upstream from the diversion (2-3 percent; Figure 3.3-2 and Section 3.3 above). The actual timeframe for the re-adjustment will be dependent on the storm events in the years following the diversion dam’s removal. Assuming there is not a very high peak flow in the decade following dam removal, the re-adjustment would take place over a decadal or longer time scale following the initial channel adjustment that would take place just upstream from the diversion structure.

4.1.2 Sediment Transport Analysis

Based on stream hydraulics and the current stream substrate size, the flow that could initiate substrate movement was calculated under current conditions (reach-averaged stream gradient 2.2 percent) and under conditions with the diversion removed (Table 4.1-1). Frequencies listed in the table reflect the values calculated for the peak flow recurrence intervals at the USGS gage just upstream from the diversion (see Table 3.2-1 in previous discussion of stream hydrology). Particles up to 512 mm in diameter were mobilized between the 2021 and 2022 field visits; the peak flow in November 2021 was 4,920 cfs, indicating that boulders up to at least 512 mm are mobile in the stream under those flow conditions.

Table 4.1-1. Calculated discharge required to transport substrate upstream of diversion structure under existing conditions and following diversion removal, historic peak flows.

Stream Gradient	Discharge and frequency of median (D_{50}) grain size transport	Discharge and frequency of larger (D_{84}) grain size transport
2.2% (reach average over long term)	250 cfs; every year	3,000 cfs; 5 years
1.3% (existing local slope just upstream from diversion)	1,500 cfs; 1.5 years	over 9,000 cfs; 100+ years
3.8% (short term local slope upstream from diversion with diversion removal and drop in base level)	120 cfs (many times/year)	1,500 cfs; 1.5 years

In the short-term, immediately following diversion removal, the local stream gradient just upstream of the diversion would increase from 1.3 to 3.8 percent, which would increase the sediment transport frequency of the median (D_{50}) sized substrate from every 1.5 years to many times/year. Transport of larger particles (e.g., D_{84}) would increase from very infrequently (over 100-year recurrence frequency) to movement under a 1.5-year peak flow event. This analysis suggests that the bed immediately upstream from the diversion structure would respond quickly to diversion removal. It is anticipated that the substrate just upstream from the removed diversion structure would be mobilized as soon as the diversion/cofferdams were removed, and an armor layer would form quickly as finer material was transported downstream and larger, immobile particles (e.g., boulders) remained on the bed. As flows increase during subsequent larger flow events, some of the bigger substrate particles would be mobilized and transported downstream and the process would continue until Newhalem Creek reaches a new, stable profile.

As material on the bed is transported downstream, the locally high stream gradient above the removed diversion structure would migrate upstream. The bed adjustment would migrate upstream until a grade control is reached, such as the large, immobile boulders in the channel 320 ft upstream from the diversion or the set of large boulders between 1,251 and 1,390 ft upstream from the diversion.

As the bed adjustment progresses upstream, the local gradient increase would become less and less until a new long-term average slope condition is reached. As the local gradient increase becomes less and less, the corresponding energy to move particles becomes less, resulting in less frequent bedload movement and a slowing of the process. Bed adjustments can migrate upstream fairly rapidly in fine-grained sediments, but the large particle sizes in Newhalem Creek will form an armor layer and further reduce the speed of adjustment migration and the large, immobile boulders noted above will limit channel incision. It is anticipated that as an armor layer forms, the larger substrate will be mobile much less frequently and channel adjustments will take several decades. Over time, a new equilibrium channel gradient will develop.

The grain size transport frequency in Table 4.1-1 assumes similar peak flow magnitudes as historic conditions. As discussed in Section 3.2.1, climate change modeling suggests that future peak flows may be higher magnitude than historic conditions, although higher magnitude peaks have not been documented as of 2022 at the Newhalem gage. If future peak flows are higher, Newhalem Creek

would adjust more quickly to diversion removal as the higher flows transport material through the river system. If higher future peak flows do occur, the entire Newhalem/Skagit river system would experience the increased peak flows, resulting in more active sediment transport/geomorphic change throughout the river system and mute the more rapid changes resulting from the Newhalem Creek diversion removal.

4.1.3 Potential Grade Control Structure Considerations

FERC has requested the cost for design of a grade control structure near the current diversion dam in the October 28, 2022, Additional Information Request in response to some resource agency interest in a grade control structure.

The need for a grade control structure should be balanced between the desire to return the stream to a natural condition (with no structures) and the risk of headcutting. As discussed in previous sections, there is a low risk of rapid or far-reaching headcutting (past the 1,251–1,390-foot boulder clusters) in Newhalem Creek following diversion dam removal for the following reasons:

1. The diversion structure is underlain by bedrock that will provide a stable, long-term base level.

2. There are large, immobile boulders (5- to 12-foot diameter) underlying the channel at several locations upstream from the diversion structure (320; 1,251; and 1,390 ft). These boulders will not be mobile under current or future flows and will provide natural grade controls in the stream that will limit headcutting.

3. The large substrate in Newhalem Creek does and will continue to form an armor layer that is resistant to rapid erosion of the channel.

4.2 Changes Downstream from the Diversion Removal

Sediment that is moved out of the diversion area will be transported rapidly through the high gradient canyon (8.9 percent slope) and 100-foot-high waterfall reach to the alluvial fan area. Boulders and large cobble will be deposited at the upstream end of the Newhalem Creek alluvial fan in the Skagit River valley; actual deposition locations will reflect gradient and stream conditions on the fan. Some cobble, gravel and finer sediment will be transported farther downstream and eventually reach the Skagit River, providing a source of sediment for spawning and aquatic habitat.

4.2.1 Turbidity

Turbidity effects resulting from disturbance of the streambed during instream work has been identified as a potential concern. During structure removal, instream work areas will be isolated from the streamflow by cofferdams and appropriate erosion/streamflow control measures as described as part of engineering/construction operations in separate documentation. Following instream work, the cofferdams will be removed and Newhalem Creek water will again flow over the streambed and begin readjustment to the new base level without the diversion structure.

Turbidity levels following diversion removal could increase under the following conditions:

- Immediately following cofferdam removal until the stream forms a surficial armor layer; and
- During subsequent peak flow events that disrupt the armor layer as the stream re-adjusts to the new base level.

Sub-surface sampling (Section 3.4) at two locations upstream of the diversion structure in 2022 found less than 1 percent silt/clay material in the streambed. The low levels of fine-grained sediment will result in minor increases in turbidity during either of the streambed-disturbing flow conditions listed above. The Newhalem Creek watershed is underlain by the Skagit Gneiss that primarily weathers to sand-sized particles rather than finer-grained silt and clay, so there are only minor sources of fine-grained material in the watershed (such as Quaternary glacial deposits).

As part of operation of the Newhalem Project, the intake pool upstream of the diversion dam was cleaned out on a regular basis. During low flow periods, approximately 250 to 425 cubic yards of accumulated material was removed with an excavator and placed on the concrete apron downstream from the diversion structure and allowed to move downstream (Figure 4.2-1, Figure 4.2-2, and Figure 4.2-3). Turbidity monitoring took place during the cleanout events; these data provide another indication of levels of turbidity expected immediately following diversion and cofferdam removal. The baseline and peak turbidity levels measured during 2012, 2015, and 2016 cleanout events are shown in Table 4.2-1. Peak turbidity levels from 0.88 to 58.79 NTUs over background were measured immediately following gravel placement but reached background levels in less than 24 hours.

It is anticipated that turbidity level increases following cofferdam removal will be similar to those during pool cleanout and that turbidity levels will decrease quickly after initial higher levels. Turbidity levels will also likely increase during subsequent higher flows as the armor layer upstream from the diversion location is disrupted and the stream adjusts to the new base level. These turbidity increases are also anticipated to be minor and transient due to the low level of fine-grained material in the subsurface material.

Figure 4.2-1. Intake pool area during cleanout.

Figure 4.2-2. Intake pool following cleanout.

Figure 4.2-3. Material removed from intake pool placed on concrete apron downstream from diversion structure.

Table 4.2-1. Newhalem Creek intake pool cleanout turbidity monitoring data.

Monitoring Date	Baseline NTU	Peak NTU after excavation	Change in NTUs (over background)
9/17/2012	0.18	30.0	+29.82
9/18/2012	0.21	59.0	+58.79 (max)[2]
8/7/2015	0.13	4.5	+4.37
8/8/2015	0.50	21.1	+20.6
8/9/2015	0.46	16.6	+16.14
8/17/2015	0.20	1.08	+0.88
8/22/2016	0.35	5.46	+5.11
8/24/2016	0.2	39.5	+39.3
8/24/2018	0.1	18.18	+18.08
8/25/2018	0.31	18.29	+17.98
8/26/2018	0.70	17.6	+16.9
8/27/2018	0.90	9.98	+9.08
8/28/2018	0.33	11.28	+10.95
8/29/2018	0.40	13.56	+13.16
8/30/2018	0.32	13.45	+13.13

4.2.2 Potential for Filling Step Pools

The step pools downstream from the diversion structure have been identified as important cultural resources, with a concern that removal of the diversion and transport of material from upstream may fill the step pools. Modeling or calculation of sediment transport through step pool structures is difficult due to the complex 3-dimensional hydraulics, but observations of sediment movement through the step pools following cleanout of the intake pool provides empirical evidence of sediment transport and accumulation in the step pools.

The step pools were not observed to fill with material following intake excavation events which took place during low flow conditions (Figure 4.2-4). Gravel was observed on the sides of the step pools, but velocities in the pools was high and turbulent enough at low flow to transport material through and maintain the pool structure among the boulders and bedrock forming the pools. During higher flows, velocities and turbulence in the pools are much higher and material on the edges of the pools is also transported downstream. Observations made during the 2021–2022 site visit indicated that cobble, boulder, and gravel material had filled the intake pool and was being transported over the intake structure. No evidence of filled step pools downstream of the diversion was observed indicating that flows high enough to mobilize material upstream of the diversion are high enough to transport the same material through the higher gradient/confined step pool section of the stream (Figure 4.2-5).

Following diversion structure removal, cobble, gravel, and boulders would move downstream and through the step pools in a similar manner as during the intake cleanout events and current high flow events. As flows increase, additional material will be mobilized upstream of the diversion structure location and the higher flows will transport the material through the step pools. It is

[2] Turbidity suspected to be higher due to pockets of sandy sediments that were encountered in 2012.

anticipated that step pools will retain pool depth following diversion removal and there will be minimal or no long-term effects.

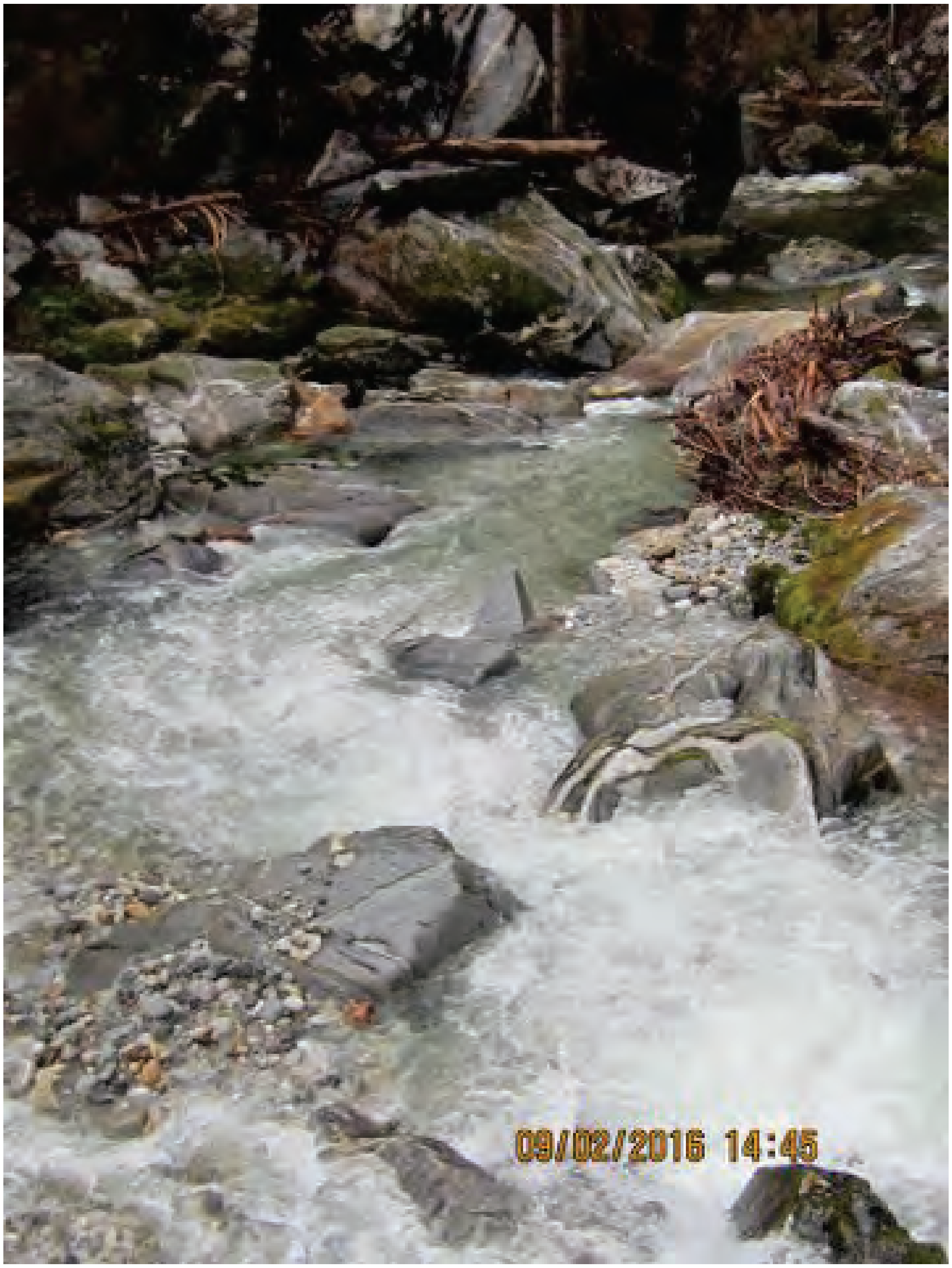


Figure 4.2-4. Step pools downstream from diversion structure following August 24, 2016 intake pool cleaning.

Figure 4.2-5. Step pools downstream from diversion structure in September 2022.

4.2.3 Potential for Changes to Downstream Debris Slide

There is a large, ancient landslide on the southwestern (left bank) side of Newhalem Creek that extends from several hundred feet upstream of the diversion structure to the base of the waterfall approximately 1,100 ft downstream from the diversion. A much smaller debris slide is located at the downstream end of the larger slide; the smaller debris slide has been active for at least several decades and affects the Newhalem Creek dam access road. The NPS questioned whether the accumulation of material in Newhalem Creek following removal of the diversion structure could result in erosion of the toe of the landslide that could re-activate the slide. A memorandum describing the landslide and debris slide provides information describing the slide complex (Findley 2021) and is summarized in the next two paragraphs.

The active debris slide consists of alpine glacial deposits overlying Skagit gneiss bedrock. The large, ancient slide likely consists of similar material and the toe of the large slide blocks the Newhalem Creek valley, diverting the flow to the northeast side of the drainage where Newhalem Creek currently flows (Figure 4.2-6). The older slide has mature trees that are straight and plumb suggesting little recent ground movement, while trees within the active, smaller debris slide area exhibit leaning trunks consistent with ground movement.

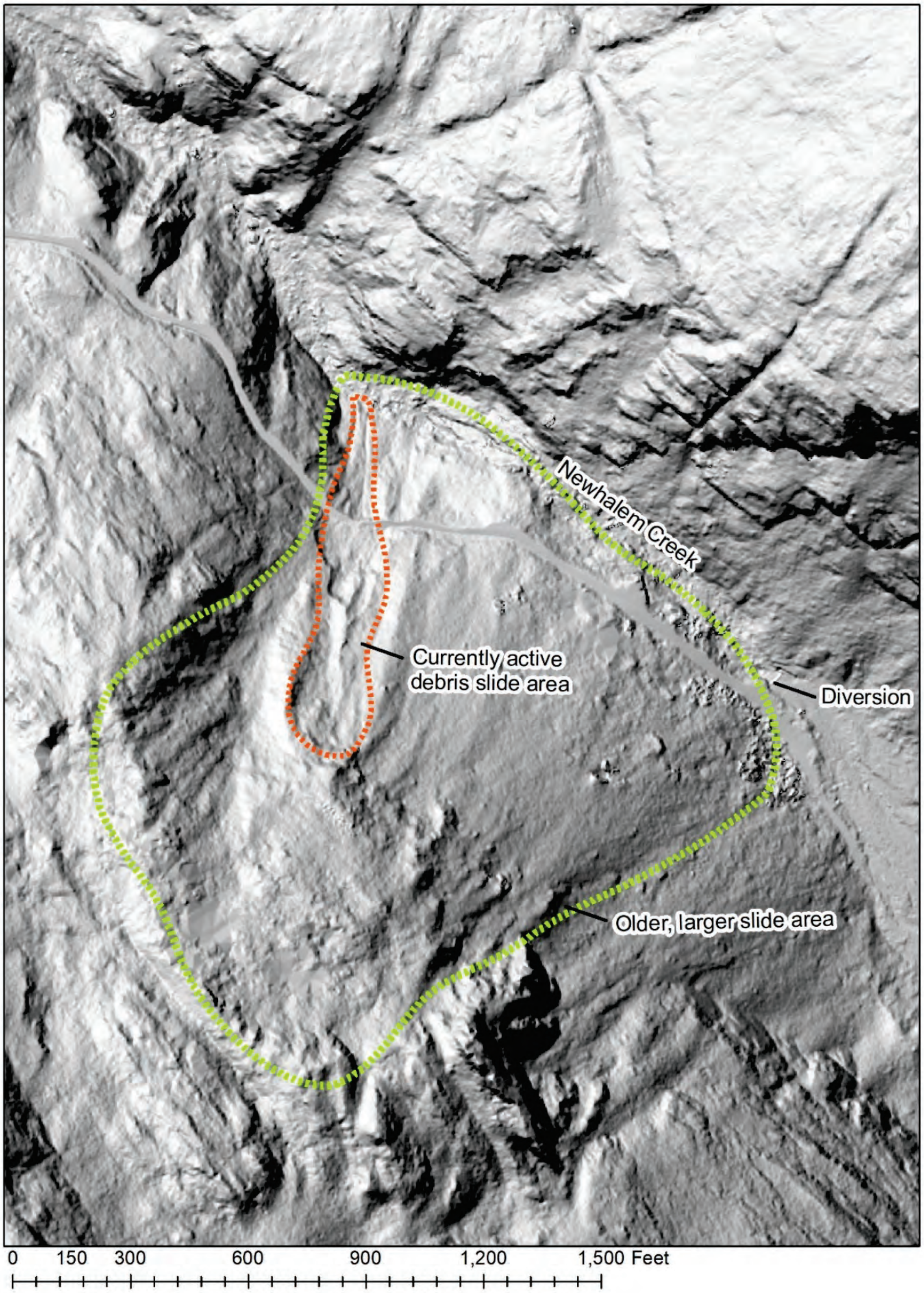


Figure 4.2-6. LiDAR hillshade image showing older, larger and younger, active debris slide areas (after Findley 2021).

The active landslide area uphill from the access road is approximately 250 ft wide and 500 ft high with a slope inclination of 40–45 degrees steepening to 70 degrees in the headscarp. Soil is coarse subangular cobbles and boulders in a silty/sandy matrix. Numerous boulders larger than 10 ft in diameter were observed in the landslide area. The toe of the smaller, active slide is at the base of the 100-foot-high waterfall in Newhalem Creek. Findley (2021) notes that the large, older landslide does not appear to be currently active based on field observations but erosion along the toe of the mass by Newhalem Creek presents a potential for future reactivation.

The 2015 LiDAR elevation data were subtracted from the 2022 LiDAR data to produce a map showing areas of lower topography (erosion—in blue on map) and accumulation (in red on map) for the smaller, active slide area (Figure 4.2-7; yellow areas indicate little change in elevation from 2015 to 2022). As expected, there was erosion/elevation drop at the headscarp of the active slide and deposition of material on the roadway. The 2015–2022 slide movement was primarily uphill from the roadway and does not appear to be directly connected to erosion at the toe of the slide since there was little movement of the slope between the road and the stream despite evidence of up to 5 ft of erosion within the creek at the toe of the slide. This indicates Newhalem Creek has the potential to erode the toe of the smaller, active landslide under current conditions.

Determining the stability of either the larger, old landslide or the smaller active landslide is not possible with the available data, so a slope stability analysis of how any accumulation or scour of material in Newhalem Creek following diversion removal may affect either slide area is not possible. However, based on field observations of mature trees and the large boulders within the stream and at the base of the slide, the large, older slide has not been affected by Newhalem Creek flowing at the toe of the slide for a very long time. Newhalem Creek is eroding the toe of the smaller, active slide under current conditions, Based on the results of a reconnaissance of the smaller landslide on June 2, 2023, by Seattle City Light staff, the toe of this landslide is armored by 20–25 ft of large boulder debris. The erosion currently being caused by Newhalem Creek is surficial material or accumulated material within the streambed and is not destabilizing the landslide. In order for toe erosion to destabilize the landslide, the creek would have to erode material above the 20–25 ft of protective boulder armoring at the toe. It is not feasible that 20–25 ft of material could be deposited following dam removal in this high gradient, confined location in the stream.

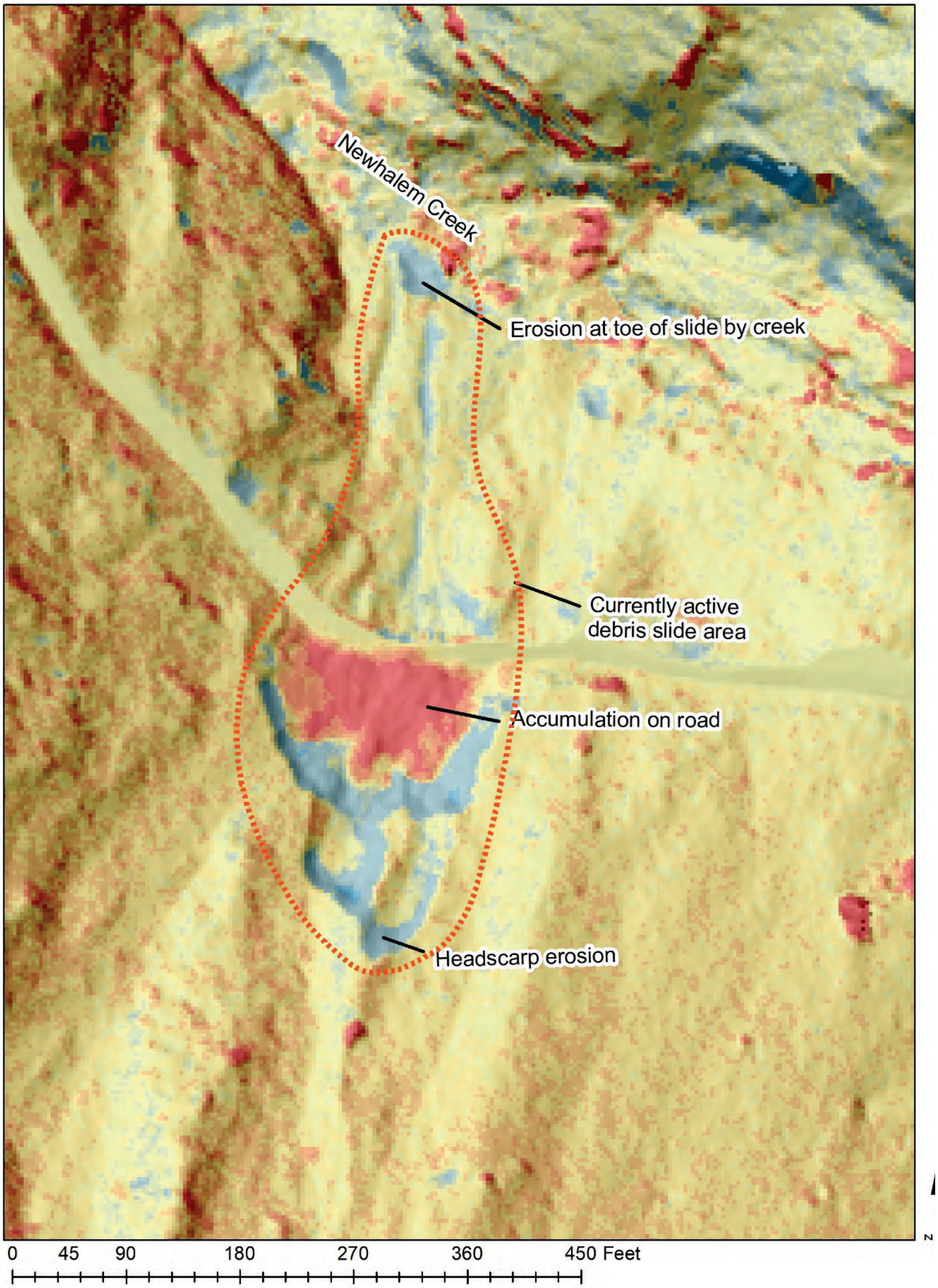


Figure 4.2-7. Difference between 2015 and 2022 LiDAR showing erosion (blue) and accumulation (red) zones within smaller, active debris slide (yellow areas had little change).

4.2.4 Potential for Changes to Alluvial Fan and Skagit River

Downstream from the diversion structure, Newhalem Creek has a confined, step-pool structure, a 100-foot waterfall, another confined step-pool section, and then a lower-gradient, less confined alluvial fan reach before entering the Skagit River (see Figure 3.1-1 above). Sediment that is transported from the area upstream of the diversion following diversion removal will enter the alluvial fan reach and some material will be deposited on the fan with the remainder transported into the Skagit River depending on the size of the sediment and flow levels. The largest material (e.g., boulders) will be deposited at the upstream end of the fan with smaller material transported farther downstream, similar to the deposition patterns of sediment that moves through Newhalem Creek under current conditions. Note that the average gradient of the alluvial fan reach is 5 percent and the average gradient of Newhalem Creek upstream of the diversion structure is 2–3 percent. Since bedload transport is directly proportional to stream gradient, the majority of smaller material (gravel and finer) will be transported into the Skagit River rather than being deposited on the alluvial fan and provide substrate suitable for use by spawning fish.

NPS has requested information on the likelihood of deposition of material on the alluvial fan re-activating old channels on the fan, or the likelihood of material being deposited at the confluence with the Skagit River and pushing the river channel toward the north.

As discussed in Section 4.1.1, the total volume of coarse-grained sediment (gravel, cobble, boulder) that is likely to be eroded from upstream of the diversion and transported to the alluvial fan/Skagit River confluence is between 4,400 and 12,900 cubic yards, the equivalent of less than one year to up to 6.5 years of the average annual coarse sediment supply from Newhalem Creek depending upon the method of estimation. It is anticipated that the additional material will not be transported in a single year but will take several years or decades to be mobilized, depending upon actual streamflow in the years following diversion removal. Based on aerial photographs and LiDAR evidence, the Newhalem Creek alluvial fan appears to have characteristics of an incised streamflow "fossil" fan surface (National Research Council 1996). The Newhalem Creek channel does not appear to have occupied many of the relic channels on the fan during at least the past hundred or more years based on the mature trees developed on these surfaces, with the exception of distributary channels at the junction with the Skagit River (Figure 3.3-1 above). As such, it is unlikely that the addition of the anticipated 1- to 6.5-times the average annual coarse sediment supply to the Newhalem Creek channel would cause enough aggradation to re-activate the older, elevated channels in the alluvial fan, particularly given the higher average stream gradient in the fan (5 percent) compared to the source reach (upstream from the diversion structure, 2-3 percent). It is anticipated that much of the gravel and cobble would move through the fan and supply sediment to the Skagit River.

As an upper bounding estimate, if the total volume of potential additional material was deposited evenly within the Newhalem Creek channel (average wetted width 50 ft) in the alluvial fan reach (2,500 ft long), it would result in deposition of approximately 1–3 ft of sediment. This is not a realistic scenario, however, since the total volume of material will not be eroded from the diversion in a single year. In addition, the alluvial fan is higher gradient than Newhalem Creek upstream from the diversion, so the majority of finer-grained material (e.g., small gravel) that is in the streambed upstream from the diversion structure would be transported through the alluvial fan reach.

To provide context to help compare total potential volume of sediment with existing channel dimensions and further assess the likelihood of deposition in the alluvial fan re-activating old channels, the potential depth of sediment deposits calculated above was compared to the height of the alluvial fan surface above the existing stream channel at several locations along the fan. Bank heights at the upper end of the alluvial fan in the location of old channel traces are 5–7 ft above the current stream channel, 10–13 ft above the current stream channel in the middle of the fan, and 4–5 ft above the current stream channel at the lower end of the fan near the Skagit River confluence. Based on the unlikely scenario that sediment deposited at the calculated maximum potential depths of less than 3 ft, it is unlikely that enough sediment would be deposited in the Newhalem Creek channel in the alluvial fan section to re-activate old channels.

The median (D_{50}) particle size on bars in the Skagit River between Gorge Dam and Bacon Creek is approximately 45 mm, and the estimated bedload sediment transport rates in the Skagit River near the Newhalem Creek confluence are 10,000 to 50,000 cubic yards/year (Seattle City Light 2023). Comparing these bedload transport rates to total potential sediment input from the Newhalem Creek diversion removal (4,400–12,900 cubic yards), the total potential sediment input from diversion removal is less than or equal to the average annual sediment transport rate in the Skagit River. It is therefore unlikely that removal of the Newhalem Creek diversion structure will result in substantial deposition within the Skagit River. It is likely that there may be small amounts of deposition, but deposited material will likely be mobilized during subsequent high flows in the Skagit River.

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NEWHALEM CREEK DECOMISSIONING GEOMORPHOLOGY CONSIDERATIONS

ATTACHMENT A

GEOMORPHIC STREAM ASSESSMENT NOTES

Newhalem Ck. Geomorphic Unit geometry, boulders, banks, and large wood data collected by Andrew Nelson and Ed Fordham on 10/14/22 upstream from Project diversion structure

Sediment size classes used in notes

fG Fine gravel (none noted): 8-22 mm
G Gravel: 22-64 mm
C Cobble: 64-180 mm
LgC Large Cobble: 180-360 mm
B Boulder: >360 mm

Geomorphic Units, Substrate, Bankfull Dimensions, Bank Height/Materials

Distance upstream from diversion (ft)	Geo morphic Unit Type	Dom-inant Bed Material	Sub dominant Bed Material	Other important bed material	Bankfull width (ft)	Bankfull depth (ft)	Tailout Depth (ft)	Pool Depth (ft)	Right Bank total height (ft)	Right Bank Lay back (ft)	Right bank material	Left Bank total height (ft)	Left Bank layback (ft)	Left Bank material
0	Riffle	LgC	C	B, G	50	3	NA	NA	NA	NA		12	6	pool dredge spoils
79	Glide	LgC	C	B, G	63	2	0.5	1	2	3	Bouldery alluvium	7	8	Angular boulder
198	Pool	LgC	B	G	48	3.5	1	2.5	5	7	Bouldery alluvium	7	8	Cobbly Alluvium
290	Cascade	LgC	C	B	95	6	NA	NA	8	14	Cobble w/ small boulders	6	20	Landslide boulder debris
490	Glide	C	LgC	B	136	3	1	2	2	18	not noted	3	5	Cobbly Alluvium
673	Pool	LgC	B	G	55	3.5	1	3	2	12	Gravel bar over cobbly alluvium	4	8	Cobbly Alluvium
840	Pocket Water	LgC	C	B	76	3.5	1	1.5	3	7	not noted	6	3	not noted, actively eroding (cobbly alluv if memory serves right)
956	Step Pool	B	C		81	3	1	2	4	4	not noted	9	7	0.5 ft silty sand over 1' sandy gravel w/ sm. Cobble over 0.5 ft coarse sand over 7' poorly graded cobble (sand-boulder sizes)
1040	Step Pool	B	C		162	3	1	2	0.5	20	boulder levee seperating side channel offtake	10	7	poorly graded cobble (sand-boulder sizes)
1136	Pool	C	LgC	B	82	5	0.5	3	no noted	not noted	Cobbly gravel with boulders	8	6	6' sandy gravel over 2' cobbly gravel with boulders
1315	Riffle	B	C		56	3.5	0.5	1	4	4	boulder cobble	3	3	boulder cobble
1390	Pocket Water	C	LgC	B, G	59	2.5	0.5	1.5	4	6	Cobble and boulder	7	3	Rounded boulder & cobble, lots of root reinfocement

Distance upstream from diversion (ft)	Geo morphic Unit Type	Dom-inant Bed Material	Sub dominant Bed Material	Other important bed material	Bankfull width (ft)	Bankfull depth (ft)	Tailout Depth (ft)	Pool Depth (ft)	Right Bank total height (ft)	Right Bank Lay back (ft)	Right bank material	Left Bank total height (ft)	Left Bank layback (ft)	Left Bank material
1500	Pocket Water	C	B		55	3.5	0.5	1.5	5	8	boulder and cobble	8	6	angular small boulder and cobble
1576	Step Pool	C	B		50	3	0.5	2	4	8	rounded boulder-cobble	6	9	angular cobble-boulder
1619	Plane bed	B	C		50	3	NA	NA	3	6	rounded boulder-cobble	6	9	angular cobble-boulder
1703	plane bed	B	C		50	2	NA	NA	4	6	rounded cobble-boulder	3	6	not visible
1905	Pocket Water	LgC	B		65	3	not noted	not noted	4	6	rounded cobble-boulder	6	8	rounded cobble-boulder
2027	Step Pool	B	LgC		60	3	not noted	not noted	6	6	not noted	8	6	not noted
2081	Pocket Water	LgC	C	B	65	2.5	not noted	not noted	4	15	not noted	8	8	not noted
2351	Step Pool	C	LgC	B	50	3	0.5	2	7	12	not noted	6	1	not noted
2432	Glide	C	LgC	B, G	70	2	not noted	not noted	5	10	not noted	3	6	not noted
2513	Pocket Water	LgC	C	B	60	3			3	5	not noted	3	5	not noted
2661	Pocket Water	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted
Maximum	**n/a**	**n/a**	**n/a**	**n/a**	**162**	**6**	**1**	**3**	**8**	**20**	**n/a**	**12**	**20**	**n/a**
Mininimum	**n/a**	**n/a**	**n/a**	**n/a**	**48**	**2**	**0.5**	**1**	**0.5**	**3**	**n/a**	**3**	**1**	**n/a**
Mean	**n/a**	**n/a**	**n/a**	**n/a**	**70**	**3**	**1**	**2**	**4**	**9**	**n/a**	**6**	**7**	**n/a**

Large Wood and Boulders

Distance upstream from diversion (ft)	Feature	Notes	Boulder b axis diameter (ft)	Boulder a axis diameter (ft)	Large Wood Diameter (dbh in)	Large Wood Length (ft)	Large Wood Rootwad?
25	Large Wood (LW)				12-18	25-49	unknown (buried)
188	USGS GAGE						
227	Boulder	4' and 8' angular boulders towards LB	4				
227	Boulder		8				
261	Boulder	4' angular boulder on RB; cluster of 2-3' rounded boulders	4				
281	Boulder	4'X8' angular boulder on slipface cascade	4	8			
320	Boulder	10 and 12' angular boulders along LB flowpath	10				
320	Boulder	10 and 12' angular boulders along LB flowpath	12				
320	Boulder	6' boulder in rb flowpath	6				
280	LW	jammed against left bank ad not really impacting channel			18-23	25-49	N
280	LW	jammed against left bank ad not really impacting channel			18-23	15-24	N
280	Boulder	on LB	15				
280	Boulders	many 3-5' angular boulders in LB flowpath	4				
280	Boulder	in middle bar	5				
355	Bank stratigraphy	LB 6" sand over cobbly alluvium with few boulders					
355	RB side channel confluence						
440	Boulders	many 3-6' angular boulders on LB					
468	LW				24-35	25-49	N
600	Boulder	on LB	10				
640	LW	on RB			36	24	N
702	LW	pool forcing, wedged in between bank trees			24	20	N
730	LW	Jam piece, lots of brush, trees project 30' into channel, pinned on floodplain trees			24	75	
730	LW	Jam piece, lots of brush, trees project 30' into channel, pinned on floodplain trees			24	75	
900	LW	along bank, little geomorphic function			24	40	N
1025	LW				30	50	Y
1035	LW				30	25	N
1083	LW				24	18	N
1083	LW				18	15	N
1130	LB side channel offtake						

Distance upstream from diversion (ft)	Feature	Notes	Boulder b axis diameter (ft)	Boulder a axis diameter (ft)	Large Wood Diameter (dbh in)	Large Wood Length (ft)	Large Wood Rootwad?
1251	Boulder	Angular boulders across channel	5				
1251	Boulder	Angular boulders across channel	5				
1251	Boulder	Angular boulders across channel	5				
1390	Boulders	ten or more 4' to 7' angular boulders scattered across unit	7				
1500	Pocket Water						
1770	LW				14	18	N
1824	Boulder	in RB	15				
1824	Boulder	in RB	15				
1824	LW	not significantly impacting hydrualics			48	50	
1824	LW	not significantly impacting hydrualics			48	25	
2067	Boulders	cluster of seven 4-5' boulders in middle of channel	5				
2240	LW				12	35	Y
2256	LW				36-48	50-75	
2256	LW				36-48	50-75	
2337	LW				12	45	Y
2351	LW				12	50	Y
2351	LW				36	45	N
2410	LW				16	30	Y
2548	LW				24	30	N
2631	Boulder	15' boulder in RB	15				
2661	LW				48	40	
2661	Notes	terrace feature comes to channel; end of survey					

NEWHALEM CREEK DECOMISSIONING GEOMORPHOLOGY CONSIDERATIONS

ATTACHMENT B

CONSULTATION RECORD

Newhalem Creek Hydroelectric Project (FERC No. 2705)

City Light's responses to comments received on the *Newhalem Creek Dam Decommissioning Geomorphology Considerations* (report) are provided in this table. The report was distributed to decommissioning participants for comment on December 23, 2022.This table has been created and is included in the record as a summary of resolution of the comments received.

Comments on the report were received from U.S. Fish and Wildlife Service, Washington Department of Fish and Wildlife, and National Park Service.

Entity	Date	Comment ID #	Comment	Response
U.S. Fish and Wildlife Service (USFWS)	1/31/2023, Email	1.	<u>USFWS Comment in 1/31/2023 email:</u> In general, the report seems to accurately characterize what was observed in the field at last year's site visit in terms of grain size and the series of three large boulder grade control features. The assessment of the rate of bed movement following the removal of the diversion dam was lacking specificity, however; no quantification or even estimation of bed load movement over time is made. The report simply states initial movement will occur quickly, but it will be several decades before the creek reaches equilibrium. Furthermore, under future climate projections with increased peak flows, the report simply indicates that bedload transport will occur at an even faster rate. We do not disagree with any of these statements. However, we were expecting analysis quantifying/estimating the transport rates given current peak flows and durations, future flows and duration, and a range of sediment expected to be mobilized annually until equilibrium is reached. Understanding the rate/volume of annual bed load movement would aid in determining if temporary grade control/stream energy dissipation is needed to prevent large movements of sediment. Short of this analysis, we request that Seattle City Light consider installing structures to dissipate energy (e.g. log jams or felling of trees) above the diversion, prior to removal of the structure.	City Light and USFWS met on February 16, 2023 to discuss USWFS comments on the report and USFWS data and information needs related to the Biological Opinion. Meeting summary is attached. <u>The response to this comment is as follows, as recorded in the attached meeting summary:</u> There are challenges of quantification. Hydraulic models of moving water are fairly simple. But the sediment becomes problematic in supply-limited systems such as Newhalem Creek where modeling must begin with an assumption of how much sediment is mobilized. There are spreadsheets and models, but the predictions vary wildly. If you need to know for sure, you have to calibrate a model with actual measured volumes moved based on data collected under known conditions over a couple years at a minimum. This would be a substantial effort for a very uncertain result, especially in the context of this dam removal and the approximately 6,000 – 12,000 cy of sediment estimated to be mobilized. Even if it all went at once, it would not be different from a common landslide event.
USFWS	1/31/2023, Email	2.	<u>USFWS Comment in 1/31/2023 email:</u> Related to the rate of bed movement, sub-surface D84 (183mm) is reported being smaller than surficial D84 (290-326mm). Assuming the sub-surface samples are an accurate representation of what lies beneath, would we expect the volume of bedload transport to increase over time?	<u>Response as recorded in the attached 2/16/23 meeting summary:</u> The current streambed is armored, with larger surface substrate covering smaller sub-surface material as is typical in gravel/cobble-bedded streams. Following dam removal, the streambed will mobilize and then become armored with larger material over the top of the smaller material that is protected and stabilized until subsequent large flow events move the armoring.
Washington Department of Fish and Wildlife	2/3/2023, Email	3.	The report is thorough and appropriate for the study. It considers future climate, and the projected river responses seem reasonable.	Comment acknowledged.
USFWS	3/2/203, Email	4.	USFWS acknowledges receipt of requested gravel passage monitoring notes, and states USFWS will reach out with any other comments.	Comment acknowledged. City Light responded on May 9, 2023 offering to set up a meeting to provide information to USFWS to assist with preparation of the BO. The meeting took place August 28, 2023. USFWS had no further comments or questions about the report.

Entity	Date	Comment ID #	Comment	Response
National Park Service (NPS) and City Light	5/11/2023 Meeting	5.	City Light met with the NPS to assist with facilitating comments on the report. The meeting resulted in three main comments and one consideration, as summarized in meeting minutes and subsequently reviewed by the NPS: 1. SCL to develop some explanations of potential effects of Newhalem decommissioning on the alluvial fan at the mouth of Newhalem Creek in the Skagit River. 2. SCL to develop some information about the effects of decommissioning on the toe of the existing landslide. Will dam removal be an additive effect to the landslide effect? 3. SCL to evaluate the old channels on the alluvial fan and estimate how much fill would have to occur to re-activate them. 4. Regarding the landslide and other information in the Golder report such as slope stability, SCL may want to pull more information into the Geomorphology Report from the Golder report where it is applicable.	The meeting minutes were provided to the NPS for review on May 17, 2023, with no changes proposed by the NPS. The presentation and minutes are included in the consultation record. Following the meeting, comments were incorporated into the geomorphology report and provided to the NPS in an attachment to a 6/16/2023 email. The NPS' comments resulted in five revisions to the report: **Sentence on page 1-2**. Explains that the report includes an evaluation of concerns provided after initial drafts of the report. **Edits or additions to Section 4.1.1, pages 4-4 through 4-5**. Compares anticipated volume of sediment from dam removal to estimated average annual sediment yields to support NPS question regarding likelihood of reactivating old channels on the alluvial fan and pushing the Skagit River north due to deposition. New section 4.2.3. Addresses NPS question regarding the effects of decommissioning on the toe of the existing landslide. Also summarizes geology from the Golder report as requested. **New Section 4.2.4**. Addresses NPS questions about 1) reactivating old channels on the alluvial fan and 2) effects of decommissioning at the confluence of the Skagit River (whether Skagit River would be pushed to the north). **2 new references in literature cited**. Includes citations referenced in new sections described above.
NPS	7/17/2023, Email	6.	<u>NPS comments on the 6/16/2023 version of the geomorphology report:</u> Page 4-5: More detail is needed on how sediment yield was determined, specifically on the 2000 cubic yards value. This value is used as the "goldilocks" value, but the methods are poorly defined. Methods are described as based on grain size and channel dimension - is there a reference for this method? The report says bed lowering would be slow, occurring over decades or longer. Are there references supporting this estimate? We suspect bed lowering as non-linear and episodic, resulting in pulses of bedload moving through the lower reach. The initial bed adjustment near the diversion likely occurring over a much short timeframe with volumes close to the lower bounding volume of 4,400 cu yds.	<u>City Light response in 7/21/2023 email:</u> The 2000 cubic yards/year value was derived using the relationships described in DeVries (2000; DeVries, P. 2000. Scour in low gradient gravel bed streams: patterns, processes, and implications for the survival of salmonid embryos. PhD dissertation. University of Washington.) We agree that bedload transport will likely be an episodic process and pulses of material will move through the system as high flows mobilize the material. If very high flows occur immediately after diversion structure removal, more sediment will be moved than if lower peak flows occur in the years following removal. These same high flows that mobilize the material will have the energy to transport it downstream; note that the stream gradient in the canyon/waterfall reach and alluvial fan (average 5 percent) are higher than gradients in the reach upstream from the diversion (2-3 percent; Figure 3.3-2 and Section 3.3). The timeframe will likely be dependent on the storm events in the years following the diversion dam's removal.
NPS	7/17/2023, Email	7.	<u>NPS comments on the 6/16/2023 version of the geomorphology report:</u> Page 4-15: We did a site visit to assess conditions at the landslide toe last week. We agree that site observations are consistent with the description in the report - essentially armored with large rock and the stream gradient is steep enough to move material through this section, thereby avoiding large accumulations of material from diversion structure decommission. Although the report does state that stability of the slide can't be determined with available information, we agree it is a reasonable conclusion. However, our field crew did observe concrete and rebar from the road in the channel. There is concern about	<u>City Light response in 7/21/2023 email:</u> City Light is in the process of determining the extent and methods needed to clear and stabilize the access road to re-establish access to the diversion dam for decommissioning work. We would like to hear your comments at this time so that any major elements can be incorporated into the design and Road Decommissioning Plan. Early coordination will help to ensure that only minor tweaks and adjustments are needed following your review of the Road Decommissioning Plan. We will

Entity	Date	Comment ID #	Comment	Response
			material from scaling and road stabilization (Hilfiker wall) ending up in channel and impeding flow. Whether it's in the geomorph report or an implementation plan for the decommissioning, we'll want to comment on slope destabilization from activities tied to decommissioning.	setup a meeting soon with our engineers and your staff to discuss your concerns related to scaling and road stabilization.
NPS	7/17/2023, Email	8.	NPS comments on the 6/16/2023 version of the geomorphology report: Page 4-17: We are not sure the relevancy of methods used to determine likelihood of deposition in the alluvial fan reactivating old channels. The report averages total volume of sediment by channel length and determines depth would be below elevations of relict channel on the fan. Averaging of sediment doesn't represent actual river process and could underestimate local bed elevations as pulses of material moves downstream. Is there a reference that supports the approach outlined in the report?	City Light response in 7/21/2023 email: The report's conclusion was guided by information provided in a publication by the National Research Council's Commission on Geosciences, Environment, and Resources, "Alluvial Fan Flooding" (1996). Based on aerial photographs and LiDAR evidence, the Newhalem Creek alluvial fan appears to have characteristics of an incised streamflow "fossil" fan surface. The Newhalem Creek channel does not appear to have occupied many of the relic channels on the fan (Figure 3.3-1) during at least the past hundred or more years based on the mature trees developed on these surfaces (with the exception of distributary channels at the junction with the Skagit River). As such, it is unlikely that the addition of the anticipated 1- to 6.5-times the average annual coarse sediment supply to the Newhalem Creek channel would cause enough aggradation to re-activate the older, elevated channels in the alluvial fan, particularly given the higher average stream gradient in the fan (5 percent) compared to the source reach (upstream from the diversion structure, 2-3 percent). It is anticipated that much of the gravel and cobble would move through the fan and supply sediment to the Skagit River. There is not a specific reference for the computation of total volume of sediment by channel length; this was provided as context to help compare total potential volume of sediment with existing channel dimensions. Reference: National Research Council. 1996. Alluvial Fan Flooding. Washington, DC: The National Academies Press. https://doi.org/10.17226/5364
NPS	8/23/2023, Email	9.	Thanks for those clarifications [see response to comments #6 through #8] we don't have any further technical questions at this time. Will you incorporate those clarifications in the report (as applicable)?	Final report dated October 2023 and filed with FERC includes clarifications as applicable. A highlighted track-change version is attached.

Attachments:

February 16, 2023 Meeting Summary, USFWS and Seattle City Light. (Comment #1)

Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report. October 2023 track change version to highlight revisions based on NPS July 17, 2023 comments. (Comment #9)

Adams, Shelly

From: Adams, Shelly
Sent: Friday, December 23, 2022 5:00 PM
To: Adams, Shelly
Cc: Adams, Shelly
Subject: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705
Attachments: Newhalem Geomorph Report_final.pdf

Good afternoon,

Seattle City Light (City Light) is pleased to provide the attached *Newhalem Creek Dam Decommissioning Geomorphology Considerations* report for the proposed license surrender and decommissioning of the Newhalem Creek Hydroelectric Project (Federal Energy Regulatory Commission (FERC) Project No. 2705). The attached report provides an analysis of the effects of the proposed diversion dam removal on stream geomorphology and aquatic habitat. This report supersedes the October 2021 draft previously filed with FERC on September 28, 2022 and on December 12, 2022. All parties on FERC's service list are included in this distribution of the report.

City Light looks forward to any feedback that you may have. Please provide any comments to me by **January 26, 2023**. Should you have any questions, please feel free to contact me via email or at the phone number listed below.

Sincerely,

Shelly Adams

SHELLY ADAMS
DECOMMISSIONING PROJECT MANAGER
NEWHALEM CREEK HYDROELECTRIC PROJECT | ENVIRONMENTAL, LAND, AND LICENSING BUSINESS UNIT
Seattle City Light
O: 206-684-3117 | M: 425-891-1765 | shelly.adams@seattle.gov
We Power Seattle seattle.gov/city-light

Adams, Shelly

From: Garnett, Jeffrey A <jeffrey_garnett@fws.gov>
Sent: Tuesday, January 31, 2023 11:38 AM
To: Adams, Shelly
Cc: Garnett, Jeffrey A
Subject: RE: [EXTERNAL] Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

Shelly,

I drafted the below comments last week and thought that I had submitted them, but I just found the email below in Drafts folder. Apologies for not getting these comments to you at the deadline; nevertheless, below are USFWS comments on the Newhalem Geomorphology Report.

Thanks for the opportunity to comment on the Newhalem Geomorphology Final Report. USFWS comments are as follows:

- In general, the report seems to accurately characterize what was observed in the field at last year's site visit in terms of grain size and the series of three large boulder grade control features. The assessment of the rate of bed movement following the removal of the diversion dam was lacking specificity, however; no quantification or even estimation of bed load movement over time is made. The report simply states initial movement will occur quickly, but it will be several decades before the creek reaches equilibrium. Furthermore, under future climate projections with increased peak flows, the report simply indicates that bedload transport will occur at an even faster rate. We do not disagree with any of these statements. However, we were expecting analysis quantifying/estimating the transport rates given current peak flows and durations, future flows and duration, and a range of sediment expected to be mobilized annually until equilibrium is reached. Understanding the rate/volume of annual bed load movement would aid in determining if temporary grade control/stream energy dissipation is needed to prevent large movements of sediment. Short of this analysis, we request that Seattle City Light consider installing structures to dissipate energy (e.g. log jams or felling of trees) above the diversion, prior to removal of the structure.
- Related to the rate of bed movement, sub-surface D84 (183mm) is reported being smaller than surficial D84 (290-326mm). Assuming the sub-surface samples are an accurate representation of what lies beneath, would we expect the volume of bedload transport to increase over time?

Thanks, and please let me know if you have any questions.

Jeff

Jeffrey Garnett
U.S. Fish and Wildlife Service | Lacey, WA
jeffrey_garnett@fws.gov
360-701-6838
(he/him/his)

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Friday, December 23, 2022 5:00 PM

To: Adams, Shelly <Shelly.Adams@seattle.gov>
Cc: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: [EXTERNAL] Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.

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Sincerely,

Shelly Adams

SHELLY ADAMS
DECOMMISSIONING PROJECT MANAGER
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Seattle City Light
O: 206-684-3117 | M: 425-891-1765 | shelly.adams@seattle.gov
We Power Seattle seattle.gov/city-light

Adams, Shelly

From:	Adams, Shelly
Sent:	Friday, February 3, 2023 10:36 AM
To:	Ashley Rawhouser
Subject:	RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

Hi Ash,

Following up with you to see if you had any comments on the final geomorphology report. Have a great weekend,

Shelly

From: Adams, Shelly
Sent: Friday, December 23, 2022 5:00 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Cc: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

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We Power Seattle seattle.gov/city-light

Adams, Shelly

From: Applegate, Brock A (DFW) <Brock.Applegate@dfw.wa.gov>
Sent: Friday, February 3, 2023 12:26 PM
To: Adams, Shelly
Subject: RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

CAUTION: External Email

Hi Shelly, WDFW does not really have anything to add. Our geomorphologist said, "The report is thorough and appropriate for the study. It considers future climate, and the projected river responses seem reasonable."

Have A Great Weekend, Brock

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Friday, February 3, 2023 10:38 AM
To: Applegate, Brock A (DFW) <Brock.Applegate@dfw.wa.gov>
Subject: RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

External Email

Hi Brock,

Following up on the email below... Will you or your geomorphologist be providing comments today?

Thanks,

Shelly

From: Applegate, Brock A (DFW) <Brock.Applegate@dfw.wa.gov>
Sent: Friday, January 27, 2023 4:32 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

CAUTION: External Email

Thanks Shelly, I will relay that message.

Sincerely, Brock

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Friday, January 27, 2023 12:41 PM
To: Applegate, Brock A (DFW) <Brock.Applegate@dfw.wa.gov>
Subject: Re: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

External Email

Yes, but please provide it as soon as possible next week.

From: Applegate, Brock A (DFW) <Brock.Applegate@dfw.wa.gov>
Sent: Friday, January 27, 2023, 12:08 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

CAUTION: External Email

Hi Shelly, I have our geomorphologist reviewing the Geomorphology Report. Could we turn in some comments next week?

Sorry about the Delay, Brock

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Friday, December 23, 2022 5:00 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Cc: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

External Email

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Sincerely,

Shelly Adams

SHELLY ADAMS
DECOMMISSIONING PROJECT MANAGER
NEWHALEM CREEK HYDROELECTRIC PROJECT | ENVIRONMENTAL, LAND, AND LICENSING BUSINESS UNIT

From:	Adams, Shelly
To:	Garnett, Jeffrey A
Subject:	RE: [EXTERNAL] Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705
Date:	Tuesday, February 7, 2023 1:49:00 PM
Attachments:	image001.png

Hi Jeff,
Thank you again for your comments below. It would be helpful if we could meet to answer your questions and get clarity on your concerns. I would have Kathy Dube, our geomorphologist, and Becky Holloway, our biologist who prepared the BA, in attendance. Are there good days/timeframes for you next week, or could I send you a Doodle poll to identify a good date for all of us?
Thanks,
Shelly

SHELLY ADAMS
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From: Garnett, Jeffrey A <jeffrey_garnett@fws.gov>
Sent: Tuesday, January 31, 2023 11:38 AM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
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Subject: RE: [EXTERNAL] Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

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- Related to the rate of bed movement, sub-surface D84 (183mm) is reported being smaller than surficial D84 (290-326mm). Assuming the sub-surface samples are an accurate representation of what lies beneath, would we expect the volume of bedload transport to increase over time?

Thanks, and please let me know if you have any questions.
Jeff

Jeffrey Garnett
U.S. Fish and Wildlife Service | Lacey, WA
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From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Friday, December 23, 2022 5:00 PM
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Sincerely,
Shelly Adams

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We Power Seattle seattle.gov/city-light

Seattle City Light

MEETING SUMMARY

NEWHALEM CREEK HYDROELECTRIC PROJECT
SURRENDER OF LICENSE AND DECOMMISSIONING

Date: February 16, 2023
Time: 3:00-4:10 p.m.
Location: Microsoft Teams

MEETING PURPOSE

- Respond to questions and comments from USFWS on the *Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report*.
- Provide clarification and information to support USFWS' project understanding.

ATTENDEES

Jeff Garnett, USFWS
Shelly Adams, City Light
Aaron Couch, City Light
Scott Luchessa, City Light
Kathy Dubé, Watershed GeoDynamics
Nancy Craig, HDR
Becky Holloway, HDR

AGENDA

1) Introductions

Personal introductions all around.
Shelly introduced the agenda, and encouraged dialogue and questions.
The current version of the BA is available with the December 2022 AIR response filing.

2) Kathy summarizes geomorphology report findings.

- Kathy shared her screen to present slides.
- Kathy said she read Jeff's comments on *Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report* (report) to be related to concern for the Newhalem Creek reach below the 100' waterfall extending into the alluvial fan where Newhalem Creek enters Skagit River.
- Kathy presents a photograph typical of this stream reach and summarizes that Jeff's questions relate to what is going to happen to this habitat.
- Kathy explains that following removal of the diversion dam, the streambed upstream of the diversion will become armored with larger material over the top of the smaller material that is protected and stabilized until large flow events move the armoring.
- Kathy summarizes the stream profile and potential profile changes with a graph from the report. She notes that there are some large boulders in the stream upstream of the diversion dam.

- Upon dam removal, the bed immediately upstream will begin to adjust to the new base level that will be controlled by the bedrock underlying the dam. Most material that will be moved out is sitting just upstream of the dam at this time in. There is a sediment wedge that will move out upon dam removal.
- The report estimated a lower, upper, and middle bound of transport load, estimated at 4,000 cy, 9,000 cy, and 12,900 cy.
- Kathy calculated under what flows sediment movement would occur given what we know about the grain size in the armored layer.
- Probably the wedge behind the dam will move quickly and soon after dam removal. But then armoring would re-occur and a higher flow would be needed for more sediment movement to occur.
- Kathy explained that the past annual maintenance activity is representative and typical of how the sediment would transport initially after dam removal.
- Jeff asked whether Kathy was thinking about what would happen in first 1.5 years before equilibrium occurs.
- Kathy said she thinks the wedge behind dam will not go all at once, and that there will be a few flushes from the wedge, probably in the first fall/winter after dam removal. It probably will take several years to mobilize all the material; but that does depend on what flows are experienced immediately after removal.

3) City Light summarizes determination of effects presented in the Biological Assessment (BA)

- Becky said that few individual fish have been collected in Newhalem Creek. It does not seem heavily used. But it is accessible, suitable habitat for bull trout.
- The BA conservatively postulates that there is likelihood of effect, but probably not jeopardy.
- Becky said it does not seem that dam removal would deliver smothering materials.
- Jeff said the determinations in the BA make a lot of sense to him.
- Jeff asks about short-term adverse effects. What will the take statement look like? How many seasons of the sediment pulses will produce adverse effects? Jeff says he is also looking for more education on the grain sizes and lack of turbidity. Will the sub-armored material include fines in the interstitial space?
- Becky said any fines will not settle out in Newhalem Creek. They will move through.
- Kathy said the results of the sediment sampling were 11% sand and less than 1% silt and clay. This makes sense in the Skagit gneiss geologic formation. There is not a lot of fine grain in this system. Landslide fine-grained material, when landslides occur, move out very quickly.
- Shelly described the annual gravel maintenance activities. Turbidity was monitored during this maintenance; and the creek would return to 1 NTU over baseline within 2 hours after the gravel was placed in the stream.
- Kathy said this information is in the report.
- Becky said there is some discussion in BA, and the report is a good source.
- Scott said the work he has done on Newhalem Creek had the same outcome - return to baseline turbidity in a very short time.
- Jeff asked how many large pulses can we expect? Kathy says one big one when coffer dams are removed. This will occur at low flow. Then it will stabilize. And then a fall or winter flow will move a little more, and re-armoring will occur. In the first year after

removal, there will be a few pulses probably. And if there is a very high flow in that first winter, it would be bringing a lot of material from upstream of the dam removal site. This system is supply-limited under most flow conditions. It takes a high flow event or a landslide to provide material to be moved.

- To answer how many pulses, Kathy says it will depend on flows in the time after removal. And if we think about how it will disperse and deposit, it will be hard to discern downstream. And there are benefits of moving gravels down Newhalem and into the Skagit River. There could be several flushes in the months after the removal; it depends on what flows occur.
- Jeff acknowledges that it is hard to predict what the environment will do in the time immediately after removal. The long-term benefit of gravel is a good. But Jeff is grappling with any short-term negative impacts as he thinks about writing the BO.
- Kathy says the wedge will adjust with each higher flow, and these flows will come further and further apart in time – a logarithmic decay process.
- Jeff says what is the point in time when Newhalem Creek starts "acting like a normal stream"?
- Shelly summarizes that Jeff is looking for information to prepare the incidental take statement. She says that the qualitative information is available as described, but quantifying data is harder to develop.

4) Respond to USFWS Question:
Related to the rate of bed movement, sub-surface D84 (183mm) is reported being smaller than surficial D84 (290-326mm). Assuming the sub-surface samples are an accurate representation of what lies beneath, would we expect the volume of bedload transport to increase over time?

- Kathy addressed this above, when she explained that the streambed will become armored with larger material over the top of the smaller material that is protected and stabilized until large flow events move the armoring.

5) Discuss USFWS Comment:

We were expecting analysis quantifying/estimating the transport rates given current peak flows and durations, future flows and duration, and a range of sediment expected to be mobilized annually until equilibrium is reached. Understanding the rate/volume of annual bed load movement would aid in determining if temporary grade control/stream energy dissipation is needed to prevent large movements of sediment.

- Jeff says this question in the email was related to expecting to see quantities in the material to be moved under normal and maybe extreme climate scenarios. But he sees the challenge. He says he thinks he can work with the information available in the BA, the report, and the information Shelly will send to him from the past gravel maintenance events.
- Kathy said that quantifying bedload transport rates would require modeling and several years of sampling for calibration. The model will not provide an answer - would only be an estimate and wouldn't necessarily reflect what would actually happen. There likely would be disagreement among the parties on interpreting the results. Also, to determine future flows, it is unclear which future climate change scenario should be used.

- Kathy explains some specific challenges of quantification. Hydraulic models of moving water are fairly simple. But the sediment becomes problematic in theses supply-limited systems. How do you do accounting of how much sediment is mobilized. There are spreadsheets and models, but the predictions vary wildly. If you need to know for sure, you have to calibrate a model with actual measured volumes moved based on data collected under known conditions over a couple years at a minimum. Shelly says we would rather not do this effort for such an uncertain result, especially in the context of 6,000 – 12,000 cy bounds. Even if it all went at once, it would not be different from a common landslide event.
- Shelly asks about the discussion during the field visit about inserting log jam in the stream – what questions Jeff still has. Jeff says he does not remember where it was left at the field visit and he would like City Light to entertain this. But it is just a 13,000 cy question, so he won't hang his hat on it.
- Shelly agrees dropping logs and maybe other materials into the stream was discussed during the field visit as a possible mitigation for dam removal. However, when working on the FERC AIR response, City Light gathered and vetted more details: maintenance, concept of designed to fail but at a certain time and not before. And risks were identified. It would be a responsibility for City Light to manage the stream. And it would be a continuation of disrupted stream dynamics. City Light stepped back from the log jam concept after looking further into it.
- Jeff agrees that the challenges with a logjam are significant.

6) Discuss effects to fish and resulting data needs.

- Shelly asks what are the effects we are trying to ameliorate – Turbidity? Smothering?
- Jeff says it is both - both are plausible pathways to an adverse effect. Turbidity resulting in gill trauma or other harms, but also smothering of redds.

7) Conclusion/action items.

- Jeff asks for a reminder on the timeline. Shelly said FERC has a schedule to issue a draft EA in March or April. But this is FERC's schedule and not certain.
- Jeff requests the information from the annual sediment/gravel placement. He can use that for writing his piece BO and take statement. And he may want to meet with Shelly and Becky in the next month or so to talk about the BA. The BO will not be a copy and paste, but Jeff can use information from the sources discussed.

ACTION ITEMS:

- Kathy and Shelly to finalize the report based on the sediment information in the current version. No additional quantification will be attempted or included.
- Shelly to send Jeff annual gravel maintenance activities reports. (Sent March 2, 2023.)
- Shelly, Becky, and Jeff to schedule a meeting to discuss the BA. NOAA will also be invited. (Meeting held August 28, 2023.)

Adams, Shelly

From: Adams, Shelly
Sent: Wednesday, February 15, 2023 7:59 PM
To: Ashley Rawhouser
Subject: RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

Ashley,

Checking in to see if you had any comments on the final geomorphology report. Hope all is well!

Thanks,

Shelly

From: Adams, Shelly
Sent: Friday, December 23, 2022 5:00 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Cc: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

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Sincerely,

Shelly Adams

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Adams, Shelly

From: Adams, Shelly
Sent: Thursday, February 23, 2023 2:38 PM
To: Ashley Rawhouser
Subject: RE: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

Hi Ashley,

We have not filed the report yet with FERC as we'd like to work with you to resolve your comments before filing. Could you please provide them to me? We will attach your comments when we file the report with FERC.

Thanks,

Shelly

From: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>
Sent: Thursday, February 16, 2023 8:14 AM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: Re: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

CAUTION: External Email

Hi Shelly,

We do have comments. Been focusing on DLA for Skagit project. We will likely be submitting them to FERC. I'll send you a copy when we get everything ready.

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Wednesday, February 15, 2023 7:58 PM
To: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>
Subject: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

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Ashley,

Checking in to see if you had any comments on the final geomorphology report. Hope all is well!

Thanks,

Shelly

From: Adams, Shelly
Sent: Friday, December 23, 2022 5:00 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Cc: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

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City Light looks forward to any feedback that you may have. Please provide any comments to me by **January 26, 2023**. Should you have any questions, please feel free to contact me via email or at the phone number listed below.

Sincerely,

Shelly Adams

SHELLY ADAMS
DECOMMISSIONING PROJECT MANAGER
NEWHALEM CREEK HYDROELECTRIC PROJECT | ENVIRONMENTAL, LAND, AND LICENSING BUSINESS UNIT
Seattle City Light
O: 206-684-3117 | M: 425-891-1765 | shelly.adams@seattle.gov
We Power Seattle seattle.gov/city-light

Adams, Shelly

From: Garnett, Jeffrey A <jeffrey_garnett@fws.gov>
Sent: Thursday, March 2, 2023 3:17 PM
To: Adams, Shelly
Subject: RE: [EXTERNAL] Gravel Passage Monitoring Notes - Newhalem Creek

Thanks for this, Shelly! I will review this and the other geomorph/sediment related info and reach out to you, Becky, and Kathy in the coming weeks. Obviously, don't hesitate to reach out before then if something comes up. Thanks again!

Jeff

Jeffrey Garnett
U.S. Fish and Wildlife Service | Lacey, WA
jeffrey_garnett@fws.gov
360-701-6838
(he/him/his)

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Thursday, March 2, 2023 10:25 AM
To: Garnett, Jeffrey A <jeffrey_garnett@fws.gov>
Subject: [EXTERNAL] Gravel Passage Monitoring Notes - Newhalem Creek

Hi Jeff,

Thank you again for meeting with us regarding your comments on the final geomorphology report. We found the meeting very helpful in understanding your interests and hope that you left with a fuller understanding of the project and its effects. At your request, I'm attaching a summary of our gravel passage monitoring notes since 2012.

It sounded like it would be helpful to meet again in a few weeks with Becky, Kathy, and I to assist with information needed to prepare the BO, so please let me know when you'd to set that up. In the meantime, feel free to reach out with any further questions or information requests.

Sincerely,

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From:	Adams, Shelly
To:	Ashley Rawhouser
Subject:	RE: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705
Date:	Monday, April 10, 2023 9:59:00 AM
Attachments:	image001.png

Hi Ashley,
I meant to follow up with you earlier on this, but I've had a long absence due to unanticipated medical leave. Has the NPS completed their comments on the final geomorphology report? We would like to file the report with FERC soon.
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Sent: Thursday, February 23, 2023 2:38 PM
To: Ashley Rawhouser <Ashley_Rawhouser@nps.gov>
Subject: RE: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

Hi Ashley,
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SHELLY ADAMS

DECOMMISSIONING PROJECT MANAGER

NEWHALEM CREEK HYDROELECTRIC PROJECT | ENVIRONMENTAL, LAND, AND LICENSING BUSINESS UNIT

O: 206-684-3117 | M: 425-891-1765 | shelly.adams@seattle.gov

We Power Seattle seattle.gov/city-light

From:	Rawhouser, Ashley K
To:	Adams, Shelly
Subject:	Re: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705
Date:	Thursday, April 20, 2023 3:32:24 PM
Attachments:	image001.png

CAUTION: External Email

Hi Shelly,

We've completed our review. Unfortunately, the relicense has really tied up my time and now we are focused on completing the USR review and comments. Can we schedule a meeting in May?

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Thursday, April 20, 2023 2:37 PM
To: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>
Subject: RE: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

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Let me know what works best for you.

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Subject: RE: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

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Cc: Adams, Shelly <Shelly.Adams@seattle.gov>
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SHELLY ADAMS
DECOMMISSIONING PROJECT MANAGER
NEWHALEM CREEK HYDROELECTRIC PROJECT | ENVIRONMENTAL, LAND, AND LICENSING BUSINESS UNIT

From: Adams, Shelly
To: Ashley Rawhouser; Sharon White; rob_burrows@nps.gov; mike_larrabee@nps.gov; Dube, Kathy; Couch, Aaron; Craig, Nancy; Holloway, Becky E.
Subject: Review Final Geomorph Report: Newhalem Creek

Please join me in reviewing the final geomorphology report for decommissioning the Newhalem Creek Hydroelectric Project.

A high-level agenda is proposed below, but we can update if before the meeting if folks at the NPS would like to provide discussion topics.

1. Introductions
2. SCL summarize geomorphology report findings
3. Discuss NPS' thoughts, concerns, ideas, and/or questions
4. Conclusion/Action items

Microsoft Teams meeting

Join on your computer, mobile app or room device

Click here to join the meeting <https://teams.microsoft.com/l/meetup-join/19%3ameeting_Nzc5MDRmMzktYjgyYS00ZjlkLTg0MGQtMDMwYWYyZjlkNDcy%40thread.v2/0?context=%7b%22Tid%22%3a%2278e61e45-6beb-4009-8f99-359d8b54f41b%22%2c%22Oid%22%3a%228dba4305-50af-48d9-b418-1ad006577676%22%7d>

Meeting ID: 252 523 445 287
Passcode: rDnvvE

Download Teams <https://www.microsoft.com/en-us/microsoft-teams/download-app> | Join on the web <https://www.microsoft.com/microsoft-teams/join-a-meeting>

Join with a video conferencing device

seattle@m.webex.com <mailto:seattle@m.webex.com>

Video Conference ID: 117 048 862 1

Alternate VTC instructions <https://www.webex.com/msteams?confid=1170488621&tenantkey=seattle&domain=m.webex.com>

Or call in (audio only)

+1 206-686-8357,,687863199# <tel:+12066868357,,687863199#> United States, Seattle

Phone Conference ID: 687 863 199#

Find a local number <https://dialin.teams.microsoft.com/f83dfb2b-53ff-4047-97f1-69d51d7a2b36?id=687863199> | Reset PIN <https://dialin.teams.microsoft.com/usp/pstnconferencing>

Learn More <https://aka.ms/JoinTeamsMeeting> | Meeting options <https://teams.microsoft.com/meetingOptions/?organizerId=8dba4305-50af-48d9-b418-1ad006577676&tenantId=78e61e45-6beb-4009-8f99-359d8b54f41b&threadId=19_meeting_Nzc5MDRmMzktYjgyYS00ZjlkLTg0MGQtMDMwYWYyZjlkNDcy@thread.v2&messageId=0&language=en-US>

From:	Adams, Shelly
To:	Garnett, Jeffrey A
Subject:	RE: Gravel Passage Monitoring Notes - Newhalem Creek
Attachments:	image001.png

Hi Jeff,
I hope all is well with you. I've been on a bit of unexpected medical leave, so I apologize for not following up with you sooner… The last time we met, we had discussed setting up a meeting to assist with anything you may need in preparation of the BO. Would you like me to set that up with you? Should we include David Price?
Thanks,
Shelly

SHELLY ADAMS
DECOMMISSIONING PROJECT MANAGER
NEWHALEM CREEK HYDROELECTRIC PROJECT | ENVIRONMENTAL, LAND, AND LICENSING BUSINESS UNIT
O: 206-684-3117 | M: 425-891-1765 | shelly.adams@seattle.gov
We Power Seattle seattle.gov/city-light

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It sounded like it would be helpful to meet again in a few weeks with Becky, Kathy, and I to assist with information needed to prepare the BO, so please let me know when you'd to set that up. In the meantime, feel free to reach out with any further questions or information requests.
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Adams, Shelly

From: Adams, Shelly
Sent: Wednesday, May 10, 2023 4:37 PM
To: Craig, Nancy
Subject: FW: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

From: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>
Sent: Wednesday, May 10, 2023 4:29 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: Re: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

CAUTION: External Email

Thanks Shelly. Agree with what you have lined out. Unfortunately I'll have to cut out at 2PM. Sorry not much time for me to prep for this one. Agree on need for future meetings.

Sent from mobile phone

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Tuesday, May 9, 2023 9:50:32 AM
To: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>
Subject: RE: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

Ashley,

No problem… I had a procedural question for FERC regarding their expectations on the timing of the final geomorphology report since comments were due on January 26. FERC expressed an interest in seeing the report soon but preferred that we continue to reach out and resolve any comments if possible before filing. FERC is not aware of our upcoming meeting so has no expectations of it. The purpose of our upcoming meeting is to facilitate resolution of any comments or concerns in the easiest way possible considering your and your staff's workload. We recognize that further meetings, exchanges, and actions may be necessary, however.

I respect your concerns about SCL providing a summary of the NPS' concerns to FERC. Thus, during the meeting, and for any follow-up meetings, we will take detailed notes of the NPS' comments and resultant discussion. We will provide you the meeting minutes and a summary of resolution for review before filing with FERC (as an appendix to the report).

I hope that eases your mind. Again, if you can jot down any discussion points beforehand, we would appreciate the opportunity to prepare for a thoughtful discussion on Thursday.

Thanks,

Shelly

From: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>
Sent: Monday, May 8, 2023 11:10 AM
To: Adams, Shelly <Shelly.Adams@seattle.gov>
Subject: Re: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

CAUTION: External Email

Can you share the communication with FERC about what they would like to see as an outcome from our meeting on Thur? I'm nervous about SCL providing a summary of our concerns directly to FERC.

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Thursday, April 20, 2023 2:37 PM
To: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>
Subject: RE: [EXTERNAL] RE: Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report, FERC Project No. 2705

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Cc: Adams, Shelly <Shelly.Adams@seattle.gov>
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We Power Seattle seattle.gov/city-light

From:	Adams, Shelly
To:	Ashley Rawhouser; rob_burrows@nps.gov; mike_larrabee@nps.gov; Sarrantonio, Sharon M
Cc:	Dube, Kathy; Couch, Aaron; Craig, Nancy; Holloway, Becky E.; Luchessa, Scott
Subject:	RE: Review Final Geomorph Report: Newhalem Creek
Date:	Wednesday, May 17, 2023 12:00:00 PM
Attachments:	NPS_SCL_Geomorphology Meeting Summary Draft_051123.docx Newhalem Geomorphology Presentation 2023-05-11 NPS.pdf image001.png

Hi all,

Thank you again for meeting to discuss the final geomorphology report. I've attached the meeting summary for your review. Please let me know if anything is missing or requires correction.

The meeting summary outlines three main topics that the NPS is interested in evaluating further. There was also a request to integrate information from the Golder Report into the geomorphology report. We will update the geomorphology report accordingly and will provide you the updated report for review. We're targeting the first week of June. The NPS can then decide whether we need follow-up meetings.

Thanks again for working with us to finalize this report!

Shelly

SHELLY ADAMS
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Seattle City Light

DRAFT MEETING SUMMARY

NEWHALEM CREEK HYDROELECTRIC PROJECT
SURRENDER OF LICENSE AND DECOMMISSIONING

Date: May 11, 2023
Time: 1:00-3:00 p.m.
Location: Microsoft Teams

MEETING PURPOSE

- Opportunity for NPS to provide comments, concerns, ideas from NPS on the *Newhalem Creek Dam Decommissioning Geomorphology Considerations, Final Report* (Geomorphology Report).
- Provide clarification and information to support NPS' project understanding.
- Work toward resolution on any NPS concerns.

ATTENDEES

Rob Burrows, NPS
Mike Larrabee, NPS
Ashley Rawhouser, NPS (left the meeting at 2:00 PM)
Sharon Sarrantonio, NPS
Shelly Adams, City Light
Aaron Couch, City Light
Scott Luchessa, SCL (joined the meeting at 1:30 PM)
Kathy Dubé, Watershed GeoDynamics
Nancy Craig, HDR
Becky Holloway, HDR

MEETING MATERIALS (ATTACHED)

Geomorphology Report PowerPoint slides

AGENDA

1) Introductions/ice breaker
Shelly opened the meeting and attendees introduced themselves.
This meeting is an informal way for NPS to provide comments on the Geomorphology Report. SCL will draft a meeting summary and provide it to all attendees for review before finalizing and including in the record.
Today's purpose is for SCL to hear NPS comments on the Geomorphology Report.
There will likely be follow-up meetings, with SCL's ultimate goal being to resolve concerns which may include making agreed-upon revisions to the Geomorphology Report based on NPS comments, and then file the Geomorphology Report with FERC along with any comments and resolutions.
Shelly offered that Kathy is prepared with a summary presentation of the Geomorphology Report.

2) SCL summary of Geomorphology Report findings:

- Kathy Dube presented a summary of the Geomorphology Report. PowerPoint Slide presentation attached.
- Mike asked what the boulder size is on the Newhalem Creek alluvial fan. Kathy said the boulders near the road/bridge crossing were observed to be approximately 2-feet diameter. She said no pebble count was conducted in this area.
- Ashley asked if it is standard to have smaller material underneath a surface armor layer of larger material. Kathy said this is typical of cobble-gravel streams in the Northwest.
- Ashley asked what flows would be needed to move D_{50} boulders. Kathy refers to a later slide – Estimate of Discharge to Mobilize Surficial Substrate.
- Ashley said atmospheric river events are projected to be large, unpredictable, and watershed specific; what error bars are needed to capture the currently projected range of climate change effects? Kathy said there seems to be large error bars on most climate change data; a climate change expert perhaps could speak more specifically to error bars and confidence in the data, but the chart represented average peak flow changes according to the models.
- Kathy says the upper bound estimate of potential profile change after dam removal is 12,900 cubic yards; and this is similar to the estimated average annual bedload for Newhalem Creek of 11,500-17,000 cubic yards. Kathy confirmed the average annual bedload data come from the Skagit Relicensing GE-04 Geomorphology Report.
- Ashley asked what the physical features are at 900-1,000 feet upstream of the dam. Kathy said there is a side-channel in this location and the stream bed is less confined than locations immediately upstream.
- Regarding potential for incision, the Geomorphology Report examines bed-lowering profile changes as seen on slide 15 from the PowerPoint presentation.
- Estimate of Discharge to Mobilize Surficial Substrate – D_{50} grain size will typically move every year on stream gradients of 1.3-3.9%. Flows that would move D_{84} grain size would occur less frequently.
- Kathy said the total material volume projected to be moved as a result of dam removal is likely less than what moves downs Newhalem Creek in a large flow event.
- Mike asked if the same bed material is expected to be present above and below the dam. Kathy said gradient will be the major factor for bed material; and the gradient is much steeper immediately below the dam than above so grain size would be larger (boulder step pool area).
- [Jump to Agenda Item 3 before Ashley has to leave the meeting.]

3) NPS provide comments on Geomorphology Report

- Ashley said the Geomorphology Report does a good job at describing transport and downcutting. He asked to look at the Potential Profile Changes slide. Ashley said the dashed blue line is "worst case" and asked where the 5-foot profile change is projected to occur. Kathy said it is at approximately 600 feet – which is probably where build-up has occurred behind the large boulders at 300 feet.
- Ashley said he thinks the most likely profile change outcome will be the middle line. Shelly added that the middle line assumed the natural grade control was eliminated or somehow didn't function.
- Ashley asked what would produce the worst-case scenario? Something more dramatic than the loss of the grade control at 300 feet upstream from the Newhalem dam? Kathy said the

"worst-case" is not likely and the scenario would be that the grade control at 300 feet would be lost and the river would grade to a flat profile up to the upper grade control boulders. Kathy explained the creek has not exhibited a flat profile in the past prior to the dam and referenced the 1920 profile.

- Ashley said the September 2022 site visit was helpful to see the existing grade control in the stream at 300 feet.
- Ashley asked if we could talk about the alluvial fan – what effects will be at this location?
- Mike said a concern is the Newhalem Creek delta building up and pushing material toward the north shore of the Skagit River. Skagit flow management may not move this material if it starts to build up in this way. Kathy referenced the geomorphology information prepared for Skagit River Project relicensing (GE-04 Updated Study Report) and said important context for this consideration is that the "worst-case" scenario in the Newhalem Decommissioning Geomorphology Report is a similar volume to the estimated average annual cobble/gravel load in Newhalem Creek. Kathy said she can develop some explanations of potential effects on the alluvial fan.
- Ashley said NPS and the Skagit relicensing groups are talking about when the sediment load will come from Newhalem and how it might be coordinated with a pulse flow in the Skagit.
- [Ashley leaves the meeting.]
- Mike said regarding the interplay at the landslide that is affecting the access road: There is some information in the Golder report. The landslide is not stable and may be reactivated to create a new source of material in Newhalem Creek if the Creek undermines the toe of the slope. What will the dam removal do to the toe of the landslide in Newhalem Creek? Will it be an additive effect to the landslide effect? Kathy said the report can be revised to address this.
- Sharon said we need to understand the base levels of the old channels on the terrace in the Newhalem Creek alluvial fan. Where Newhalem Creek exits the confined reach onto the terrace, will the dam removal result in reactivation of the old channels? Kathy said the Geomorphology Report can be revised to look at the heights of the old channels and how much fill would have to occur to re-activate them.

4) SCL summary of Geomorphology Report findings – Kathy completes presentation

- Kathy presented on turbidity resulting from dam removal.
- Sharon asked about step pool information. She asked if a big pulse of sediment upon dam removal could potentially clog the step pools. Kathy said past annual gravel passage occurred during low flow, and the sediment moved immediately through the step pools; since dam removal would also occur at low flow, a worst-case scenario could result in a few months' time before the pools are cleared. Sharon will review Geomorphology Report Section 4.6.2 and follow-up with any further questions on step pools.
- Rob asked where the step pools were. Kathy said the Tribes have not shared specific locations of the step pools of interest to them, but that step pools are present above and likely also below the waterfall.
- Mike asked about the large boulders – will they get stuck in the step pools? Kathy said some boulders are moving through the system with or without the dam. Shelly asked about the dynamic process of step pools. Kathy said the step pools above the falls may have formed by a landslide that deposited large talus material, and the stream with or without the dam passes material through the step pools.

- Mike asked about SCL's gravel removal activities. Shelly said it was a maintenance activity when the Newhalem Project was operational, pre-1997 license, to keep the intake functioning; then it became a license requirement in 1997 for resource purposes (moving gravel downstream for habitat) and operational purposes.
- Rob would like to understand how much material will be released upon dam removal compared to what typically moves through the system, and what are the margins of error on those estimates. Shelly says the project is designed as "run-of-the-river" meaning there is little to no reservoir. The forebay fills with cobble and gravel nearly every year, at least every two years; material moves over the dam once the dam has filled. Additional information can be added to the Geomorphology Report on this topic.

5) Discussion

- Rob asked Shelly to provide a refresher on Newhalem Decommissioning schedule and process. Shelly said FERC has control over much of the schedule. FERC provided in the Notice of Surrender of License Application that the draft EA would be issued in March 2023. However, FERC may be waiting for the submission of the Geomorphology Report before issuing the draft EA.
- Shelly said there do not appear to be any major disagreements on the Geomorphology Report, and that SCL will be able to address the questions and comments NPS has voiced in today's meeting in an update to the Geomorphology Report.
- FERC will issue draft EA, final EA, and then the decommissioning Order. SCL will work on engineering design and permitting as decommissioning details are confirmed. Meanwhile, SCL is conducting ESA and Section 106 consultation. There are similarities to a construction project, with an overlay of a FERC proceeding. SCL's ideal schedule would be to decommission in 2025, but that window may be closing. The next few months may bring more clarity to the schedule, and SCL will coordinate with NPS as the process moves forward.
- Rob asked about road vs helicopters, and whether the road will have to be repaired to do the dam removal. Shelly said intervenors did not support the helicopter option. So, the road will be minimally repaired to make for safe passage during dam removal.
- Sharon asked for more information on the road and any repairs to it, and how will the road area be restored after dam removal. Shelly said the road will continue to be maintained up to the emergency evacuation location. Beyond that, the proposal is for the roadbed to be roughened and loosened after decommissioning and the culverts removed.
- Shelly said for construction access, the slope will be scaled, and the road graded as needed for worker safety just before the dam removal, which will occur at low flow time of year (August/September). The goal is a minimum amount of work to provide road access. After dam removal, the roadbed will be roughened and loosened. SCL plans to talk with NPS about seeding or planting. Sharon said this is of interest to NPS; it has impacts to drainage and the watershed. Shelly said, at this time, SCL is waiting for FERC to issue the EA to learn what the scope of decommissioning will be before getting into detailed restoration discussions, but discussions will definitely happen. Aaron said conversations with NPS about details will occur after the official scope of decommissioning is more certain.

6) Conclusion/next steps/action items

- Shelly recapped three comments on the Geomorphology Report that need follow-up:

    - SCL to develop some explanations of potential effects of Newhalem decommissioning on the alluvial fan at the mouth of Newhalem Creek in the Skagit River.
    - SCL to develop some information about the effects of decommissioning on the toe of the existing landslide. Will dam removal be an additive effect to the landslide effect?
    - SCL to evaluate the old channels on the alluvial fan and estimate how much fill would have to occur to re-activate them.
    - Mike added that regarding the landslide and other information in the Golder report such as slope stability, SCL may want to pull more information into the Geomorphology Report from the Golder report where it is applicable. Shelly will think about how to integrate Golder's information into Kathy's report. Shelly reminded everyone that the Golder report was prepared in anticipation of Newhalem relicensing, not decommissioning; it explores ways in which road access would be achieved and maintained over time, rather than assuming that the road will be removed from service above the emergency evacuation elevation.
- Shelly proposed that SCL provide a response to the comments received at the meeting today in the form of a revised Geomorphology Report or an Appendix. NPS will be provided with the new materials for review and can decide if SCL and NPS should meet again.
- Rob and Mike said they will defer to Ashley, but this loose plan is good for now.
- Shelly thanked NPS for meeting and feedback. NPS thanked Shelly for the meeting.

NEWHALEM CREEK HYDROELECTRIC PROJECT

Final Geomorphology Report Summary

May 11, 2023 NPS Meeting

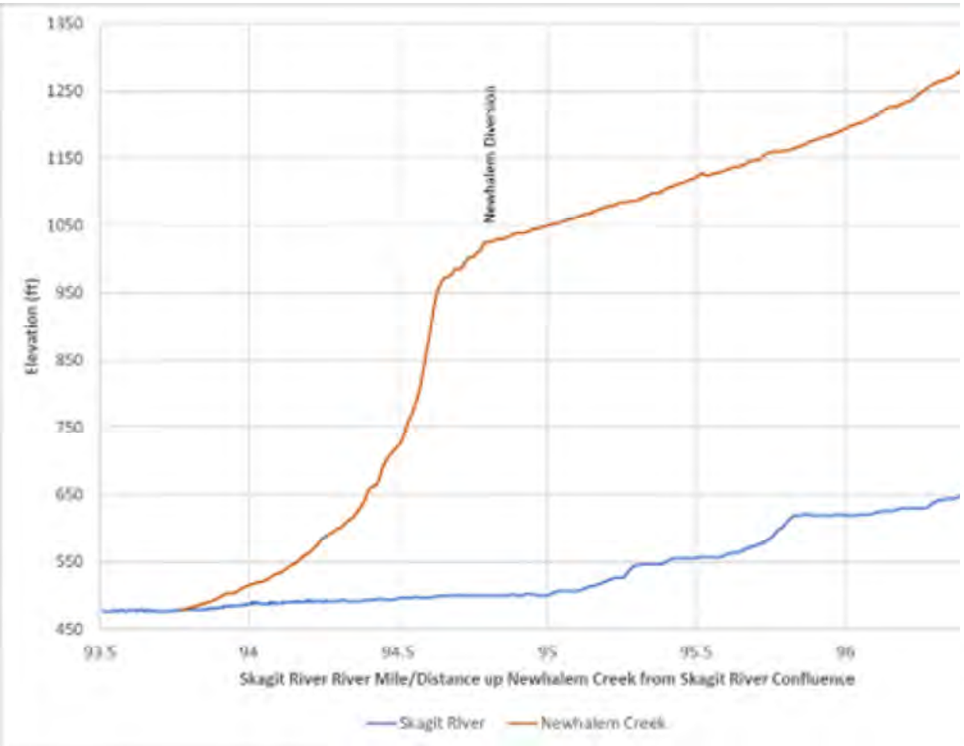
NEWHALEM CREEK HYDROELECTRIC PROJECT

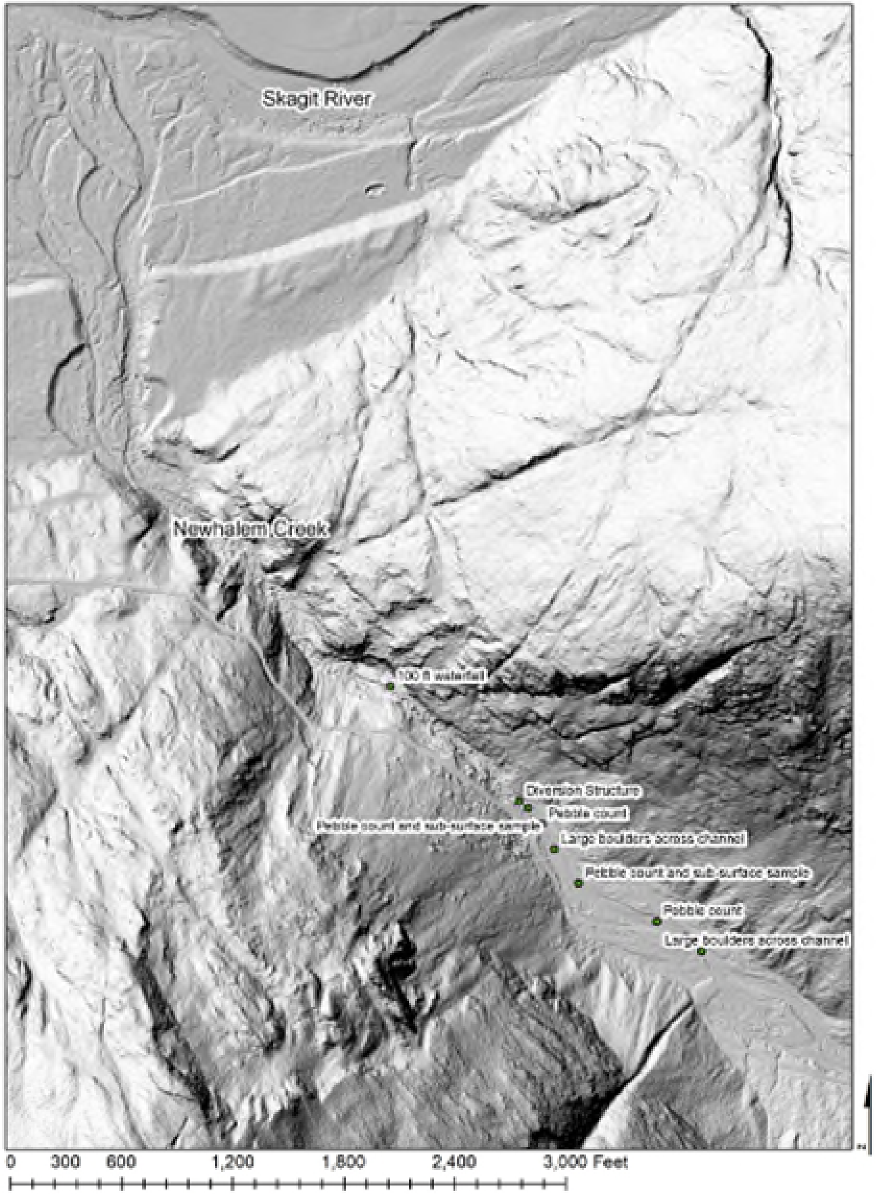
(FERC No. 2705)

POTENTIAL GEOMORPHIC EFFECT CONCERNS

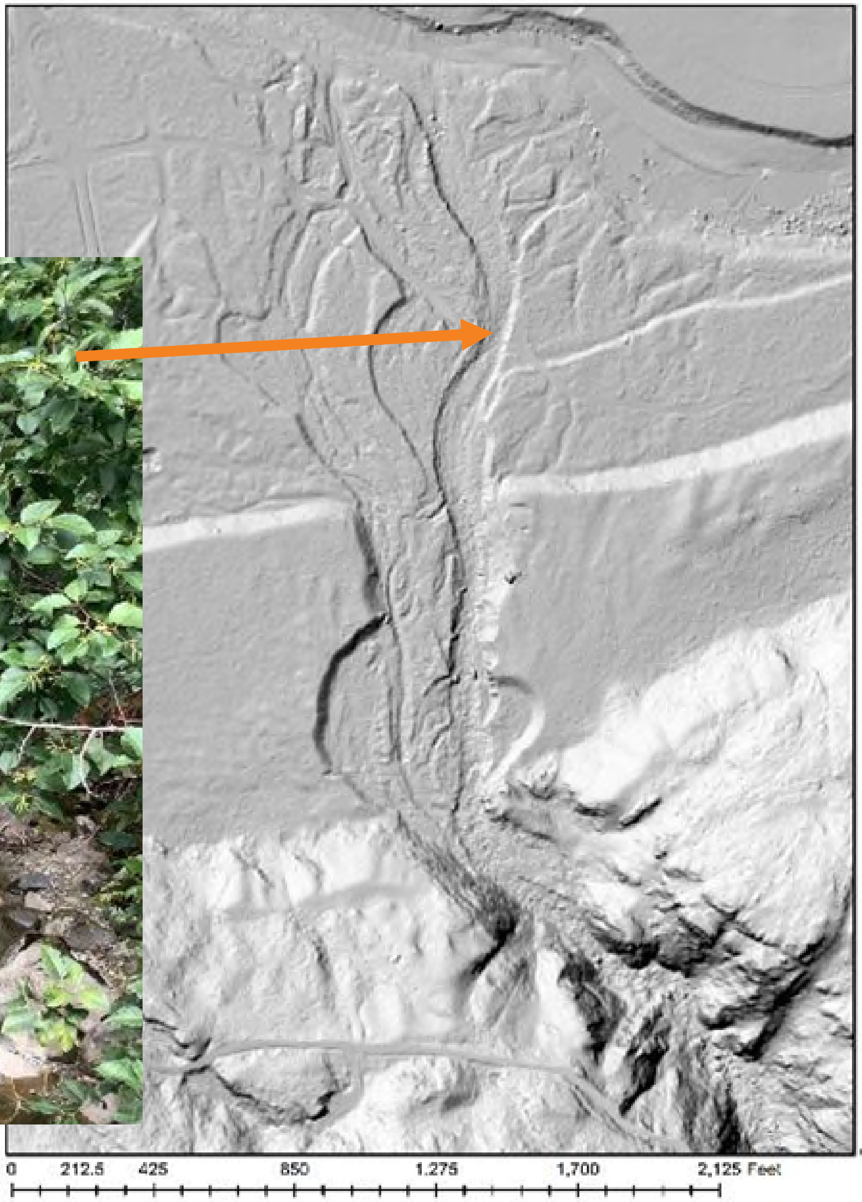
- Concern about headcutting/incision upstream from diversion dam
- Effects of transport of sediment into downstream reaches (Newhalem Creek and Skagit River)
  - Turbidity (fine sediment)
  - Gravel/cobble/boulder transport

GEOMORPHIC SETTING

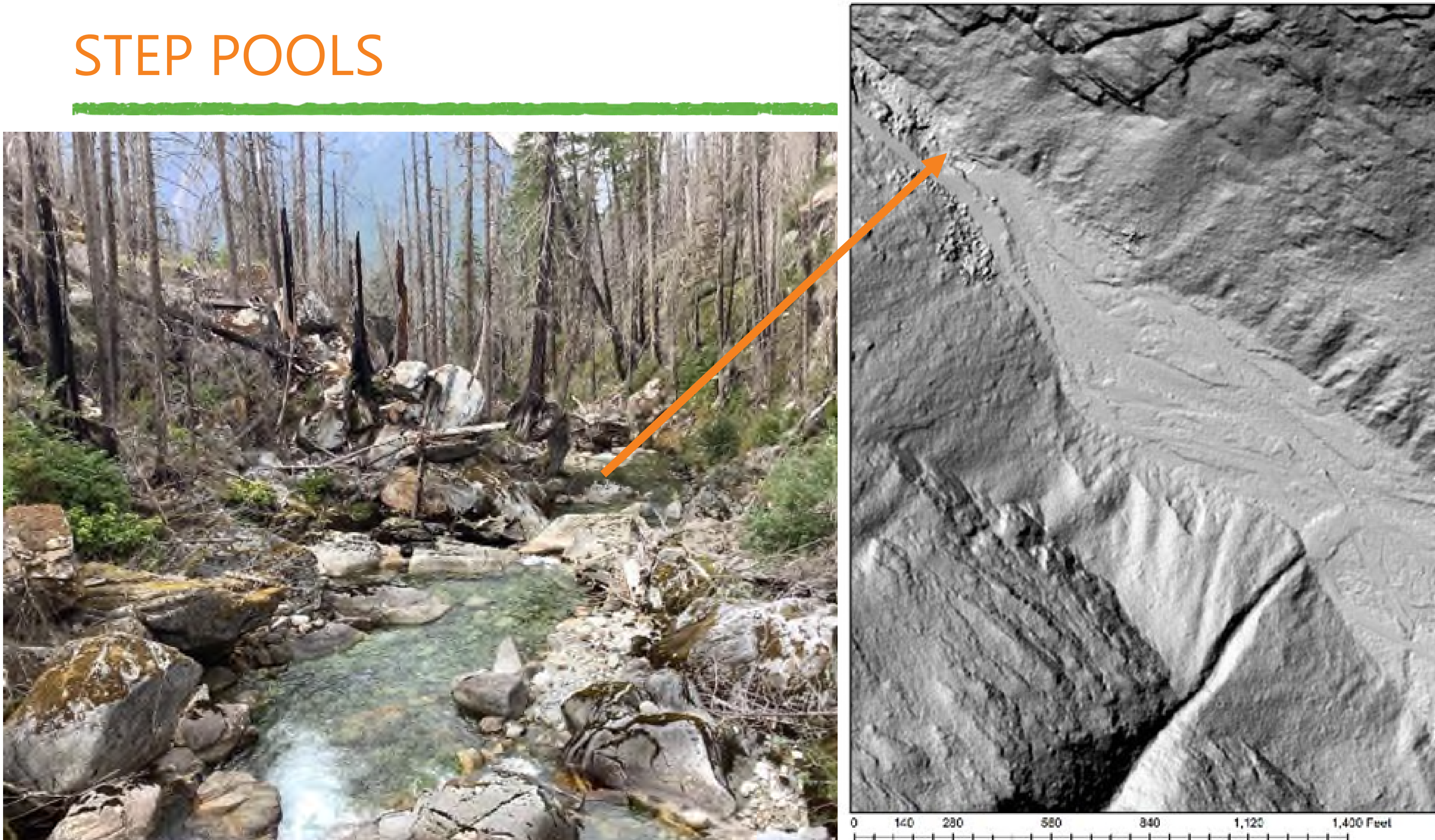




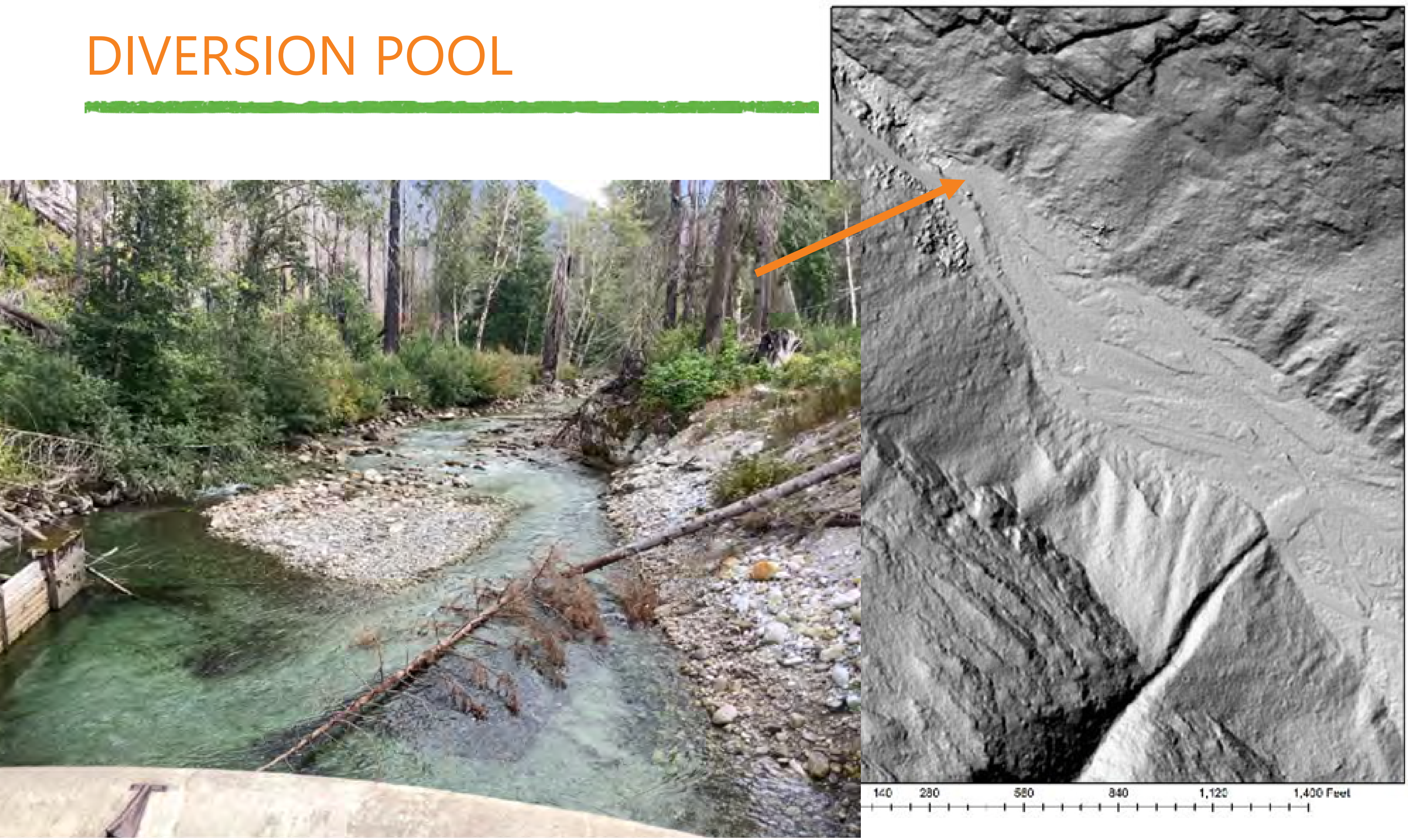
ALLUVIAL FAN



STEP POOLS



DIVERSION POOL



550 FEET UPSTREAM FROM DIVERSION

1,000 FEET UPSTREAM FROM DIVERSION

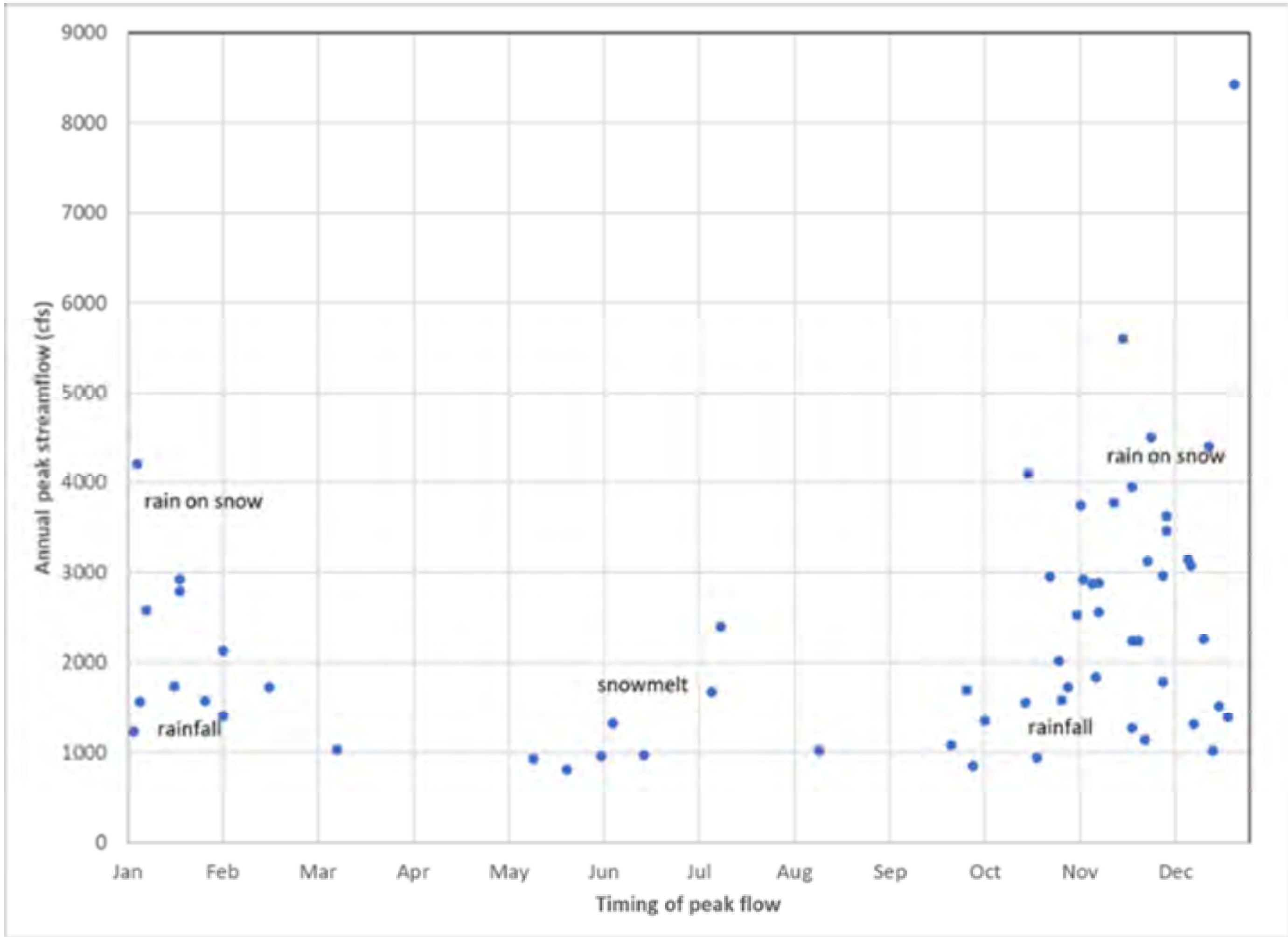
EXISTING SUBSTRATE

Location	D_{50} (mm)	Percent Gravel	Percent Cobble	Percent Boulder	D_{50} Subsurface (mm)
50 feet upstream from diversion	106-115	25%	47%	28%	39
USGS gage (180 feet upstream from diversion)	117 – 89	25%	39%	36%	
550 feet upstream from diversion	118 – 238	21%	49%	29%	61
1,000 feet upstream from diversion	123 – 105	21%	49%	31%	
AVERAGE	116 - 137	23%	46%	31%	

GEOMORPHIC AND LARGE WOOD INVENTORY

- Inventory of Newhalem Creek from diversion to 0.5 miles upstream from diversion
  - Habitat type, dominant/subdominant substrate, bankfull width (mean 70 ft) and depth (3 ft), bank height (4-6 ft), bank angle, bank material (cobble-boulder)
  - Large wood and large boulder inventory (length, diameter, rootwad?) and location

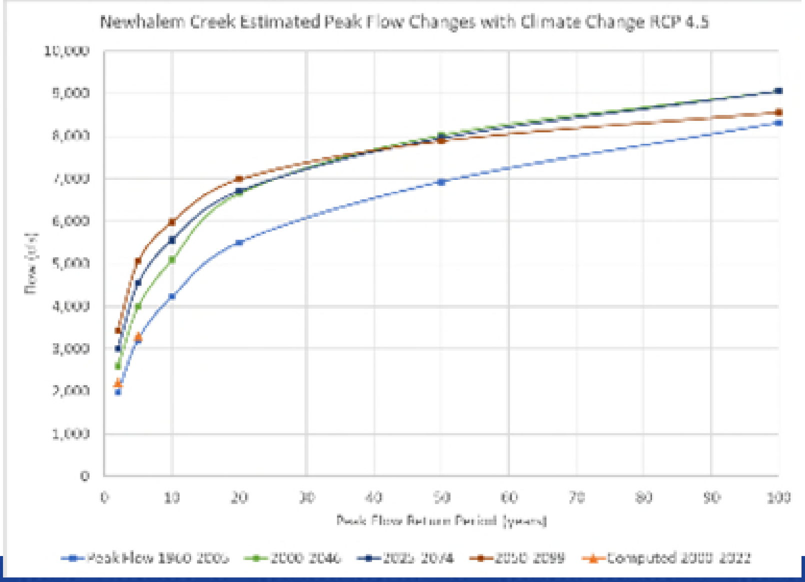
HISTORIC PEAK FLOWS (1960-2020)

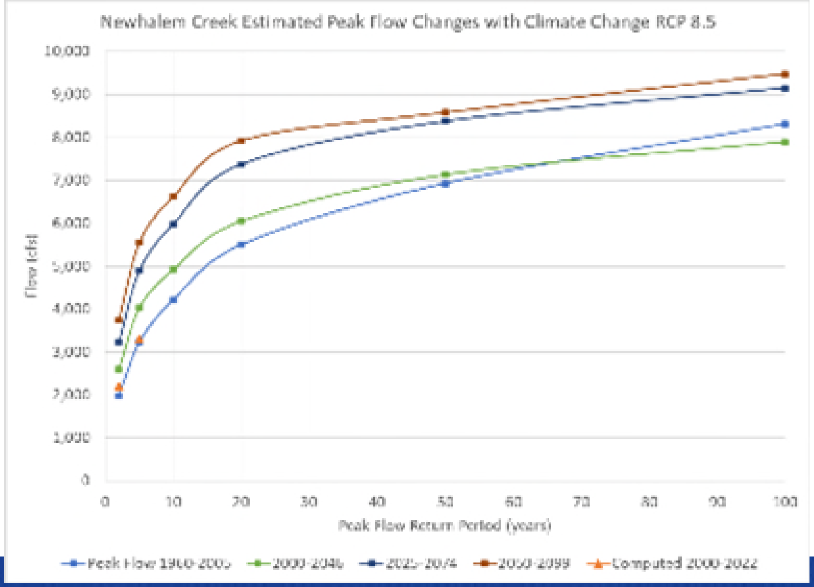


HISTORIC PEAK FLOWS (1960-2020) AND CLIMATE CHANGE SCENARIOS[1]

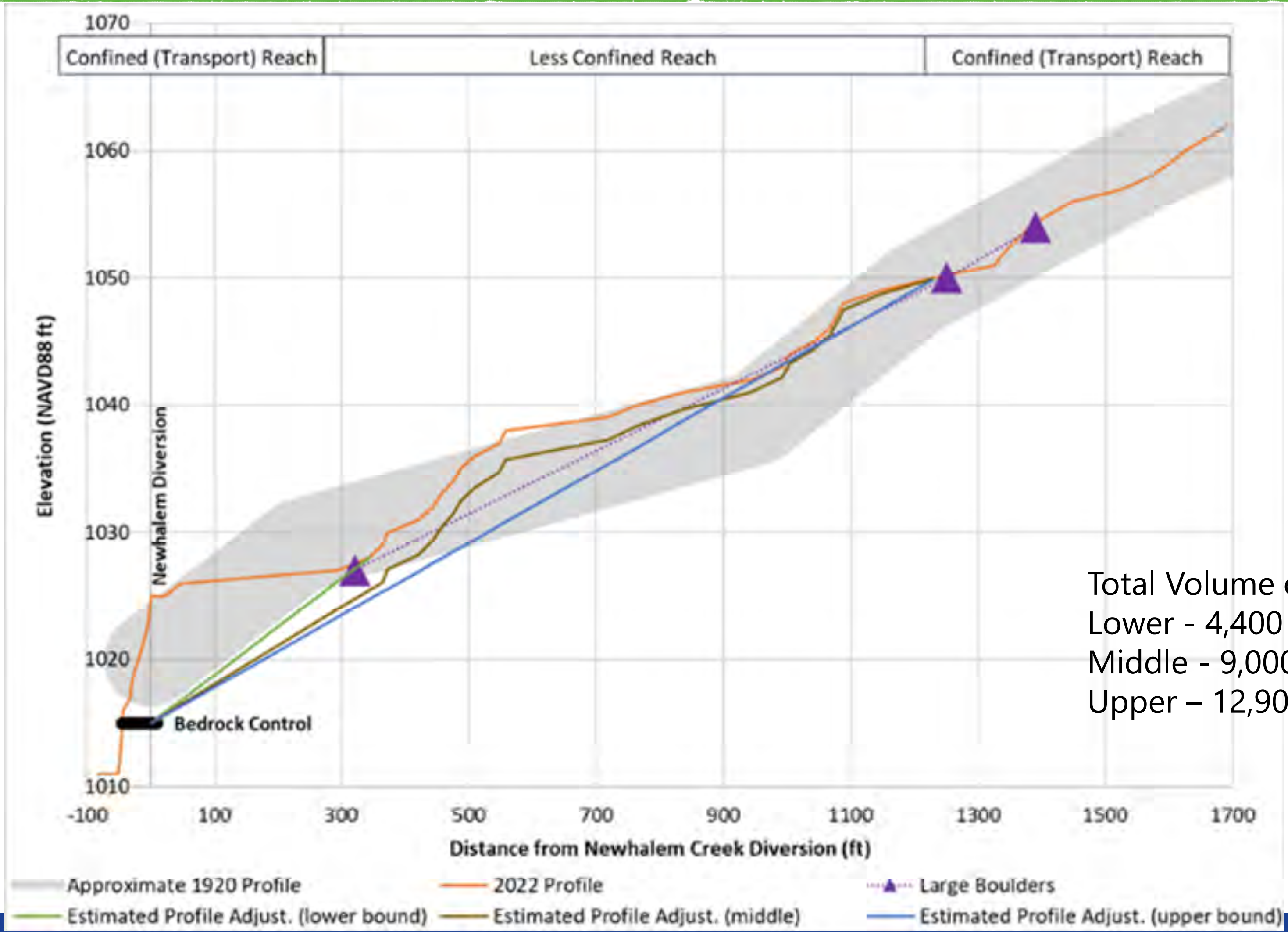
Recurrence interval (years)	Annual percent chance	Peak discharge (cfs)	95% Confidence upper limit (cfs)	95% Confidence lower limit (cfs)
100	1	7,680	10,000	6,260
50	2	6,470	8,220	5,370
25	4	5,370	6,640	4,550
10	10	4,060	4,820	3,530
5	20	3,150	3,630	2,790
2	50	1,990	2,230	1,770

[1] Climate change from Ranoa and Lee 2021



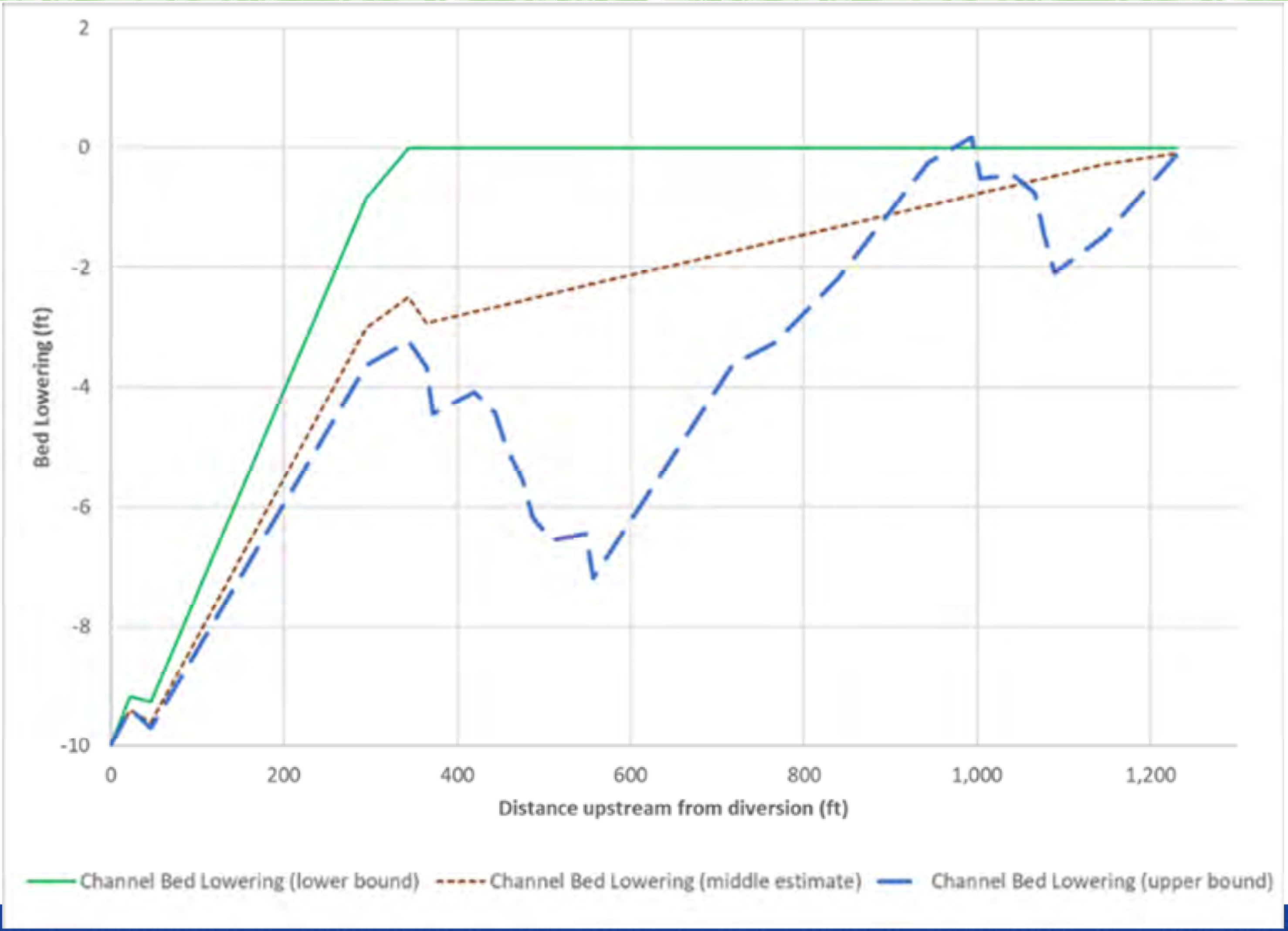


POTENTIAL PROFILE CHANGES



Total Volume of Sediment:
Lower - 4,400 cu yd
Middle - 9,000 cu yd
Upper – 12,900 cu yd

POTENTIAL PROFILE CHANGES – BED LOWERING



ESTIMATE OF DISCHARGE TO MOBILIZE SURFICIAL SUBSTRATE

Stream Gradient	Discharge and frequency of median (D_{50}) grain size transport	Discharge and frequency of larger (D_{84}) grain size transport
2.8% (reach average over long term)	250 cfs; every year	3,000 cfs; 5 years
1.3% (existing local slope just upstream from diversion)	1,500 cfs; 1.5 years	over 9,000 cfs; 100+ years
3.9% (short term local slope upstream from diversion with diversion removal and drop in base level)	120 cfs (many times/year)	1,500 cfs; 1.5 years

DOWNSTREAM FROM INTAKE - PAST SEDIMENT MAINTENANCE EVENTS

- 250-425 cubic yards removed from intake pool on a regular basis (during low flow)
- Gravel/cobble transported through step pools quickly

TURBIDITY

- Turbidity levels monitored during cleanout
  - Peak NTU 1.08-59 NTU after excavation (most less than 20 NTU)
  - Reached background in less than 24 hours
  - Subsurface samples - 0.5% silt/clay, 11% sand

From:	Adams, Shelly
To:	Ashley Rawhouser; Sarrantonio, Sharon M; Mike_Larrabee@nps.gov; rob_burrows@nps.gov
Cc:	Dube, Kathy; Craig, Nancy; Couch, Aaron; Holloway, Becky E.; Luchessa, Scott
Subject:	Revised Newhalem Creek Decommissioning Geomorphology Report
Date:	Friday, June 16, 2023 3:02:00 PM
Attachments:	image001.png Newhalem Geomorph Report 06_16_2023_highlighted.pdf Newhalem Geomorph Report 06_16_2023.pdf

Ashley, Rob, Sharon, and Mike,

Thank you again for taking the time to meet with us on May 11. We have revised the geomorphology report to address your concerns and comments provided in the meeting. For your convenience, I've attached one copy of the report with all changes highlighted and one clean copy. In summary, the changes to the report are:

- **Sentence on page 1-2.** Explains that the report includes an evaluation of concerns provided after initial drafts of the report.
- **Edits or additions to Section 4.1.1, pages 4-4 through 4-5.** Compares anticipated volume of sediment from dam removal to estimated average annual sediment yields to support NPS question regarding likelihood of reactivating old channels on the alluvial fan and pushing the Skagit River north due to deposition.
- **New section 4.2.3.** Addresses NPS question regarding the effects of decommissioning on the toe of the existing landslide. Also summarizes geology from the Golder report as requested.
- **New Section 4.2.4.** Addresses NPS questions about 1) reactivating old channels on the alluvial fan and 2) effects of decommissioning at the confluence of the Skagit River (whether Skagit River would be pushed to the north).
- **2 new references in literature cited**. Includes citations referenced in new sections described above.

Please review the changes and let us know if you have any outstanding questions or concerns by July 17, 2023. We would be happy to meet again if it is helpful. If your comments have been adequately addressed, following your review, we would like to file the report with FERC.

Thank you again for your time.

Shelly

SHELLY ADAMS
DECOMMISSIONING PROJECT MANAGER
NEWHALEM CREEK HYDROELECTRIC PROJECT | ENVIRONMENTAL, LAND, AND LICENSING BUSINESS UNIT
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NEWHALEM DAM DECOMMISSIONING GEOMORPHOLOGY CONSIDERATIONS

NEWHALEM CREEK HYDROELECTRIC PROJECT
FERC NO. 2705

Prepared by:
Kathy Vanderwal Dubé
Watershed GeoDynamics

June 2023

List of Acronyms and Abbreviations

BAGS..........................Bedload Assessment in Gravel-bedded Streams
City Light...................Seattle City Light
cfs...............................cubic feet per second
CM ....creek mile
FERC..........................Federal Energy Regulatory Commission
ft ....feet
LiDAR........................Light Detection and Ranging
mm ....millimeter
MW ....megawatt
NPS ....National Park Service
Project ....Newhalem Creek Hydroelectric Project
RLNRA ....Ross Lake National Recreation Area
USGS .........................U.S. Geological Survey

Table of Contents

List of Figures

List of Tables

List of Attachments

1.0 INTRODUCTION

1.1 Project Description

Seattle City Light (City Light) is licensed by the Federal Energy Regulatory Commission (FERC) to operate and maintain the Newhalem Creek Hydroelectric Project, FERC No. 2705 (Project). The Project is located on Newhalem Creek in northern Washington State in the Cascade Mountains of the upper Skagit River watershed. Newhalem Creek is a tributary to the Skagit River and enters the south side of the river at mile 93.3 (Figure 1.1-1).

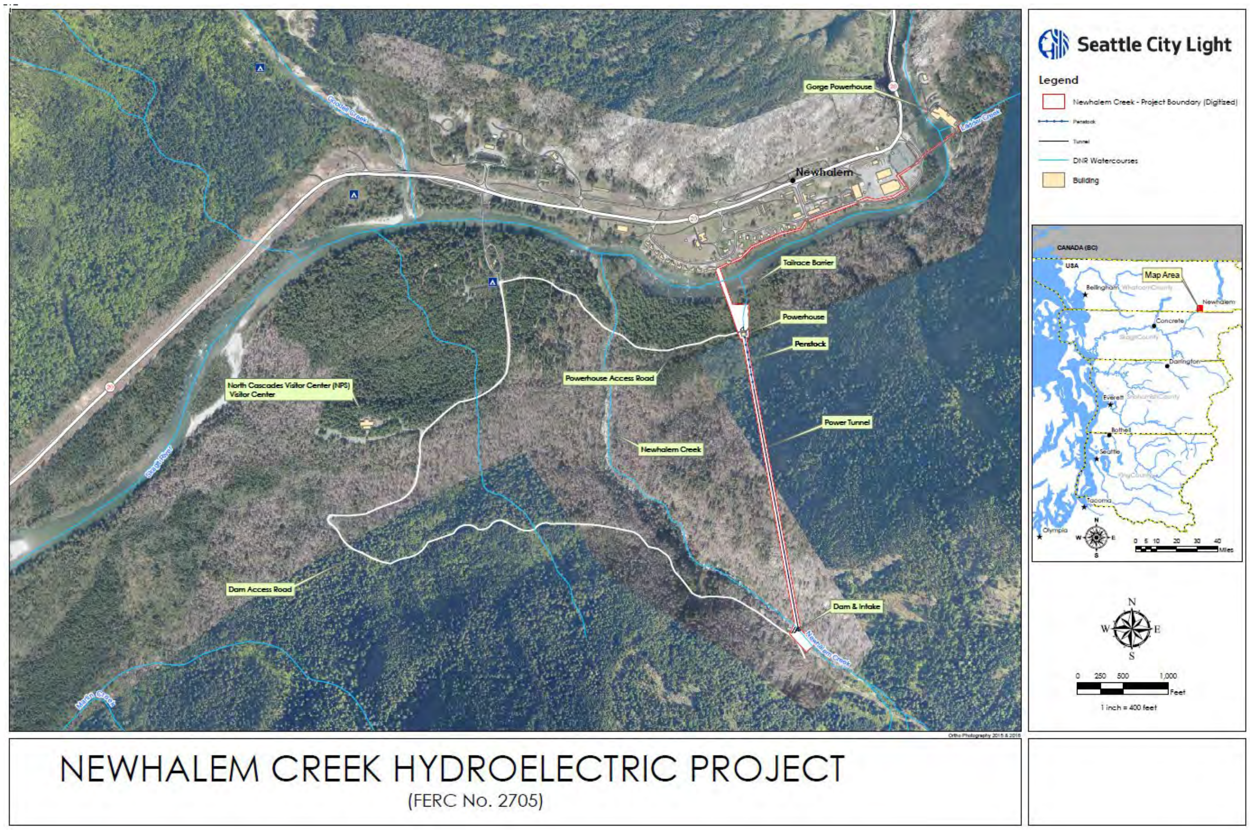


Figure 1.1-1. Newhalem Creek Project location map

The Project began operations in 1921 to supply power to the town of Newhalem and to construct Gorge Dam and Powerhouse, the latter of which are part of the Skagit River Hydroelectric Project (FERC No. 553). The Project has an authorized installed capacity of 2.2 megawatts (MW). The current Project license expires on January 31, 2027. City Light filed a Notice of Intent with FERC on April 28, 2021, to surrender the license and submitted an Application for Surrender of License for the Project on January 28, 2022.

The Project occupies 6.4 acres of federal lands within the Ross Lake National Recreation Area (RLNRA), which is managed by the National Park Service (NPS) as part of the North Cascades National Park Complex. The Project's diversion structure is located at Creek Mile (CM) 1.0, above a 100-foot waterfall, and impounds very little water (0.1-acre/0.6 acre-ft). Newhalem Creek flows

are diverted into a power tunnel and penstock that lead to the powerhouse. These flows bypass an approximately 1-mile reach of Newhalem Creek. There is a U.S. Geological Survey (USGS) stream gage just upstream of the diversion.

1.2 Proposed Action and Report Purpose

As part of decommissioning the Project, City Light is proposing to remove the diversion structure and associated facilities. The current proposal is to remove concrete at the current diversion location and grade to elevation 1,009 feet (Skagit Project datum, approximately equivalent to 1,015 feet [ft, NAVD88 datum]) at the downstream end of the existing spillway. The new streambed base level at this location would be approximately 10 ft lower than the top of the existing diversion structure. The purpose of this report is to evaluate potential geomorphic effects of removing the diversion structure on Newhalem Creek. Two primary geomorphic effects identified include:

- Potential for headcutting and incision upstream of the diversion location after diversion is removed due to change in base level of stream,
- Transport of sediment currently stored in and upstream of the impoundment into downstream reaches of Newhalem Creek and the Skagit River (including potential effects on turbidity levels in Newhalem Creek).

The report also evaluates concerns and questions raised during the decommissioning proceeding and after review of the initial drafts of this report.

This report relies on existing maps, reports, hydrologic data, and topographic (Light Detection and Ranging [LiDAR]) information; observations made during four 1-day field visits to the Project; surficial and sub-surface grain size sampling; and cross sections surveyed during the field visits.

2.0 METHODS

2.1 Field Data

Observations of site conditions and stream characteristics were made during a site visit on June 14, 2021, with a follow-up geomorphic assessment on October 14, 2022. Substrate pebble counts were made and a stream cross section was surveyed during a site visit on September 8, 2021. Repeat surficial pebble counts and sub-surface sampling was conducted on September 12, 2022, to assess changes in substrate following a 4,920[1] cubic-foot-per-second (cfs) peak flow in November 2021. Streamflow at the Newhalem gage (USGS 12178100) was 499 cfs during the June 2021 site visit, 28 cfs during the September 2021 site visit, 25 cfs during the September 2022 visit, and 15 during the October 2022 geomorphic assessment.

2.1.1 Surface Grain Size Sampling

Surficial Wolman pebble counts were made at four locations upstream of the Newhalem Creek diversion dam in 2021 and repeated in 2022 (Figure 2.1-1; Wolman 1954). A minimum of 100 pebbles were selected approximately every foot across the channel at two locations (at the USGS gage site and approximately 500 ft upstream from the dam) and in a grid pattern in deposits just upstream from the diversion and at the head of a point bar approximately 1,000 ft upstream from the diversion. Each particle was passed through a gravelometer to measure the equivalent particle size class in half phi increments (e.g., < 2 millimeters [mm], 2–4 mm, 4–8 mm, 8–16 mm, 16–32 mm, etc..... up to the 512 mm size class). The gravelometer provides the same results as sieving a sample. Pebble count data were entered into a spreadsheet for computation of particle size statistics and graphing of the grain size distribution.

2.1.2 Sub-surface Grain Size Sampling

Bulk samples of the material below the surface armor layer were collected at two of the pebble count locations in September 2022 following the method of Church et al. (1987; bulk sample locations shown on Figure 2.1-1). To do this, the surface armor layer was removed and then a pit was excavated until either the practical sampling limit of 440 pounds or a volume sufficient that the largest particles in the deposit made up no more than one percent of the sample weight was obtained (the 1 percent criteria). The bulk sample material was field sieved to separate material at the 32 mm size. Material larger than 32 mm was divided into half-phi grainsize classes using a gravelometer, and the weight of each class was measured in the field. A 30- to 45-pound sub-sample of the material smaller than 32 mm was retained for grainsize analysis following American Society for Testing and Materials standards, and was performed by Materials Testing & Consulting, Inc. Field and lab grainsize distributions for each bulk sample were then combined based on the split ratio of the material; water weight was assumed to be evenly distributed through the <32 mm fraction.

[1] Note: all flow data was obtained from the USGS website (https://waterdata.usgs.gov/monitoring-location/12178100/). Recent data (2021–2022) is provisional.

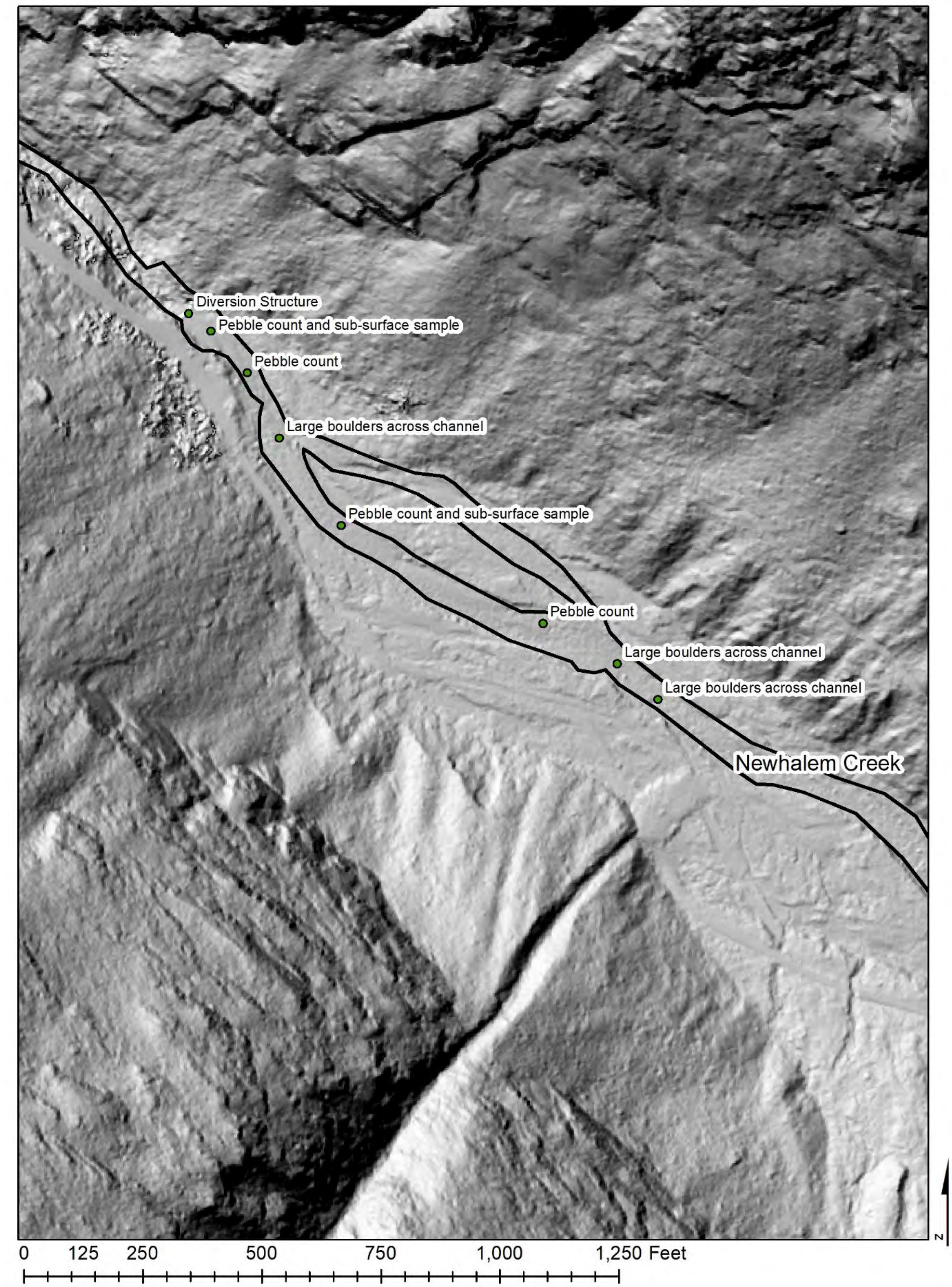


Figure 2.1-1. Newhalem Creek sediment sampling locations

Since the practical sampling limit of 440 pounds determined for this study was below the recommended 1 percent criteria (Church et. al, 1987), the hybrid method of Rice and Haschenburger (2004) was applied to characterize the coarse tail of the bulk grainsize distribution, consistent with Skagit Hydroelectric Project relicensing methodology. This method assumes that the surface and subsurface material come from the same source grainsize population and that the surface armor layer formed through selective horizontal removal of fine sediment (winnowing). This implies that the ratio of the weight of a specified match fraction (between the surface and subsurface samples) and each larger grainsize fraction in the surface material can be used to determine the distribution of the coarser material more reliably than would be possible with only the undersized sample. Selection of the match fraction was determined by identifying the largest grainsize fraction meeting the 1 percent sample size criteria. In other words, the match fraction was chosen for the largest grainsize where the cumulative weight of the sample through that size class (smallest to largest) was greater than the 1 percent criteria for material of that size. For our 440-pound samples, the match fraction was 64–91 mm.

2.1.3 Cross Section Survey

A cross section at the USGS gage site was surveyed using a tape, laser level, and survey rod in September 2021. The concrete platform at the Project intake was used as a known elevation to allow correlation of the survey data with LiDAR data to extend the cross section across the valley on each side of the transect. The transect and USGS gage records (stage: discharge) were used for sediment transport analysis.

2.1.4 Geomorphic Stream Assessment

On October 14, 2022, a team of two geomorphologists completed a geomorphic assessment of the channel by walking the stream from the existing weir upstream approximately 0.5 mile. Stationing along the channel was determined by measurement with a long fiberglass tape up to 1,500 ft above the weir and by pacing, calibrated to landmarks visible in the LiDAR data, between station 1,500 and 2,661 ft. Individual geomorphic units were identified as belonging to one of the following classes: pool, glide, riffle, pocket water, step pool, plane bed or cascade. These followed the same definitions as previous work completed for the Skagit River Hydroelectric Project (FERC Project No. 553) relicensing except that step pool morphologies were distinguished from pocket water morphologies. The differentiation is that pocket water consists of disorganized features with a generally planar bed geometry but very high relative roughness (boulders protruding through the free surface), while step pool morphologies have organized the boulders into step features that create added “jammed state” stability (e.g., Church and Zimmermann, 2007; Zimmermann et al., 2010).

In each geomorphic unit, dominant and subdominant bed material were visually determined. The dominant bed material was the grain size class (Table 2.1-1) visually determined to make up the largest portion of the bed surface, and the sub-dominant was the grain size class visually determined to make up the second largest portion of the bed surface. The presence of other geomorphically important grainsize classes (for example finer gravel pocket deposits that may be important spawning habitat or boulders that might be controlling the channel gradient or roughness) were also noted.

Table 2.1-1. Bed material size ranges used in geomorphic assessment notes

Size Range	Grain size (abbreviation in notes)
2–8 mm	Fine Pebbles (fP)
8–22 mm	Fine Gravel (fG)
22–64 mm	Gravel (G)
64–128 mm	Cobble (C)
128–360 mm	Large Cobble (LgC)
>360 mm	Boulder (B)

The width and general cross section shape of each geomorphic unit were measured at a characteristic location. Bankfull width was measured using a fiberglass long tape and bankfull depth was measured to the nearest 0.5 ft with a level rod. In addition, the total height of the bank (e.g., from bank toe to the top of a terrace that lies above the bankfull elevation) and width of the bank (horizontal distance from bank toe to the elevation of the top of bank) were measured with a level rod, so that the bank angle could be determined. Tailout and maximum depths of pool, glides, and step pool features were measured so that residual pool depths could be calculated. The characteristics of the bank materials were noted for each bank, with a description of the stratigraphy including dominant grainsizes, angularity of the material, and interpreted type of material (alluvial or colluvial).

2.2 Data Analysis

Mean daily and annual instantaneous peak flows for the period of record were obtained from the USGS NWIS website for the Newhalem Creek near Newhalem, WA, gage (USGS 12178100). Annual peak flows were entered into a spreadsheet for log-Pearson Frequency Analysis using the Bulletin 17B methods.

LiDAR data and aerial imagery from 2015, 2018, and 2022 were used to map channel position and produce stream profiles and gradients. A 1920 survey map (Figure 2.2-1) was used to estimate pre-Project streambed elevation and gradients by direct measurement from the map and geo-rectifying the map in ArcMap 10.8.1. Note that scale, vertical datum differences, and geo-rectifying challenges introduces some error into calculations using old maps, so the resulting 1920 profile should be considered an estimate.

The Bedload Assessment in Gravel-bedded Streams (BAGS) spreadsheet transport tool (https://www.fs.fed.us/biology/nsaec/products-tools.html) was used to analyze hydraulic characteristics, potential sediment transport/deposition areas and headcutting in the Newhalem Creek intake area based on the surveyed cross section, pebble count data, and local and reach-averaged stream gradients measured from LiDAR data.

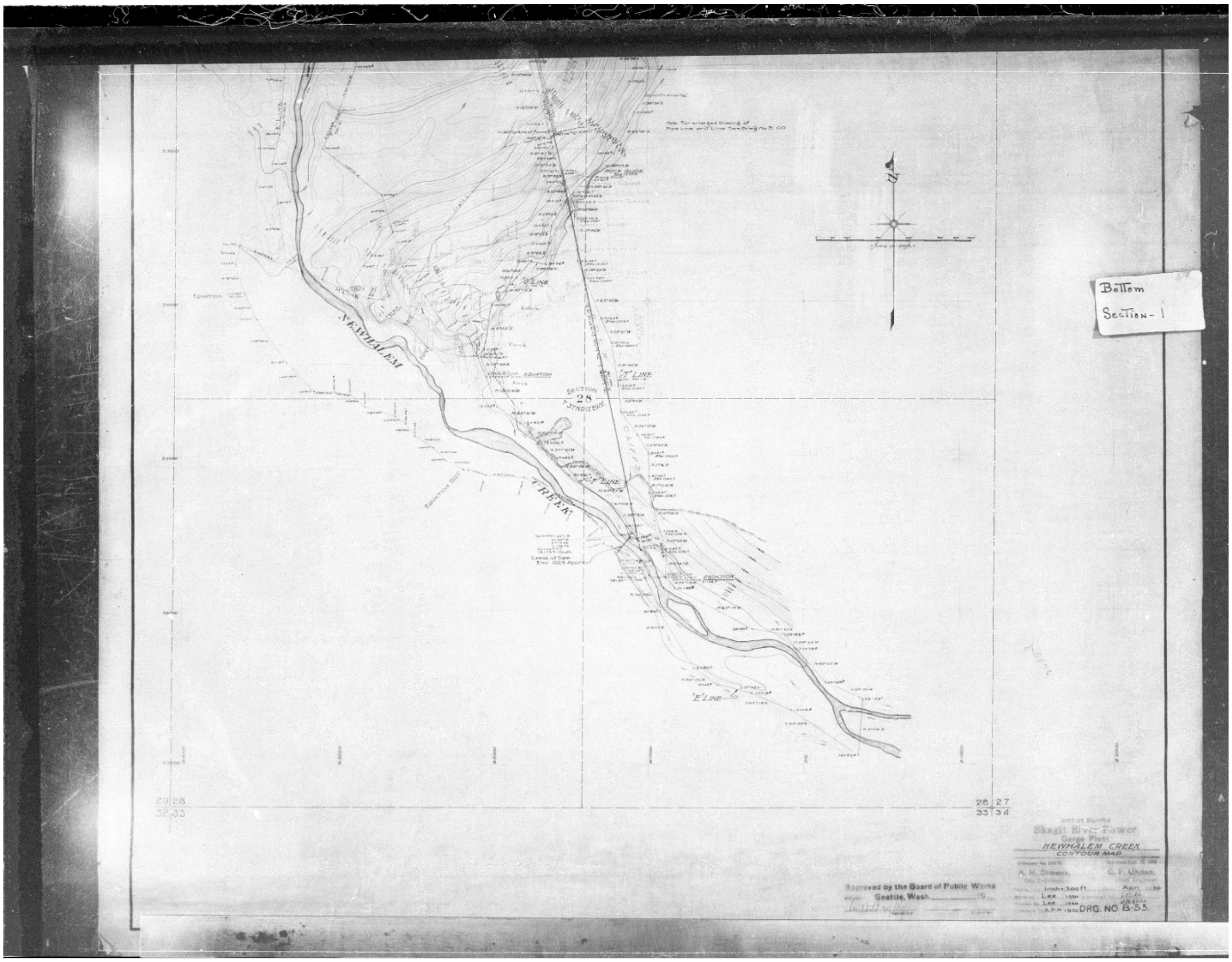


Figure 2.2-1. **Scanned 1920 Newhalem Creek map (source: Seattle City Light archives).**

3.0 GEOMORPHIC SETTING AND EXISTING CONDITIONS

The Newhalem Creek Project is in the North Cascades of Washington state, a geomorphically active, geologically diverse, and climatically cool and wet area with high mountain peaks and steep valley walls and canyons.

3.1 Geology and Landforms

The North Cascades is a complex mosaic of geologic terranes that were formed as the Pacific Ocean plate and the North American continental plate collided, breaking off pieces of volcanic island arcs, deep ocean sediments, ocean floor, continental rocks, and subcrustal mantle over the past 400 million years (Haugerud and Tabor 2009). These terranes were then uplifted, thrust on top of each other, eroded, or buried to further complicate the geology and form the high peaks of the North Cascades. Newhalem Creek is within the Metamorphic Core Domain of the North Cascades and is underlain by the Skagit Gneiss (labeled TKbg(s) and TKog(s) on Figure 3.1-1). The Skagit Gneiss has a high level of metamorphism and is resistant to weathering and erosion, forming the steep stream canyon with numerous waterfalls downstream from the Newhalem diversion structure. While resistant to erosion, the steep valleys formed in the rocks of the Metamorphic Core are also subject to rockfalls, landslides, and avalanches as evidenced by the mass movements along the western slopes downstream from the diversion (the active rockfall/mass wasting area on the access road is one of these unstable areas).

During the Quaternary Period, starting about 2.6 million years ago, continental and alpine glaciers covered much of the area in the Project vicinity, with several major advances of thick continental ice from the north and smaller alpine glaciers originating from mountain peaks. The most recent continental glacial advance, culminating approximately 15,000 years ago, resulted in many of the surficial geologic features and deposits in the Newhalem Creek vicinity. Following melting of the glaciers, surficial processes further re-shaped the landscape resulting in development of alluvium (river deposits), terraces, and alluvial fans. Surficial geology around Project includes Quaternary and Holocene glacial and stream deposits (Qad and Qa), alluvial fan/debris cone deposits (Qaf), and colluvium derived from local soils and underlying geologic units.

Landforms have been mapped by the NPS for areas within RLNRA (Riedel et al. 2012). Landform mapping provides information on surficial geologic features and processes by grouping areas of the landscape into units formed by discrete geologic processes. Landforms include features that are depositional in nature (e.g., moraines, alluvial fans) or erosional (horns, bedrock benches). Mapped landforms are shown on Figure 3.1-1 and include the steep valley walls surrounding the Newhalem Creek valley, the floodplain features in the lower gradient area upstream from the diversion, the bedrock canyon downstream from the diversion, and the alluvial fan near the confluence with the Skagit River that has cut into the moraines and terraces in the Skagit River valley. Note that several debris cones control floodplain width at the diversion structure and in the valley upstream from the diversion; these debris cones control the confined/unconfined reaches of the stream and limit channel movement across the floodplain as well as providing extremely large (up to 12-foot diameter) boulders that were noted at several locations in the channel.

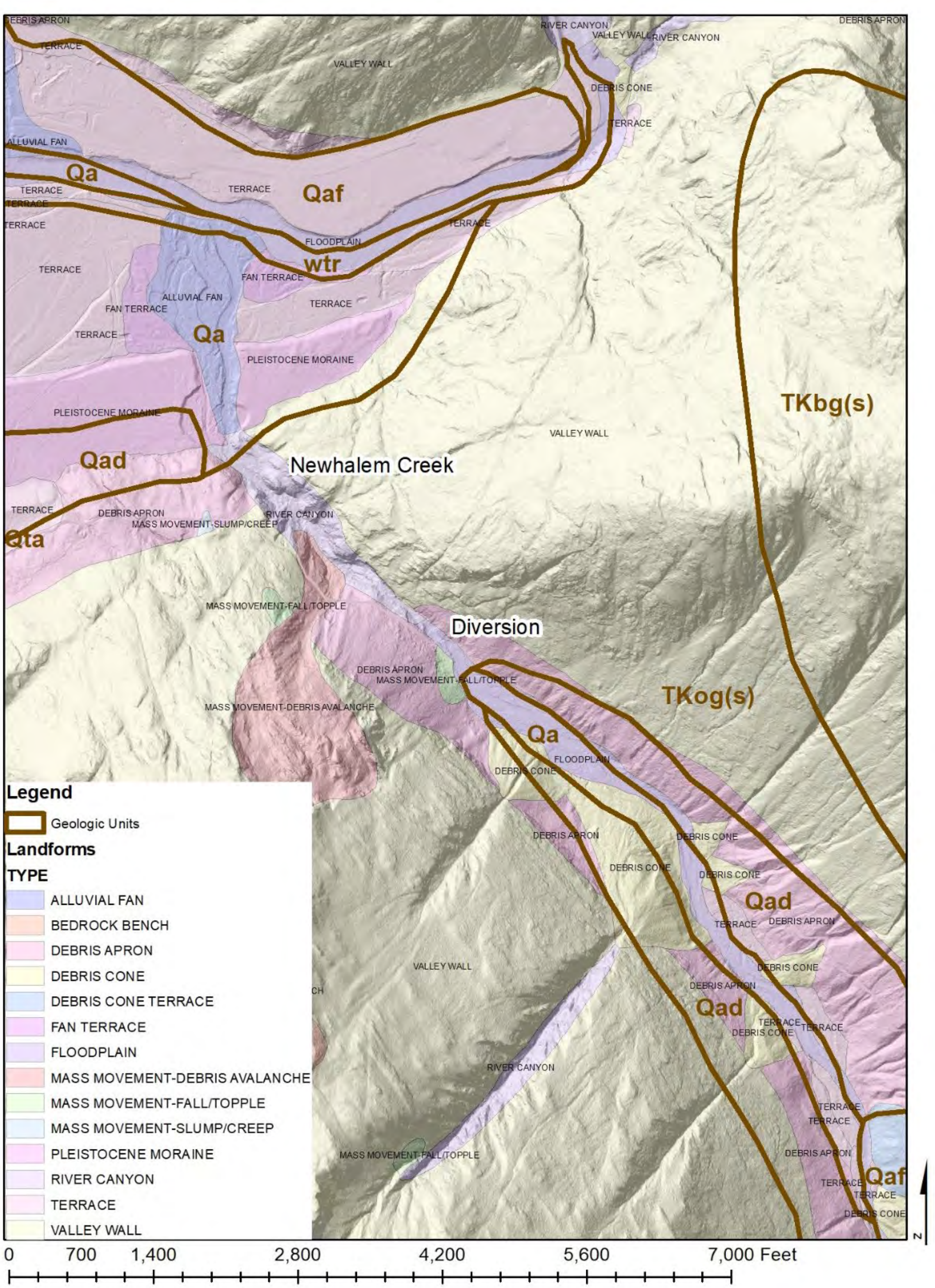


Figure 3.1-1. Geologic units and landforms in the Newhalem Project vicinity

3.2 Newhalem Creek Hydrology

Newhalem Creek has a drainage area of 26.9 square miles at the Project intake. Mean daily flows typically range from a low of 20 to 30 cfs in September to peaks of 1,000 to 3,000–4,000 cfs during rain, rain-on-snow, and snowmelt from November through late June (Figure 3.2-1).

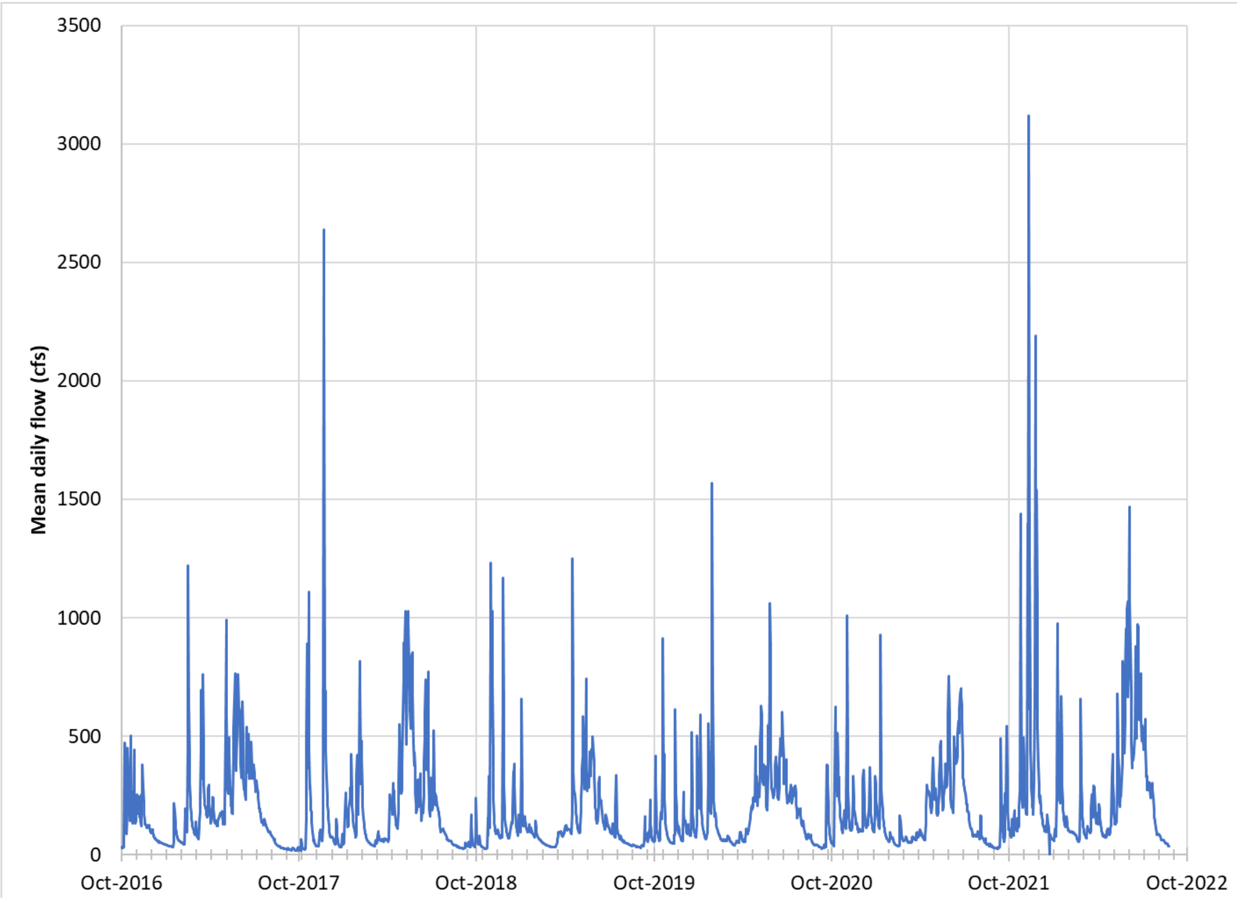


Figure 3.2-1. Daily flow at Newhalem Creek Gage (USGS 12178100) Water Years 2017–2022

The majority of bedload transport and geomorphic "work" is done during high flows when stream energy is high enough to disrupt the coarser armor layer on the bed of the stream and transport gravel/cobble/boulder downstream. Annual instantaneous peak flows recorded at the Newhalem gage range from less than 1,000 cfs to nearly 9,000 cfs (Figure 3.2-2). The highest peak flows occur during the November to February timeframe as a result of rain-on-snow events (Figure 3.2-3). Smaller magnitude peak flows between October and March are the result of rainfall events; peaks during May–July are driven by snowmelt from the higher elevations in the watershed.

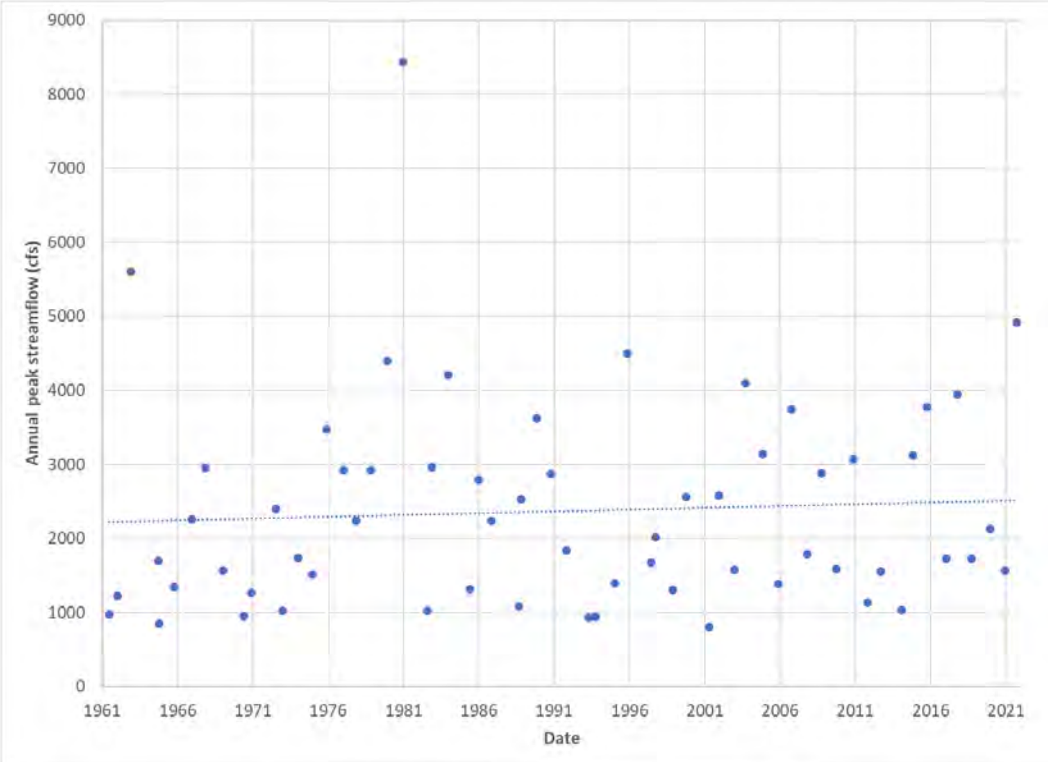


Figure 3.2-2. Annual peak streamflow at Newhalem Creek gage (USGS 12178100; 1961–2022)

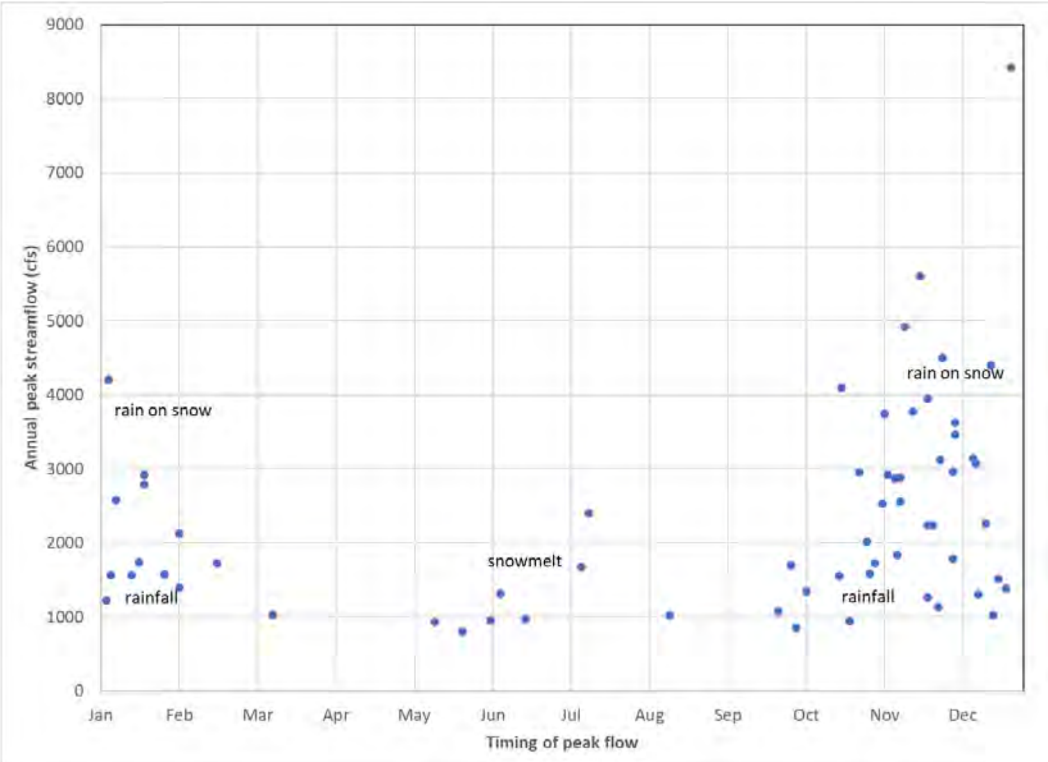


Figure 3.2-3. Timing and cause of peak streamflow at Newhalem Creek gage (USGS 12178100; 1961–2022)

Computed peak flow recurrence intervals for the period of record (1961–2022) at the diversion dam range from 884 cfs for the 1.05-year recurrence interval to 7,840 cfs for the 100-year event (Table 3.2-1). Note that the highest peak flow recorded at the gage (8,430 cfs on 12/26/80) was an extreme event and was higher than the computed 100-year recurrence interval flow. Peak flow recurrence intervals are statistically-based computations and take into account the probability of a given flow occurring based on the entire period of record. The 1.25- to 2-year recurrence interval event is often considered to be the formative discharge for stream channel shape and bedload transport and often corresponds to the bankfull discharge in alluvial streams.

Table 3.2-1. Peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2022).

Recurrence interval (years)	Annual percent chance	Peak discharge (cfs)	95% Confidence upper limit (cfs)	95% Confidence lower limit (cfs)
100	1	7,840	10,200	6,400
50	2	6,600	8,370	5,490
25	4	5,470	6,740	4,640
10	10	4,120	4,890	3,590
5	20	3,190	3,680	2,830
2	50	2,010	2,240	1,790
1.25	80	1,300	1,470	1,130
1.05	95	884	1,030	731

3.2.1 Potential Future Changes to Peak Flows

Estimates of potential changes to future peak flows in the Skagit River watershed have been made by researchers at Seattle University (Ranoa and Lee 2021). They used the 1960–2005 peak flows as a base and projected how streamflow and water availability may change in the future for three different time ranges (2000–2049; 2025–2074; and 2050–2099) at 20 sites within the Skagit River basin under low and high greenhouse gas emission scenarios (Representative Concentration Pathways [RCPs] 4.5 and 8.5, respectively). The Newhalem to Marblemount area gages were predicted to change from -5 percent to +90 percent for various peak flow recurrence/future time range scenarios, with greater changes predicted for more frequent peak flows and under the high greenhouse gas emissions scenarios (Figure 3.2-4 and Figure 3.2-5).

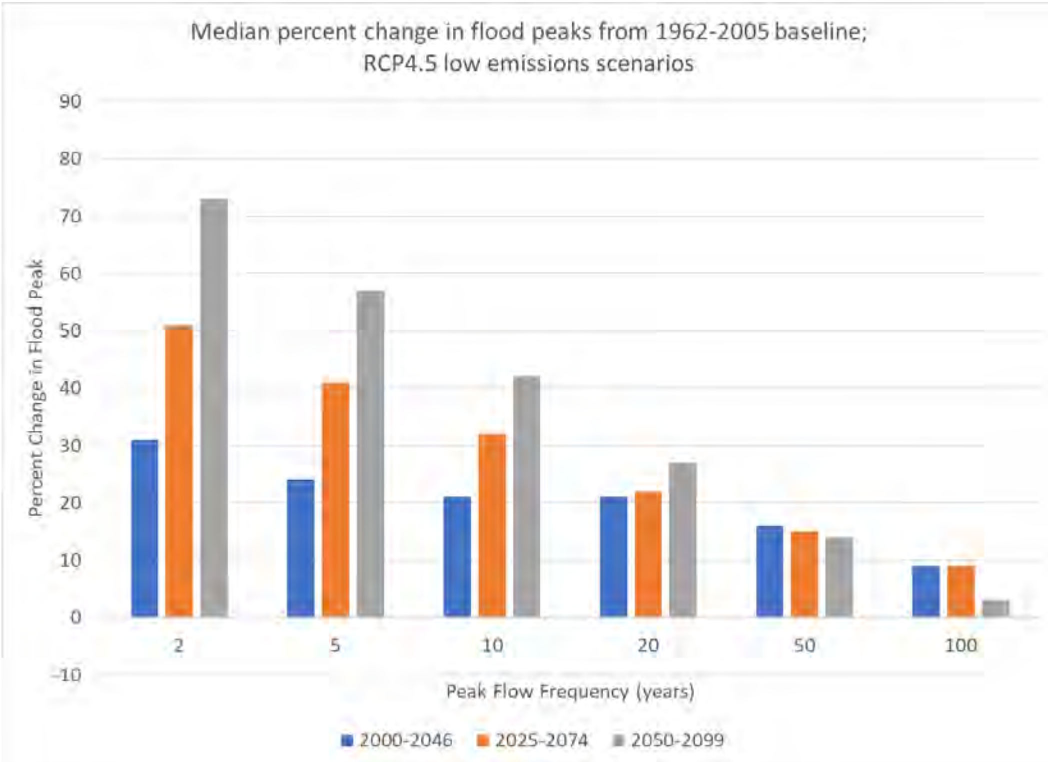


Figure 3.2-4. Median predicted percent change in flood peaks at the Newhalem Creek gage from 1962–2005 baseline, RCP 4.5.

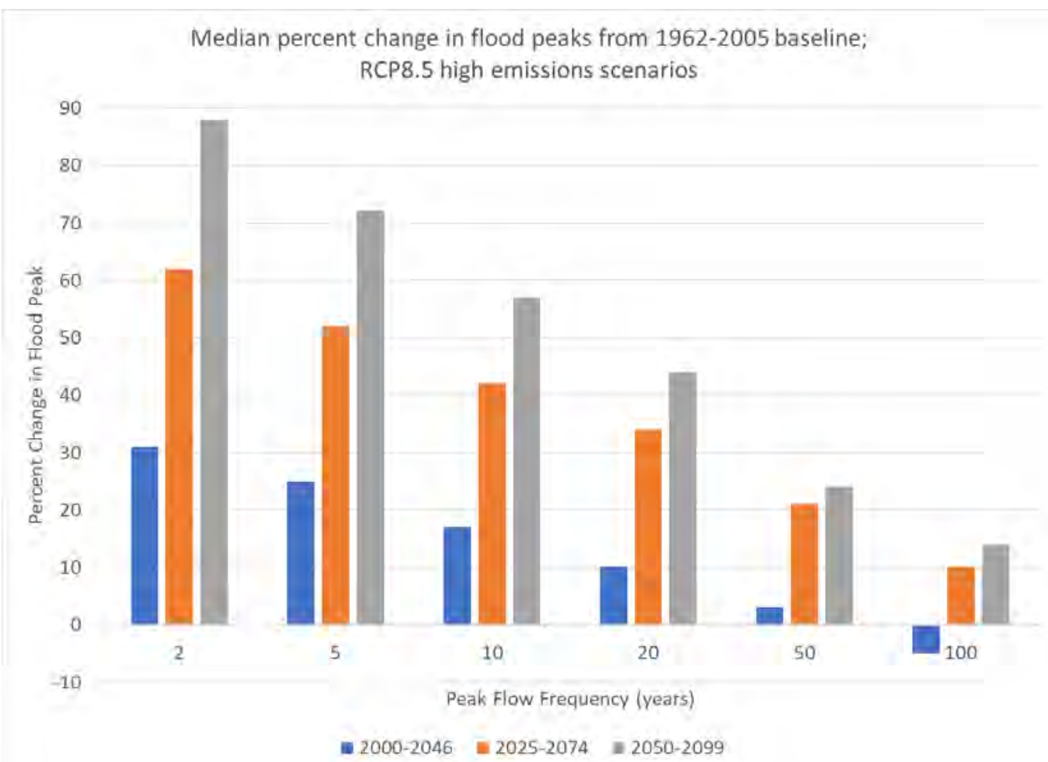


Figure 3.2-5. Median predicted percent change in flood peaks at the Newhalem Creek gage from 1962–2005 baseline, RCP 8.5.

The calculated peak flow recurrence for the Newhalem Creek USGS gage for the 1961–2005 and 2000–2022 time ranges as well as predicted future peak flows for the three time ranges and RCP 4.5 scenarios based on Ranoa and Lee (2021) are shown in Figure 3.2-6 and Table 3.2-2. Predicted flows under the RCP 8.5 scenarios are shown in Figure 3.2-7 and Table 3.2-3. The 2000–2022 actual peak flows at the Newhalem gage were used to calculate the 2-year and 5-year recurrence interval peak flows and are shown on Figure 3.2-6 and Figure 3.2-7 for comparison with the estimated future flow scenarios (note that the 2000–2022 timeframe is not sufficient to feel confident in longer-interval peak flow calculations). The computed 2000–2022 2-year and 5-year peak flow events, shown as orange triangles on the graphs, are very similar to the baseflow period (1960–2005) peak flows and do not show evidence that substantial increases in peak flow magnitudes for these frequent floods have occurred to date at the Newhalem gage.

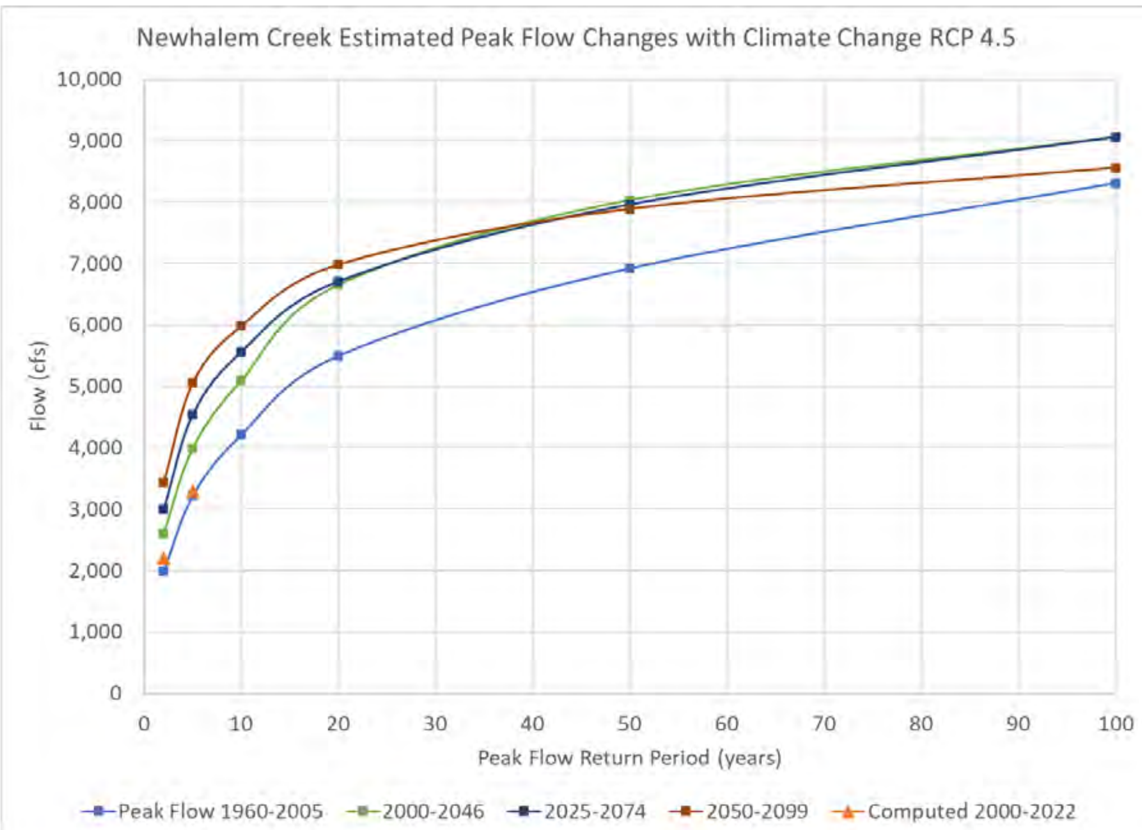


Figure 3.2-6. Estimated changes in peak flows at the Newhalem Creek gage (RCP 4.5)

Table 3.2-2. Calculated peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2005) and predicted future climate change peaks under RCP 4.5.

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
100	1	8,310	n/a	9,140	9,140	8,810
50	2	6,920	n/a	7,960	8,100	8,100
10	10	4,220	n/a	5,150	5,740	6,120

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
5	20	3,220	3,300	4,030	4,570	5,150
2	50	1,990	2,210	2,610	3,000	3,440

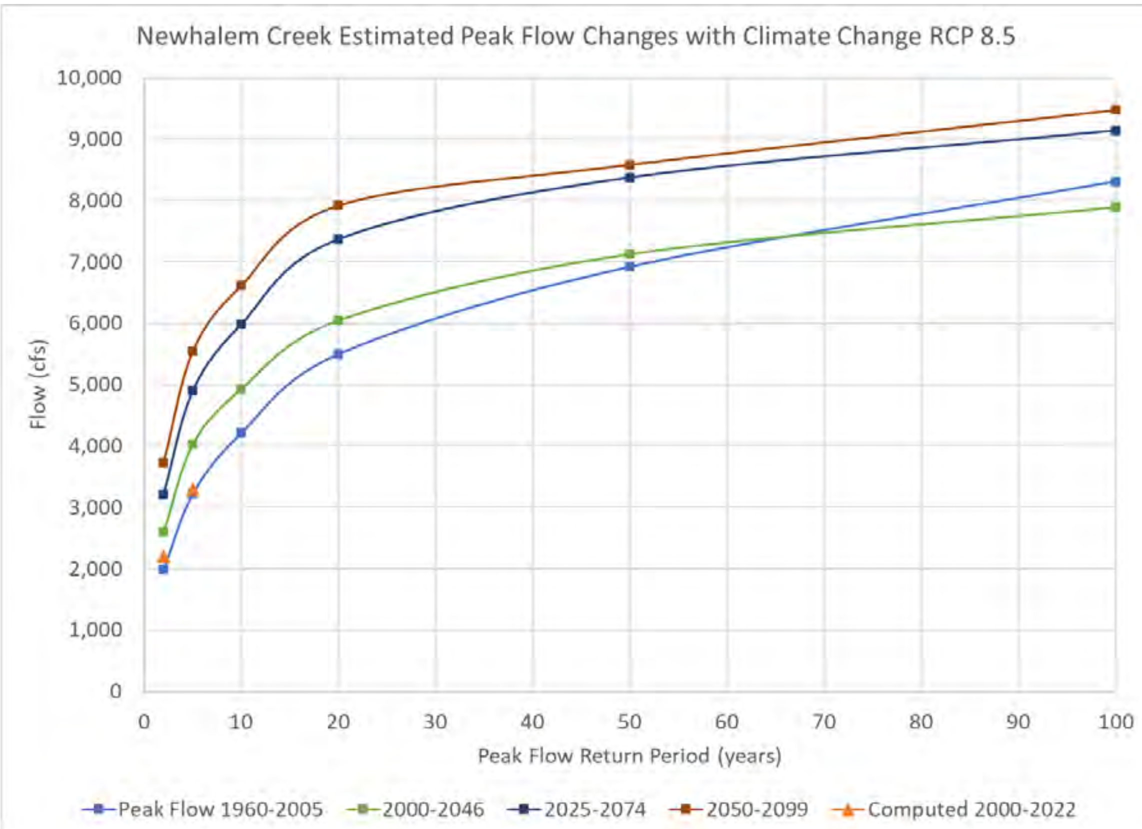


Figure 3.2-7. Estimated changes in peak flows at the Newhalem Creek gage (RCP 8.5)

Table 3.2-3. Calculated peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2005) and predicted future climate change peaks under RCP 8.5.

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
100	1	8,310	n/a	7,890	8,970	9,720
50	2	6,920	n/a	7,060	8,230	8,790
10	10	4,220	n/a	4,980	5,990	6,750
5	20	3,220	3,300	4,030	4,930	5,600
2	50	1,990	2,210	2,610	3,260	3,760

3.3 Newhalem Creek Existing Geomorphic Characteristics

Newhalem Creek has several distinct geomorphic reaches between the confluence with the Skagit River and the valley upstream from the diversion dam that influence how the stream processes water and sediment moving through the system and ultimately affects instream habitat characteristics (Figure 3.3-1, Figure 3.3-2).

Upstream from the diversion structure the stream has a relatively consistent gradient (2–3 percent) with a cobble/boulder/gravel bed, bankfull channel width of approximately 75 ft, and valley widths of 500 ft in relatively unconfined reaches and 150–200 ft in areas where the stream is confined by debris cone deposits coming off the valley walls. There is a confining debris cone approximately 0.25 mile upstream from the diversion and another, larger cone approximately 0.5 mile upstream from the diversion. These two features limit channel movement across the valley.

The Newhalem Creek bed 500 ft upstream from the diversion consists of cobble, boulders, and gravel that span the width of the Creek.

At and downstream from the diversion, the stream enters a very high gradient (10–25 percent) bedrock canyon with numerous waterfalls. This area was not visited but based on observations just downstream from the diversion it is likely that substrate is bedrock with patches of cobble/gravel/boulder. This reach is a transport reach – sediment supplied from upstream areas moves relatively quickly through the reach into the downstream alluvial fan.

Downstream from the canyon reach Newhalem Creek encounters the Skagit River valley terraces and forms an alluvial fan with numerous relict channels. The stream averages 5 percent gradient with gradients decreasing closer to the Skagit confluence and has cut through the higher Skagit valley terraces. Alluvial fans are geomorphically active areas where the stream deposits the largest sized material near the top of the fan and finer-grained sediment near the distal (downstream) portion of the fan as the stream gradient/power drops. Observations at the Powerhouse Road crossing show a boulder/cobble bed with what appear to be lag boulders (moss-covered boulders indicating infrequent transport) interspersed with fresh gravel/cobble material.

The Newhalem Creek alluvial fan appears to be forcing the Skagit River to the North; the Skagit River narrows and has a locally higher gradient at the confluence with the creek. Gravel and cobble material transported from Newhalem Creek provides a source of spawning-sized material to the Skagit River.

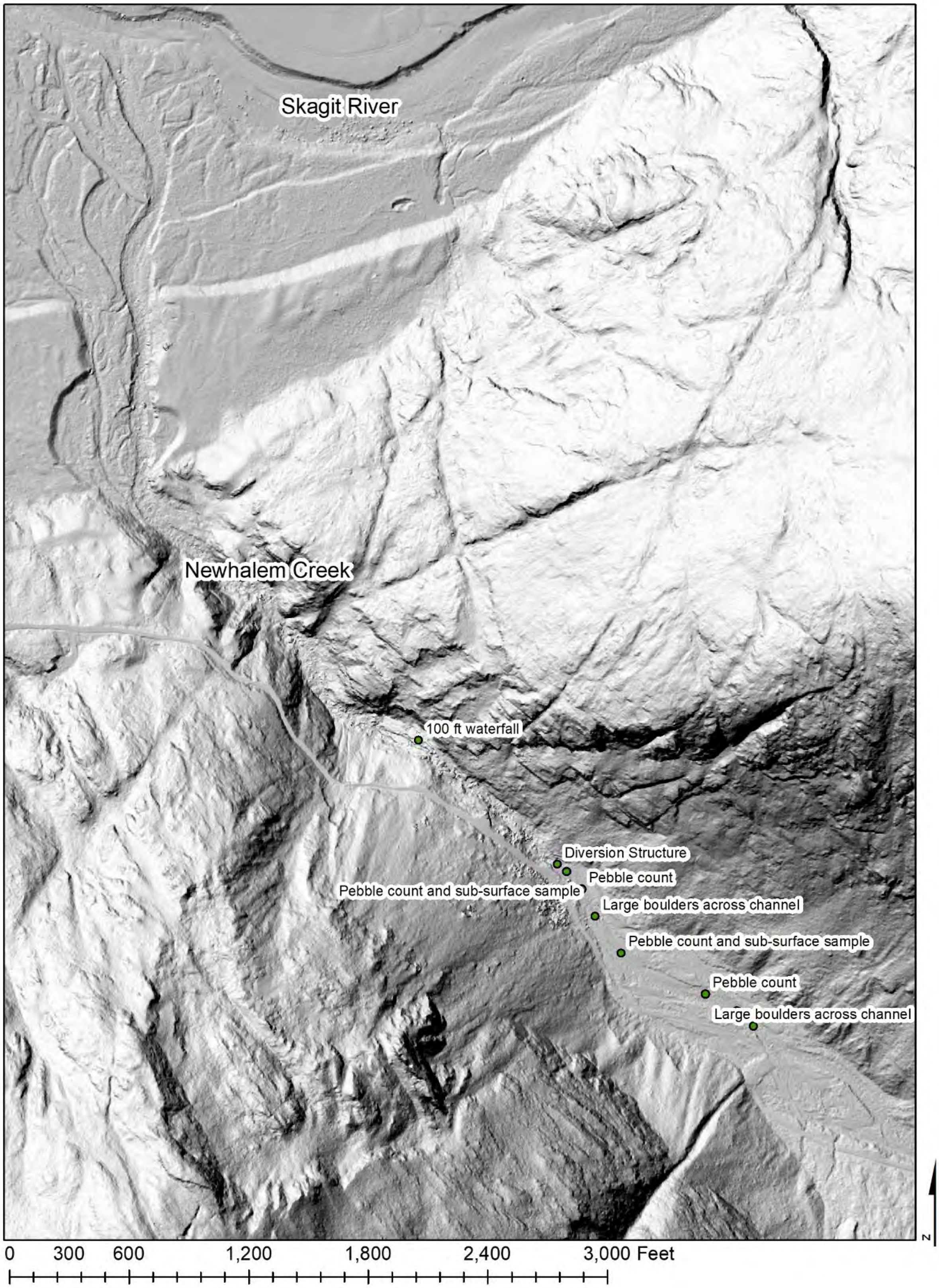


Figure 3.3-1. Topography of Newhalem Creek and Skagit River in Project area (2022 LiDAR hillshade)

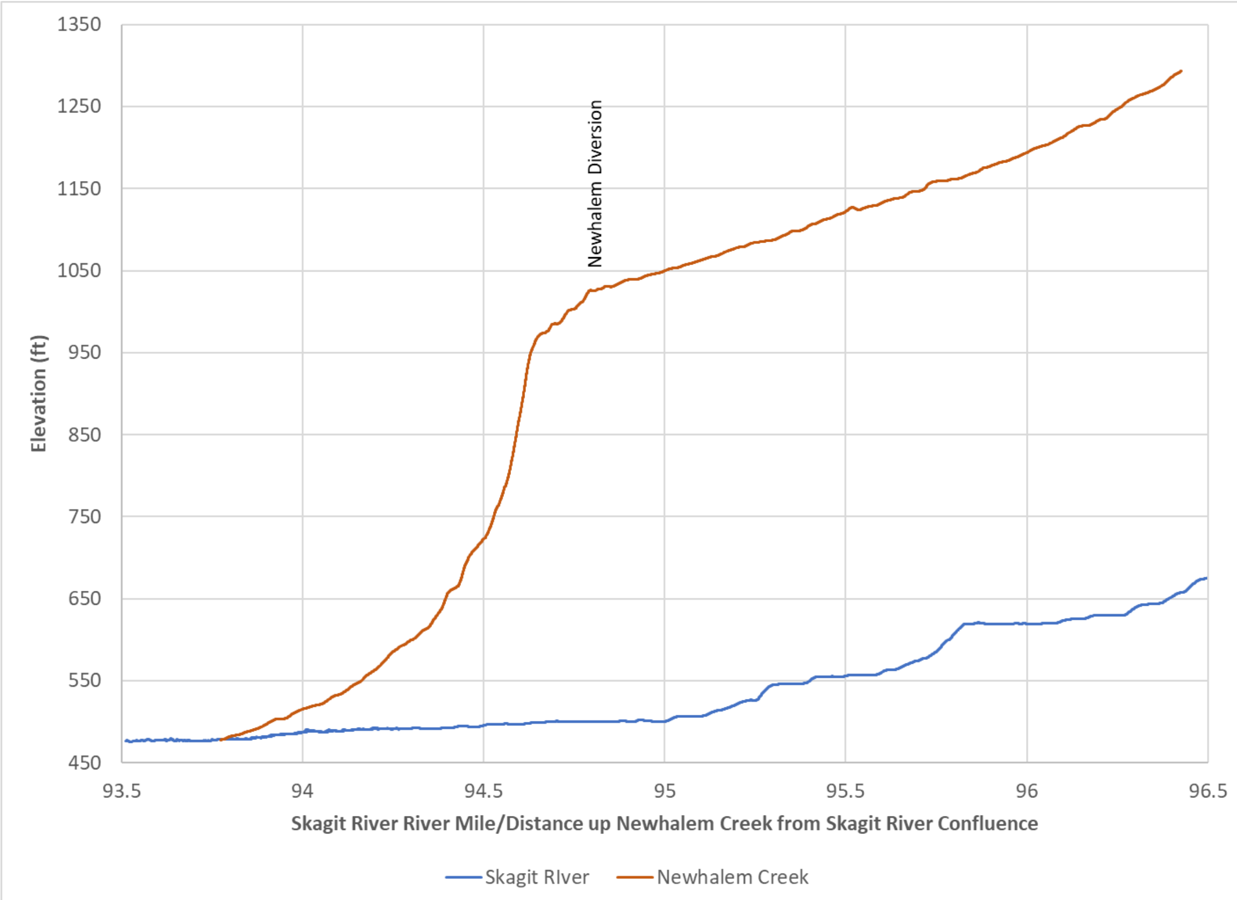


Figure 3.3-2. Longitudinal profile of Newhalem Creek and Skagit River.

3.3.1 Geomorphic Assessment of Newhalem Creek Upstream from Project Diversion Structure

Upstream from the Project diversion structure, Newhalem Creek is a high gradient stream. The 0.5-mile-long reach upstream of the intake has an average 2.2 percent slope gradient and includes a mix of pocket water (32 percent of reach length), pools (16 percent), glides (14 percent), step pools (13 percent), plane bed (11 percent), cascades (8 percent) and riffles (6 percent). Bankfull width ranges from 48 to 162 ft (average 70 ft) and bankfull depths ranged from 2 to 6 ft (average 3 ft, Figure 3.3-3). Bank heights ranged from 0.5 to 12 ft (average 5 ft) and varied considerably based on channel incision into the adjacent terraces, with left bank heights generally higher than right bank heights because of higher left bank terrace/fan features (Figure 3.3-4). Bank material was primarily boulder/cobble/gravel alluvium with some landslide debris.

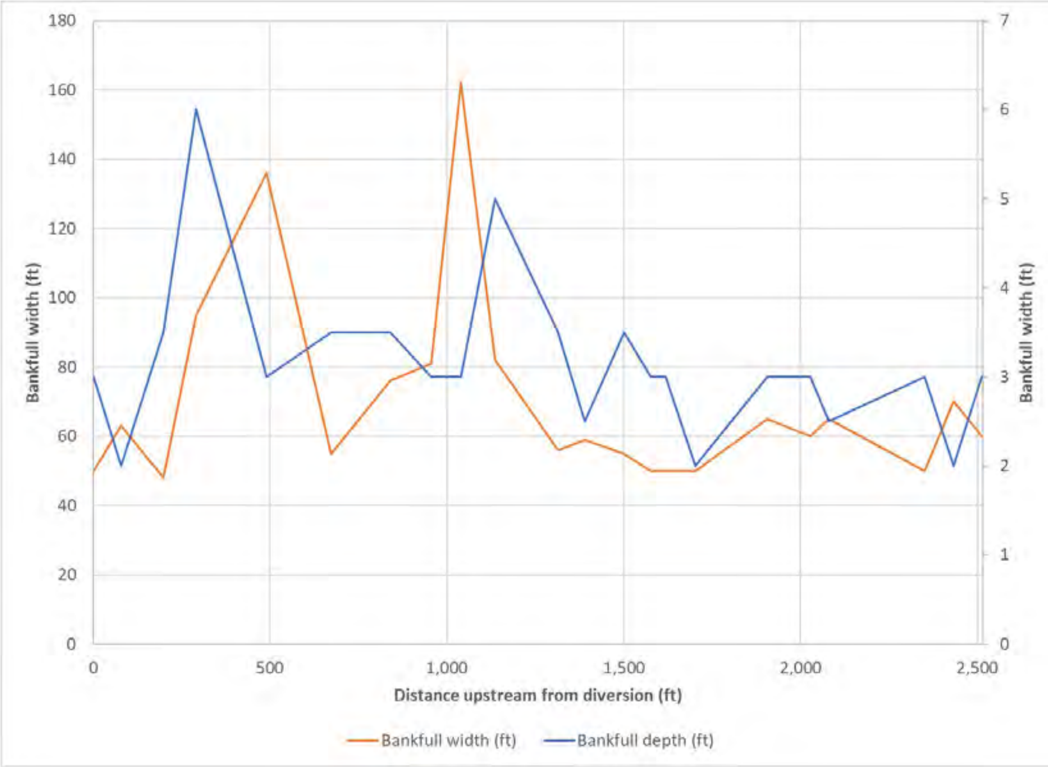


Figure 3.3-3. Bankfull width and depth upstream from Project diversion structure.

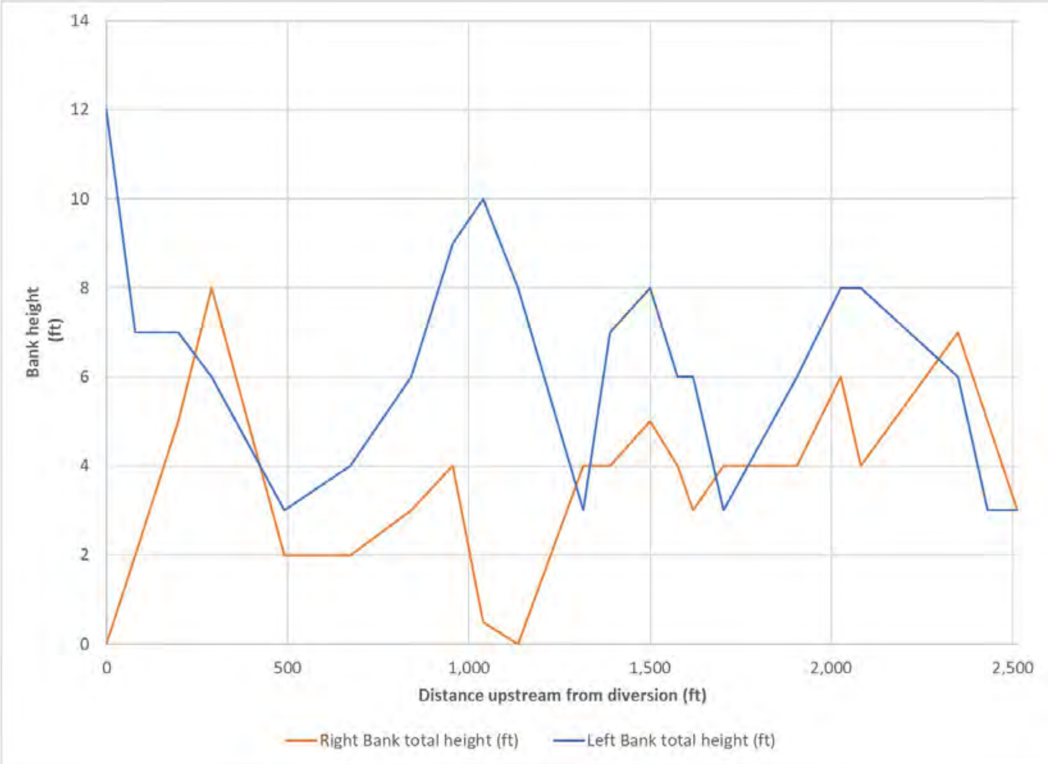


Figure 3.3-4. Bank heights upstream from Project diversion structure (right and left designations looking downstream).

Large, channel-shaping boulders (4- to 15-foot diameter) and large woody debris were also assessed during the field visit to help determine locations where boulders or large wood deposits will control the adjustment of the channel to removal of the Project diversion dam and associated structures. Numerous large boulders are located along the banks or across the channel between 227 and 440 ft upstream from the Project diversion structure, likely as the result of a large ancient slope failure from the left bank hillside. At 320 ft upstream from the diversion structure (station 320), several 6- to 12-foot-diameter boulders are located under the current stream channel and are forming a grade control, resulting in a cascade upstream from this location. Between 1,251 and 1,390 ft upstream from the diversion structure other groups of 5- to 7-foot-diameter boulders across the channel are forming a grade control. These boulders are large enough that they are not mobile under peak flows and appear to be forming persistent grade controls.

Large wood pieces and jams were noted during the geomorphic assessment, but most were along the banks and did not appear to be substantially impacting channel hydraulics except for several pieces of wood that were forming a pool between 702 and 730 ft upstream from the intake.

Details of the geomorphic unit assessment are included in Attachment A.

3.4 Grain Size Data

Pebble counts in Newhalem Creek upstream of the diversion in 2021 and 2022 show surficial substrate is composed of cobble, boulder, and gravel material (Figure 3.4-1 and Figure 3.4-2, Table 3.4-1 and Table 3.4-2). Median (D_{50}) grain sizes ranged from 106 to123 mm in 2021 and 89 to 238 mm in 2022 following an approximate 20-year return interval peak flow event in November 2021.

Sub-surface samples collected at two locations show that sub-armor material is, as expected, finer that the surface armor layer, with median grain sizes from 39 to 61 mm (Table 3.4-3, Figure 3.4-3). There was very little (less than 0.5 percent) silt/clay material in the sub-surface samples so high turbidity levels are not expected during streambed disturbing activities.

Boulder sized particles (larger than 512 mm diameter) were observed to have been transported into the intake area from upstream as a result of the November 2021 peak flow (provisional peak of 4,920 cfs). The grain size information was used to evaluate bed mobility, headcutting potential, and expected turbidity levels.

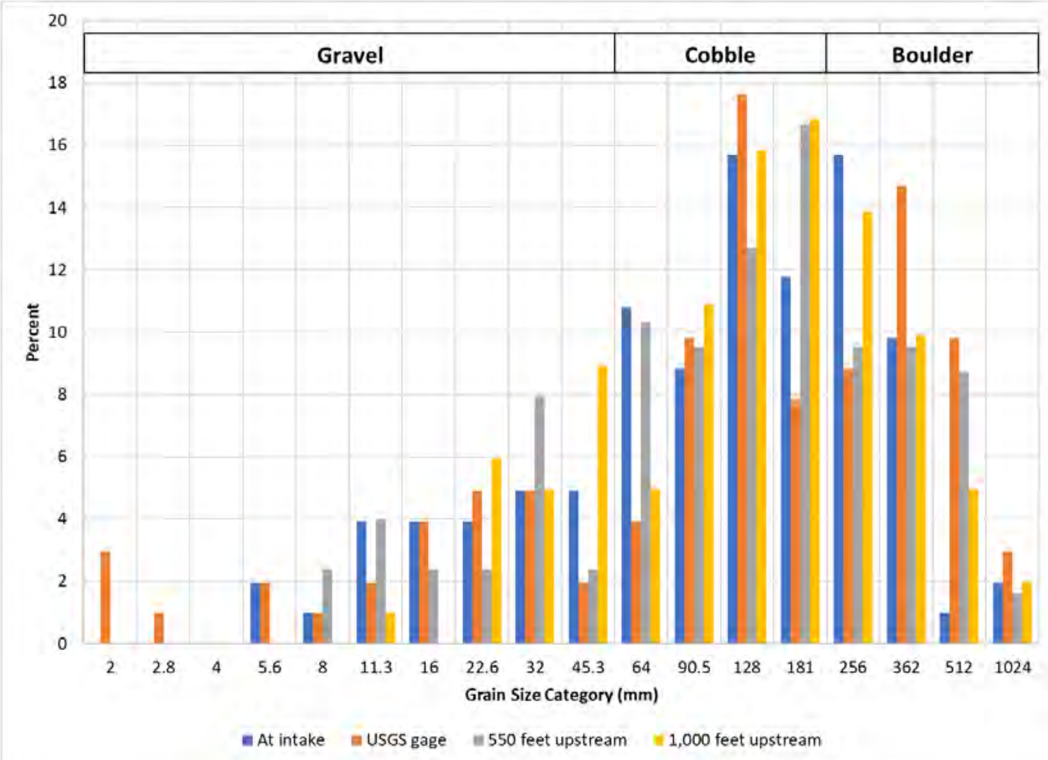


Figure 3.4-1. Grain size distribution of substrate upstream from Newhalem Creek diversion structure, 2021.

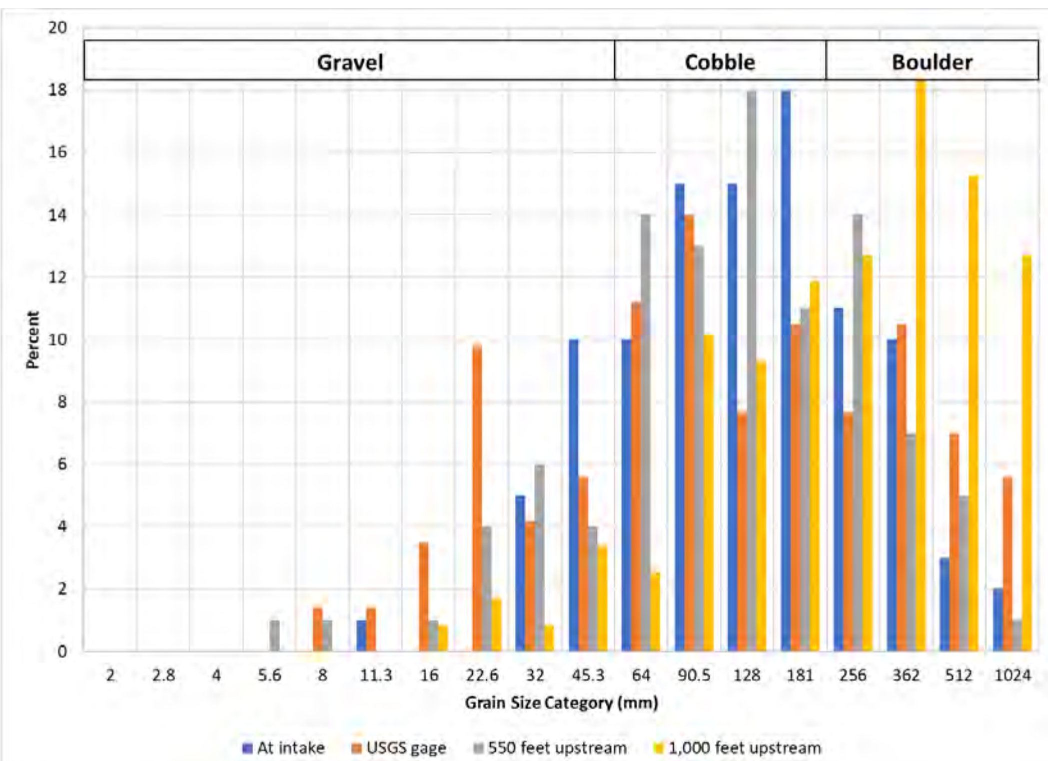


Figure 3.4-2. Grain size distribution of substrate upstream from Newhalem Creek diversion structure, 2022.

Table 3.4-1. Surficial grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2021).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	25	106	242	25%	47%	28%
USGS gage (180 ft upstream from diversion)	21	117	341	25%	39%	36%
550 ft upstream from diversion	29	118	312	21%	49%	29%
1,000 ft upstream from diversion	40	123	265	21%	49%	31%
AVERAGE	**29**	**116**	**290**	**23**%	**46**%	**31**%

Table 3.4-2. Surficial grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2022).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	45	115	250	16%	58%	26%
USGS gage (180 ft upstream from diversion)	23	89	329	26%	43%	31%
550 ft upstream from diversion	84	238	482	17%	56%	27%
1,000 ft upstream from diversion	42	105	241	7%	34%	59%
AVERAGE	**49**	**137**	**326**	**16%**	**48%**	**36%**

Table 3.4-3. Sub-surface grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2022).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Silt/clay	Percent Sand	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	3.5	39	164	0.5%	9%	53%	30%	8%
550 ft upstream from diversion	3.6	61	202	0.5%	12%	39%	40%	9%
AVERAGE	**4**	**50**	**183**	**0.5%**	**11%**	**46%**	**35%**	**9%**

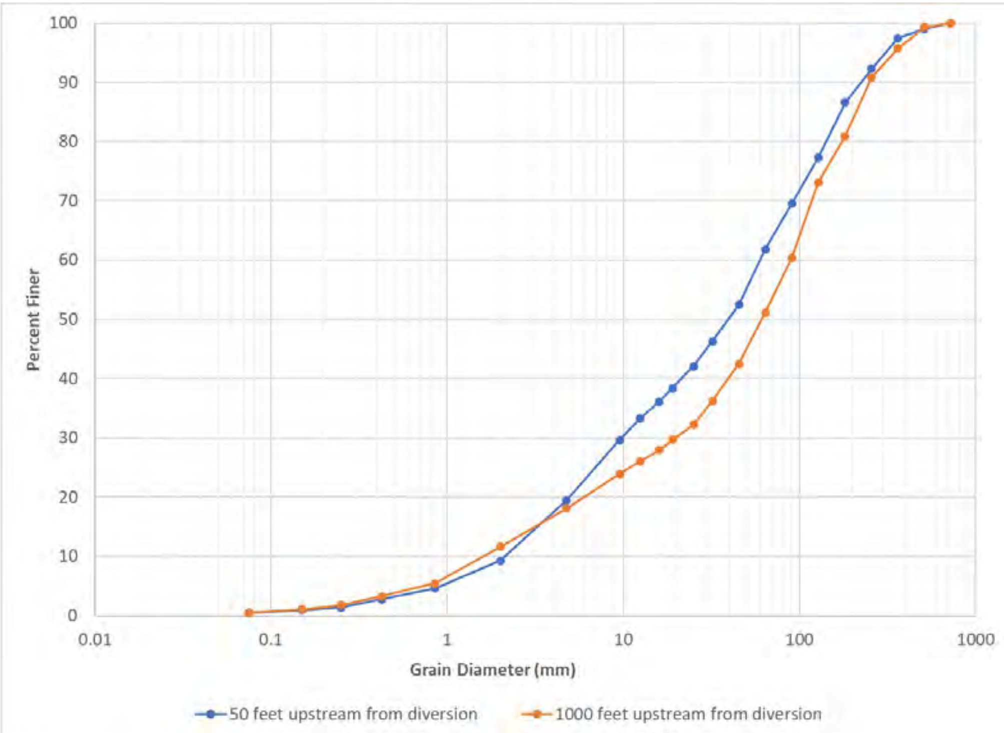


Figure 3.4-3. Grain size distribution of sub-surface samples upstream from Newhalem Creek diversion structure, 2022.

3.5 Existing Effects of Newhalem Project on Newhalem Creek Geomorphology

The Newhalem Project started operation over 100 years ago; the primary geomorphic effects on the Newhalem Creek have been:

- Diversion structure (8–10 ft tall) that provides a grade control for the stream (note that the original dam was replaced with the current structure in 1969);
- A small impoundment that retains some portion of the bedload transported from upstream reaches; and
- Diversion of water through the intake and out of Newhalem Creek when the Project was operating.

Over the 100 years since the Project began operating, Newhalem Creek has re-adjusted its profile upstream from the diversion structure to the new base level provided by the diversion dam. The small impoundment retains at least some portion of the bedload coming from the watershed upstream from the diversion. City Light reports that while the Project was operating, an average of 200–400 cubic yards of material were removed from the impoundment and placed in the channel downstream from the diversion dam on an annual basis to keep the area near the intake clear of sediment for Project operations. This provides a minimum estimate of the annual bedload transport volume in the stream. Since the removed sediment was placed downstream from the dam and the impoundment is very small, the Project did not cause a major net change in sediment supply to downstream reaches of Newhalem Creek.

4.0 DISCUSSION

The primary geomorphic effect associated with decommissioning the Newhalem Project will be the response of the streambed to removal of the diversion structure. Current plans are to remove the diversion structure to the underlying bedrock at an elevation of 1015 ft NAVD88 (approx. 1009 ft Project datum), 10 ft below the top of the existing diversion. This will lower the base level of Newhalem Creek at the diversion location and the stream will adjust to the new base level.

4.1 Potential Future Geomorphic Effects

Potential geomorphic effects of diversion removal include:

- Higher local stream gradient will increase sediment transport capacity immediately upstream from the diversion location in the short term (see Section 4.1.1).
- Existing sediment in the impoundment area will be transported downstream (see Section 4.2, particularly 4.2.2).
- As the channel adjusts to the lower base level over the longer term, the streambed upstream from the (removed) diversion structure will be lower than under existing conditions (see Section 4.1.1).
- There will be increases in turbidity immediately following diversion/cofferdam removal and during subsequent peak flow events that disrupt the armor layer; these are expected to be small and short-term increases (see Section 4.2.1).

Site conditions will minimize the amount of geomorphic change. The channel under and immediately downstream from the diversion is a high gradient (9 percent), boulder/bedrock channel. The bedrock provides a limit to the depth of channel incision at the diversion site and the high gradient channel downstream from the diversion site will quickly transport sediment from the impoundment to the alluvial fan and Skagit River.

4.1.1 Changes to Stream Profile Upstream of Diversion Structure

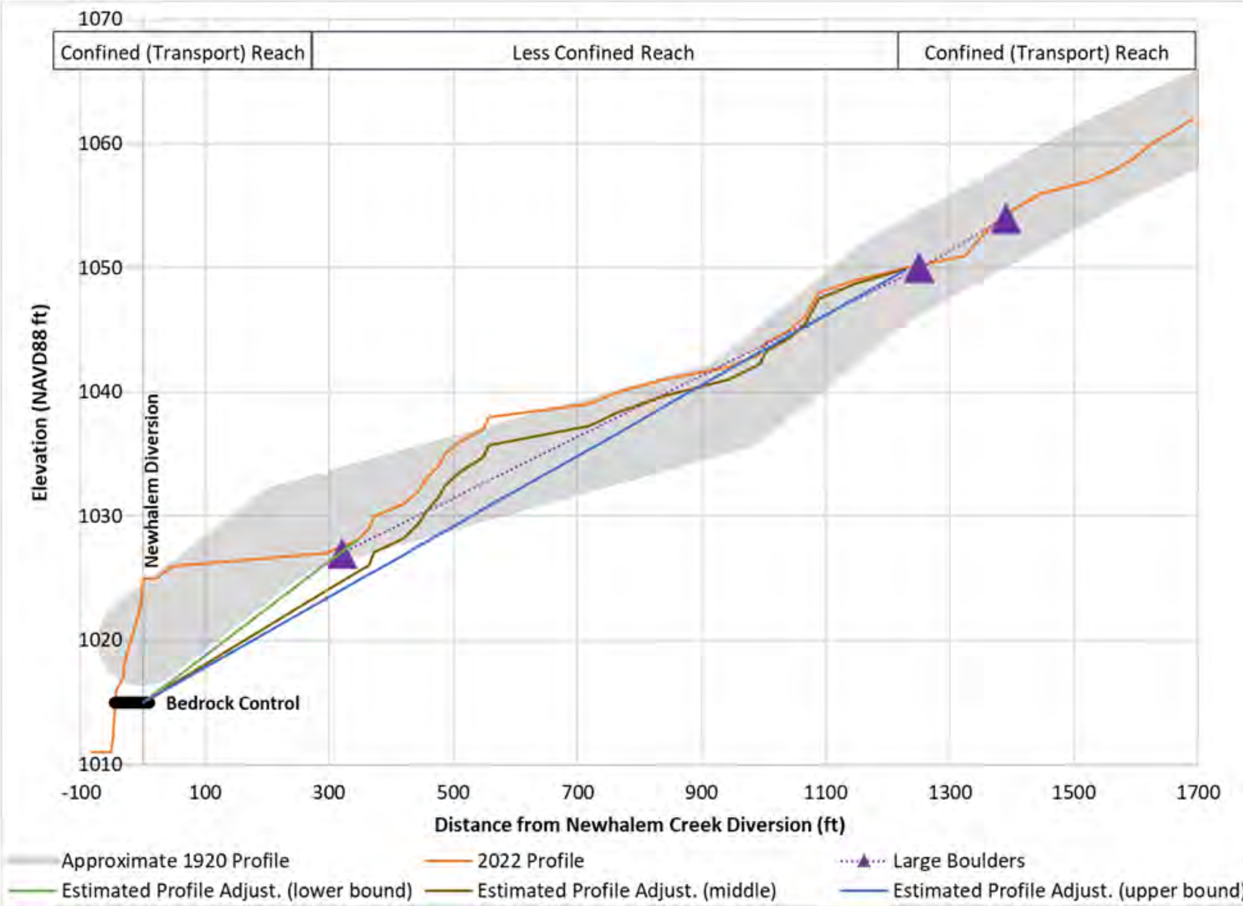
Removal of the diversion structure will result in adjustment of the bed of Newhalem Creek to the new base level. An approximate 1920 longitudinal profile (from Figure 2.2-1 above) and 2022 longitudinal profile (from LiDAR data) upstream from the diversion structure were plotted to compare approximate pre-Project and current stream profiles (Figure 4.1-1). There is uncertainty in horizontal location and vertical datum on the 1920 map, so the 1920 stream profile is shown as a wide band and should be considered approximate. The location of large, immobile (5- to 12-foot diameter) boulders from the field inventory were also plotted. These data were used to estimate the potential amount of channel downcutting that could take place following removal of the diversion structure.

Note that the 2022 stream profile includes several “steps,” in the 1,200-foot reach just upstream from the diversion/intake pool. A major step is located approximately 550 ft upstream from the diversion and is likely controlled by the large boulders at station 320 ft. This step is visible in the field as a steep cobble/boulder riffle located at the downstream end of a split high flow channel/island area. Several very large (10- to 12-foot diameter) boulders were observed under the existing channel at station 320 ft. These large boulders appear to have originated from an ancient,

large landslide on the west bank of the river and are not mobile, providing a stable grade control at this location. Two additional sets of large channel-spanning boulders were mapped at 1,251 and 1,390 ft upstream from the diversion. These are also at the toe of a landslide deposit. Steps are also apparent in the 1920 stream profile, suggesting that this type of stepped profile is a naturally occurring feature of the Newhalem Creek channel in this location.

Three bounding estimates of the amount of potential channel lowering shown in Figure 4.1-1 were made based on the following assumptions:

- Lower bounding estimate – assumes the 8- to 12-foot-diameter boulders 320 ft upstream from the existing diversion will be a grade control; the channel downstream from this location would lower to the green line in Figure 4.1-1.
- Middle bounding estimate: Assumes Newhalem Creek erodes into the right bank at the location of the 8- to 12-foot-diameter boulders (320 ft upstream from the existing diversion) and there are smaller boulders in the new channel location that allow some downcutting at this location. The stream continues to adjust the profile, but instead of a straight line (like the upper bounding estimate described below), the stream adjusts to a new profile with a similar shape as the existing profile. The brown line in Figure 4.1-1 shows a hypothetical new profile using these assumptions.
- Upper bounding estimate: Assumes the stream erodes toward the right bank and around the boulders at Station 320, there are no boulders in the right bank to form a grade control and the stream continues to adjust upstream to the location of the 5-foot angular boulders distributed across the stream 1,251 ft upstream from the diversion. In this scenario, the streambed adjusts to a straight-line profile from the bedrock under the diversion structure to the boulders at station 1,251, shown as the blue line in Figure 4.1-1. This straight line future channel condition is not likely given the character of Newhalem Creek, but it is provided as an upper bounding estimate.



Elevation is NAVD88

Figure 4.1-1. Longitudinal profile of Newhalem Creek upstream from diversion structure with potential profile adjustments.

Potential future change in channel bed elevation following diversion removal was determined by subtracting the 2022 bed elevation from the estimated lower, middle, and upper bounding profile lines. Bed lowering would be greatest just upstream from the removed diversion and at the top of the "steps" in the 2022 profile, with a maximum of 10 ft of bed lowering at the diversion structure (Figure 4.1-2). Estimated bed lowering would extend upstream at varying depths, from the diversion dam for 320 ft (lower estimate, green line) or 1,251 ft (middle and higher estimate, brown dotted and blue dashed lines respectively).

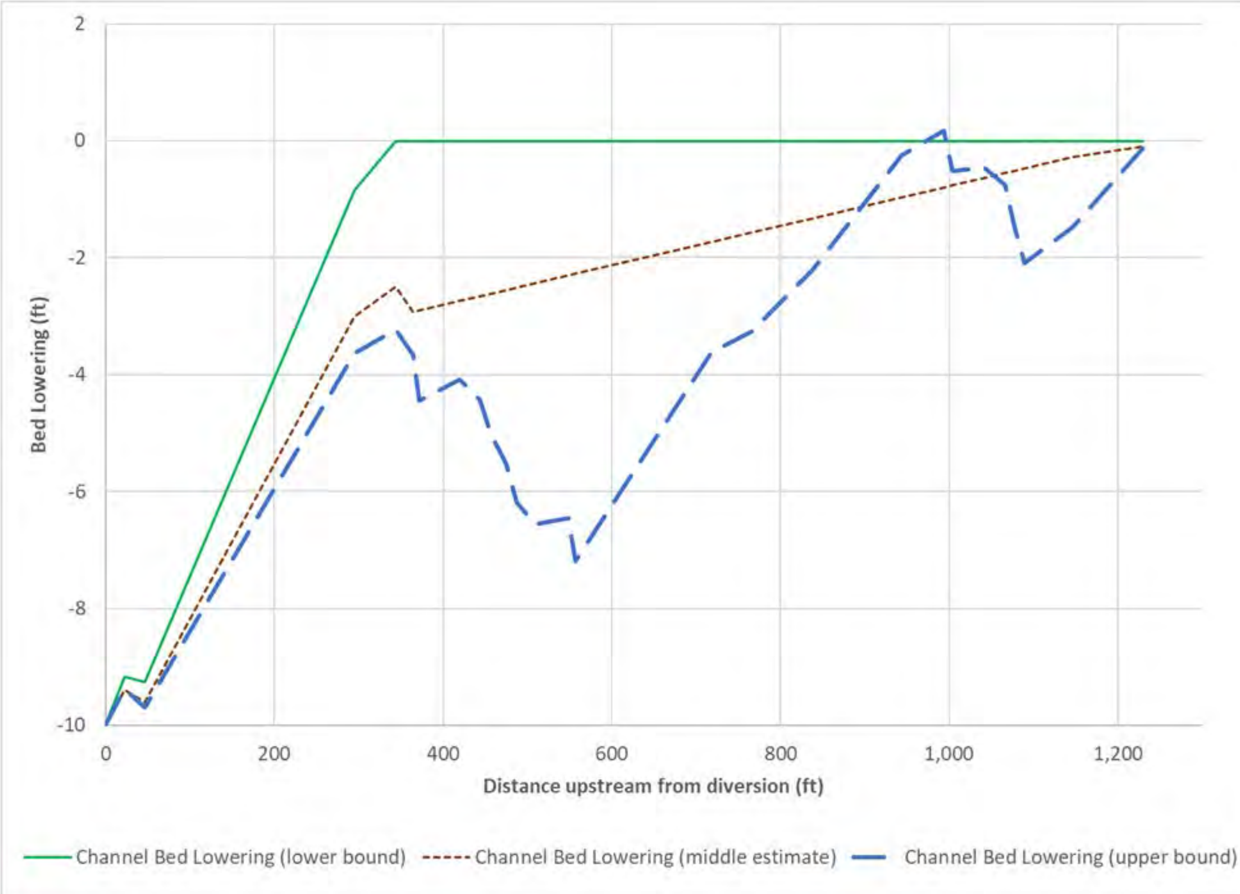


Figure 4.1-2. Estimated depth of bed lowering following removal of diversion structure for three channel adjustment scenarios.

The total volume of sediment that may be transported out of the adjustment area was calculated based on change in bed elevation and an average channel width of 70 ft (average bankfull width). Total potential volume of sediment transported is 4,400 cubic yards (lower bounding estimate), 9,000 cubic yards (middle estimate), or 12,900 cubic yards (upper bound estimate). These volumes can be compared to the estimated existing sediment load of Newhalem Creek made as part of the Skagit River Hydroelectric Project relicensing studies (Seattle City Light 2023). Estimates of coarse-grained sediment yield from Newhalem Creek were made using three different methods for the relicensing studies, as summarized below:

1. Based on the volume of gravel/cobble/boulder material removed from the Newhalem Creek diversion structure during past cleanout procedures, a minimum of 500–1,000 cubic yards/year of coarse-grained sediment is transported to the Newhalem Creek diversion structure. This is an absolute minimum annual volume because once the diversion pool fills with sediment any additional bedload would be transported over the diversion structure; during high flow years the volume of sediment movement would be much higher. Therefore, the average annual long-term bedload supply is higher than this amount.

2. Based on grain size sampling within Newhalem Creek and channel dimensions, an average of 2,000 cubic yards/year of bedload was estimated to move past the diversion. This is a more realistic volume of the average annual bedload movement rate near the diversion structure.

3. Based on a regional sediment yield equation, an estimated 10,000–15,000 cubic yards/year of gravel and cobble are supplied into the Skagit River from the Newhalem Creek watershed. This estimate takes into account very high flow events.

There is a wide range in the estimated average annual bedload supply volumes, but given even a lower-end estimate of 2,000 cubic yards/year under current conditions, the estimated volume of additional bed sediment that may be eroded following diversion removal is at most 6.5 times the average annual bedload supply rate (assuming the upper bound estimate of sediment is eroded following dam removal) and may be as little as 2.2 times the average annual amount of bedload sediment (assuming the lower bound estimate of sediment is eroded following dam removal).

If the amount of sediment eroded under existing conditions is closer to the higher end estimates from the regional sediment yield equation, the total amount of sediment transported downstream from dam removal would be equal to or less than the average yearly amount of bedload moving through Newhalem Creek under current conditions.

Under all potential future bed lowering scenarios, the re-adjustment to the new base level would likely take place relatively slowly due to the coarse nature of the streambed (cobble/boulder/gravel). The re-adjustment would take place over a decadal or longer time scale following the initial channel adjustment that would take place just upstream from the diversion structure.

4.1.2 Sediment Transport Analysis

Based on stream hydraulics and the current stream substrate size, the flow that could initiate substrate movement was calculated under current conditions (reach-averaged stream gradient 2.2 percent) and under conditions with the diversion removed (Table 4.1-1). Frequencies listed in the table reflect the values calculated for the peak flow recurrence intervals at the USGS gage just upstream from the diversion (see Table 3.2-1 in previous discussion of stream hydrology). Particles up to 512 mm in diameter were mobilized between the 2021 and 2022 field visits; the peak flow in November 2021 was 4,920 cfs, indicating that boulders up to at least 512 mm are mobile in the stream under those flow conditions.

Table 4.1-1. Calculated discharge required to transport substrate upstream of diversion structure under existing conditions and following diversion removal, historic peak flows.

Stream Gradient	Discharge and frequency of median (D_{50}) grain size transport	Discharge and frequency of larger (D_{84}) grain size transport
2.2% (reach average over long term)	250 cfs; every year	3,000 cfs; 5 years
1.3% (existing local slope just upstream from diversion)	1,500 cfs; 1.5 years	over 9,000 cfs; 100+ years
3.8% (short term local slope upstream from diversion with diversion removal and drop in base level)	120 cfs (many times/year)	1,500 cfs; 1.5 years

In the short-term, immediately following diversion removal, the local stream gradient just upstream of the diversion would increase from 1.3 to 3.8 percent, which would increase the sediment transport frequency of the median (D_{50}) sized substrate from every 1.5 years to many times/year. Transport of larger particles (e.g., D_{84}) would increase from very infrequently (over 100-year recurrence frequency) to movement under a 1.5-year peak flow event. This analysis suggests that the bed immediately upstream from the diversion structure would respond quickly to diversion removal. It is anticipated that the substrate just upstream from the removed diversion structure would be mobilized as soon as the diversion/cofferdams were removed, and an armor layer would form quickly as finer material was transported downstream and larger, immobile particles (e.g., boulders) remained on the bed. As flows increase during subsequent larger flow events, some of the bigger substrate particles would be mobilized and transported downstream and the process would continue until Newhalem Creek reaches a new, stable profile.

As material on the bed is transported downstream, the locally high stream gradient above the removed diversion structure would migrate upstream. The bed adjustment would migrate upstream until a grade control is reached, such as the large, immobile boulders in the channel 320 ft upstream from the diversion or the set of large boulders between 1,251 and 1,390 ft upstream from the diversion.

As the bed adjustment progresses upstream, the local gradient increase would become less and less until a new long-term average slope condition is reached. As the local gradient increase becomes less and less, the corresponding energy to move particles becomes less, resulting in less frequent bedload movement and a slowing of the process. Bed adjustments can migrate upstream fairly rapidly in fine-grained sediments, but the large particle sizes in Newhalem Creek will form an armor layer and further reduce the speed of adjustment migration and the large, immobile boulders noted above will limit channel incision. It is anticipated that as an armor layer forms, the larger substrate will be mobile much less frequently and channel adjustments will take several decades. Over time, a new equilibrium channel gradient will develop.

The grain size transport frequency in Table 4.1-1 assumes similar peak flow magnitudes as historic conditions. As discussed in Section 3.2.1, climate change modeling suggests that future peak flows may be higher magnitude than historic conditions, although higher magnitude peaks have not been documented as of 2022 at the Newhalem gage. If future peak flows are higher, Newhalem Creek

would adjust more quickly to diversion removal as the higher flows transport material through the river system. If higher future peak flows do occur, the entire Newhalem/Skagit river system would experience the increased peak flows, resulting in more active sediment transport/geomorphic change throughout the river system and mute the more rapid changes resulting from the Newhalem Creek diversion removal.

4.1.3 Potential Grade Control Structure Considerations

FERC has requested the cost for design of a grade control structure near the current diversion dam in the October 28, 2022, Additional Information Request in response to some resource agency interest in a grade control structure.

The need for a grade control structure should be balanced between the desire to return the stream to a natural condition (with no structures) and the risk of headcutting. As discussed in previous sections, there is a low risk of rapid or far-reaching headcutting (past the 1,251–1,390-foot boulder clusters) in Newhalem Creek following diversion dam removal for the following reasons:

1. The diversion structure is underlain by bedrock that will provide a stable, long-term base level.

2. There are large, immobile boulders (5- to 12-foot diameter) underlying the channel at several locations upstream from the diversion structure (320; 1,251; and 1,390 ft). These boulders will not be mobile under current or future flows and will provide natural grade controls in the stream that will limit headcutting.

3. The large substrate in Newhalem Creek does and will continue to form an armor layer that is resistant to rapid erosion of the channel.

4.2 Changes Downstream from the Diversion Removal

Sediment that is moved out of the diversion area will be transported rapidly through the high gradient canyon (8.9 percent slope) and 100-foot-high waterfall reach to the alluvial fan area. Boulders and large cobble will be deposited at the upstream end of the Newhalem Creek alluvial fan in the Skagit River valley; actual deposition locations will reflect gradient and stream conditions on the fan. Some cobble, gravel and finer sediment will be transported farther downstream and eventually reach the Skagit River, providing a source of sediment for spawning and aquatic habitat.

4.2.1 Turbidity

Turbidity effects resulting from disturbance of the streambed during instream work has been identified as a potential concern. During structure removal, instream work areas will be isolated from the streamflow by cofferdams and appropriate erosion/streamflow control measures as described as part of engineering/construction operations in separate documentation. Following instream work, the cofferdams will be removed and Newhalem Creek water will again flow over the streambed and begin readjustment to the new base level without the diversion structure.

Turbidity levels following diversion removal could increase under the following conditions:

- Immediately following cofferdam removal until the stream forms a surficial armor layer; and
- During subsequent peak flow events that disrupt the armor layer as the stream re-adjusts to the new base level.

Sub-surface sampling (Section 3.4) at two locations upstream of the diversion structure in 2022 found less than 1 percent silt/clay material in the streambed. The low levels of fine-grained sediment will result in minor increases in turbidity during either of the streambed-disturbing flow conditions listed above. The Newhalem Creek watershed is underlain by the Skagit Gneiss that primarily weathers to sand-sized particles rather than finer-grained silt and clay, so there are only minor sources of fine-grained material in the watershed (such as Quaternary glacial deposits).

As part of operation of the Newhalem Project, the intake pool upstream of the diversion dam was cleaned out on a regular basis. During low flow periods, approximately 250 to 425 cubic yards of accumulated material was removed with an excavator and placed on the concrete apron downstream from the diversion structure and allowed to move downstream (Figure 4.2-1, Figure 4.2-2, and Figure 4.2-3). Turbidity monitoring took place during the cleanout events; these data provide another indication of levels of turbidity expected immediately following diversion and cofferdam removal. The baseline and peak turbidity levels measured during 2012, 2015, and 2016 cleanout events are shown in Table 4.2-1. Peak turbidity levels from 0.88 to 58.79 NTUs over background were measured immediately following gravel placement but reached background levels in less than 24 hours.

It is anticipated that turbidity level increases following cofferdam removal will be similar to those during pool cleanout and that turbidity levels will decrease quickly after initial higher levels. Turbidity levels will also likely increase during subsequent higher flows as the armor layer upstream from the diversion location is disrupted and the stream adjusts to the new base level. These turbidity increases are also anticipated to be minor and transient due to the low level of fine-grained material in the subsurface material.

Figure 4.2-1. Intake pool area during cleanout.

Figure 4.2-2. Intake pool following cleanout.

Figure 4.2-3. Material removed from intake pool placed on concrete apron downstream from diversion structure.

Table 4.2-1. Newhalem Creek intake pool cleanout turbidity monitoring data.

Monitoring Date	Baseline NTU	Peak NTU after excavation	Change in NTUs (over background)
9/17/2012	0.18	30.0	+29.82
9/18/2012	0.21	59.0	+58.79 (max)[2]
8/7/2015	0.13	4.5	+4.37
8/8/2015	0.50	21.1	+20.6
8/9/2015	0.46	16.6	+16.14
8/17/2015	0.20	1.08	+0.88
8/22/2016	0.35	5.46	+5.11
8/24/2016	0.2	39.5	+39.3
8/24/2018	0.1	18.18	+18.08
8/25/2018	0.31	18.29	+17.98
8/26/2018	0.70	17.6	+16.9
8/27/2018	0.90	9.98	+9.08
8/28/2018	0.33	11.28	+10.95
8/29/2018	0.40	13.56	+13.16
8/30/2018	0.32	13.45	+13.13

[2] Turbidity suspected to be higher due to pockets of sandy sediments that were encountered in 2012.

4.2.2 Potential for Filling Step Pools

The step pools downstream from the diversion structure have been identified as important cultural resources, with a concern that removal of the diversion and transport of material from upstream may fill the step pools. Modeling or calculation of sediment transport through step pool structures is difficult due to the complex 3-dimensional hydraulics, but observations of sediment movement through the step pools following cleanout of the intake pool provides empirical evidence of sediment transport and accumulation in the step pools.

The step pools were not observed to fill with material following intake excavation events which took place during low flow conditions (Figure 4.2-4). Gravel was observed on the sides of the step pools, but velocities in the pools was high and turbulent enough at low flow to transport material through and maintain the pool structure among the boulders and bedrock forming the pools. During higher flows, velocities and turbulence in the pools are much higher and material on the edges of the pools is also transported downstream. Observations made during the 2021–2022 site visit indicated that cobble, boulder, and gravel material had filled the intake pool and was being transported over the intake structure. No evidence of filled step pools downstream of the diversion was observed indicating that flows high enough to mobilize material upstream of the diversion are high enough to transport the same material through the higher gradient/confined step pool section of the stream (Figure 4.2-5).

Following diversion structure removal, cobble, gravel, and boulders would move downstream and through the step pools in a similar manner as during the intake cleanout events and current high flow events. As flows increase, additional material will be mobilized upstream of the diversion structure location and the higher flows will transport the material through the step pools. It is anticipated that step pools will retain pool depth following diversion removal and there will be minimal or no long-term effects.

Figure 4.2-4. Step pools downstream from diversion structure following August 24, 2016 intake pool cleaning.

Figure 4.2-5. Step pools downstream from diversion structure in September 2022.

4.2.3 Potential for Changes to Downstream Debris Slide

There is a large, ancient landslide on the southwestern (left bank) side of Newhalem Creek that extends from several hundred feet upstream of the diversion structure to the base of the waterfall approximately 1,100 ft downstream from the diversion. A much smaller debris slide is located at the downstream end of the larger slide; the smaller debris slide has been active for at least several decades and affects the Newhalem Creek dam access road. The NPS questioned whether the accumulation of material in Newhalem Creek following removal of the diversion structure could result in erosion of the toe of the landslide that could re-activate the slide. A memorandum describing the landslide and debris slide provides information describing the slide complex (Findley 2021) and is summarized in the next two paragraphs.

The active debris slide consists of alpine glacial deposits overlying Skagit gneiss bedrock. The large, ancient slide likely consists of similar material and the toe of the large slide blocks the Newhalem Creek valley, diverting the flow to the northeast side of the drainage where Newhalem Creek currently flows (Figure 4.2-6). The older slide has mature trees that are straight and plumb suggesting little recent ground movement, while trees within the active, smaller debris slide area exhibit leaning trunks consistent with ground movement.

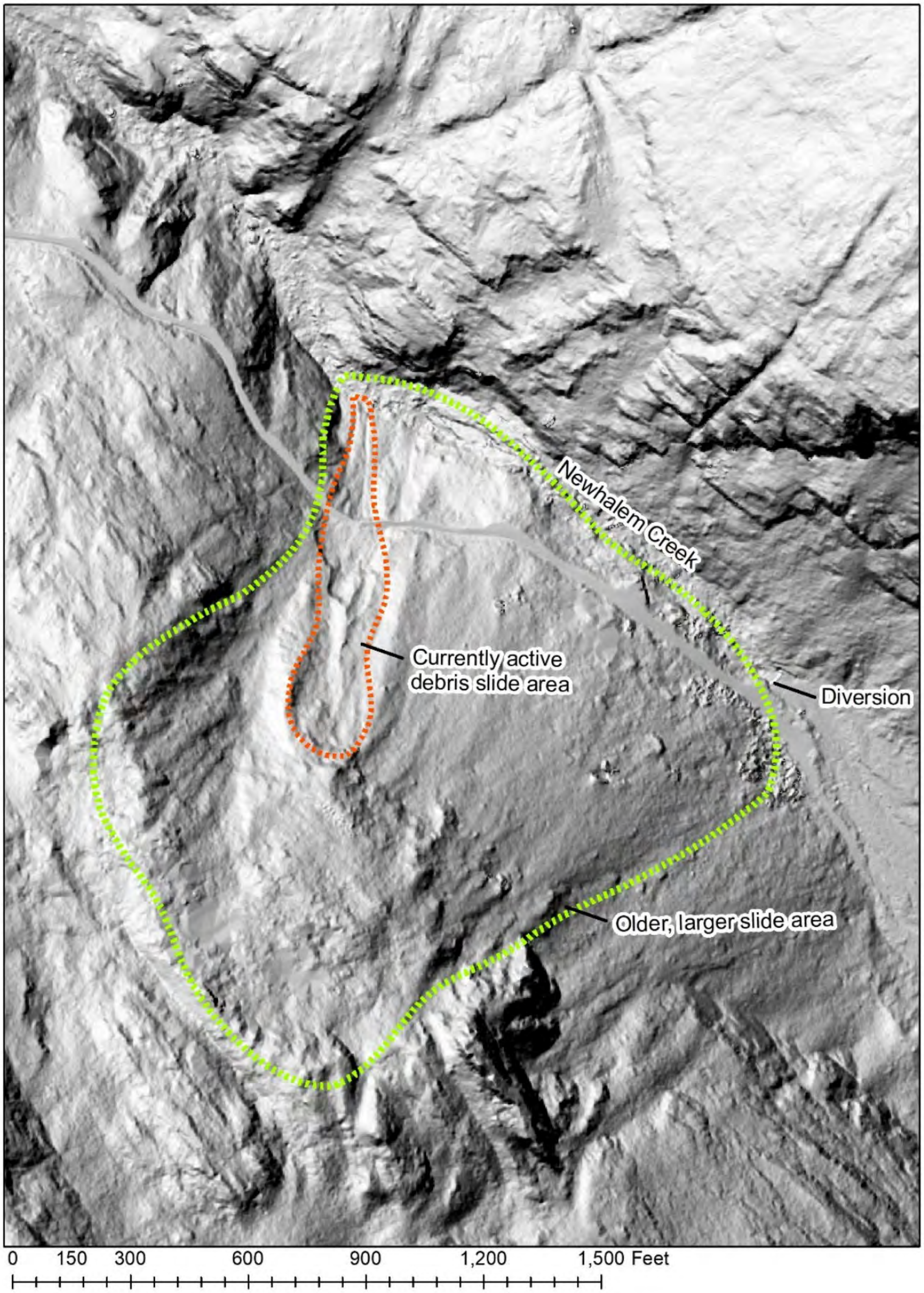


Figure 4.2-6. LiDAR hillshade image showing older, larger and younger, active debris slide areas (after Findley 2021).

The active landslide area uphill from the access road is approximately 250 ft wide and 500 ft high with a slope inclination of 40–45 degrees steepening to 70 degrees in the headscarp. Soil is coarse subangular cobbles and boulders in a silty/sandy matrix. Numerous boulders larger than 10 ft in diameter were observed in the landslide area. The toe of the smaller, active slide is at the base of the 100-foot-high waterfall in Newhalem Creek. Findley (2021) notes that the large, older landslide does not appear to be currently active based on field observations but erosion along the toe of the mass by Newhalem Creek presents a potential for future reactivation.

The 2015 LiDAR elevation data were subtracted from the 2022 LiDAR data to produce a map showing areas of lower topography (erosion—in blue on map) and accumulation (in red on map) for the smaller, active slide area (Figure 4.2-7; yellow areas indicate little change in elevation from 2015 to 2022). As expected, there was erosion/elevation drop at the headscarp of the active slide and deposition of material on the roadway. The 2015–2022 slide movement was primarily uphill from the roadway and does not appear to be directly connected to erosion at the toe of the slide since there was little movement of the slope between the road and the stream despite evidence of up to 5 ft of erosion within the creek at the toe of the slide. This indicates Newhalem Creek has the potential to erode the toe of the smaller, active landslide under current conditions.

Determining the stability of either the larger, old landslide or the smaller active landslide is not possible with the available data, so a slope stability analysis of how any accumulation or scour of material in Newhalem Creek following diversion removal may affect either slide area is not possible. However, based on field observations of mature trees and the large boulders within the stream and at the base of the slide, the large, older slide has not been affected by Newhalem Creek flowing at the toe of the slide for a very long time. Newhalem Creek is eroding the toe of the smaller, active slide under current conditions, Based on the results of a reconnaissance of the smaller landslide on June 2, 2023, by Seattle City Light staff, the toe of this landslide is armored by 20–25 ft of large boulder debris. The erosion currently being caused by Newhalem Creek is surficial material or accumulated material within the streambed and is not destabilizing the landslide. In order for toe erosion to destabilize the landslide, the creek would have to erode material above the 20–25 ft of protective boulder armoring at the toe. It is not feasible that 20–25 ft of material could be deposited following dam removal in this high gradient, confined location in the stream.

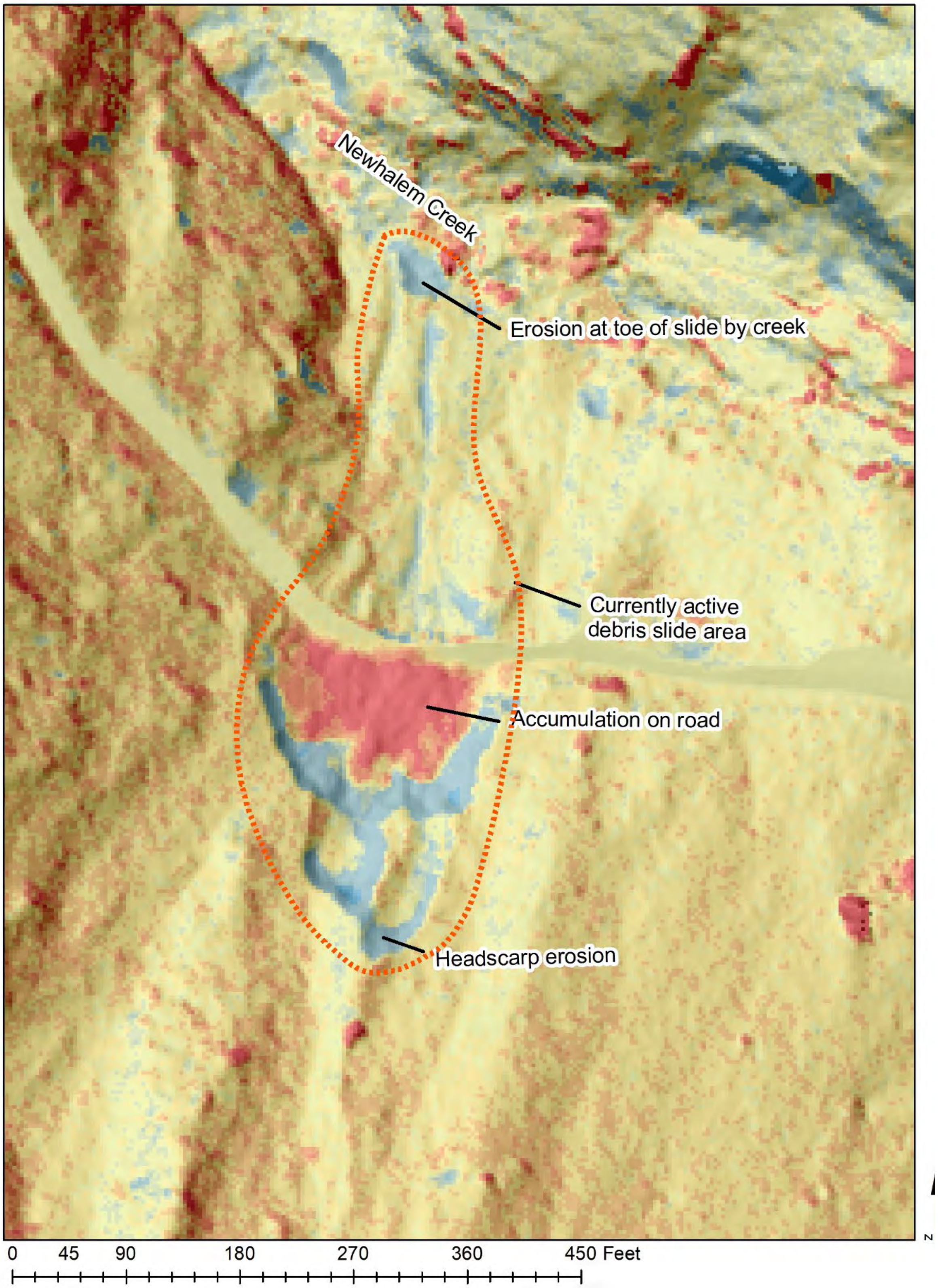


Figure 4.2-7. Difference between 2015 and 2022 LiDAR showing erosion (blue) and accumulation (red) zones within smaller, active debris slide (yellow areas had little change).

4.2.4 Potential for Changes to Alluvial Fan and Skagit River

Downstream from the diversion structure, Newhalem Creek has a confined, step-pool structure, a 100-foot waterfall, another confined step-pool section, and then a lower-gradient, less confined alluvial fan reach before entering the Skagit River (see Figure 3.1-1 above). Sediment that is transported from the area upstream of the diversion following diversion removal will enter the alluvial fan reach and some material will be deposited on the fan with the remainder transported into the Skagit River depending on the size of the sediment and flow levels. The largest material (e.g., boulders) will be deposited at the upstream end of the fan with smaller material transported farther downstream, similar to the deposition patterns of sediment that moves through Newhalem Creek under current conditions. Note that the average gradient of the alluvial fan reach is 5 percent and the average gradient of Newhalem Creek upstream of the diversion structure is 2–3 percent. Since bedload transport is directly proportional to stream gradient, the majority of smaller material (gravel and finer) will be transported into the Skagit River rather than being deposited on the alluvial fan and provide substrate suitable for use by spawning fish.

NPS has requested information on the likelihood of deposition of material on the alluvial fan re-activating old channels on the fan, or the likelihood of material being deposited at the confluence with the Skagit River and pushing the river channel toward the north.

As discussed in Section 4.1.1, the total volume of coarse-grained sediment (gravel, cobble, boulder) that is likely to be eroded from upstream of the diversion and transported to the alluvial fan/Skagit River confluence is between 4,400 and 12,900 cubic yards, the equivalent of less than one year to up to 6.5 years of the average annual coarse sediment supply from Newhalem Creek depending upon the method of estimation. It is anticipated that the additional material will not be transported in a single year but will take several years or decades to be mobilized, depending upon actual streamflow in the years following diversion removal. As an upper bounding estimate, if the total volume of potential additional material was deposited evenly within the Newhalem Creek channel (average wetted width 50 ft) in the alluvial fan reach (2,500 ft long), it would result in deposition of approximately 1–3 ft of sediment. This is not a realistic scenario, however, since the total volume of material will not be eroded from the diversion in a single year. In addition, the alluvial fan is higher gradient than Newhalem Creek upstream from the diversion, so the majority of finer-grained material (e.g., small gravel) that is in the streambed upstream from the diversion structure would be transported through the alluvial fan reach.

To assess the likelihood of deposition in the alluvial fan re-activating old channels, the potential depth of sediment deposits calculated above was compared to the height of the alluvial fan surface above the existing stream channel at several locations along the fan. Bank heights at the upper end of the alluvial fan in the location of old channel traces are 5–7 ft above the current stream channel, 10–13 ft above the current stream channel in the middle of the fan, and 4–5 ft above the current stream channel at the lower end of the fan near the Skagit River confluence. Based on the unlikely scenario that sediment deposited at the calculated maximum potential depths of less than 3 ft, it is unlikely that enough sediment would be deposited in the Newhalem Creek channel in the alluvial fan section to re-activate old channels.

The median (D_{50}) particle size on bars in the Skagit River between Gorge Dam and Bacon Creek is approximately 45 mm, and the estimated bedload sediment transport rates in the Skagit River near the Newhalem Creek confluence are 10,000 to 50,000 cubic yards/year (Seattle City Light

2023). Comparing these bedload transport rates to total potential sediment input from the Newhalem Creek diversion removal (4,400–12,900 cubic yards), the total potential sediment input from diversion removal is less than or equal to the average annual sediment transport rate in the Skagit River. It is therefore unlikely that removal of the Newhalem Creek diversion structure will result in substantial deposition within the Skagit River. It is likely that there may be small amounts of deposition, but deposited material will likely be mobilized during subsequent high flows in the Skagit River.

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NEWHALEM CREEK DECOMISSIONING GEOMORPHOLOGY CONSIDERATIONS

ATTACHMENT A

GEOMORPHIC STREAM ASSESSMENT NOTES

Newhalem Ck. Geomorphic Unit geometry, boulders, banks, and large wood data collected by Andrew Nelson and Ed Fordham on 10/14/22 upstream from Project diversion structure

Sediment size classes used in notes

fG Fine gravel (none noted): 8-22 mm
G Gravel: 22-64 mm
C Cobble: 64-180 mm
LgC Large Cobble: 180-360 mm
B Boulder: >360 mm

Geomorphic Units, Substrate, Bankfull Dimensions, Bank Height/Materials

Distance upstream from diversion (ft)	Geo morphic Unit Type	Dom-inant Bed Material	Sub dominant Bed Material	Other important bed material	Bankfull width (ft)	Bankfull depth (ft)	Tailout Depth (ft)	Pool Depth (ft)	Right Bank total height (ft)	Right Bank Lay back (ft)	Right bank material	Left Bank total height (ft)	Left Bank layback (ft)	Left Bank material
0	Riffle	LgC	C	B, G	50	3	NA	NA	NA	NA		12	6	pool dredge spoils
79	Glide	LgC	C	B, G	63	2	0.5	1	2	3	Bouldery alluvium	7	8	Angular boulder
198	Pool	LgC	B	G	48	3.5	1	2.5	5	7	Bouldery alluvium	7	8	Cobbly Alluvium
290	Cascade	LgC	C	B	95	6	NA	NA	8	14	Cobble w/ small boulders	6	20	Landslide boulder debris
490	Glide	C	LgC	B	136	3	1	2	2	18	not noted	3	5	Cobbly Alluvium
673	Pool	LgC	B	G	55	3.5	1	3	2	12	Gravel bar over cobbly alluvium	4	8	Cobbly Alluvium
840	Pocket Water	LgC	C	B	76	3.5	1	1.5	3	7	not noted	6	3	not noted, actively eroding (cobbly alluv if memory serves right)
956	Step Pool	B	C		81	3	1	2	4	4	not noted	9	7	0.5 ft silty sand over 1' sandy gravel w/ sm. Cobble over 0.5 ft coarse sand over 7' poorly graded cobble (sand-boulder sizes)
1040	Step Pool	B	C		162	3	1	2	0.5	20	boulder levee seperating side channel offtake	10	7	poorly graded cobble (sand-boulder sizes)
1136	Pool	C	LgC	B	82	5	0.5	3	no noted	not noted	Cobbly gravel with boulders	8	6	6' sandy gravel over 2' cobbly gravel with boulders
1315	Riffle	B	C		56	3.5	0.5	1	4	4	boulder cobble	3	3	boulder cobble
1390	Pocket Water	C	LgC	B, G	59	2.5	0.5	1.5	4	6	Cobble and boulder	7	3	Rounded boulder & cobble, lots of root reinfocement

Distance upstream from diversion (ft)	Geo morphic Unit Type	Dom-inant Bed Material	Sub dominant Bed Material	Other important bed material	Bankfull width (ft)	Bankfull depth (ft)	Tailout Depth (ft)	Pool Depth (ft)	Right Bank total height (ft)	Right Bank Lay back (ft)	Right bank material	Left Bank total height (ft)	Left Bank layback (ft)	Left Bank material
1500	Pocket Water	C	B		55	3.5	0.5	1.5	5	8	boulder and cobble	8	6	angular small boulder and cobble
1576	Step Pool	C	B		50	3	0.5	2	4	8	rounded boulder-cobble	6	9	angular cobble-boulder
1619	Plane bed	B	C		50	3	NA	NA	3	6	rounded boulder-cobble	6	9	angular cobble-boulder
1703	plane bed	B	C		50	2	NA	NA	4	6	rounded cobble-boulder	3	6	not visible
1905	Pocket Water	LgC	B		65	3	not noted	not noted	4	6	rounded cobble-boulder	6	8	rounded cobble-boulder
2027	Step Pool	B	LgC		60	3	not noted	not noted	6	6	not noted	8	6	not noted
2081	Pocket Water	LgC	C	B	65	2.5	not noted	not noted	4	15	not noted	8	8	not noted
2351	Step Pool	C	LgC	B	50	3	0.5	2	7	12	not noted	6	1	not noted
2432	Glide	C	LgC	B, G	70	2	not noted	not noted	5	10	not noted	3	6	not noted
2513	Pocket Water	LgC	C	B	60	3			3	5	not noted	3	5	not noted
2661	Pocket Water	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted
Maximum	**n/a**	**n/a**	**n/a**	**n/a**	**162**	**6**	**1**	**3**	**8**	**20**	**n/a**	**12**	**20**	**n/a**
Mininimum	**n/a**	**n/a**	**n/a**	**n/a**	**48**	**2**	**0.5**	**1**	**0.5**	**3**	**n/a**	**3**	**1**	**n/a**
Mean	**n/a**	**n/a**	**n/a**	**n/a**	**70**	**3**	**1**	**2**	**4**	**9**	**n/a**	**6**	**7**	**n/a**

Large Wood and Boulders

Distance upstream from diversion (ft)	Feature	Notes	Boulder b axis diameter (ft)	Boulder a axis diameter (ft)	Large Wood Diameter (dbh in)	Large Wood Length (ft)	Large Wood Rootwad?
25	Large Wood (LW)				12-18	25-49	unknown (buried)
188	USGS GAGE						
227	Boulder	4' and 8' angular boulders towards LB	4				
227	Boulder		8				
261	Boulder	4' angular boulder on RB; cluster of 2-3' rounded boulders	4				
281	Boulder	4'X8' angular boulder on slipface cascade	4	8			
320	Boulder	10 and 12' angular boulders along LB flowpath	10				
320	Boulder	10 and 12' angular boulders along LB flowpath	12				
320	Boulder	6' boulder in rb flowpath	6				
280	LW	jammed against left bank ad not really impacting channel			18-23	25-49	N
280	LW	jammed against left bank ad not really impacting channel			18-23	15-24	N
280	Boulder	on LB	15				
280	Boulders	many 3-5' angular boulders in LB flowpath	4				
280	Boulder	in middle bar	5				
355	Bank stratigraphy	LB 6" sand over cobbly alluvium with few boulders					
355	RB side channel confluence						
440	Boulders	many 3-6' angular boulders on LB					
468	LW				24-35	25-49	N
600	Boulder	on LB	10				
640	LW	on RB			36	24	N
702	LW	pool forcing, wedged in between bank trees			24	20	N
730	LW	Jam piece, lots of brush, trees project 30' into channel, pinned on floodplain trees			24	75	
730	LW	Jam piece, lots of brush, trees project 30' into channel, pinned on floodplain trees			24	75	
900	LW	along bank, little geomorphic function			24	40	N
1025	LW				30	50	Y
1035	LW				30	25	N
1083	LW				24	18	N
1083	LW				18	15	N
1130	LB side channel offtake						

Distance upstream from diversion (ft)	Feature	Notes	Boulder b axis diameter (ft)	Boulder a axis diameter (ft)	Large Wood Diameter (dbh in)	Large Wood Length (ft)	Large Wood Rootwad?
1251	Boulder	Angular boulders across channel	5				
1251	Boulder	Angular boulders across channel	5				
1251	Boulder	Angular boulders across channel	5				
1390	Boulders	ten or more 4' to 7' angular boulders scattered across unit	7				
1500	Pocket Water						
1770	LW				14	18	N
1824	Boulder	in RB	15				
1824	Boulder	in RB	15				
1824	LW	not significantly impacting hydrualics			48	50	
1824	LW	not significantly impacting hydrualics			48	25	
2067	Boulders	cluster of seven 4-5' boulders in middle of channel	5				
2240	LW				12	35	Y
2256	LW				36-48	50-75	
2256	LW				36-48	50-75	
2337	LW				12	45	Y
2351	LW				12	50	Y
2351	LW				36	45	N
2410	LW				16	30	Y
2548	LW				24	30	N
2631	Boulder	15' boulder in RB	15				
2661	LW				48	40	
2661	Notes	terrace feature comes to channel; end of survey					

From: Rawhouser, Ashley K
To: Adams, Shelly; Sarrantonio, Sharon M; Larrabee, Michael A; Burrows, Robert A
Cc: Dube, Kathy; Craig, Nancy; Couch, Aaron; Holloway, Becky E.; Luchessa, Scott
Subject: Re: [EXTERNAL] Revised Newhalem Creek Decommissioning Geomorphology Report
Date: Monday, June 26, 2023 7:59:36 PM
Attachments: image001.png

Hi Shelly,

We are going to make an additional site visit and will get back to you ASAP.

ash

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Friday, June 16, 2023 3:02 PM
To: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>; Sarrantonio, Sharon M <Sharon_Sarrantonio@nps.gov>; Larrabee, Michael A <Mike_Larrabee@nps.gov>; Burrows, Robert A <rob_burrows@nps.gov>
Cc: Dube, Kathy <kdube@watershedgeodynamics.com>; Craig, Nancy <nancy.craig@hdrinc.com>; Couch, Aaron <Aaron.Couch@seattle.gov>; Holloway, Becky E. <becky.holloway@hdrinc.com>; Luchessa, Scott <Scott.Luchessa@seattle.gov>
Subject: [EXTERNAL] Revised Newhalem Creek Decommissioning Geomorphology Report

Ashley, Rob, Sharon, and Mike,

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alluvial fan and 2) effects of decommissioning at the confluence of the Skagit River (whether Skagit River would be pushed to the north).
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Please review the changes and let us know if you have any outstanding questions or concerns by July 17, 2023. We would be happy to meet again if it is helpful. If your comments have been adequately addressed, following your review, we would like to file the report with FERC.

Thank you again for your time.

Shelly

SHELLY ADAMS
DECOMMISSIONING PROJECT MANAGER
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Seattle City Light
O: 206-684-3117 | M: 425-891-1765 | shelly.adams@seattle.gov
We Power Seattle seattle.gov/city-light

From:	Burrows, Robert A
To:	Adams, Shelly; Rawhouser, Ashley K; Sarrantonio, Sharon M; Larrabee, Michael A
Cc:	Dube, Kathy; Craig, Nancy; Couch, Aaron; Holloway, Becky E.; Luchessa, Scott
Subject:	Re: [EXTERNAL] Revised Newhalem Creek Decommissioning Geomorphology Report
Date:	Monday, July 17, 2023 4:12:46 PM
Attachments:	image001.png

CAUTION: External Email

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Sincerely,
Mike, Sharon, Rob, and Ash

Rob Burrows (he/him/his)
Environmental Protection Specialist
360-854-7313
Hours: 7:00 am-5:30 pm, Monday-Thursday

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Marblemount, WA 98267

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Cc: Dube, Kathy <kdube@watershedgeodynamics.com>; Craig, Nancy <nancy.craig@hdrinc.com>; Couch, Aaron <Aaron.Couch@seattle.gov>; Holloway, Becky E. <becky.holloway@hdrinc.com>; Luchessa, Scott <Scott.Luchessa@seattle.gov>
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Please review the changes and let us know if you have any outstanding questions or concerns by July 17, 2023. We would be happy to meet again if it is helpful. If your comments have been adequately addressed, following your review, we would like to file the report with FERC.

Thank you again for your time.

Shelly

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Seattle City Light
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We Power Seattle seattle.gov/city-light

From:	Adams, Shelly
To:	rob_burrows@nps.gov; Ashley Rawhouser; Sarrantonio, Sharon M; Mike_Larrabee@nps.gov
Cc:	Dube, Kathy; Couch, Aaron; Craig, Nancy; Holloway, Becky E.; Luchessa, Scott
Subject:	RE: [EXTERNAL] Revised Newhalem Creek Decommissioning Geomorphology Report
Date:	Friday, July 21, 2023 4:03:00 PM
Attachments:	image001.png

Rob, Ashley, Sharon, and Mike,

Thank you again for your comments and continued coordination on this project. We've provided responses to your questions and comments below, and we hope they provide more clarity. Please let us know if our responses to #1 and #3 resolve your comments such that the geomorphological report is sufficient to file with FERC, or if there is more to work out. We would be glad to schedule a follow-up meeting for further discussion. Regarding comment #2, we will be reaching out to you soon to schedule a meeting as provided in our response below.

Comment #1: *Page 4-5: More detail is needed on how sediment yield was determined, specifically on the 2000 cubic yards value. This value is used as the "goldilocks" value, but the methods are poorly defined. Methods are described as based on grain size and channel dimension - is there a reference for this method? The report says bed lowering would be slow, occurring over decades or longer. Are there references supporting this estimate? We suspect bed lowering as non-linear and episodic, resulting in pulses of bedload moving through the lower reach. The initial bed adjustment near the diversion likely occurring over a much short timeframe with volumes close to the lower bounding volume of 4,400 cu yds.*

Response #1: The 2000 cubic yards/year value was derived using the relationships described in DeVries (2000; DeVries, P. 2000. Scour in low gradient gravel bed streams: patterns, processes, and implications for the survival of salmonid embryos. PhD dissertation. University of Washington.)

We agree that bedload transport will likely be an episodic process and pulses of material will move through the system as high flows mobilize the material. If very high flows occur immediately after diversion structure removal, more sediment will be moved than if lower peak flows occur in the years following removal. These same high flows that mobilize the material will have the energy to transport it downstream; note that the stream gradient in the canyon/waterfall reach and alluvial fan (average 5 percent) are higher than gradients in the reach upstream from the diversion (2-3 percent; Figure 3.3-2 and Section 3.3). The timeframe will likely be dependent on the storm events in the years following the diversion dam's removal.

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Response #2: City Light is in the process of determining the extent and methods needed to clear and stabilize the access road to re-establish access to the diversion dam for decommissioning work. We would like to hear your comments at this time so that any major elements can be incorporated into the design and Road Decommissioning Plan. Early coordination will help to ensure that only minor tweaks and adjustments are needed following your review of the Road Decommissioning Plan. We will set up a meeting soon with our engineers and your staff to discuss your concerns related to scaling and road stabilization.

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Response #3: The report's conclusion was guided by information provided in a publication by the National Research Council's Commission on Geosciences, Environment, and Resources, "Alluvial Fan Flooding" (1996). Based on aerial photographs and LiDAR evidence, the Newhalem Creek alluvial fan appears to have characteristics of an incised streamflow "fossil" fan surface. The Newhalem Creek channel does not appear to have occupied many of the relic channels on the fan (Figure 3.3-1) during at least the past hundred or more years based on the mature trees developed on these surfaces (with the exception of distributary channels at the junction with the Skagit River). As such, it is unlikely that the addition of the anticipated 1- to 6.5-times the average annual coarse sediment supply to the Newhalem Creek channel would cause enough aggradation to re-activate the older, elevated channels in the alluvial fan, particularly given the higher average stream gradient in the fan (5 percent) compared to the source reach (upstream from the diversion structure, 2-3 percent). It is anticipated that much of the gravel and cobble would move through the fan and supply sediment to the Skagit River. There is not a specific reference for the computation of total volume of sediment by channel length; this was provided as context to help compare total potential volume of sediment with existing channel dimensions.

Reference: National Research Council. 1996. Alluvial Fan Flooding. Washington, DC: The National Academies Press. https://doi.org/10.17226/5364

Thanks again,

Shelly

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We Power Seattle seattle.gov/city-light

From: Burrows, Robert A <rob_burrows@nps.gov>
Sent: Monday, July 17, 2023 4:13 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>; Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>; Sarrantonio, Sharon M <Sharon_Sarrantonio@nps.gov>; Larrabee, Michael A <Mike_Larrabee@nps.gov>
Cc: Dube, Kathy <kdube@watershedgeodynamics.com>; Craig, Nancy <nancy.craig@hdrinc.com>; Couch, Aaron <Aaron.Couch@seattle.gov>; Holloway, Becky E. <becky.holloway@hdrinc.com>; Luchessa, Scott <Scott.Luchessa@seattle.gov>
Subject: Re: [EXTERNAL] Revised Newhalem Creek Decommissioning Geomorphology Report

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From:	Burrows, Robert A
To:	Adams, Shelly; Rawhouser, Ashley K; Sarrantonio, Sharon M; Larrabee, Michael A
Cc:	Dube, Kathy; Couch, Aaron; Craig, Nancy; Holloway, Becky E.; Luchessa, Scott
Subject:	Re: [EXTERNAL] Revised Newhalem Creek Decommissioning Geomorphology Report
Date:	Wednesday, August 23, 2023 3:58:11 PM
Attachments:	image001.png

CAUTION: External Email

Hi Shelly,

Thanks for those clarifications we don't have any further technical questions at this time. Will you incorporate those clarifications in the report (as applicable)?

We are open to meeting about the road decommissioning in September some time (barring some additional catastrophe in the park). How's the process for determining extent and methods for to clear and stabilize the access road for decommissioning going on your end?

Sincerely, Rob

Rob Burrows (he/him/his)
Environmental Protection Specialist
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Hours: 7:00 am-5:30 pm, Monday-Thursday

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Shelly

SHELLY ADAMS
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From: Burrows, Robert A <rob_burrows@nps.gov>
Sent: Monday, July 17, 2023 4:13 PM
To: Adams, Shelly <Shelly.Adams@seattle.gov>; Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>; Sarrantonio, Sharon M <Sharon_Sarrantonio@nps.gov>; Larrabee, Michael A <Mike_Larrabee@nps.gov>
Cc: Dube, Kathy <kdube@watershedgeodynamics.com>; Craig, Nancy <nancy.craig@hdrinc.com>; Couch, Aaron <Aaron.Couch@seattle.gov>; Holloway, Becky E. <becky.holloway@hdrinc.com>; Luchessa, Scott <Scott.Luchessa@seattle.gov>
Subject: Re: [EXTERNAL] Revised Newhalem Creek Decommissioning Geomorphology Report

Hi Shelly,

Thank you for the opportunity to review this report. We have just a few additional comments and questions as outlined below. We would be happy to meet to discuss them.

- Page 4-5: More detail is needed on how sediment yield was determined, specifically on the 2000 cubic yards value. This value is used as the "goldilocks" value, but the methods are poorly defined. Methods are described as based on grain size and channel dimension - is there a reference for this method? The report says bed lowering would be slow, occurring over decades or longer. Are there references supporting this estimate? We suspect bed lowering as non-linear and episodic, resulting in pulses of bedload moving through the lower reach. The initial bed adjustment near the diversion likely occurring over a much short timeframe with volumes close to the lower bounding volume of 4,400 cu yds.
- Page 4-15: We did a site visit to assess conditions at the landslide toe last week. We agree that site observations are consistent with the description in the report - essentially armored with large rock and the stream gradient is steep enough to move material through this section, thereby avoiding large accumulations of material from diversion structure decommission. Although the report does state that stability of the slide can't be determined with available information, we agree it is a reasonable conclusion. However, our field crew did observe concrete and rebar from the road in the channel. There is concern about material from scaling and road stabilization (Hilfiker wall) ending up in channel and impeding flow. Whether it's in the geomorph report or an implementation plan for the decommissioning, we'll want to comment on slope destabilization from activities tied to decommissioning.
- Page 4-17: We are not sure the relevancy of methods used to determine likelihood of deposition in the alluvial fan reactivating old channels. The report averages total volume of sediment by channel length and determines depth would be below elevations of relict channel on the fan. Averaging of sediment doesn't represent actual river process and could underestimate local bed elevations as pulses of material moves downstream. Is there a reference that supports the approach outlined in the report?

Sincerely,
Mike, Sharon, Rob, and Ash

Rob Burrows (he/him/his)
Environmental Protection Specialist
360-854-7313
Hours: 7:00 am-5:30 pm, Monday-Thursday

North Cascades National Park
7280 Ranger Station Rd
Marblemount, WA 98267

I am a *proud* graduate of the GOAL Leadership Academy. Ask me about the program!

From: Adams, Shelly <Shelly.Adams@seattle.gov>
Sent: Friday, June 16, 2023 3:02 PM
To: Rawhouser, Ashley K <Ashley_Rawhouser@nps.gov>; Sarrantonio, Sharon M <Sharon_Sarrantonio@nps.gov>; Larrabee, Michael A <Mike_Larrabee@nps.gov>; Burrows, Robert A <rob_burrows@nps.gov>
Cc: Dube, Kathy <kdube@watershedgeodynamics.com>; Craig, Nancy <nancy.craig@hdrinc.com>; Couch, Aaron <Aaron.Couch@seattle.gov>; Holloway, Becky E. <becky.holloway@hdrinc.com>; Luchessa, Scott <Scott.Luchessa@seattle.gov>
Subject: [EXTERNAL] Revised Newhalem Creek Decommissioning Geomorphology Report

Ashley, Rob, Sharon, and Mike,

Thank you again for taking the time to meet with us on May 11. We have revised the geomorphology report to address your concerns and comments provided in the meeting. For your convenience, I've attached one copy of the report with all changes highlighted and one clean copy. In summary, the changes to the report are:

- **Sentence on page 1-2.** Explains that the report includes an evaluation of concerns provided after initial drafts of the report.
- **Edits or additions to Section 4.1.1, pages 4-4 through 4-5.** Compares anticipated volume of sediment from dam removal to estimated average annual sediment yields to support NPS question regarding likelihood of reactivating old channels on the alluvial fan and pushing the Skagit River north due to deposition.
- **New section 4.2.3.** Addresses NPS question regarding the effects of decommissioning on the toe of the existing landslide. Also summarizes geology from the Golder report as requested.
- **New Section 4.2.4.** Addresses NPS questions about 1) reactivating old channels on the alluvial fan and 2) effects of decommissioning at the confluence of the Skagit River (whether Skagit River would be pushed to the north).
- **2 new references in literature cited**. Includes citations referenced in new sections described above.

Please review the changes and let us know if you have any outstanding questions or concerns by

July 17, 2023. We would be happy to meet again if it is helpful. If your comments have been adequately addressed, following your review, we would like to file the report with FERC.

Thank you again for your time.

Shelly

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NEWHALEM DAM DECOMMISSIONING GEOMORPHOLOGY CONSIDERATIONS

NEWHALEM CREEK HYDROELECTRIC PROJECT
FERC NO. 2705

Prepared by:
Kathy Vanderwal Dubé
Watershed GeoDynamics

October 2023

List of Acronyms and Abbreviations

BAGS.........................Bedload Assessment in Gravel-bedded Streams
City Light...................Seattle City Light
cfs...............................cubic feet per second
CM ....creek mile
FERC..........................Federal Energy Regulatory Commission
ft ....feet
LiDAR........................Light Detection and Ranging
mm ....millimeter
MW ....megawatt
NPS ....National Park Service
Project ....Newhalem Creek Hydroelectric Project
RLNRA ....Ross Lake National Recreation Area
USGS .........................U.S. Geological Survey

Table of Contents

List of Figures

List of Tables

List of Attachments

1.0 INTRODUCTION

1.1 Project Description

Seattle City Light (City Light) is licensed by the Federal Energy Regulatory Commission (FERC) to operate and maintain the Newhalem Creek Hydroelectric Project, FERC No. 2705 (Project). The Project is located on Newhalem Creek in northern Washington State in the Cascade Mountains of the upper Skagit River watershed. Newhalem Creek is a tributary to the Skagit River and enters the south side of the river at mile 93.3 (Figure 1.1-1).

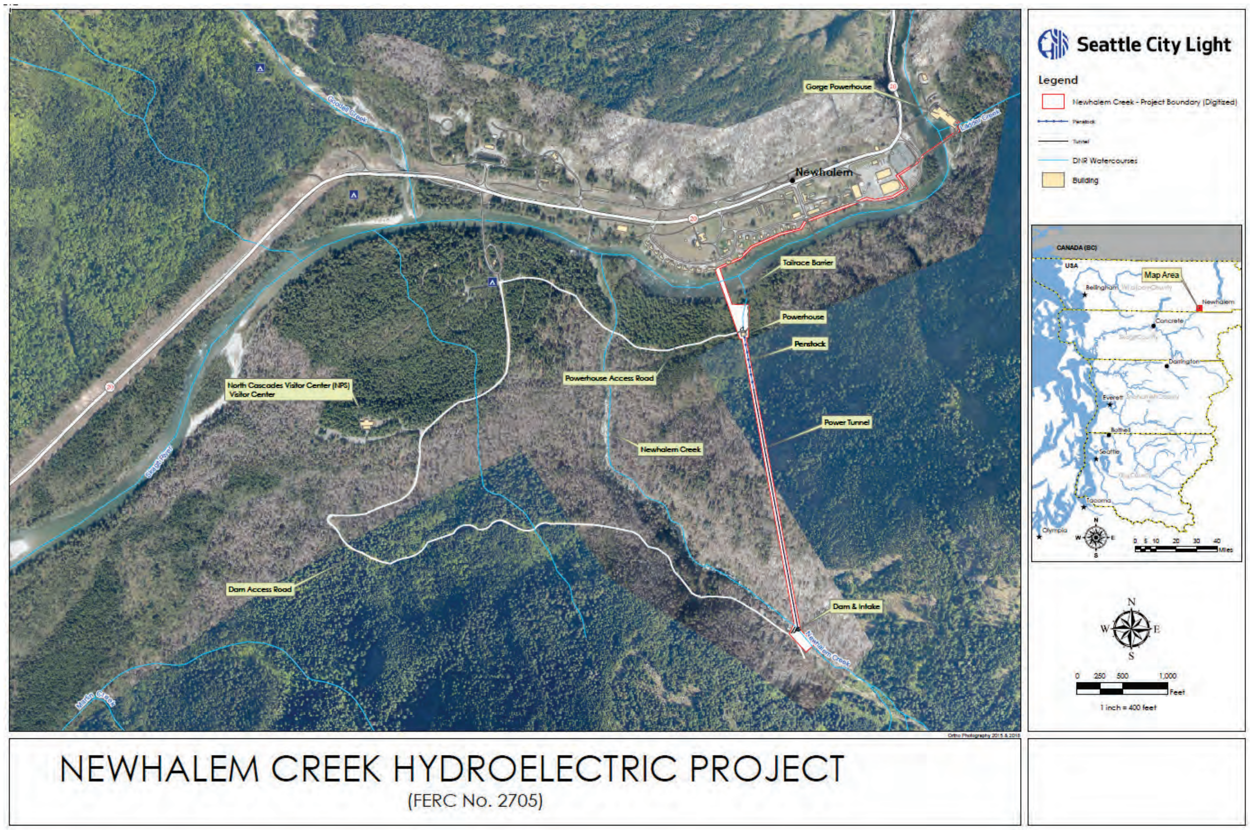


Figure 1.1-1. Newhalem Creek Project location map

The Project began operations in 1921 to supply power to the town of Newhalem and to construct Gorge Dam and Powerhouse, the latter of which are part of the Skagit River Hydroelectric Project (FERC No. 553). The Project has an authorized installed capacity of 2.2 megawatts (MW). The current Project license expires on January 31, 2027. City Light filed a Notice of Intent with FERC on April 28, 2021, to surrender the license and submitted an Application for Surrender of License for the Project on January 28, 2022.

The Project occupies 6.4 acres of federal lands within the Ross Lake National Recreation Area (RLNRA), which is managed by the National Park Service (NPS) as part of the North Cascades National Park Complex. The Project's diversion structure is located at Creek Mile (CM) 1.0, above a 100-foot waterfall, and impounds very little water (0.1-acre/0.6 acre-ft). Newhalem Creek flows

are diverted into a power tunnel and penstock that lead to the powerhouse. These flows bypass an approximately 1-mile reach of Newhalem Creek. There is a U.S. Geological Survey (USGS) stream gage just upstream of the diversion.

1.2 Proposed Action and Report Purpose

As part of decommissioning the Project, City Light is proposing to remove the diversion structure and associated facilities. The current proposal is to remove concrete at the current diversion location and grade to elevation 1,009 feet (Skagit Project datum, approximately equivalent to 1,015 feet [ft, NAVD88 datum]) at the downstream end of the existing spillway. The new streambed base level at this location would be approximately 10 ft lower than the top of the existing diversion structure. The purpose of this report is to evaluate potential geomorphic effects of removing the diversion structure on Newhalem Creek. Two primary geomorphic effects identified include:

- Potential for headcutting and incision upstream of the diversion location after diversion is removed due to change in base level of stream,
- Transport of sediment currently stored in and upstream of the impoundment into downstream reaches of Newhalem Creek and the Skagit River (including potential effects on turbidity levels in Newhalem Creek).

The report also evaluates concerns and questions raised during the decommissioning proceeding and after review of the initial drafts of this report. The consultation record is presented in Attachment B.

This report relies on existing maps, reports, hydrologic data, and topographic (Light Detection and Ranging [LiDAR]) information; observations made during four 1-day field visits to the Project; surficial and sub-surface grain size sampling; and cross sections surveyed during the field visits.

2.0 METHODS

2.1 Field Data

Observations of site conditions and stream characteristics were made during a site visit on June 14, 2021, with a follow-up geomorphic assessment on October 14, 2022. Substrate pebble counts were made and a stream cross section was surveyed during a site visit on September 8, 2021. Repeat surficial pebble counts and sub-surface sampling was conducted on September 12, 2022, to assess changes in substrate following a 4,920[1] cubic-foot-per-second (cfs) peak flow in November 2021. Streamflow at the Newhalem gage (USGS 12178100) was 499 cfs during the June 2021 site visit, 28 cfs during the September 2021 site visit, 25 cfs during the September 2022 visit, and 15 during the October 2022 geomorphic assessment.

2.1.1 Surface Grain Size Sampling

Surficial Wolman pebble counts were made at four locations upstream of the Newhalem Creek diversion dam in 2021 and repeated in 2022 (Figure 2.1-1; Wolman 1954). A minimum of 100 pebbles were selected approximately every foot across the channel at two locations (at the USGS gage site and approximately 500 ft upstream from the dam) and in a grid pattern in deposits just upstream from the diversion and at the head of a point bar approximately 1,000 ft upstream from the diversion. Each particle was passed through a gravelometer to measure the equivalent particle size class in half phi increments (e.g., < 2 millimeters [mm], 2–4 mm, 4–8 mm, 8–16 mm, 16–32 mm, etc..... up to the 512 mm size class). The gravelometer provides the same results as sieving a sample. Pebble count data were entered into a spreadsheet for computation of particle size statistics and graphing of the grain size distribution.

2.1.2 Sub-surface Grain Size Sampling

Bulk samples of the material below the surface armor layer were collected at two of the pebble count locations in September 2022 following the method of Church et al. (1987; bulk sample locations shown on Figure 2.1-1). To do this, the surface armor layer was removed and then a pit was excavated until either the practical sampling limit of 440 pounds or a volume sufficient that the largest particles in the deposit made up no more than one percent of the sample weight was obtained (the 1 percent criteria). The bulk sample material was field sieved to separate material at the 32 mm size. Material larger than 32 mm was divided into half-phi grainsize classes using a gravelometer, and the weight of each class was measured in the field. A 30- to 45-pound sub-sample of the material smaller than 32 mm was retained for grainsize analysis following American Society for Testing and Materials standards, and was performed by Materials Testing & Consulting, Inc. Field and lab grainsize distributions for each bulk sample were then combined based on the split ratio of the material; water weight was assumed to be evenly distributed through the <32 mm fraction.

[1] Note: all flow data was obtained from the USGS website (https://waterdata.usgs.gov/monitoring-location/12178100/). Recent data (2021–2022) is provisional.

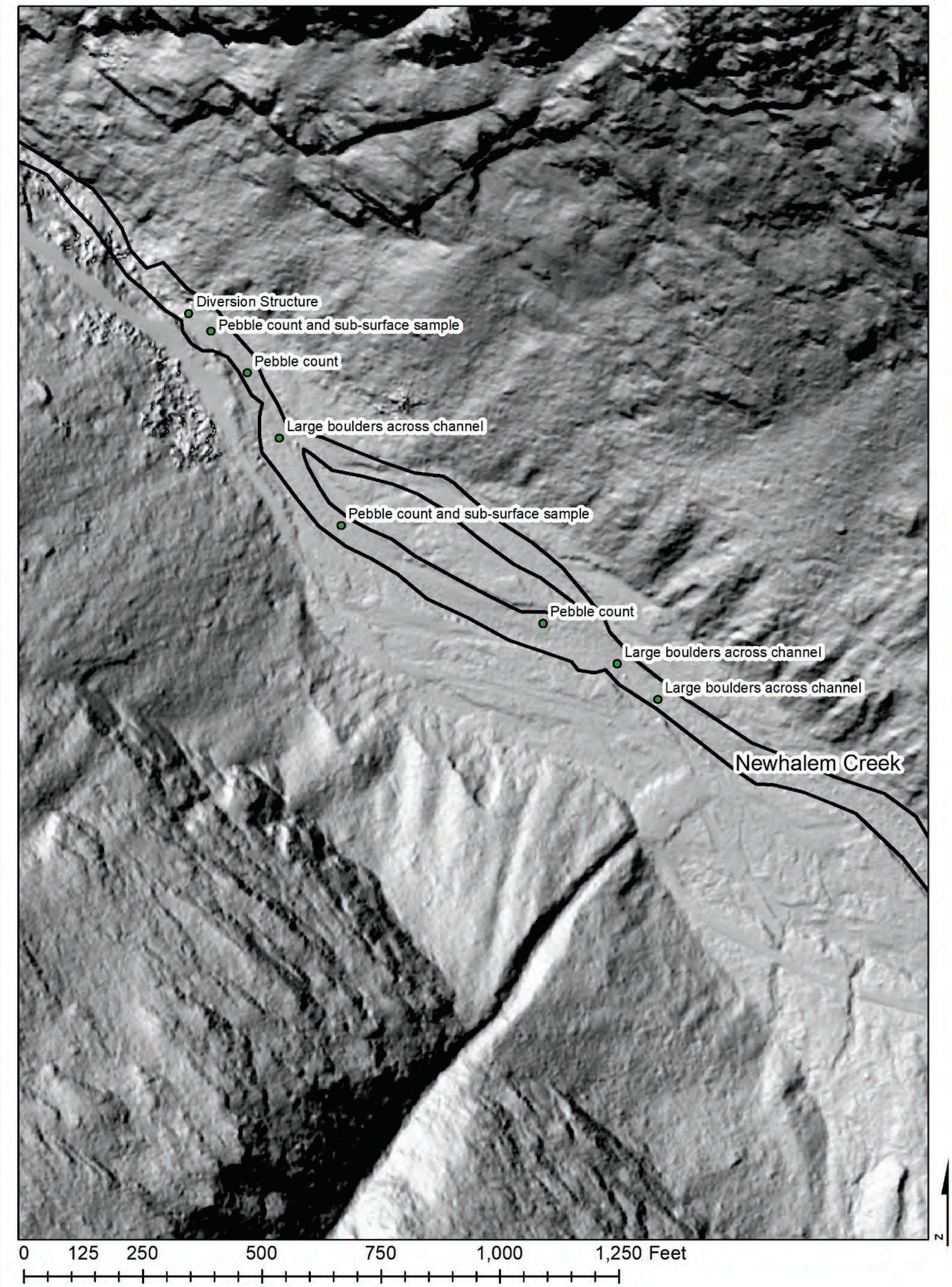


Figure 2.1-1. Newhalem Creek sediment sampling locations

Since the practical sampling limit of 440 pounds determined for this study was below the recommended 1 percent criteria (Church et. al, 1987), the hybrid method of Rice and Haschenburger (2004) was applied to characterize the coarse tail of the bulk grainsize distribution, consistent with Skagit Hydroelectric Project relicensing methodology. This method assumes that the surface and subsurface material come from the same source grainsize population and that the surface armor layer formed through selective horizontal removal of fine sediment (winnowing). This implies that the ratio of the weight of a specified match fraction (between the surface and subsurface samples) and each larger grainsize fraction in the surface material can be used to determine the distribution of the coarser material more reliably than would be possible with only the undersized sample. Selection of the match fraction was determined by identifying the largest grainsize fraction meeting the 1 percent sample size criteria. In other words, the match fraction was chosen for the largest grainsize where the cumulative weight of the sample through that size class (smallest to largest) was greater than the 1 percent criteria for material of that size. For our 440-pound samples, the match fraction was 64–91 mm.

2.1.3 Cross Section Survey

A cross section at the USGS gage site was surveyed using a tape, laser level, and survey rod in September 2021. The concrete platform at the Project intake was used as a known elevation to allow correlation of the survey data with LiDAR data to extend the cross section across the valley on each side of the transect. The transect and USGS gage records (stage: discharge) were used for sediment transport analysis.

2.1.4 Geomorphic Stream Assessment

On October 14, 2022, a team of two geomorphologists completed a geomorphic assessment of the channel by walking the stream from the existing weir upstream approximately 0.5 mile. Stationing along the channel was determined by measurement with a long fiberglass tape up to 1,500 ft above the weir and by pacing, calibrated to landmarks visible in the LiDAR data, between station 1,500 and 2,661 ft. Individual geomorphic units were identified as belonging to one of the following classes: pool, glide, riffle, pocket water, step pool, plane bed or cascade. These followed the same definitions as previous work completed for the Skagit River Hydroelectric Project (FERC Project No. 553) relicensing except that step pool morphologies were distinguished from pocket water morphologies. The differentiation is that pocket water consists of disorganized features with a generally planar bed geometry but very high relative roughness (boulders protruding through the free surface), while step pool morphologies have organized the boulders into step features that create added “jammed state” stability (e.g., Church and Zimmermann, 2007; Zimmermann et al., 2010).

In each geomorphic unit, dominant and subdominant bed material were visually determined. The dominant bed material was the grain size class (Table 2.1-1) visually determined to make up the largest portion of the bed surface, and the sub-dominant was the grain size class visually determined to make up the second largest portion of the bed surface. The presence of other geomorphically important grainsize classes (for example finer gravel pocket deposits that may be important spawning habitat or boulders that might be controlling the channel gradient or roughness) were also noted.

Table 2.1-1. Bed material size ranges used in geomorphic assessment notes

Size Range	Grain size (abbreviation in notes)
2–8 mm	Fine Pebbles (fP)
8–22 mm	Fine Gravel (fG)
22–64 mm	Gravel (G)
64–128 mm	Cobble (C)
128–360 mm	Large Cobble (LgC)
>360 mm	Boulder (B)

The width and general cross section shape of each geomorphic unit were measured at a characteristic location. Bankfull width was measured using a fiberglass long tape and bankfull depth was measured to the nearest 0.5 ft with a level rod. In addition, the total height of the bank (e.g., from bank toe to the top of a terrace that lies above the bankfull elevation) and width of the bank (horizontal distance from bank toe to the elevation of the top of bank) were measured with a level rod, so that the bank angle could be determined. Tailout and maximum depths of pool, glides, and step pool features were measured so that residual pool depths could be calculated. The characteristics of the bank materials were noted for each bank, with a description of the stratigraphy including dominant grainsizes, angularity of the material, and interpreted type of material (alluvial or colluvial).

2.2 Data Analysis

Mean daily and annual instantaneous peak flows for the period of record were obtained from the USGS NWIS website for the Newhalem Creek near Newhalem, WA, gage (USGS 12178100). Annual peak flows were entered into a spreadsheet for log-Pearson Frequency Analysis using the Bulletin 17B methods.

LiDAR data and aerial imagery from 2015, 2018, and 2022 were used to map channel position and produce stream profiles and gradients. A 1920 survey map (Figure 2.2-1) was used to estimate pre-Project streambed elevation and gradients by direct measurement from the map and geo-rectifying the map in ArcMap 10.8.1. Note that scale, vertical datum differences, and geo-rectifying challenges introduces some error into calculations using old maps, so the resulting 1920 profile should be considered an estimate.

The Bedload Assessment in Gravel-bedded Streams (BAGS) spreadsheet transport tool (https://www.fs.fed.us/biology/nsaec/products-tools.html) was used to analyze hydraulic characteristics, potential sediment transport/deposition areas and headcutting in the Newhalem Creek intake area based on the surveyed cross section, pebble count data, and local and reach-averaged stream gradients measured from LiDAR data.

Figure 2.2-1. Scanned 1920 Newhalem Creek map (source: Seattle City Light archives).

3.0 GEOMORPHIC SETTING AND EXISTING CONDITIONS

The Newhalem Creek Project is in the North Cascades of Washington state, a geomorphically active, geologically diverse, and climatically cool and wet area with high mountain peaks and steep valley walls and canyons.

3.1 Geology and Landforms

The North Cascades is a complex mosaic of geologic terranes that were formed as the Pacific Ocean plate and the North American continental plate collided, breaking off pieces of volcanic island arcs, deep ocean sediments, ocean floor, continental rocks, and subcrustal mantle over the past 400 million years (Haugerud and Tabor 2009). These terranes were then uplifted, thrust on top of each other, eroded, or buried to further complicate the geology and form the high peaks of the North Cascades. Newhalem Creek is within the Metamorphic Core Domain of the North Cascades and is underlain by the Skagit Gneiss (labeled TKbg(s) and TKog(s) on Figure 3.1-1). The Skagit Gneiss has a high level of metamorphism and is resistant to weathering and erosion, forming the steep stream canyon with numerous waterfalls downstream from the Newhalem diversion structure. While resistant to erosion, the steep valleys formed in the rocks of the Metamorphic Core are also subject to rockfalls, landslides, and avalanches as evidenced by the mass movements along the western slopes downstream from the diversion (the active rockfall/mass wasting area on the access road is one of these unstable areas).

During the Quaternary Period, starting about 2.6 million years ago, continental and alpine glaciers covered much of the area in the Project vicinity, with several major advances of thick continental ice from the north and smaller alpine glaciers originating from mountain peaks. The most recent continental glacial advance, culminating approximately 15,000 years ago, resulted in many of the surficial geologic features and deposits in the Newhalem Creek vicinity. Following melting of the glaciers, surficial processes further re-shaped the landscape resulting in development of alluvium (river deposits), terraces, and alluvial fans. Surficial geology around Project includes Quaternary and Holocene glacial and stream deposits (Qad and Qa), alluvial fan/debris cone deposits (Qaf), and colluvium derived from local soils and underlying geologic units.

Landforms have been mapped by the NPS for areas within RLNRA (Riedel et al. 2012). Landform mapping provides information on surficial geologic features and processes by grouping areas of the landscape into units formed by discrete geologic processes. Landforms include features that are depositional in nature (e.g., moraines, alluvial fans) or erosional (horns, bedrock benches). Mapped landforms are shown on Figure 3.1-1 and include the steep valley walls surrounding the Newhalem Creek valley, the floodplain features in the lower gradient area upstream from the diversion, the bedrock canyon downstream from the diversion, and the alluvial fan near the confluence with the Skagit River that has cut into the moraines and terraces in the Skagit River valley. Note that several debris cones control floodplain width at the diversion structure and in the valley upstream from the diversion; these debris cones control the confined/unconfined reaches of the stream and limit channel movement across the floodplain as well as providing extremely large (up to 12-foot diameter) boulders that were noted at several locations in the channel.

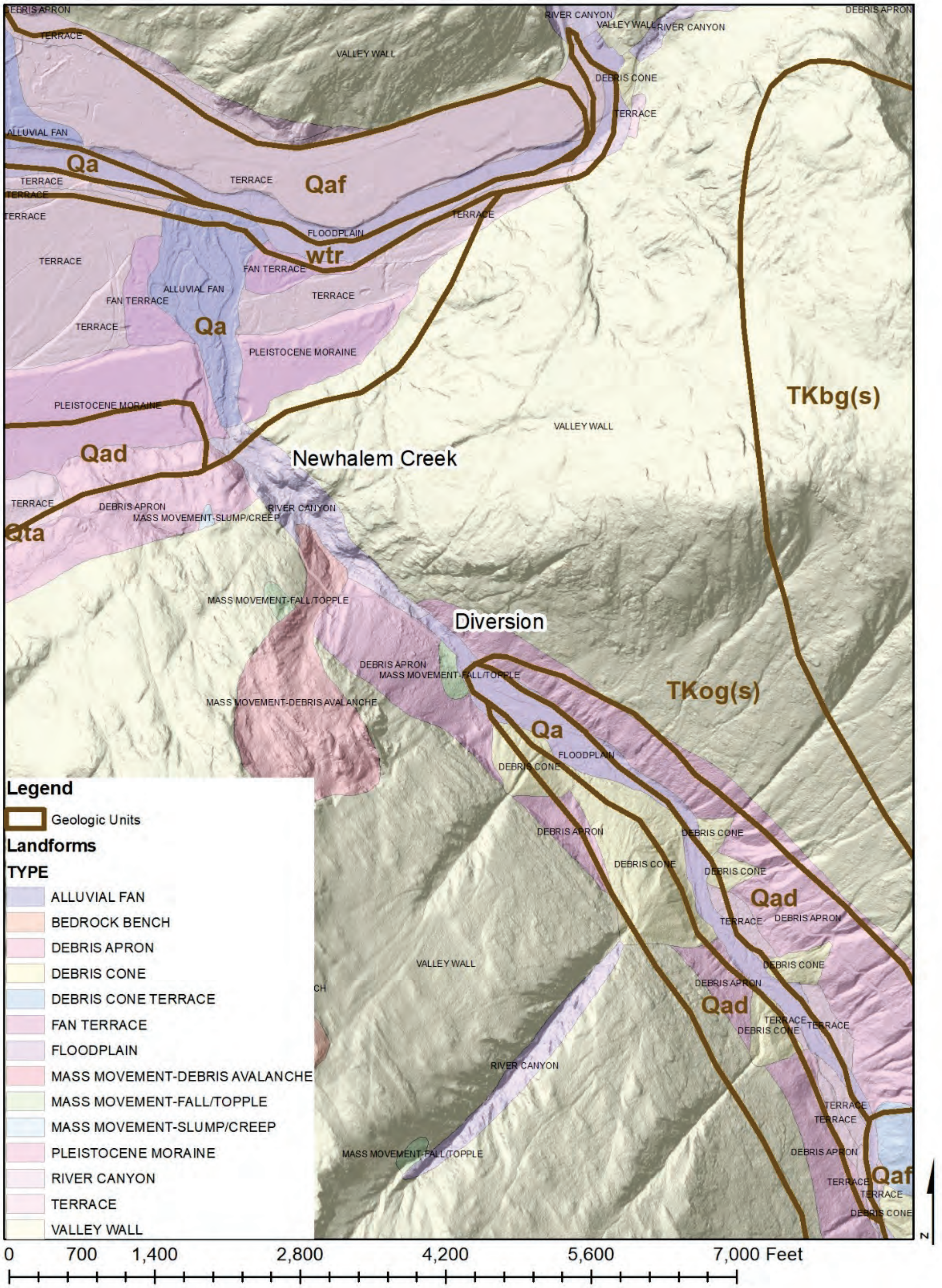


Figure 3.1-1. **Geologic units and landforms in the Newhalem Project vicinity**

3.2 Newhalem Creek Hydrology

Newhalem Creek has a drainage area of 26.9 square miles at the Project intake. Mean daily flows typically range from a low of 20 to 30 cfs in September to peaks of 1,000 to 3,000–4,000 cfs during rain, rain-on-snow, and snowmelt from November through late June (Figure 3.2-1).

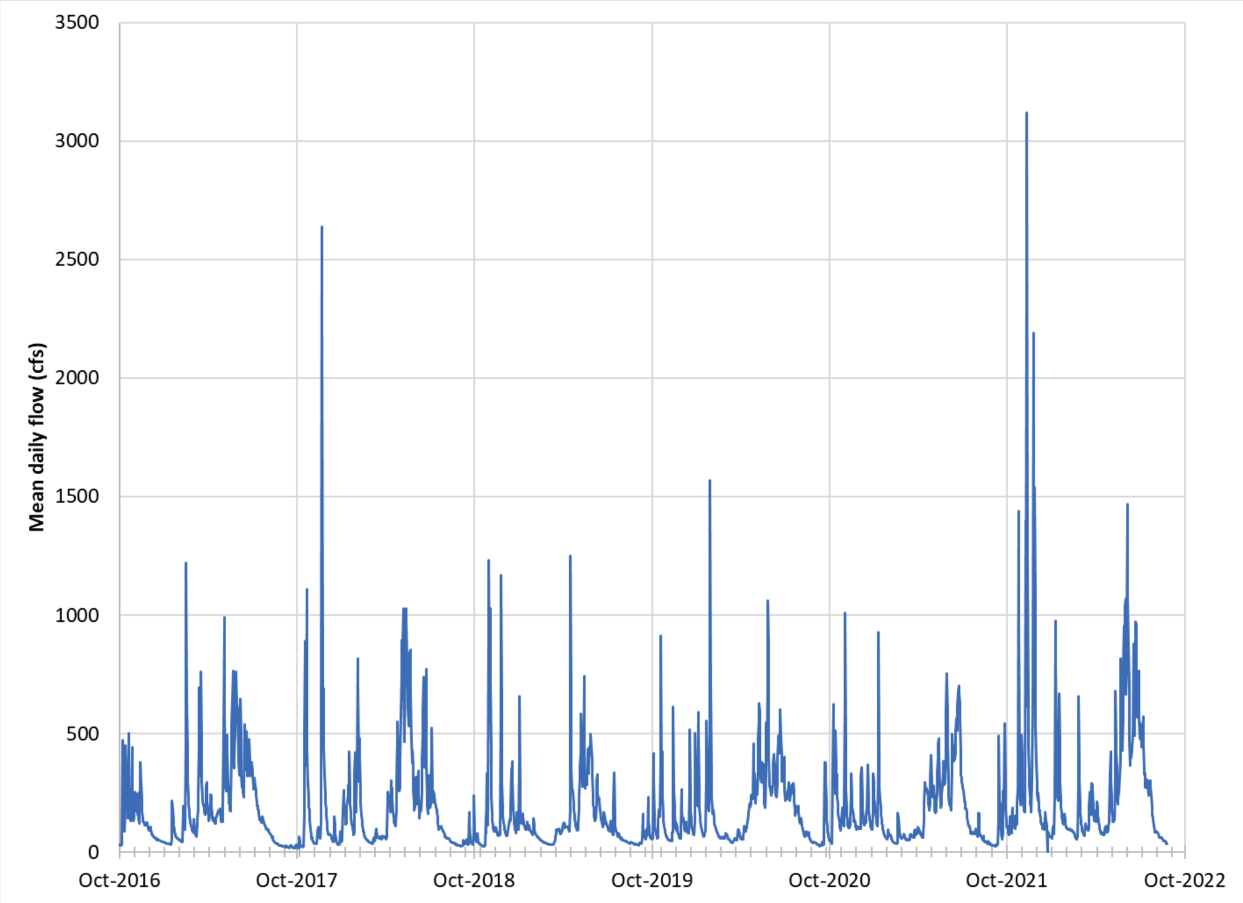


Figure 3.2-1. Daily flow at Newhalem Creek Gage (USGS 12178100) Water Years 2017–2022

The majority of bedload transport and geomorphic "work" is done during high flows when stream energy is high enough to disrupt the coarser armor layer on the bed of the stream and transport gravel/cobble/boulder downstream. Annual instantaneous peak flows recorded at the Newhalem gage range from less than 1,000 cfs to nearly 9,000 cfs (Figure 3.2-2). The highest peak flows occur during the November to February timeframe as a result of rain-on-snow events (Figure 3.2-3). Smaller magnitude peak flows between October and March are the result of rainfall events; peaks during May–July are driven by snowmelt from the higher elevations in the watershed.

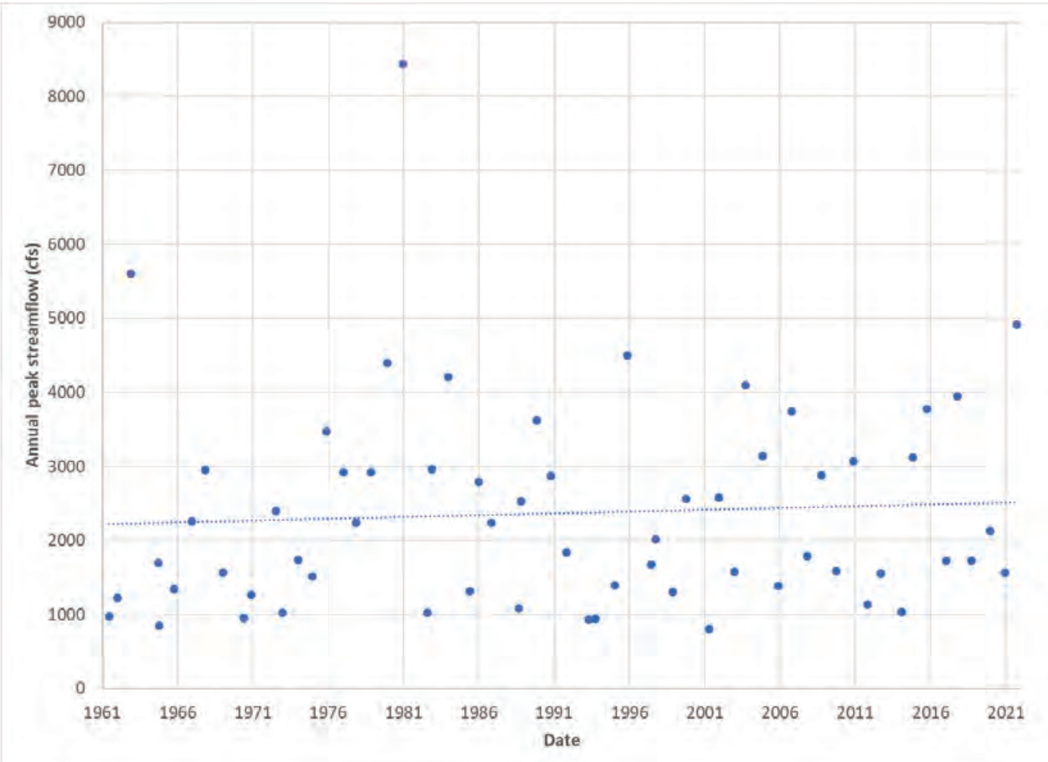


Figure 3.2-2. Annual peak streamflow at Newhalem Creek gage (USGS 12178100; 1961–2022)

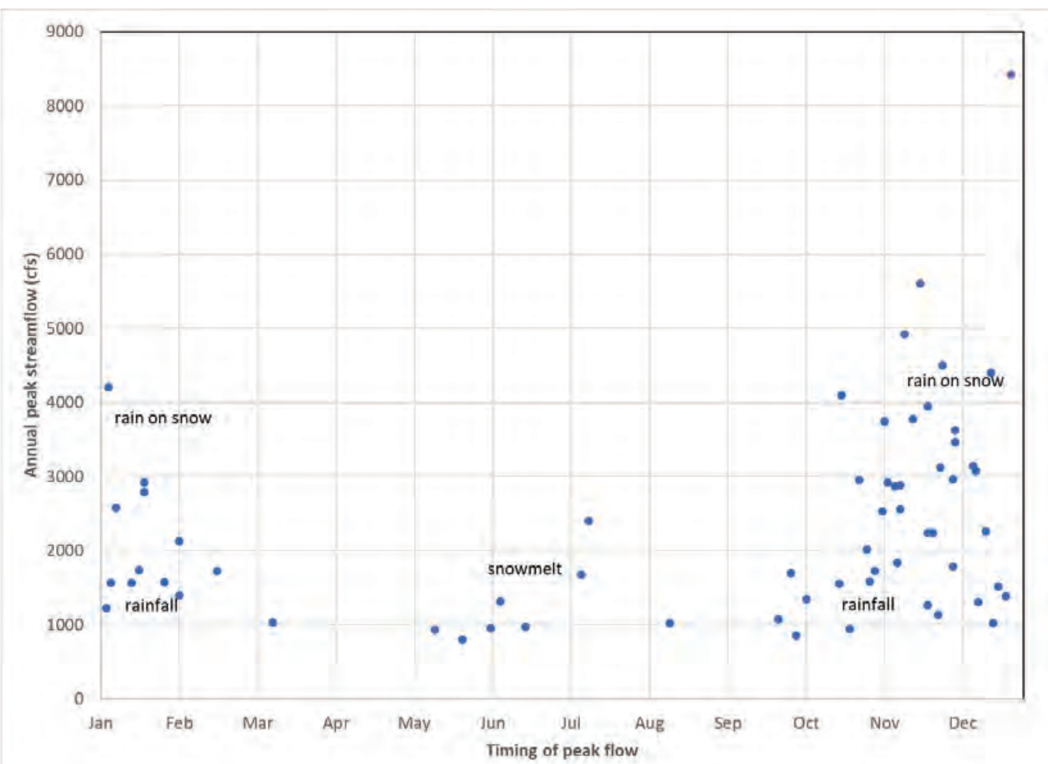


Figure 3.2-3. Timing and cause of peak streamflow at Newhalem Creek gage (USGS 12178100; 1961–2022)

Computed peak flow recurrence intervals for the period of record (1961–2022) at the diversion dam range from 884 cfs for the 1.05-year recurrence interval to 7,840 cfs for the 100-year event (Table 3.2-1). Note that the highest peak flow recorded at the gage (8,430 cfs on 12/26/80) was an extreme event and was higher than the computed 100-year recurrence interval flow. Peak flow recurrence intervals are statistically-based computations and take into account the probability of a given flow occurring based on the entire period of record. The 1.25- to 2-year recurrence interval event is often considered to be the formative discharge for stream channel shape and bedload transport and often corresponds to the bankfull discharge in alluvial streams.

Table 3.2-1. Peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2022).

Recurrence interval (years)	Annual percent chance	Peak discharge (cfs)	95% Confidence upper limit (cfs)	95% Confidence lower limit (cfs)
100	1	7,840	10,200	6,400
50	2	6,600	8,370	5,490
25	4	5,470	6,740	4,640
10	10	4,120	4,890	3,590
5	20	3,190	3,680	2,830
2	50	2,010	2,240	1,790
1.25	80	1,300	1,470	1,130
1.05	95	884	1,030	731

3.2.1 Potential Future Changes to Peak Flows

Estimates of potential changes to future peak flows in the Skagit River watershed have been made by researchers at Seattle University (Ranoa and Lee 2021). They used the 1960–2005 peak flows as a base and projected how streamflow and water availability may change in the future for three different time ranges (2000–2049; 2025–2074; and 2050–2099) at 20 sites within the Skagit River basin under low and high greenhouse gas emission scenarios (Representative Concentration Pathways [RCPs] 4.5 and 8.5, respectively). The Newhalem to Marblemount area gages were predicted to change from -5 percent to +90 percent for various peak flow recurrence/future time range scenarios, with greater changes predicted for more frequent peak flows and under the high greenhouse gas emissions scenarios (Figure 3.2-4 and Figure 3.2-5).

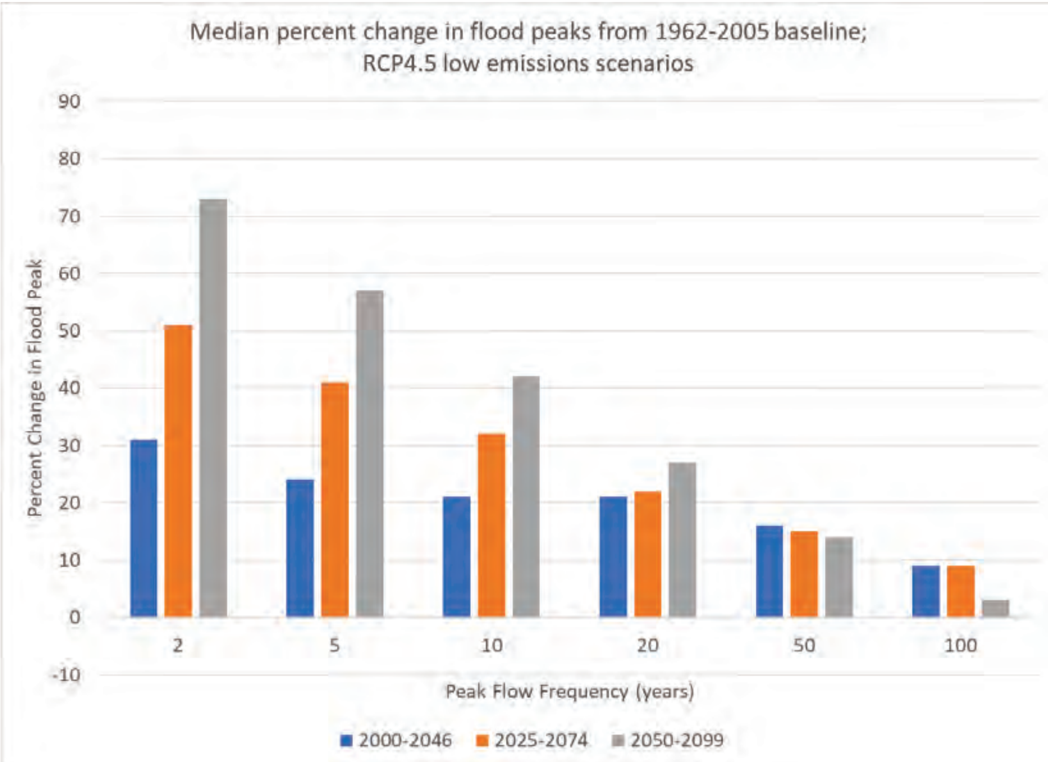


Figure 3.2-4. Median predicted percent change in flood peaks at the Newhalem Creek gage from 1962–2005 baseline, RCP 4.5.

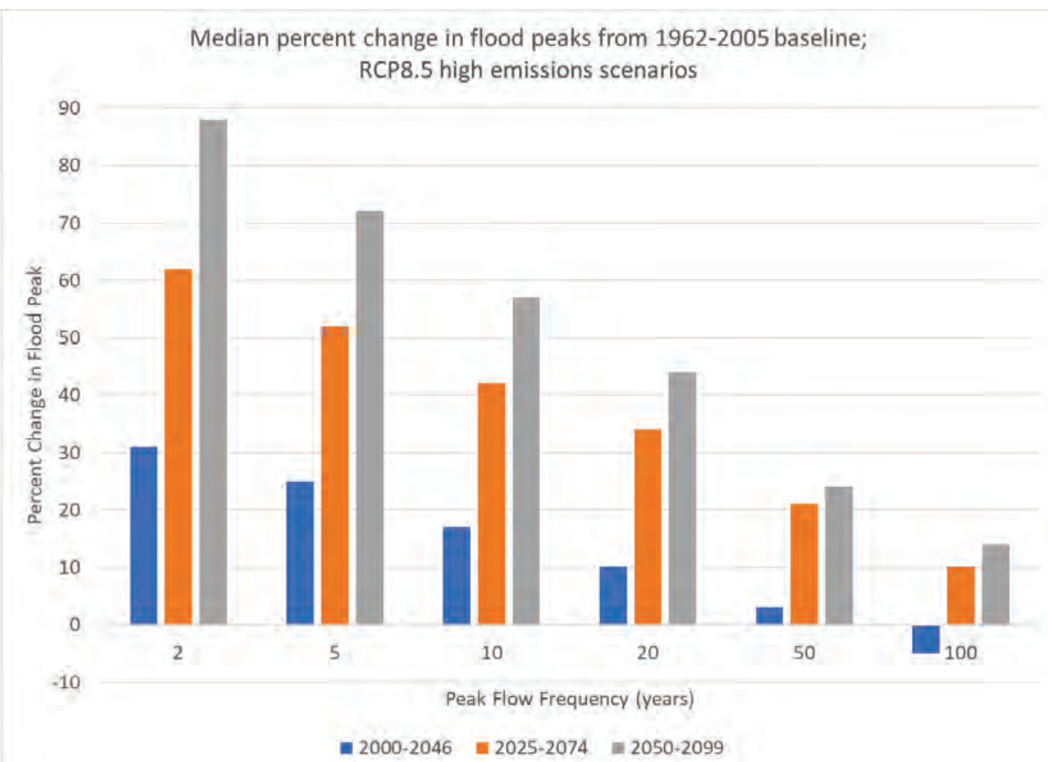


Figure 3.2-5. Median predicted percent change in flood peaks at the Newhalem Creek gage from 1962–2005 baseline, RCP 8.5.

The calculated peak flow recurrence for the Newhalem Creek USGS gage for the 1961–2005 and 2000–2022 time ranges as well as predicted future peak flows for the three time ranges and RCP 4.5 scenarios based on Ranoa and Lee (2021) are shown in Figure 3.2-6 and Table 3.2-2. Predicted flows under the RCP 8.5 scenarios are shown in Figure 3.2-7 and Table 3.2-3. The 2000–2022 actual peak flows at the Newhalem gage were used to calculate the 2-year and 5-year recurrence interval peak flows and are shown on Figure 3.2-6 and Figure 3.2-7 for comparison with the estimated future flow scenarios (note that the 2000–2022 timeframe is not sufficient to feel confident in longer-interval peak flow calculations). The computed 2000–2022 2-year and 5-year peak flow events, shown as orange triangles on the graphs, are very similar to the baseflow period (1960–2005) peak flows and do not show evidence that substantial increases in peak flow magnitudes for these frequent floods have occurred to date at the Newhalem gage.

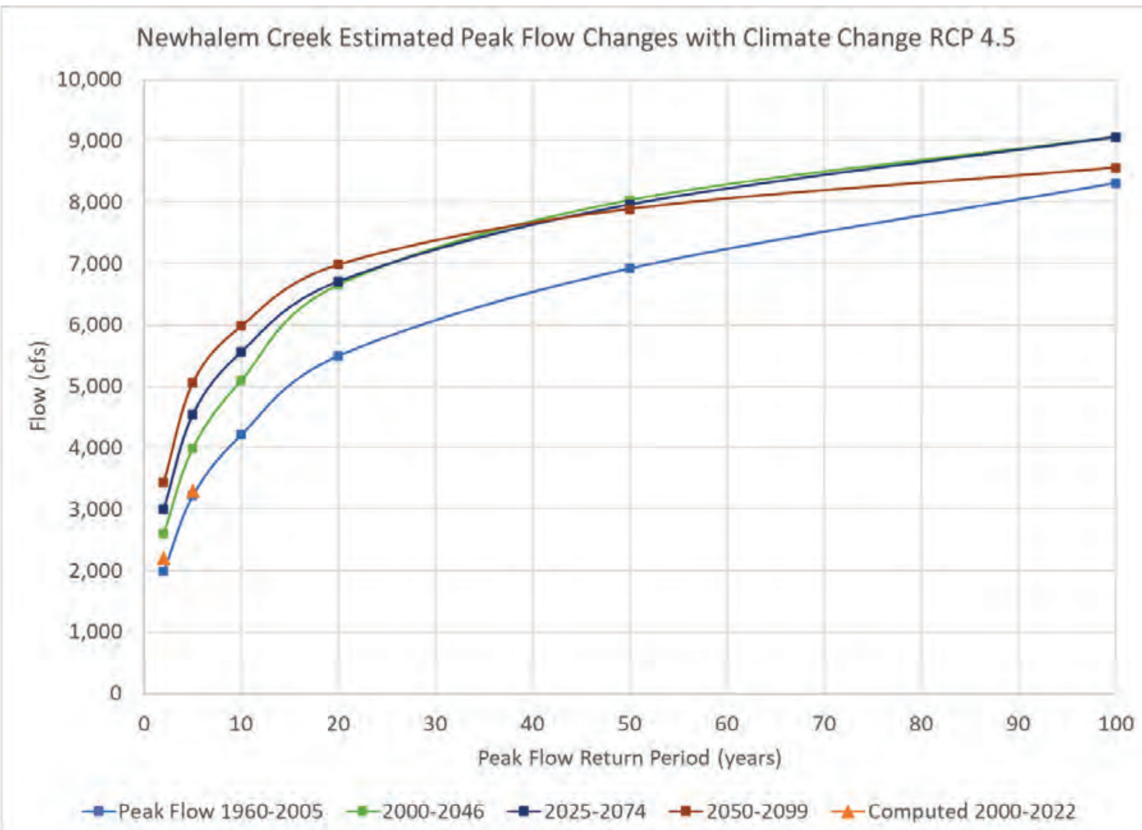


Figure 3.2-6. Estimated changes in peak flows at the Newhalem Creek gage (RCP 4.5)

Table 3.2-2. Calculated peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2005) and predicted future climate change peaks under RCP 4.5.

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
100	1	8,310	n/a	9,140	9,140	8,810
50	2	6,920	n/a	7,960	8,100	8,100
10	10	4,220	n/a	5,150	5,740	6,120

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
5	20	3,220	3,300	4,030	4,570	5,150
2	50	1,990	2,210	2,610	3,000	3,440

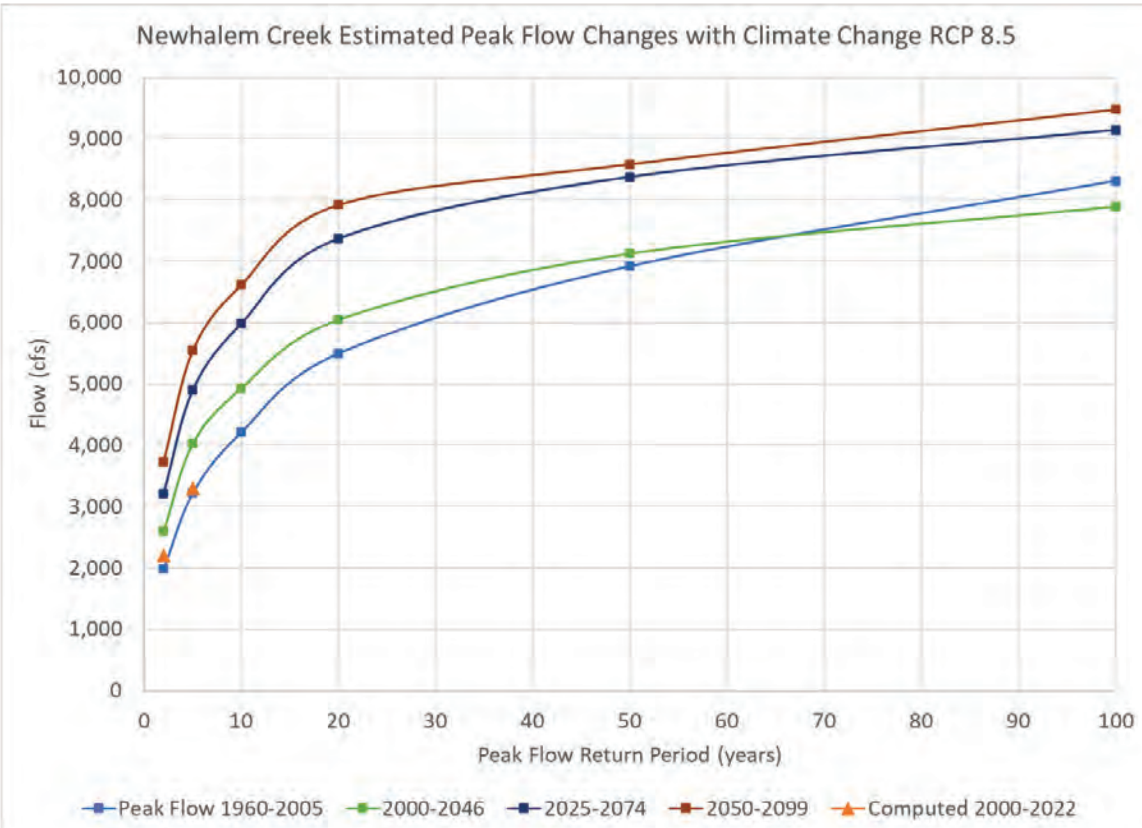


Figure 3.2-7. Estimated changes in peak flows at the Newhalem Creek gage (RCP 8.5)

Table 3.2-3. Calculated peak flow recurrence intervals, Newhalem Creek gage (USGS 12178100; 1961–2005) and predicted future climate change peaks under RCP 8.5.

Recurrence interval (years)	Annual percent chance	Calculated peak discharge 1961–2005 (cfs)	Calculated peak discharge 2000–2022 (cfs)	Estimated future peak 2000–2049	Estimated future peak 2025–2074	Estimated future peak 2050–2099
100	1	8,310	n/a	7,890	8,970	9,720
50	2	6,920	n/a	7,060	8,230	8,790
10	10	4,220	n/a	4,980	5,990	6,750
5	20	3,220	3,300	4,030	4,930	5,600
2	50	1,990	2,210	2,610	3,260	3,760

3.3 Newhalem Creek Existing Geomorphic Characteristics

Newhalem Creek has several distinct geomorphic reaches between the confluence with the Skagit River and the valley upstream from the diversion dam that influence how the stream processes water and sediment moving through the system and ultimately affects instream habitat characteristics (Figure 3.3-1, Figure 3.3-2).

Upstream from the diversion structure the stream has a relatively consistent gradient (2–3 percent) with a cobble/boulder/gravel bed, bankfull channel width of approximately 75 ft, and valley widths of 500 ft in relatively unconfined reaches and 150–200 ft in areas where the stream is confined by debris cone deposits coming off the valley walls. There is a confining debris cone approximately 0.25 mile upstream from the diversion and another, larger cone approximately 0.5 mile upstream from the diversion. These two features limit channel movement across the valley.

The Newhalem Creek bed 500 ft upstream from the diversion consists of cobble, boulders, and gravel that span the width of the Creek.

At and downstream from the diversion, the stream enters a very high gradient (10–25 percent) bedrock canyon with numerous waterfalls. This area was not visited but based on observations just downstream from the diversion it is likely that substrate is bedrock with patches of cobble/gravel/boulder. This reach is a transport reach – sediment supplied from upstream areas moves relatively quickly through the reach into the downstream alluvial fan.

Downstream from the canyon reach Newhalem Creek encounters the Skagit River valley terraces and forms an alluvial fan with numerous relict channels. The stream averages 5 percent gradient with gradients decreasing closer to the Skagit confluence and has cut through the higher Skagit valley terraces. Alluvial fans are geomorphically active areas where the stream deposits the largest sized material near the top of the fan and finer-grained sediment near the distal (downstream) portion of the fan as the stream gradient/power drops. Observations at the Powerhouse Road crossing show a boulder/cobble bed with what appear to be lag boulders (moss-covered boulders indicating infrequent transport) interspersed with fresh gravel/cobble material.

The Newhalem Creek alluvial fan appears to be forcing the Skagit River to the North; the Skagit River narrows and has a locally higher gradient at the confluence with the creek. Gravel and cobble material transported from Newhalem Creek provides a source of spawning-sized material to the Skagit River.

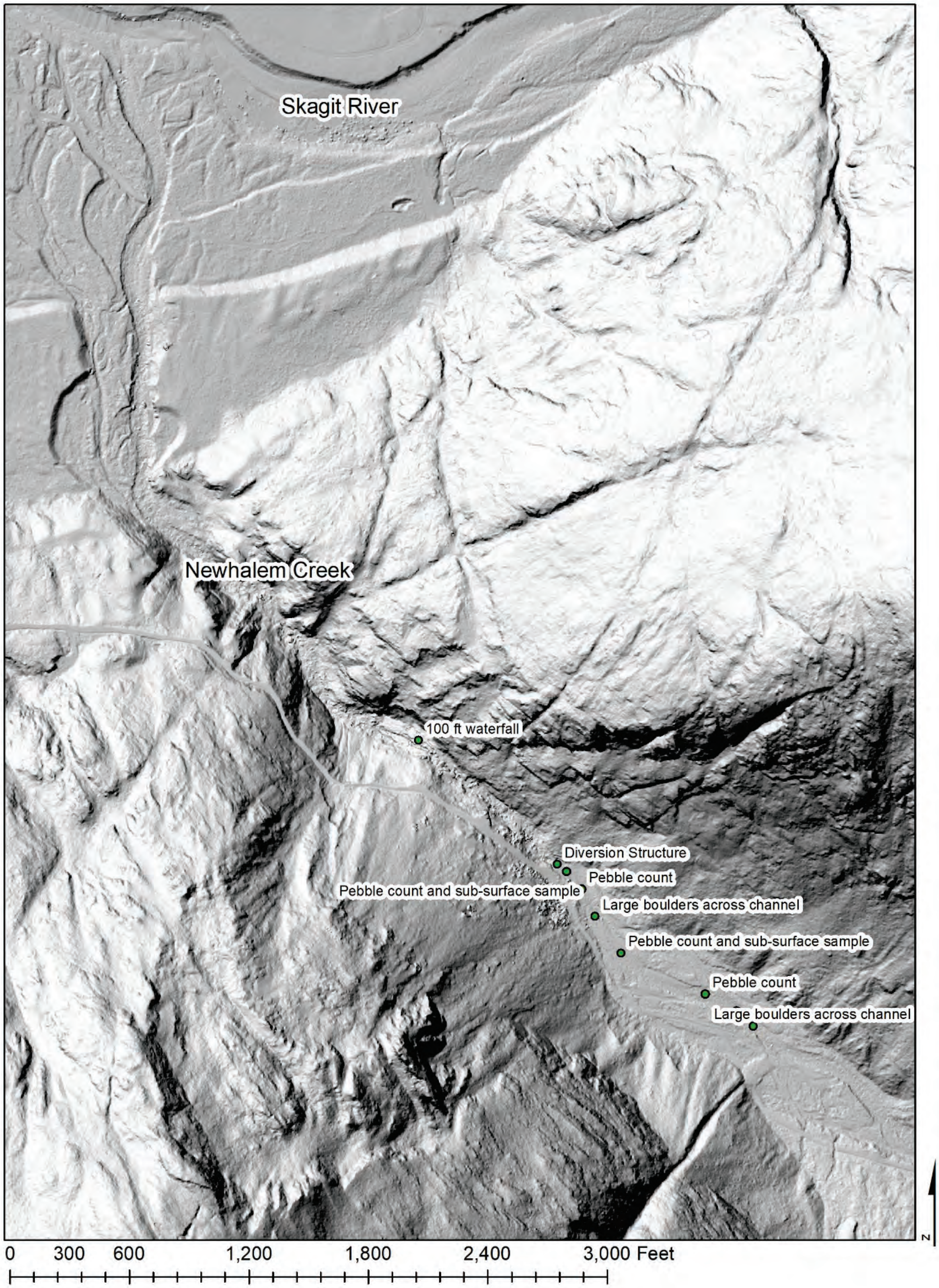


Figure 3.3-1. Topography of Newhalem Creek and Skagit River in Project area (2022 LiDAR hillshade)

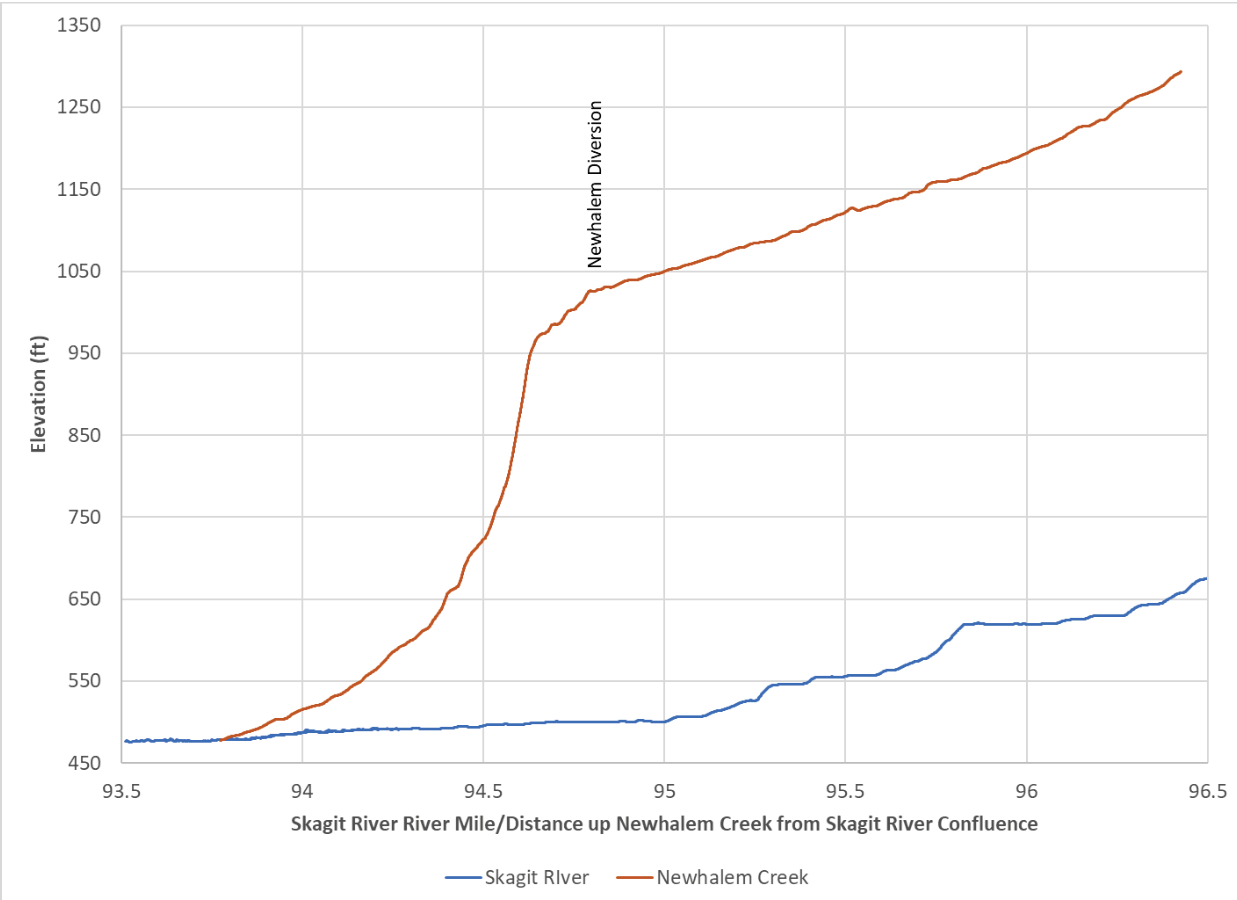


Figure 3.3-2. Longitudinal profile of Newhalem Creek and Skagit River.

3.3.1 Geomorphic Assessment of Newhalem Creek Upstream from Project Diversion Structure

Upstream from the Project diversion structure, Newhalem Creek is a high gradient stream. The 0.5-mile-long reach upstream of the intake has an average 2.2 percent slope gradient and includes a mix of pocket water (32 percent of reach length), pools (16 percent), glides (14 percent), step pools (13 percent), plane bed (11 percent), cascades (8 percent) and riffles (6 percent). Bankfull width ranges from 48 to 162 ft (average 70 ft) and bankfull depths ranged from 2 to 6 ft (average 3 ft, Figure 3.3-3). Bank heights ranged from 0.5 to 12 ft (average 5 ft) and varied considerably based on channel incision into the adjacent terraces, with left bank heights generally higher than right bank heights because of higher left bank terrace/fan features (Figure 3.3-4). Bank material was primarily boulder/cobble/gravel alluvium with some landslide debris.

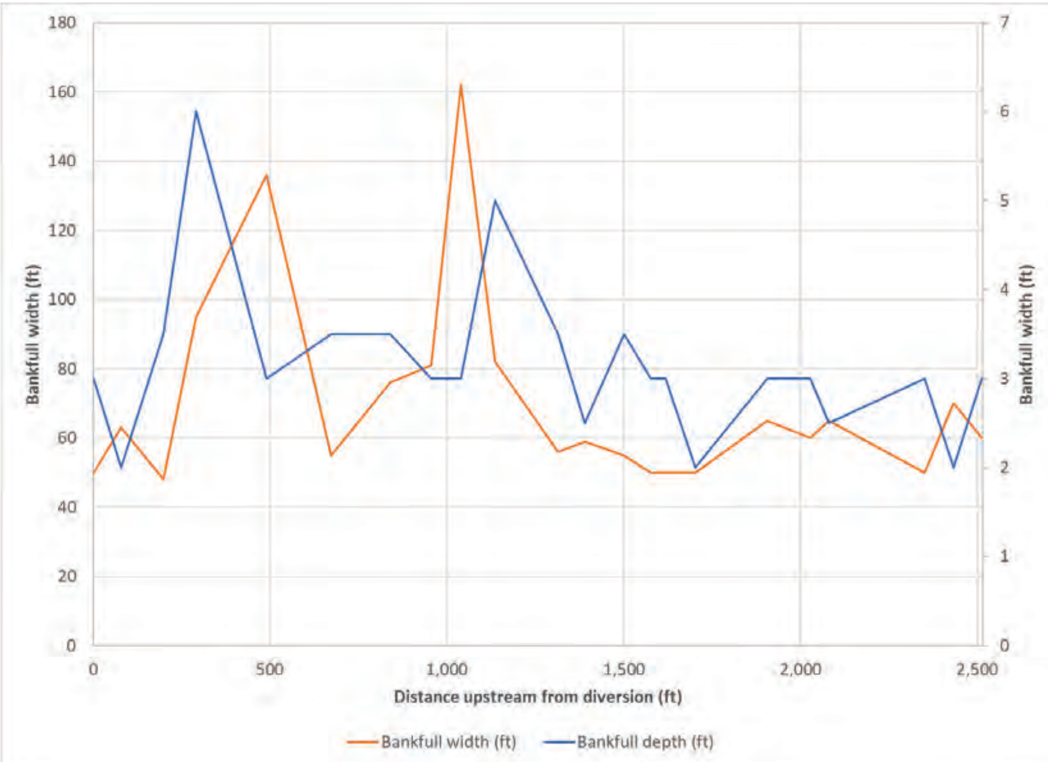


Figure 3.3-3. Bankfull width and depth upstream from Project diversion structure.

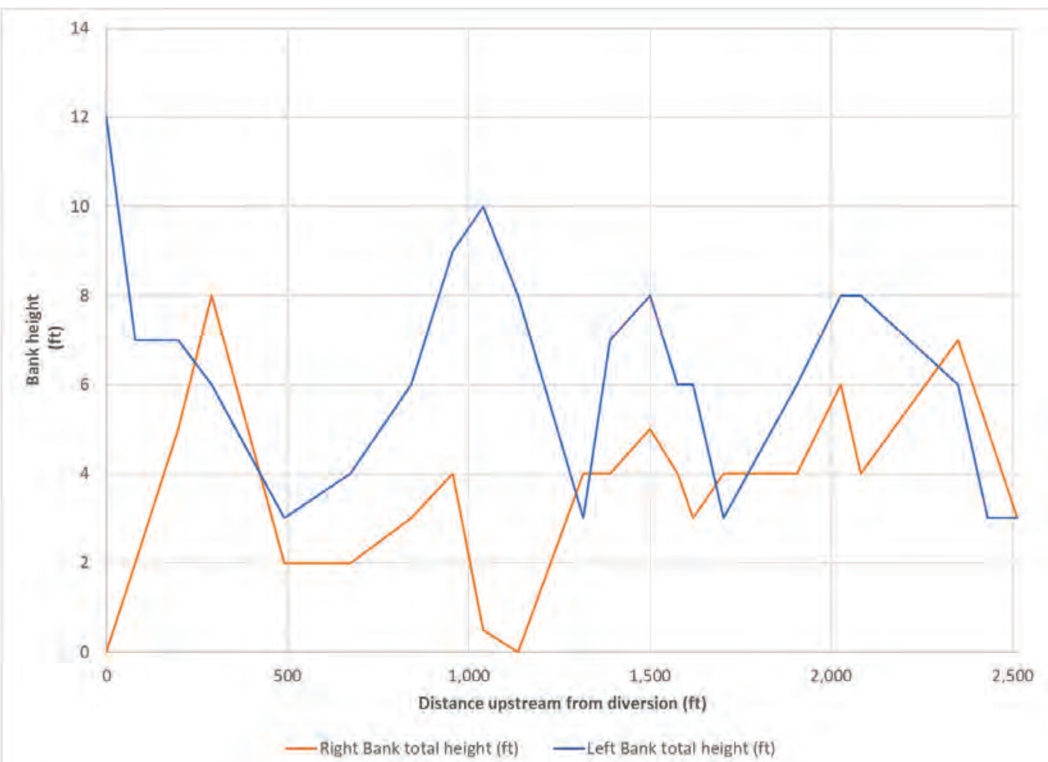


Figure 3.3-4. Bank heights upstream from Project diversion structure (right and left designations looking downstream).

Large, channel-shaping boulders (4- to 15-foot diameter) and large woody debris were also assessed during the field visit to help determine locations where boulders or large wood deposits will control the adjustment of the channel to removal of the Project diversion dam and associated structures. Numerous large boulders are located along the banks or across the channel between 227 and 440 ft upstream from the Project diversion structure, likely as the result of a large ancient slope failure from the left bank hillside. At 320 ft upstream from the diversion structure (station 320), several 6- to 12-foot-diameter boulders are located under the current stream channel and are forming a grade control, resulting in a cascade upstream from this location. Between 1,251 and 1,390 ft upstream from the diversion structure other groups of 5- to 7-foot-diameter boulders across the channel are forming a grade control. These boulders are large enough that they are not mobile under peak flows and appear to be forming persistent grade controls.

Large wood pieces and jams were noted during the geomorphic assessment, but most were along the banks and did not appear to be substantially impacting channel hydraulics except for several pieces of wood that were forming a pool between 702 and 730 ft upstream from the intake.

Details of the geomorphic unit assessment are included in Attachment A.

3.4 Grain Size Data

Pebble counts in Newhalem Creek upstream of the diversion in 2021 and 2022 show surficial substrate is composed of cobble, boulder, and gravel material (Figure 3.4-1 and Figure 3.4-2, Table 3.4-1 and Table 3.4-2). Median (D_{50}) grain sizes ranged from 106 to123 mm in 2021 and 89 to 238 mm in 2022 following an approximate 20-year return interval peak flow event in November 2021.

Sub-surface samples collected at two locations show that sub-armor material is, as expected, finer that the surface armor layer, with median grain sizes from 39 to 61 mm (Table 3.4-3, Figure 3.4-3). There was very little (less than 0.5 percent) silt/clay material in the sub-surface samples so high turbidity levels are not expected during streambed disturbing activities.

Boulder sized particles (larger than 512 mm diameter) were observed to have been transported into the intake area from upstream as a result of the November 2021 peak flow (provisional peak of 4,920 cfs). The grain size information was used to evaluate bed mobility, headcutting potential, and expected turbidity levels.

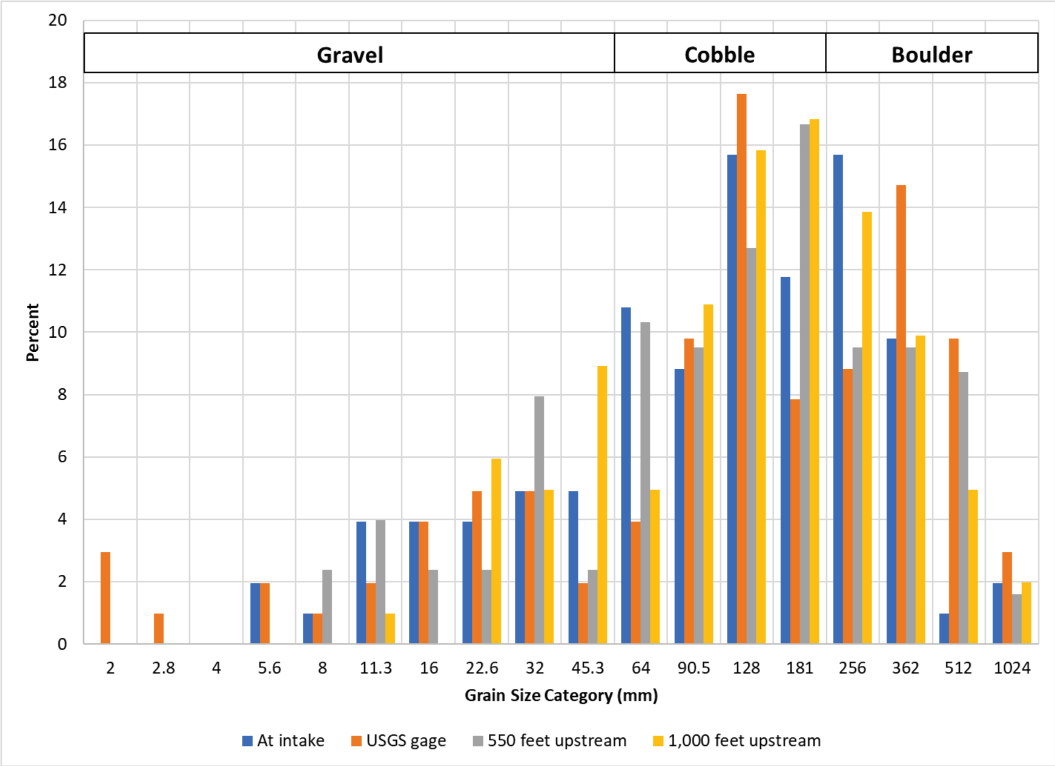


Figure 3.4-1. Grain size distribution of substrate upstream from Newhalem Creek diversion structure, 2021.

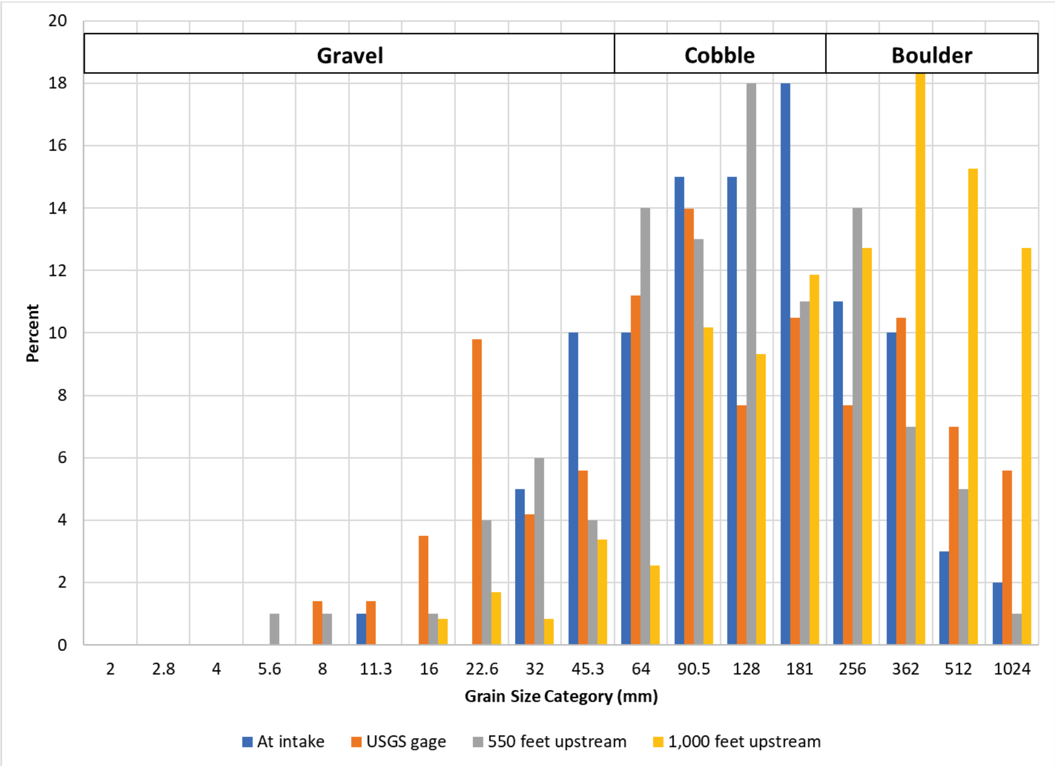


Figure 3.4-2. Grain size distribution of substrate upstream from Newhalem Creek diversion structure, 2022.

Table 3.4-1. Surficial grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2021).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	25	106	242	25%	47%	28%
USGS gage (180 ft upstream from diversion)	21	117	341	25%	39%	36%
550 ft upstream from diversion	29	118	312	21%	49%	29%
1,000 ft upstream from diversion	40	123	265	21%	49%	31%
AVERAGE	**29**	**116**	**290**	**23**%	**46**%	**31**%

Table 3.4-2. Surficial grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2022).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	45	115	250	16%	58%	26%
USGS gage (180 ft upstream from diversion)	23	89	329	26%	43%	31%
550 ft upstream from diversion	84	238	482	17%	56%	27%
1,000 ft upstream from diversion	42	105	241	7%	34%	59%
AVERAGE	**49**	**137**	**326**	**16%**	**48%**	**36%**

Table 3.4-3. Sub-surface grain size characteristics of substrate upstream from Newhalem Creek diversion structure (2022).

Location	D_{16} (mm)	D_{50} (mm)	D_{84} (mm)	Percent Silt/clay	Percent Sand	Percent Gravel	Percent Cobble	Percent Boulder
50 ft upstream from diversion	3.5	39	164	0.5%	9%	53%	30%	8%
550 ft upstream from diversion	3.6	61	202	0.5%	12%	39%	40%	9%
AVERAGE	**4**	**50**	**183**	**0.5%**	**11%**	**46%**	**35%**	**9%**

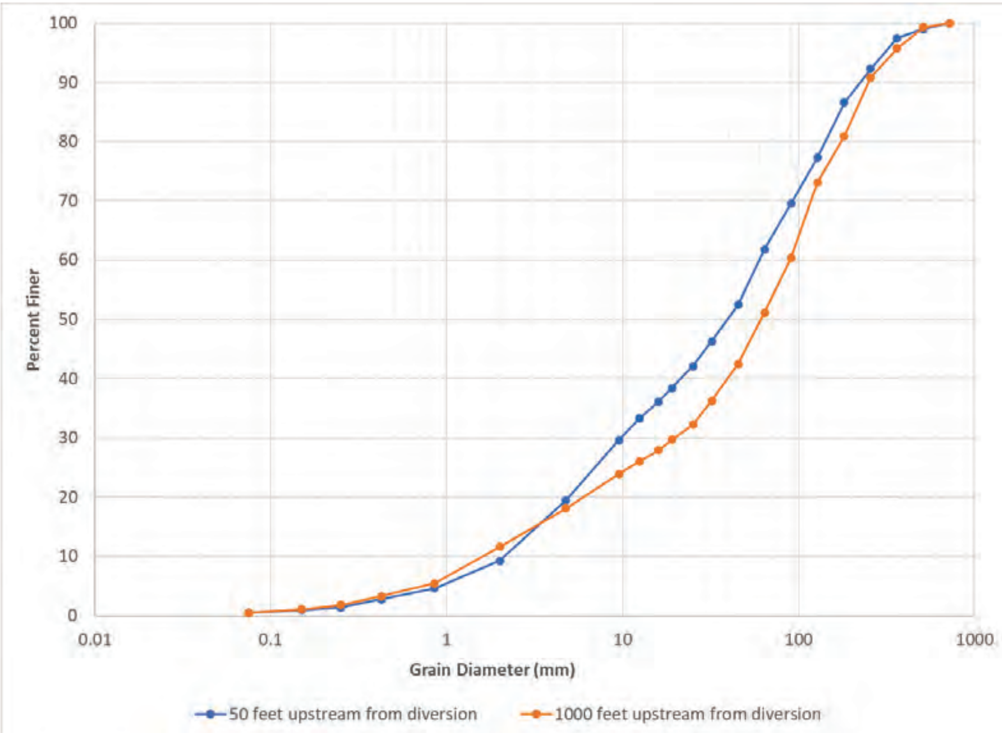


Figure 3.4-3. Grain size distribution of sub-surface samples upstream from Newhalem Creek diversion structure, 2022.

3.5 Existing Effects of Newhalem Project on Newhalem Creek Geomorphology

The Newhalem Project started operation over 100 years ago; the primary geomorphic effects on the Newhalem Creek have been:

- Diversion structure (8–10 ft tall) that provides a grade control for the stream (note that the original dam was replaced with the current structure in 1969);
- A small impoundment that retains some portion of the bedload transported from upstream reaches; and
- Diversion of water through the intake and out of Newhalem Creek when the Project was operating.

Over the 100 years since the Project began operating, Newhalem Creek has re-adjusted its profile upstream from the diversion structure to the new base level provided by the diversion dam. The small impoundment retains at least some portion of the bedload coming from the watershed upstream from the diversion. City Light reports that while the Project was operating, an average of 200–400 cubic yards of material were removed from the impoundment and placed in the channel downstream from the diversion dam on an annual basis to keep the area near the intake clear of sediment for Project operations. This provides a minimum estimate of the annual bedload transport volume in the stream. Since the removed sediment was placed downstream from the dam and the impoundment is very small, the Project did not cause a major net change in sediment supply to downstream reaches of Newhalem Creek.

4.0 DISCUSSION

The primary geomorphic effect associated with decommissioning the Newhalem Project will be the response of the streambed to removal of the diversion structure. Current plans are to remove the diversion structure to the underlying bedrock at an elevation of 1015 ft NAVD88 (approx. 1009 ft Project datum), 10 ft below the top of the existing diversion. This will lower the base level of Newhalem Creek at the diversion location and the stream will adjust to the new base level.

4.1 Potential Future Geomorphic Effects

Potential geomorphic effects of diversion removal include:

- Higher local stream gradient will increase sediment transport capacity immediately upstream from the diversion location in the short term (see Section 4.1.1).
- Existing sediment in the impoundment area will be transported downstream (see Section 4.2, particularly 4.2.2).
- As the channel adjusts to the lower base level over the longer term, the streambed upstream from the (removed) diversion structure will be lower than under existing conditions (see Section 4.1.1).
- There will be increases in turbidity immediately following diversion/cofferdam removal and during subsequent peak flow events that disrupt the armor layer; these are expected to be small and short-term increases (see Section 4.2.1).

Site conditions will minimize the amount of geomorphic change. The channel under and immediately downstream from the diversion is a high gradient (9 percent), boulder/bedrock channel. The bedrock provides a limit to the depth of channel incision at the diversion site and the high gradient channel downstream from the diversion site will quickly transport sediment from the impoundment to the alluvial fan and Skagit River.

4.1.1 Changes to Stream Profile Upstream of Diversion Structure

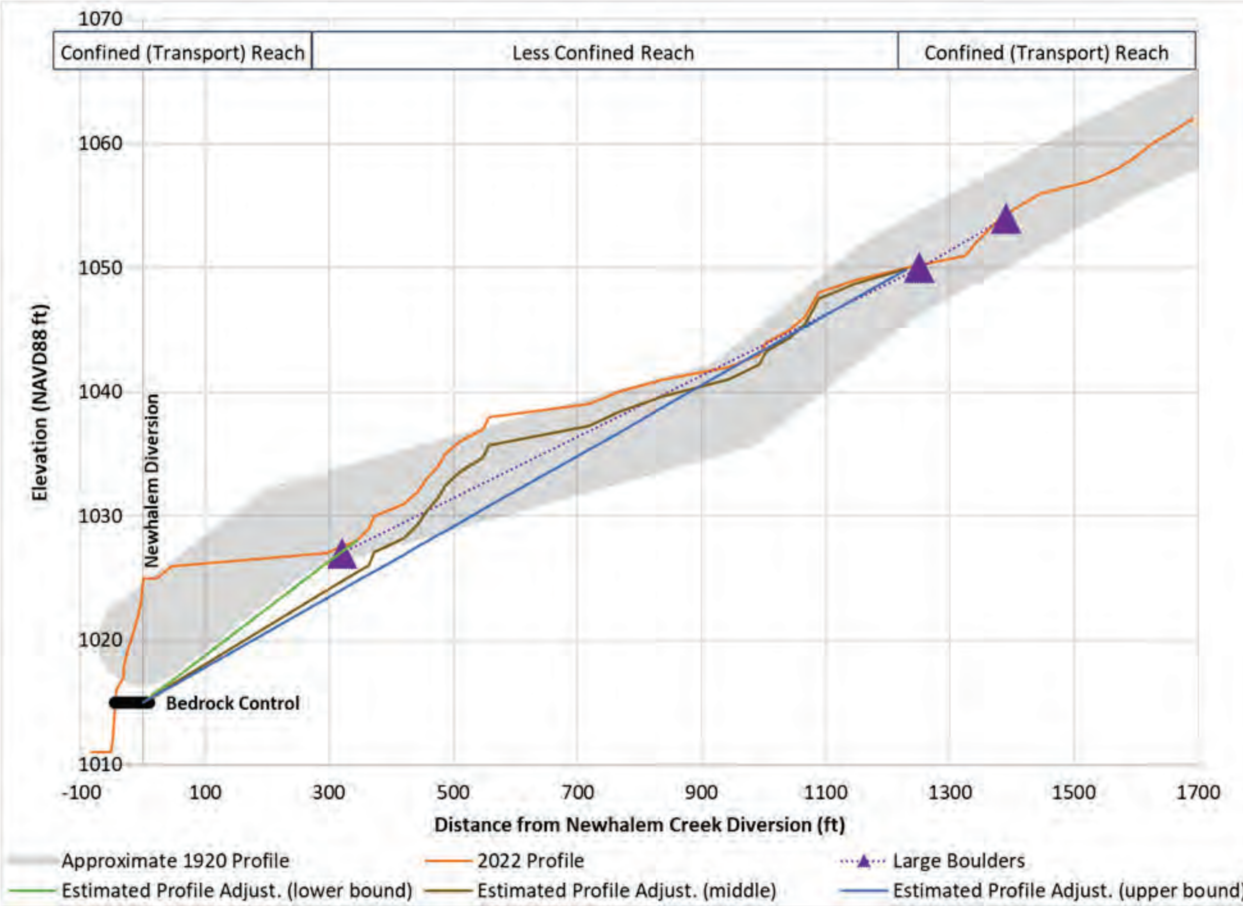
Removal of the diversion structure will result in adjustment of the bed of Newhalem Creek to the new base level. An approximate 1920 longitudinal profile (from Figure 2.2-1 above) and 2022 longitudinal profile (from LiDAR data) upstream from the diversion structure were plotted to compare approximate pre-Project and current stream profiles (Figure 4.1-1). There is uncertainty in horizontal location and vertical datum on the 1920 map, so the 1920 stream profile is shown as a wide band and should be considered approximate. The location of large, immobile (5- to 12-foot diameter) boulders from the field inventory were also plotted. These data were used to estimate the potential amount of channel downcutting that could take place following removal of the diversion structure.

Note that the 2022 stream profile includes several “steps,” in the 1,200-foot reach just upstream from the diversion/intake pool. A major step is located approximately 550 ft upstream from the diversion and is likely controlled by the large boulders at station 320 ft. This step is visible in the field as a steep cobble/boulder riffle located at the downstream end of a split high flow channel/island area. Several very large (10- to 12-foot diameter) boulders were observed under the existing channel at station 320 ft. These large boulders appear to have originated from an ancient,

large landslide on the west bank of the river and are not mobile, providing a stable grade control at this location. Two additional sets of large channel-spanning boulders were mapped at 1,251 and 1,390 ft upstream from the diversion. These are also at the toe of a landslide deposit. Steps are also apparent in the 1920 stream profile, suggesting that this type of stepped profile is a naturally occurring feature of the Newhalem Creek channel in this location.

Three bounding estimates of the amount of potential channel lowering shown in Figure 4.1-1 were made based on the following assumptions:

- Lower bounding estimate – assumes the 8- to 12-foot-diameter boulders 320 ft upstream from the existing diversion will be a grade control; the channel downstream from this location would lower to the green line in Figure 4.1-1.
- Middle bounding estimate: Assumes Newhalem Creek erodes into the right bank at the location of the 8- to 12-foot-diameter boulders (320 ft upstream from the existing diversion) and there are smaller boulders in the new channel location that allow some downcutting at this location. The stream continues to adjust the profile, but instead of a straight line (like the upper bounding estimate described below), the stream adjusts to a new profile with a similar shape as the existing profile. The brown line in Figure 4.1-1 shows a hypothetical new profile using these assumptions.
- Upper bounding estimate: Assumes the stream erodes toward the right bank and around the boulders at Station 320, there are no boulders in the right bank to form a grade control and the stream continues to adjust upstream to the location of the 5-foot angular boulders distributed across the stream 1,251 ft upstream from the diversion. In this scenario, the streambed adjusts to a straight-line profile from the bedrock under the diversion structure to the boulders at station 1,251, shown as the blue line in Figure 4.1-1. This straight line future channel condition is not likely given the character of Newhalem Creek, but it is provided as an upper bounding estimate.



Elevation is NAVD88

Figure 4.1-1. Longitudinal profile of Newhalem Creek upstream from diversion structure with potential profile adjustments.

Potential future change in channel bed elevation following diversion removal was determined by subtracting the 2022 bed elevation from the estimated lower, middle, and upper bounding profile lines. Bed lowering would be greatest just upstream from the removed diversion and at the top of the "steps" in the 2022 profile, with a maximum of 10 ft of bed lowering at the diversion structure (Figure 4.1-2). Estimated bed lowering would extend upstream at varying depths, from the diversion dam for 320 ft (lower estimate, green line) or 1,251 ft (middle and higher estimate, brown dotted and blue dashed lines respectively).

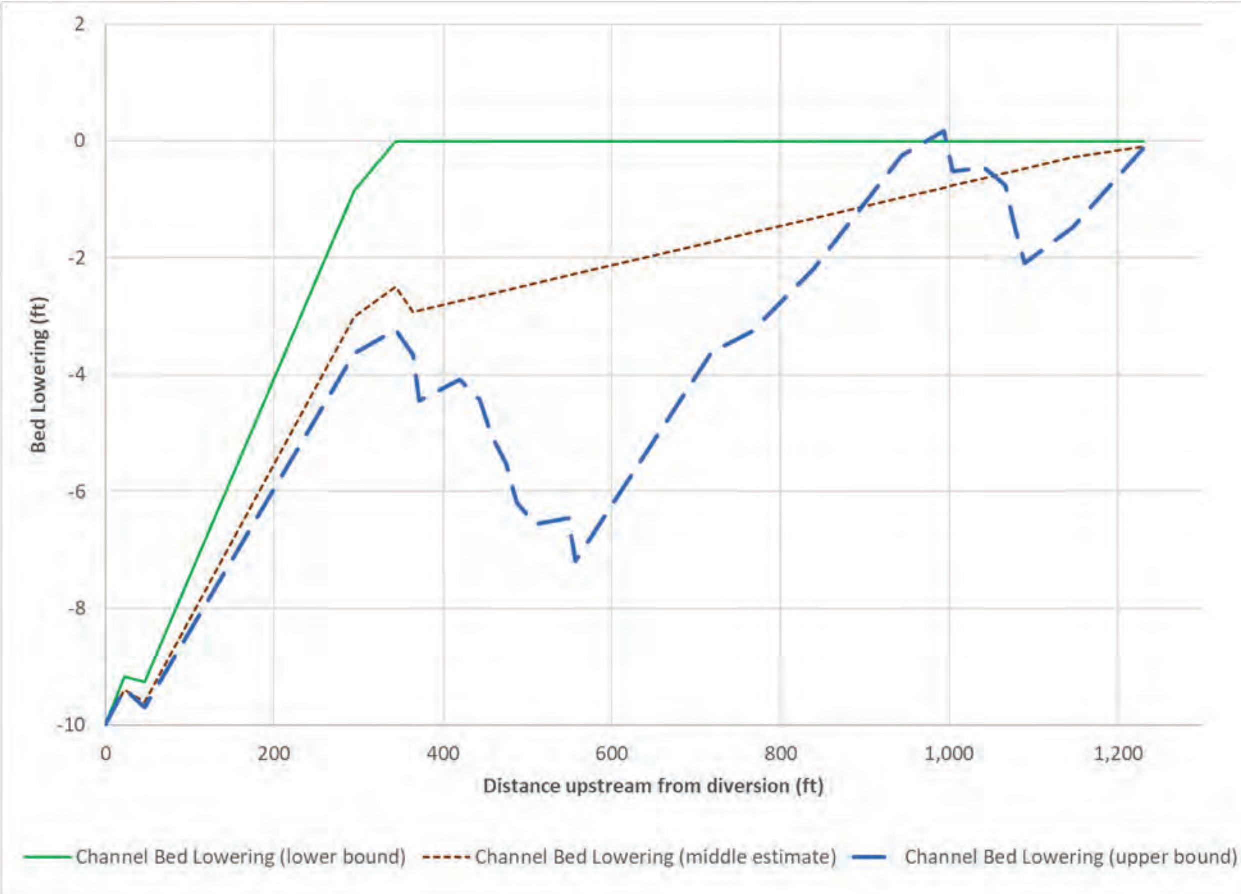


Figure 4.1-2. Estimated depth of bed lowering following removal of diversion structure for three channel adjustment scenarios.

The total volume of sediment that may be transported out of the adjustment area was calculated based on change in bed elevation and an average channel width of 70 ft (average bankfull width). Total potential volume of sediment transported is 4,400 cubic yards (lower bounding estimate), 9,000 cubic yards (middle estimate), or 12,900 cubic yards (upper bound estimate). These volumes can be compared to the estimated existing sediment load of Newhalem Creek made as part of the Skagit River Hydroelectric Project relicensing studies (Seattle City Light 2023). Estimates of coarse-grained sediment yield from Newhalem Creek were made using three different methods for the relicensing studies, as summarized below:

1. Based on the volume of gravel/cobble/boulder material removed from the Newhalem Creek diversion structure during past cleanout procedures, a minimum of 500–1,000 cubic yards/year of coarse-grained sediment is transported to the Newhalem Creek diversion structure. This is an absolute minimum annual volume because once the diversion pool fills with sediment any additional bedload would be transported over the diversion structure; during high flow years the volume of sediment movement would be much higher. Therefore, the average annual long-term bedload supply is higher than this amount.

2. Based on grain size sampling within Newhalem Creek and channel dimensions, an average of 2,000 cubic yards/year of bedload was estimated to move past the diversion using the relationships described in DeVries (2000). This is a more realistic volume of the average annual bedload movement rate near the diversion structure.

3. Based on a regional sediment yield equation, an estimated 10,000–15,000 cubic yards/year of gravel and cobble are supplied into the Skagit River from the Newhalem Creek watershed. This estimate takes into account very high flow events.

There is a wide range in the estimated average annual bedload supply volumes, but given even a lower-end estimate of 2,000 cubic yards/year under current conditions, the estimated volume of additional bed sediment that may be eroded following diversion removal is at most 6.5 times the average annual bedload supply rate (assuming the upper bound estimate of sediment is eroded following dam removal) and may be as little as 2.2 times the average annual amount of bedload sediment (assuming the lower bound estimate of sediment is eroded following dam removal).

If the amount of sediment eroded under existing conditions is closer to the higher end estimates from the regional sediment yield equation, the total amount of sediment transported downstream from dam removal would be equal to or less than the average yearly amount of bedload moving through Newhalem Creek under current conditions.

Under ~~all~~ potential future bed lowering scenarios, the re-adjustment to the new base level would likely take place relatively slowly due to the coarse nature of the streambed (cobble/boulder/gravel). However, bedload transport is an episodic process and pulses of material will move through the system as high flows mobilize the material. If very high flows occur immediately after diversion structure removal, more sediment will be moved than if lower peak flows occur in the years following removal. These same high flows that mobilize the material will have the energy to transport it downstream; note that the stream gradient in the canyon/waterfall reach and alluvial fan (average 5 percent) are higher than gradients in the reach upstream from the diversion (2-3 percent; Figure 3.3-2 and Section 3.3 above). The actual timeframe for the re-adjustment will be dependent on the storm events in the years following the diversion dam's removal. Assuming there is not a very high peak flow in the decade following dam removal, the re-adjustment would take place over a decadal or longer time scale following the initial channel adjustment that would take place just upstream from the diversion structure.

4.1.2 Sediment Transport Analysis

Based on stream hydraulics and the current stream substrate size, the flow that could initiate substrate movement was calculated under current conditions (reach-averaged stream gradient 2.2 percent) and under conditions with the diversion removed (Table 4.1-1). Frequencies listed in the table reflect the values calculated for the peak flow recurrence intervals at the USGS gage just upstream from the diversion (see Table 3.2-1 in previous discussion of stream hydrology). Particles up to 512 mm in diameter were mobilized between the 2021 and 2022 field visits; the peak flow in November 2021 was 4,920 cfs, indicating that boulders up to at least 512 mm are mobile in the stream under those flow conditions.

Table 4.1-1. Calculated discharge required to transport substrate upstream of diversion structure under existing conditions and following diversion removal, historic peak flows.

Stream Gradient	Discharge and frequency of median (D_{50}) grain size transport	Discharge and frequency of larger (D_{84}) grain size transport
2.2% (reach average over long term)	250 cfs; every year	3,000 cfs; 5 years
1.3% (existing local slope just upstream from diversion)	1,500 cfs; 1.5 years	over 9,000 cfs; 100+ years
3.8% (short term local slope upstream from diversion with diversion removal and drop in base level)	120 cfs (many times/year)	1,500 cfs; 1.5 years

In the short-term, immediately following diversion removal, the local stream gradient just upstream of the diversion would increase from 1.3 to 3.8 percent, which would increase the sediment transport frequency of the median (D_{50}) sized substrate from every 1.5 years to many times/year. Transport of larger particles (e.g., D_{84}) would increase from very infrequently (over 100-year recurrence frequency) to movement under a 1.5-year peak flow event. This analysis suggests that the bed immediately upstream from the diversion structure would respond quickly to diversion removal. It is anticipated that the substrate just upstream from the removed diversion structure would be mobilized as soon as the diversion/cofferdams were removed, and an armor layer would form quickly as finer material was transported downstream and larger, immobile particles (e.g., boulders) remained on the bed. As flows increase during subsequent larger flow events, some of the bigger substrate particles would be mobilized and transported downstream and the process would continue until Newhalem Creek reaches a new, stable profile.

As material on the bed is transported downstream, the locally high stream gradient above the removed diversion structure would migrate upstream. The bed adjustment would migrate upstream until a grade control is reached, such as the large, immobile boulders in the channel 320 ft upstream from the diversion or the set of large boulders between 1,251 and 1,390 ft upstream from the diversion.

As the bed adjustment progresses upstream, the local gradient increase would become less and less until a new long-term average slope condition is reached. As the local gradient increase becomes less and less, the corresponding energy to move particles becomes less, resulting in less frequent bedload movement and a slowing of the process. Bed adjustments can migrate upstream fairly rapidly in fine-grained sediments, but the large particle sizes in Newhalem Creek will form an armor layer and further reduce the speed of adjustment migration and the large, immobile boulders noted above will limit channel incision. It is anticipated that as an armor layer forms, the larger substrate will be mobile much less frequently and channel adjustments will take several decades. Over time, a new equilibrium channel gradient will develop.

The grain size transport frequency in Table 4.1-1 assumes similar peak flow magnitudes as historic conditions. As discussed in Section 3.2.1, climate change modeling suggests that future peak flows may be higher magnitude than historic conditions, although higher magnitude peaks have not been documented as of 2022 at the Newhalem gage. If future peak flows are higher, Newhalem Creek

would adjust more quickly to diversion removal as the higher flows transport material through the river system. If higher future peak flows do occur, the entire Newhalem/Skagit river system would experience the increased peak flows, resulting in more active sediment transport/geomorphic change throughout the river system and mute the more rapid changes resulting from the Newhalem Creek diversion removal.

4.1.3 Potential Grade Control Structure Considerations

FERC has requested the cost for design of a grade control structure near the current diversion dam in the October 28, 2022, Additional Information Request in response to some resource agency interest in a grade control structure.

The need for a grade control structure should be balanced between the desire to return the stream to a natural condition (with no structures) and the risk of headcutting. As discussed in previous sections, there is a low risk of rapid or far-reaching headcutting (past the 1,251–1,390-foot boulder clusters) in Newhalem Creek following diversion dam removal for the following reasons:

1. The diversion structure is underlain by bedrock that will provide a stable, long-term base level.

2. There are large, immobile boulders (5- to 12-foot diameter) underlying the channel at several locations upstream from the diversion structure (320; 1,251; and 1,390 ft). These boulders will not be mobile under current or future flows and will provide natural grade controls in the stream that will limit headcutting.

3. The large substrate in Newhalem Creek does and will continue to form an armor layer that is resistant to rapid erosion of the channel.

4.2 Changes Downstream from the Diversion Removal

Sediment that is moved out of the diversion area will be transported rapidly through the high gradient canyon (8.9 percent slope) and 100-foot-high waterfall reach to the alluvial fan area. Boulders and large cobble will be deposited at the upstream end of the Newhalem Creek alluvial fan in the Skagit River valley; actual deposition locations will reflect gradient and stream conditions on the fan. Some cobble, gravel and finer sediment will be transported farther downstream and eventually reach the Skagit River, providing a source of sediment for spawning and aquatic habitat.

4.2.1 Turbidity

Turbidity effects resulting from disturbance of the streambed during instream work has been identified as a potential concern. During structure removal, instream work areas will be isolated from the streamflow by cofferdams and appropriate erosion/streamflow control measures as described as part of engineering/construction operations in separate documentation. Following instream work, the cofferdams will be removed and Newhalem Creek water will again flow over the streambed and begin readjustment to the new base level without the diversion structure.

Turbidity levels following diversion removal could increase under the following conditions:

- Immediately following cofferdam removal until the stream forms a surficial armor layer; and
- During subsequent peak flow events that disrupt the armor layer as the stream re-adjusts to the new base level.

Sub-surface sampling (Section 3.4) at two locations upstream of the diversion structure in 2022 found less than 1 percent silt/clay material in the streambed. The low levels of fine-grained sediment will result in minor increases in turbidity during either of the streambed-disturbing flow conditions listed above. The Newhalem Creek watershed is underlain by the Skagit Gneiss that primarily weathers to sand-sized particles rather than finer-grained silt and clay, so there are only minor sources of fine-grained material in the watershed (such as Quaternary glacial deposits).

As part of operation of the Newhalem Project, the intake pool upstream of the diversion dam was cleaned out on a regular basis. During low flow periods, approximately 250 to 425 cubic yards of accumulated material was removed with an excavator and placed on the concrete apron downstream from the diversion structure and allowed to move downstream (Figure 4.2-1, Figure 4.2-2, and Figure 4.2-3). Turbidity monitoring took place during the cleanout events; these data provide another indication of levels of turbidity expected immediately following diversion and cofferdam removal. The baseline and peak turbidity levels measured during 2012, 2015, and 2016 cleanout events are shown in Table 4.2-1. Peak turbidity levels from 0.88 to 58.79 NTUs over background were measured immediately following gravel placement but reached background levels in less than 24 hours.

It is anticipated that turbidity level increases following cofferdam removal will be similar to those during pool cleanout and that turbidity levels will decrease quickly after initial higher levels. Turbidity levels will also likely increase during subsequent higher flows as the armor layer upstream from the diversion location is disrupted and the stream adjusts to the new base level. These turbidity increases are also anticipated to be minor and transient due to the low level of fine-grained material in the subsurface material.

Figure 4.2-1. Intake pool area during cleanout.

Figure 4.2-2. Intake pool following cleanout.

Figure 4.2-3. Material removed from intake pool placed on concrete apron downstream from diversion structure.

Table 4.2-1. Newhalem Creek intake pool cleanout turbidity monitoring data.

Monitoring Date	Baseline NTU	Peak NTU after excavation	Change in NTUs (over background)
9/17/2012	0.18	30.0	+29.82
9/18/2012	0.21	59.0	+58.79 (max)[2]
8/7/2015	0.13	4.5	+4.37
8/8/2015	0.50	21.1	+20.6
8/9/2015	0.46	16.6	+16.14
8/17/2015	0.20	1.08	+0.88
8/22/2016	0.35	5.46	+5.11
8/24/2016	0.2	39.5	+39.3
8/24/2018	0.1	18.18	+18.08
8/25/2018	0.31	18.29	+17.98
8/26/2018	0.70	17.6	+16.9
8/27/2018	0.90	9.98	+9.08
8/28/2018	0.33	11.28	+10.95
8/29/2018	0.40	13.56	+13.16
8/30/2018	0.32	13.45	+13.13

4.2.2 Potential for Filling Step Pools

The step pools downstream from the diversion structure have been identified as important cultural resources, with a concern that removal of the diversion and transport of material from upstream may fill the step pools. Modeling or calculation of sediment transport through step pool structures is difficult due to the complex 3-dimensional hydraulics, but observations of sediment movement through the step pools following cleanout of the intake pool provides empirical evidence of sediment transport and accumulation in the step pools.

The step pools were not observed to fill with material following intake excavation events which took place during low flow conditions (Figure 4.2-4). Gravel was observed on the sides of the step pools, but velocities in the pools was high and turbulent enough at low flow to transport material through and maintain the pool structure among the boulders and bedrock forming the pools. During higher flows, velocities and turbulence in the pools are much higher and material on the edges of the pools is also transported downstream. Observations made during the 2021–2022 site visit indicated that cobble, boulder, and gravel material had filled the intake pool and was being transported over the intake structure. No evidence of filled step pools downstream of the diversion was observed indicating that flows high enough to mobilize material upstream of the diversion are high enough to transport the same material through the higher gradient/confined step pool section of the stream (Figure 4.2-5).

Following diversion structure removal, cobble, gravel, and boulders would move downstream and through the step pools in a similar manner as during the intake cleanout events and current high flow events. As flows increase, additional material will be mobilized upstream of the diversion structure location and the higher flows will transport the material through the step pools. It is

[2] Turbidity suspected to be higher due to pockets of sandy sediments that were encountered in 2012.

anticipated that step pools will retain pool depth following diversion removal and there will be minimal or no long-term effects.

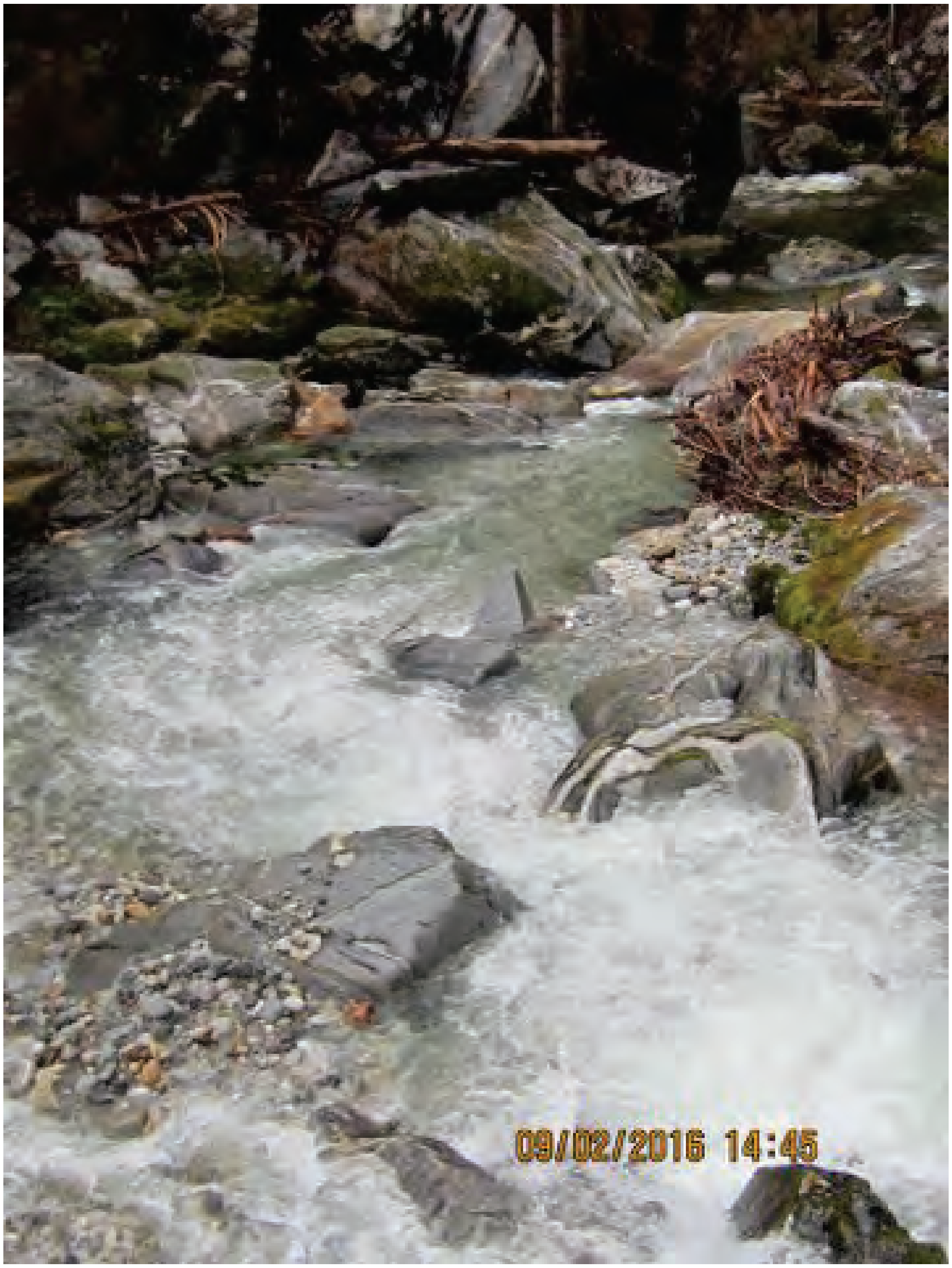


Figure 4.2-4. Step pools downstream from diversion structure following August 24, 2016 intake pool cleaning.

Figure 4.2-5. Step pools downstream from diversion structure in September 2022.

4.2.3 Potential for Changes to Downstream Debris Slide

There is a large, ancient landslide on the southwestern (left bank) side of Newhalem Creek that extends from several hundred feet upstream of the diversion structure to the base of the waterfall approximately 1,100 ft downstream from the diversion. A much smaller debris slide is located at the downstream end of the larger slide; the smaller debris slide has been active for at least several decades and affects the Newhalem Creek dam access road. The NPS questioned whether the accumulation of material in Newhalem Creek following removal of the diversion structure could result in erosion of the toe of the landslide that could re-activate the slide. A memorandum describing the landslide and debris slide provides information describing the slide complex (Findley 2021) and is summarized in the next two paragraphs.

The active debris slide consists of alpine glacial deposits overlying Skagit gneiss bedrock. The large, ancient slide likely consists of similar material and the toe of the large slide blocks the Newhalem Creek valley, diverting the flow to the northeast side of the drainage where Newhalem Creek currently flows (Figure 4.2-6). The older slide has mature trees that are straight and plumb suggesting little recent ground movement, while trees within the active, smaller debris slide area exhibit leaning trunks consistent with ground movement.

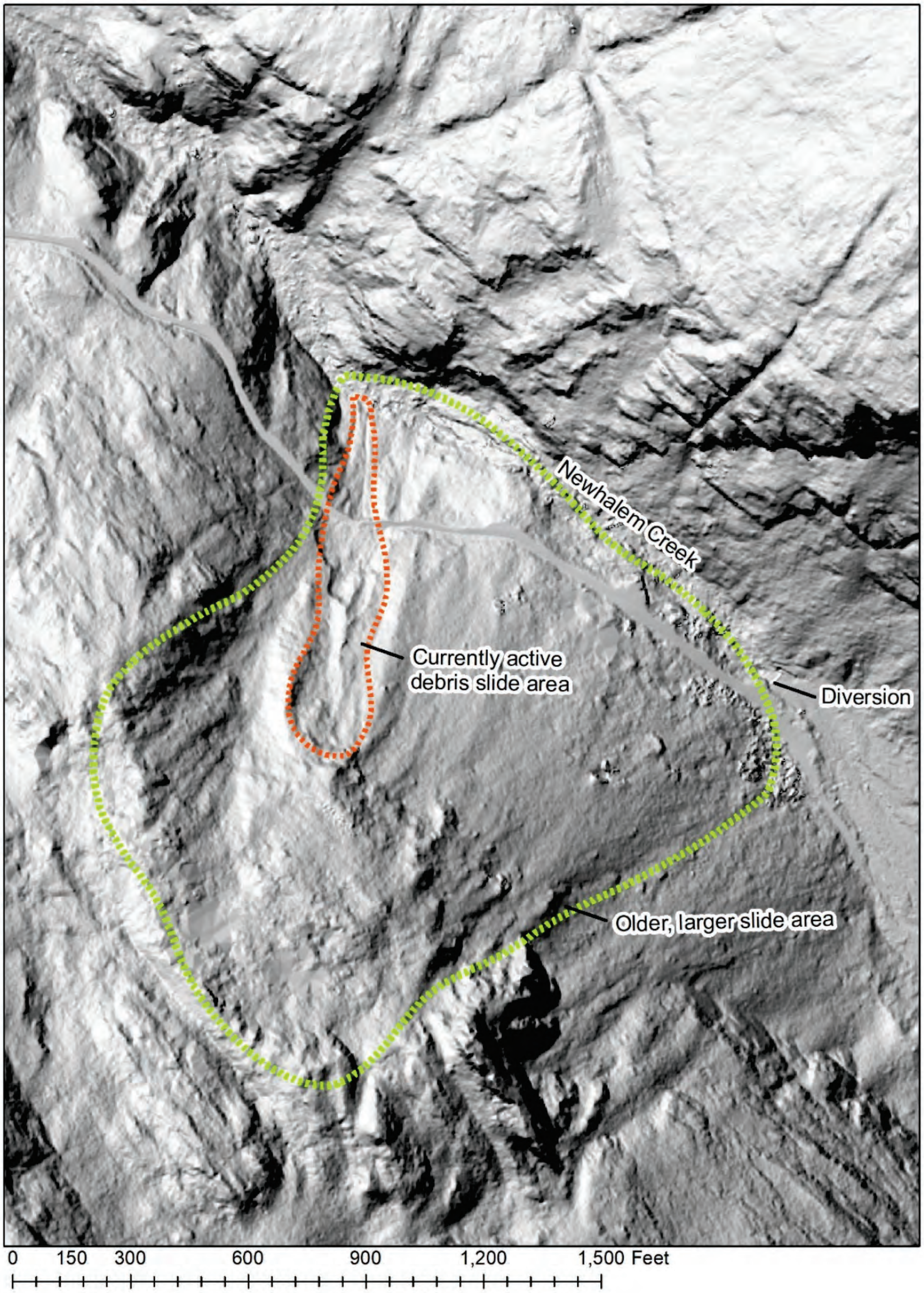


Figure 4.2-6. LiDAR hillshade image showing older, larger and younger, active debris slide areas (after Findley 2021).

The active landslide area uphill from the access road is approximately 250 ft wide and 500 ft high with a slope inclination of 40–45 degrees steepening to 70 degrees in the headscarp. Soil is coarse subangular cobbles and boulders in a silty/sandy matrix. Numerous boulders larger than 10 ft in diameter were observed in the landslide area. The toe of the smaller, active slide is at the base of the 100-foot-high waterfall in Newhalem Creek. Findley (2021) notes that the large, older landslide does not appear to be currently active based on field observations but erosion along the toe of the mass by Newhalem Creek presents a potential for future reactivation.

The 2015 LiDAR elevation data were subtracted from the 2022 LiDAR data to produce a map showing areas of lower topography (erosion—in blue on map) and accumulation (in red on map) for the smaller, active slide area (Figure 4.2-7; yellow areas indicate little change in elevation from 2015 to 2022). As expected, there was erosion/elevation drop at the headscarp of the active slide and deposition of material on the roadway. The 2015–2022 slide movement was primarily uphill from the roadway and does not appear to be directly connected to erosion at the toe of the slide since there was little movement of the slope between the road and the stream despite evidence of up to 5 ft of erosion within the creek at the toe of the slide. This indicates Newhalem Creek has the potential to erode the toe of the smaller, active landslide under current conditions.

Determining the stability of either the larger, old landslide or the smaller active landslide is not possible with the available data, so a slope stability analysis of how any accumulation or scour of material in Newhalem Creek following diversion removal may affect either slide area is not possible. However, based on field observations of mature trees and the large boulders within the stream and at the base of the slide, the large, older slide has not been affected by Newhalem Creek flowing at the toe of the slide for a very long time. Newhalem Creek is eroding the toe of the smaller, active slide under current conditions, Based on the results of a reconnaissance of the smaller landslide on June 2, 2023, by Seattle City Light staff, the toe of this landslide is armored by 20–25 ft of large boulder debris. The erosion currently being caused by Newhalem Creek is surficial material or accumulated material within the streambed and is not destabilizing the landslide. In order for toe erosion to destabilize the landslide, the creek would have to erode material above the 20–25 ft of protective boulder armoring at the toe. It is not feasible that 20–25 ft of material could be deposited following dam removal in this high gradient, confined location in the stream.

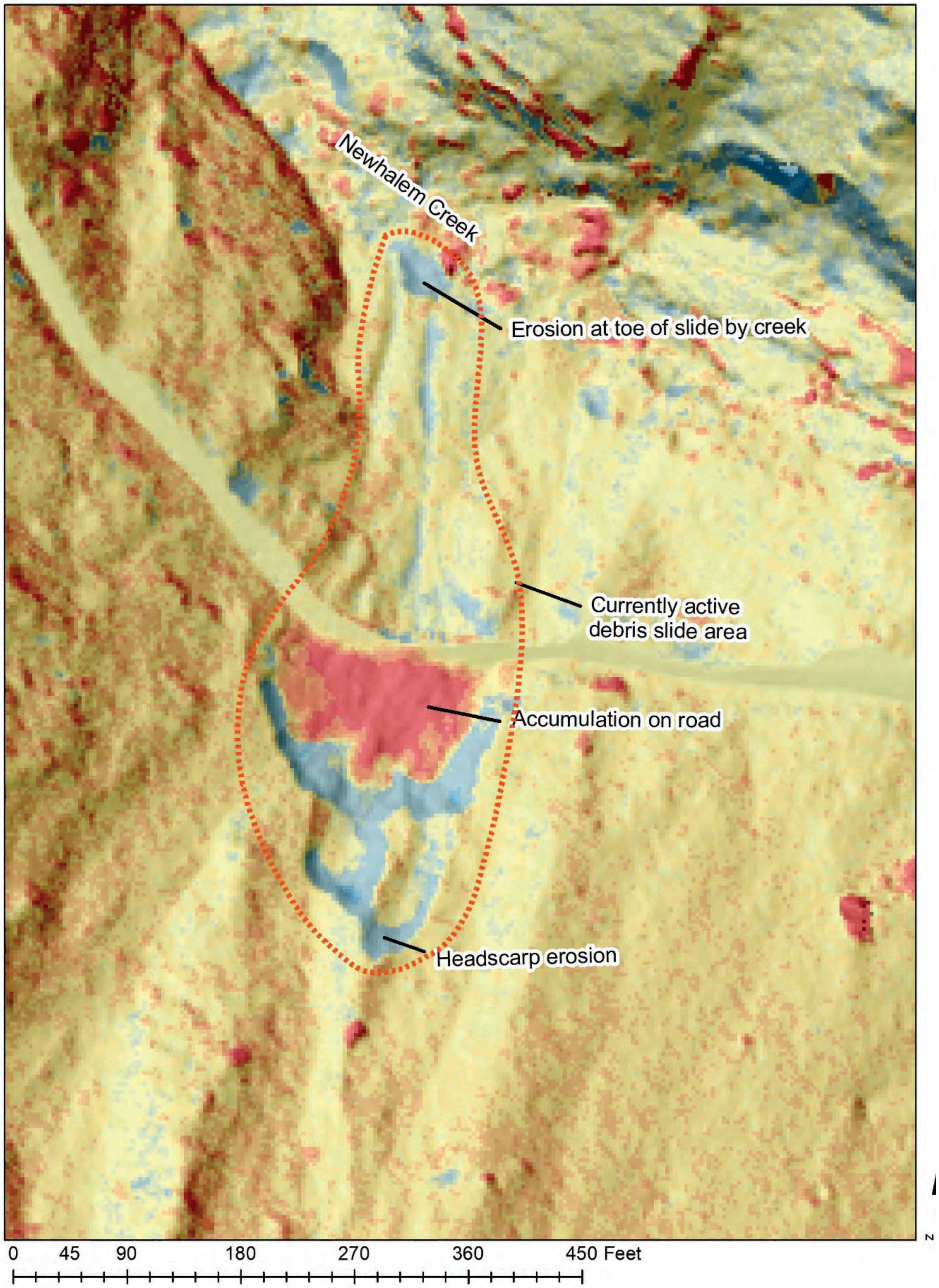


Figure 4.2-7. Difference between 2015 and 2022 LiDAR showing erosion (blue) and accumulation (red) zones within smaller, active debris slide (yellow areas had little change).

4.2.4 Potential for Changes to Alluvial Fan and Skagit River

Downstream from the diversion structure, Newhalem Creek has a confined, step-pool structure, a 100-foot waterfall, another confined step-pool section, and then a lower-gradient, less confined alluvial fan reach before entering the Skagit River (see Figure 3.1-1 above). Sediment that is transported from the area upstream of the diversion following diversion removal will enter the alluvial fan reach and some material will be deposited on the fan with the remainder transported into the Skagit River depending on the size of the sediment and flow levels. The largest material (e.g., boulders) will be deposited at the upstream end of the fan with smaller material transported farther downstream, similar to the deposition patterns of sediment that moves through Newhalem Creek under current conditions. Note that the average gradient of the alluvial fan reach is 5 percent and the average gradient of Newhalem Creek upstream of the diversion structure is 2–3 percent. Since bedload transport is directly proportional to stream gradient, the majority of smaller material (gravel and finer) will be transported into the Skagit River rather than being deposited on the alluvial fan and provide substrate suitable for use by spawning fish.

NPS has requested information on the likelihood of deposition of material on the alluvial fan re-activating old channels on the fan, or the likelihood of material being deposited at the confluence with the Skagit River and pushing the river channel toward the north.

As discussed in Section 4.1.1, the total volume of coarse-grained sediment (gravel, cobble, boulder) that is likely to be eroded from upstream of the diversion and transported to the alluvial fan/Skagit River confluence is between 4,400 and 12,900 cubic yards, the equivalent of less than one year to up to 6.5 years of the average annual coarse sediment supply from Newhalem Creek depending upon the method of estimation. It is anticipated that the additional material will not be transported in a single year but will take several years or decades to be mobilized, depending upon actual streamflow in the years following diversion removal. Based on aerial photographs and LiDAR evidence, the Newhalem Creek alluvial fan appears to have characteristics of an incised streamflow “fossil” fan surface (National Research Council 1996). The Newhalem Creek channel does not appear to have occupied many of the relic channels on the fan during at least the past hundred or more years based on the mature trees developed on these surfaces, with the exception of distributary channels at the junction with the Skagit River (Figure 3.3-1 above). As such, it is unlikely that the addition of the anticipated 1- to 6.5-times the average annual coarse sediment supply to the Newhalem Creek channel would cause enough aggradation to re-activate the older, elevated channels in the alluvial fan, particularly given the higher average stream gradient in the fan (5 percent) compared to the source reach (upstream from the diversion structure, 2-3 percent). It is anticipated that much of the gravel and cobble would move through the fan and supply sediment to the Skagit River.

As an upper bounding estimate, if the total volume of potential additional material was deposited evenly within the Newhalem Creek channel (average wetted width 50 ft) in the alluvial fan reach (2,500 ft long), it would result in deposition of approximately 1–3 ft of sediment. This is not a realistic scenario, however, since the total volume of material will not be eroded from the diversion in a single year. In addition, the alluvial fan is higher gradient than Newhalem Creek upstream from the diversion, so the majority of finer-grained material (e.g., small gravel) that is in the streambed upstream from the diversion structure would be transported through the alluvial fan reach.

To provide context to help compare total potential volume of sediment with existing channel dimensions and further assess the likelihood of deposition in the alluvial fan re-activating old channels, the potential depth of sediment deposits calculated above was compared to the height of the alluvial fan surface above the existing stream channel at several locations along the fan. Bank heights at the upper end of the alluvial fan in the location of old channel traces are 5–7 ft above the current stream channel, 10–13 ft above the current stream channel in the middle of the fan, and 4–5 ft above the current stream channel at the lower end of the fan near the Skagit River confluence. Based on the unlikely scenario that sediment deposited at the calculated maximum potential depths of less than 3 ft, it is unlikely that enough sediment would be deposited in the Newhalem Creek channel in the alluvial fan section to re-activate old channels.

The median (D_{50}) particle size on bars in the Skagit River between Gorge Dam and Bacon Creek is approximately 45 mm, and the estimated bedload sediment transport rates in the Skagit River near the Newhalem Creek confluence are 10,000 to 50,000 cubic yards/year (Seattle City Light 2023). Comparing these bedload transport rates to total potential sediment input from the Newhalem Creek diversion removal (4,400–12,900 cubic yards), the total potential sediment input from diversion removal is less than or equal to the average annual sediment transport rate in the Skagit River. It is therefore unlikely that removal of the Newhalem Creek diversion structure will result in substantial deposition within the Skagit River. It is likely that there may be small amounts of deposition, but deposited material will likely be mobilized during subsequent high flows in the Skagit River.

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NEWHALEM CREEK DECOMISSIONING GEOMORPHOLOGY CONSIDERATIONS

ATTACHMENT A

GEOMORPHIC STREAM ASSESSMENT NOTES

Newhalem Ck. Geomorphic Unit geometry, boulders, banks, and large wood data collected by Andrew Nelson and Ed Fordham on 10/14/22 upstream from Project diversion structure

Sediment size classes used in notes

fG Fine gravel (none noted): 8-22 mm
G Gravel: 22-64 mm
C Cobble: 64-180 mm
LgC Large Cobble: 180-360 mm
B Boulder: >360 mm

Geomorphic Units, Substrate, Bankfull Dimensions, Bank Height/Materials

Distance upstream from diversion (ft)	Geo morphic Unit Type	Dom-inant Bed Material	Sub dominant Bed Material	Other important bed material	Bankfull width (ft)	Bankfull depth (ft)	Tailout Depth (ft)	Pool Depth (ft)	Right Bank total height (ft)	Right Bank Lay back (ft)	Right bank material	Left Bank total height (ft)	Left Bank layback (ft)	Left Bank material
0	Riffle	LgC	C	B, G	50	3	NA	NA	NA	NA		12	6	pool dredge spoils
79	Glide	LgC	C	B, G	63	2	0.5	1	2	3	Bouldery alluvium	7	8	Angular boulder
198	Pool	LgC	B	G	48	3.5	1	2.5	5	7	Bouldery alluvium	7	8	Cobbly Alluvium
290	Cascade	LgC	C	B	95	6	NA	NA	8	14	Cobble w/ small boulders	6	20	Landslide boulder debris
490	Glide	C	LgC	B	136	3	1	2	2	18	not noted	3	5	Cobbly Alluvium
673	Pool	LgC	B	G	55	3.5	1	3	2	12	Gravel bar over cobbly alluvium	4	8	Cobbly Alluvium
840	Pocket Water	LgC	C	B	76	3.5	1	1.5	3	7	not noted	6	3	not noted, actively eroding (cobbly alluv if memory serves right)
956	Step Pool	B	C		81	3	1	2	4	4	not noted	9	7	0.5 ft silty sand over 1' sandy gravel w/ sm. Cobble over 0.5 ft coarse sand over 7' poorly graded cobble (sand-boulder sizes)
1040	Step Pool	B	C		162	3	1	2	0.5	20	boulder levee seperating side channel offtake	10	7	poorly graded cobble (sand-boulder sizes)
1136	Pool	C	LgC	B	82	5	0.5	3	no noted	not noted	Cobbly gravel with boulders	8	6	6' sandy gravel over 2' cobbly gravel with boulders
1315	Riffle	B	C		56	3.5	0.5	1	4	4	boulder cobble	3	3	boulder cobble
1390	Pocket Water	C	LgC	B, G	59	2.5	0.5	1.5	4	6	Cobble and boulder	7	3	Rounded boulder & cobble, lots of root reinfocement

Distance upstream from diversion (ft)	Geo morphic Unit Type	Dom-inant Bed Material	Sub dominant Bed Material	Other important bed material	Bankfull width (ft)	Bankfull depth (ft)	Tailout Depth (ft)	Pool Depth (ft)	Right Bank total height (ft)	Right Bank Lay back (ft)	Right bank material	Left Bank total height (ft)	Left Bank layback (ft)	Left Bank material
1500	Pocket Water	C	B		55	3.5	0.5	1.5	5	8	boulder and cobble	8	6	angular small boulder and cobble
1576	Step Pool	C	B		50	3	0.5	2	4	8	rounded boulder-cobble	6	9	angular cobble-boulder
1619	Plane bed	B	C		50	3	NA	NA	3	6	rounded boulder-cobble	6	9	angular cobble-boulder
1703	plane bed	B	C		50	2	NA	NA	4	6	rounded cobble-boulder	3	6	not visible
1905	Pocket Water	LgC	B		65	3	not noted	not noted	4	6	rounded cobble-boulder	6	8	rounded cobble-boulder
2027	Step Pool	B	LgC		60	3	not noted	not noted	6	6	not noted	8	6	not noted
2081	Pocket Water	LgC	C	B	65	2.5	not noted	not noted	4	15	not noted	8	8	not noted
2351	Step Pool	C	LgC	B	50	3	0.5	2	7	12	not noted	6	1	not noted
2432	Glide	C	LgC	B, G	70	2	not noted	not noted	5	10	not noted	3	6	not noted
2513	Pocket Water	LgC	C	B	60	3			3	5	not noted	3	5	not noted
2661	Pocket Water	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted	not noted
Maximum	**n/a**	**n/a**	**n/a**	**n/a**	**162**	**6**	**1**	**3**	**8**	**20**	**n/a**	**12**	**20**	**n/a**
Mininimum	**n/a**	**n/a**	**n/a**	**n/a**	**48**	**2**	**0.5**	**1**	**0.5**	**3**	**n/a**	**3**	**1**	**n/a**
Mean	**n/a**	**n/a**	**n/a**	**n/a**	**70**	**3**	**1**	**2**	**4**	**9**	**n/a**	**6**	**7**	**n/a**

Large Wood and Boulders

Distance upstream from diversion (ft)	Feature	Notes	Boulder b axis diameter (ft)	Boulder a axis diameter (ft)	Large Wood Diameter (dbh in)	Large Wood Length (ft)	Large Wood Rootwad?
25	Large Wood (LW)				12-18	25-49	unknown (buried)
188	USGS GAGE						
227	Boulder	4' and 8' angular boulders towards LB	4				
227	Boulder		8				
261	Boulder	4' angular boulder on RB; cluster of 2-3' rounded boulders	4				
281	Boulder	4'X8' angular boulder on slipface cascade	4	8			
320	Boulder	10 and 12' angular boulders along LB flowpath	10				
320	Boulder	10 and 12' angular boulders along LB flowpath	12				
320	Boulder	6' boulder in rb flowpath	6				
280	LW	jammed against left bank ad not really impacting channel			18-23	25-49	N
280	LW	jammed against left bank ad not really impacting channel			18-23	15-24	N
280	Boulder	on LB	15				
280	Boulders	many 3-5' angular boulders in LB flowpath	4				
280	Boulder	in middle bar	5				
355	Bank stratigraphy	LB 6" sand over cobbly alluvium with few boulders					
355	RB side channel confluence						
440	Boulders	many 3-6' angular boulders on LB					
468	LW				24-35	25-49	N
600	Boulder	on LB	10				
640	LW	on RB			36	24	N
702	LW	pool forcing, wedged in between bank trees			24	20	N
730	LW	Jam piece, lots of brush, trees project 30' into channel, pinned on floodplain trees			24	75	
730	LW	Jam piece, lots of brush, trees project 30' into channel, pinned on floodplain trees			24	75	
900	LW	along bank, little geomorphic function			24	40	N
1025	LW				30	50	Y
1035	LW				30	25	N
1083	LW				24	18	N
1083	LW				18	15	N
1130	LB side channel offtake						

Distance upstream from diversion (ft)	Feature	Notes	Boulder b axis diameter (ft)	Boulder a axis diameter (ft)	Large Wood Diameter (dbh in)	Large Wood Length (ft)	Large Wood Rootwad?
1251	Boulder	Angular boulders across channel	5				
1251	Boulder	Angular boulders across channel	5				
1251	Boulder	Angular boulders across channel	5				
1390	Boulders	ten or more 4' to 7' angular boulders scattered across unit	7				
1500	Pocket Water						
1770	LW				14	18	N
1824	Boulder	in RB	15				
1824	Boulder	in RB	15				
1824	LW	not significantly impacting hydrualics			48	50	
1824	LW	not significantly impacting hydrualics			48	25	
2067	Boulders	cluster of seven 4-5' boulders in middle of channel	5				
2240	LW				12	35	Y
2256	LW				36-48	50-75	
2256	LW				36-48	50-75	
2337	LW				12	45	Y
2351	LW				12	50	Y
2351	LW				36	45	N
2410	LW				16	30	Y
2548	LW				24	30	N
2631	Boulder	15' boulder in RB	15				
2661	LW				48	40	
2661	Notes	terrace feature comes to channel; end of survey					

Final Newhalem Geomorph Report October_2023

Final Audit Report 2023-10-24

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