**TO:** Joe Lange, P.E.
USDA Natural Resource Conservation Service
Wenatchee, WA

**FROM:** Lummi Nation Natural Resources
CC: Herrera Environmental Consultants, Inc.

**DATE:** June 6, 2018

**RE:** Public Safety Assessment of Skookum-Edfro Restoration Project South Fork Nooksack River

Whatcom County, Washington

## INTRODUCTION

This report presents the results of our revised public safety assessment (PSA) for the Skookum-Edfro Habitat Restoration Project (Project) on the South Fork Nooksack River in Whatcom County, Washington. The Lummi Nation Natural Resources Department (LNNR), with the engineering support of Herrera Environmental Consultants, Inc. (Herrera), is in the process of completing the second of two phases of this habitat restoration project within the upper South Fork Nooksack River (Figure 1). The project consists of the installing 26 engineered logjams (ELJs) and large woody material (LWM) within the river channel. This PSA is specific to recreational boaters and others user groups within the project area.

The LNNR previously submitted a PSA for this project on June 15, 2017. That PSA reflected the original project design for the middle reach (Phase 1) and upper reach (Phase 2). Phase 1 included installing one ELJ and four habitat complexity log structures during the summer of 2016. Phase 1 also included installing three more ELJs and augmenting three existing ELJs with additional LWM during the summer of 2017. Phase 2 will include installing 15 ELJs during the summer of 2018. Some of the Phase 1 (middle reach) ELJs included in the 2017 PSA were not constructed, and the location and quantity of the Phase 2 (upper reach) ELJs included in the 2017 PSA have changed. Therefore, this document presents the results of an updated PSA completed to reflect the actual Phase 1 ELJs installed in 2016 and 2017 in the middle reach and the Phase 2 ELJs that will be installed in 2018 in the upper reach. The safety ratings for the Phase 1 ELJs reported in the 2017 PSA that were installed have not changed and are included in this updated assessment. The Phase 1 ELJs reported in the 2017 PSA that were not installed have been omitted from this revised assessment. The assessment for the Phase 2 ELJs included in the 2017 PSA has been revised to reflect the current design that will be constructed in the summer of 2018.

The Project was made possible through grants from the Natural Resources Conservation Service (NRCS), Washington State Salmon Recovery Funding Board (SRFB), and the US

Environmental Protection Agency (EPA) through a grant provided to the Northwest Indian Fisheries Commission (NWIFC). All of the installed structures evaluated in this PSA lie within the ordinary high water mark (OHWM) of the South Fork Nooksack River channel (see Figures 1, 4 and 5).

The Project is being constructed in an area of the watershed that is important not only for its salmonid habitat, but also because it is located in an area that is currently closed to the public for recreational use. Per Whatcom County regulation 11.20.025, "No person shall operate a paddleboard, innertube, inflatable floatation device, foam floatation device, limb-propelled floatation device, or rubber raft intended for limb use on the section of the South Fork of the Nooksack River between Edfro Creek and the Acme Bridge between the dates of June 1st and October 31st". In addition, the South Fork Nooksack is a popular destination for trout, salmon and steelhead fishermen (fishers) below the confluence of Skookum Creek and the South Fork Nooksack River. This area is also closed to fishers, but poaching activities are still common.

## METHODS

A PSA was completed by GeoEngineers for a 2010 engineered logjam project in the Skookum Reach (~RM 14.0) and an upstream project in the Fobes Reach (~RM 18.0) in 2011. The risk assessment approach and associated matrix for the current project is modeled after the GeoEngineers (2011) PSA. Each structure in the Skookum-Edfro project was assessed for recreational use(s) and streamflows associated with the highest use period for each recreational use. Public safety during recreational use periods was assessed using hydraulic analyses, and the interaction of geomorphic attributes, structural characteristics, and other features associated with the project reach and site.

Lummi Natural Resources staff identified recreational user points of ingress (put-in) and egress (take-out), field-verified risk analyses based on hydraulic model information, and assessed the proximity of structures to geomorphic or habitat features important to recreational users. Analyses and information prepared during this task was assembled into a summary matrix table for each site. Results of project site assessments, the summary matrix, and site visit photographs (Appendix A1 through A3) of the built structures are incorporated into this letter report.

### *PROJECT ASSESSMENT*

Public safety attributes of ELJ and LWM placements were divided into two categories: (1) reach, and (2) structure specific assessments. Reach categories include: (a) definition of the recreational use, (b) access, and (c) reach-scale geomorphic factors. Structure specific categories include: (a) structure location, (b) structure type and characteristics, and (c) avoidance potential of each specific structure.

#### Definition of Recreational Use

There are several important considerations when assessing public safety impacts to recreational users associated with river restoration projects. After identifying the various recreational uses, additional information should be collected on the following by recreational user type: 1) the primary use period; 2) the frequency of use; and 3) the general skill level of the primary user group (GeoEngineers 2011). While recreational use in some form is possible on most rivers in Western Washington, this does not imply that all rivers experience a high frequency of use. The flow range occurring during the majority of the use period is also important and is defined in this assessment as the recreational flow range. When considering recreational use categories described in this document, there are often outliers or extremes to many of the categories described. For the purpose of this assessment, we focused our assessment on the majority or typical value for the specific category and omitted outliers or extremes. GeoEngineers (2011) categorized recreational use as:

Whitewater:

High: Greater than 50 trips per year,

Moderate: Between 10 and 50 trips per year,

Low: Less than 10 trips per year.

Fishing:

High: Greater than 20 trips per year,

Moderate: Between 10 and 20 trips per year,

Low: Less than 10 trips per year.

The skill level of the recreational users is an important consideration within this PSA. Large woody material within Western Washington rivers is very common in the river environment and avid recreational users are generally accustomed to dealing with hazards associated with LWM (GeoEngineers 2011). Expert and advanced whitewater paddlers and fishers will generally not be challenged navigating safely around LWM or ELJs due to their experience with naturally occurring LWM. However, safely avoiding ELJs or LWM may be more difficult for beginner to intermediate whitewater paddlers or others. Thus, skill level and frequency of use are important factors because wood structures placed in reaches frequented by beginner to intermediate skilled users will pose a greater risk to those users than structures placed in reaches frequented by expert users.

Access

The ability of recreational users to access a given reach can significantly influence many of the recreational factors discussed above (GeoEngineers 2011). Reaches with poor access will generally have a low frequency of use and thus are well suited as locations for the placement of ELJs and LWM to maximize habitat enhancement. Access to the Upper Reach of the South Fork Nooksack (above river mile 15.4) is poor because of private land ownership combined with a lack of useable roads. In contrast, access to portions of the middle reach (below RM 14.1) is good due to the presence of parking areas, which provide easier access to the shoreline, and thus the middle reach experiences a moderate frequency of recreational trips on a given year. The portion of the middle reach directly surrounding the hatchery facility (where the majority of the project structures are proposed) is closed for access and fenced.

Resources to determine the recreation type, period, flows, skill level, and access points are shown below. For this project, the frequency of use was determined through our first hand knowledge of recreational opportunities within the upper South Fork Nooksack and specifically to the Skookum-Edfro area. Additional information can be assessed through communication and outreach to local user groups and commercial guiding services, such as the following:

http://www.americanwhitewater.org/content/River/state-summary/state/WA/

http://www.professorpaddle.com/rivers/riverlist.asp/

http://www.washingtonkayakclub.org/

http://www.gonorthwest.com/Washington/Activities/rafting/nooksack.htmhttp://www.fishwhatcom.com/lakesrivers/Nooksackriver.html

http://4thcornerfly.com/

http://www.emeraldwateranglers.com/nooksack.html

http://www.cascadesfly.com/

### Reach-Scale Geomorphic Factors

Reach-scale factors commonly used by hydrologic, hydraulic and engineering service providers engaged in habitat restoration projects can also support assessing recreation-based public safety (GeoEngineers 2011). Staff from LNNR and Herrera delineated the project into two reaches; the upper reach and middle reach (Figures 4 and 5). Structures shown in the lower reach downstream were not included in the final design. Fluvial geomorphic attributes such as valley type, channel type, channel gradient, channel stability and LWM loading are factors to consider for recreational safety and structure placement. Information was obtained by LNNR about these geomorphic and hydraulic features through field observations, review of available studies, LiDAR information and through knowledge of upper South Fork Nooksack watershed conditions.

*Valley type*

The valley type within a river reach helps determine the user's exit potential. The valley type within a reach can help identify whether exit from the river channel is likely or potentially difficult. For instance, LWM or ELJ placements in a confined bedrock canyon would pose a greater risk to recreational users than placements in a broad alluvial valley where a user would likely be able to get out and walk around a placement location if needed.

*Channel type*

The channel type within a reach can help identify to what degree a recreational user might be challenged to navigate safely through a given reach. Engineered logjams and LWM placements in a reach with pool-riffle or plane bed morphology should be considered lower risk as these channel types are easier for recreational users to navigate or otherwise adjust to, in order to avoid LWM or ELJ placements.

*Channel gradient*

The average channel gradient within a reach can both help identify the inherent difficulty for a recreational use, and estimate the relative speed a recreational user will approach a LWM or ELJ placement. A steep gradient reach should be considered higher risk than low gradient reach for similar reasons as for channel type described above. A steep gradient reach will generally have a high approach velocity, reducing the reaction time of a recreational user to LWM or ELJ placements. Thus, high gradient should be considered to be higher risk than lower gradient reaches.

*Flows*

The channel stability of a given reach is a critical geomorphic reach characteristic when evaluating the safety of LWM and ELJ placements. Many structures placed in the river environment are located such that they do not pose a significant safety hazard following construction. However, if the river channel migrates or otherwise dramatically changes position, a significant safety hazard could result due to changes in the channel location, flow direction, and potential accumulation of LWM on the ELJ or other structure. The likelihood of this occurring in a dynamic and active reach is higher than in a less dynamic, slow-reactive system. Thus, ELJs or LWM placements in a dynamic geomorphic reach should be considered higher risk than those located in a slow-reactive system.

*Large wood frequency*

Large wood (LW) frequency is a key factor when assessing a reach's geomorphic character. For this project, we considered key pieces and logjams per Fox and Bolton (2007) determining protocol. Installing LW or ELJ placements as part of habitat improvement projects should not be expected to increase the risk to recreational users above natural background rates if the placements can emulate natural LW configurations. Large wood counts and associated frequency for this project conformed to findings from the original Skookum Reach project of 2010, located within the project area.

## STRUCTURE-SPECIFIC ASSESSMENTS

### Structure Location

The installation location within the river channel of ELJs is critical to public safety. The primary consideration related to the location of structures is the amount of engagement of the structure with the wetted channel during the expected recreational flow range, and whether the structure is located along the outside of a channel bend. For this project, structure location of each ELJ was assessed through observations made during the field reconnaissance, hydraulic modeling and a geomorphic feasibility.

The more a structure is engaged in the wetted channel, the more likely it is that the structure poses a risk to the safety of recreational users (GeoEngineers 2011). Structures that are not engaged in the wetted channel during the expected recreation flow range have a much lower risk to the safety of recreational users. The structures in the project area will be fully engaged within the OHWM, but are generally away from the thalweg.

Recreational users navigating through a channel bend will have a harder time avoiding structures placed along the outside of sharp channel bend than structures placed along the inside of a broad channel meander. Thus, structures placed along the outside of a channel bend should be considered higher risk to recreational user safety than structures place in a linear reach or on the inside of a channel bend.

### Structure Characteristics

GeoEngineers (2011) found the characteristics of different LWM and ELJ structure types have varying degrees of risk to recreational users. Structure characteristics that are important to public safety include "strainer" potential and the structure type. For this project, structure characteristics were determined through observations made during review of the design plans and field visits to structures already completed. Structure types were categorized using the ELJ classification developed by Abbe (2003) and Herrera (2006).

The most concerning structure characteristics to recreational users are structures that create a "strainer" condition that could trap a person or boat (GeoEngineers 2011). This strainer condition occurs when a piece or pieces of LWM within a structure allow water to pass under, over, or through the piece or pieces. The force of the moving water through the strainer can trap or pin a person or their recreational craft against the LWM and create a dangerous (potential drowning) scenario. The most common strainer condition is a single piece of LWM that extends out perpendicular to the channel bank and direction of flow, at or below the water surface (Appendix A-1). Large woody material placed in a rootwad bank protection method can commonly form a strainer condition if scour and channel migration is not considered during the design and placement process. A strainer condition is not as common for ELJs but can occur if: 1) the structure is not backfilled with material to prevent flow through the structure; 2) individual log pieces extend out beyond the general limits of the structure; or 3) the structure shifts and unravels over time. While a strainer can create a dangerous condition for recreational users, strainers also can increase channel complexity, cover and habitat variability, all of which are beneficial for salmonid habitat.

Abbe et al. (2003) classified instream woody debris accumulations observed on the Queets River in three distinctive types: (1) grade control, (2) revetment and (3) flow deflection. A summary of the different types, brief descriptions, and relative recreational risk are provided below in Table 1. For the purpose of this assessment, a risk rating system developed by GeoEngineers (2011), which uses a subjective relative risk rating for each structure type, based upon the intended function of the structure and our experience with constructed ELJs was used. In this assessment, the only structure qualifying for a low rating was a step-type structure, due to the design standard for the structure requiring a high level of embeddedness of the structure in the channel bed, and the low-risk flow profile over the structure. Valley type structures qualified for high risk rating due to their size, a typically chaotic assemblage of woody material with each structure, and the presence of flow through the structure. Bar apex structures may be assigned low to moderate rating. Variability in rating is influenced by location in the channel, sight distance (typically good), and the moderate angle of flow deflection they typically create. All other structure types were given a moderate to high rating. Ratings were influenced by location along the outside of a channel bend (higher risk), sight distance (often poor), and tendency to create a sweeper/strainer condition (higher risk). No high risk structure types are to be installed in the Skookum-Edfro project.

TABLE 1. COMMON ELJ STRUCTURE TYPES (GeoEngineers 2011)

| **Type** | **Description** | **Relative recreational risk** |
|---|---|---|
| ***Grade Control*** | | |
| **Step** | Single log structure spanning channel width and forming a scour/plunge pool immediately downstream.<br><br>Flow typically flows over the structure. | Low to moderate |
| **Valley** | Multiple log structure with a width greater than the bankfull width and accompanying a significant portion of the valley width. Flow typically proceeds through and over the structure. | High |
| ***Revetment*** | | |

| | | |
|---|---|---|
| **Bankfull bench** | Multiple log structure located along the outside of a channel bend, a width less than the bankfull width, and creating a bench surface. Flow typically flows along the structure. | Moderate |
| **Flow deflection** | Multiple log structure located along the outside of channel bend, a width less than the bankfull width that accumulates wood over time. Flow typically approaches normal to the structure and is then deflected away at a moderate to severe angle via parallel log members. | Moderate to high |
| ***Deflector*** | | |
| **Bar apex** | Multiple log structure located at the head of mid channel bar, a width less than the bankfull width, forming a stable depositional zone downstream. Flow typically approaches normal to the structure and is then deflected away at a small to moderate angle. | Low to moderate |
| **Meander** | Multiple log structure located along the outside of channel bend, a width less than the bankfull width, and creating a bench surface. Flow typically flows along the structure. | Moderate to high |

**Avoidance Potential**

If recreational users can safely avoid LWM or ELJ structures through either portaging around the structure or paddling well away from the structure, the relative risk of that structure is lower than if portaging or paddling away from the structure is difficult (GeoEngineers 2011). GeoEngineers (2011) found that the key factors when considering avoidance potential are sight distance, egress potential, approach velocity, and the combined values of depth and velocity at the approach to the structure (depth and velocity product). Restoration staff from LNNR also considers channel width an important factor in avoidance potential. All of these factors were determined for this project through a review of the design plans, hydraulic modeling results, geomorphic feasibility and discussions with the engineer of record.

The egress (exit) potential of a structure can be defined as the ability of a recreational user to exit the channel upstream of the structure in order to walk around (portage) the structure (GeoEngineers 2011). An egress point is a specific location a recreational user could exit the channel upstream of the logjam or large wood. Steep bedrock canyons or an incised channel with steep banks generally have poor egress/ingress potential. Structures with poor egress potential were assigned higher risk values than structures with good egress potential.

The sight distance of a structure can be defined as the maximum distance a recreational user will be able to see the structure when approaching along the thalweg of the channel (GeoEngineers 2011). The lower the sight distance, the less time a recreational user will have to develop a plan for how to avoid the structure and react appropriately. Thus, structures with more sight distance are safer than structures with less sight distance. Long sight distances were assigned low-risk ratings while short sight distances were assigned higher ratings.

Channel width and associated confinement play critical roles in structure avoidance. Narrow channels can prohibit avoiding a structure installed in the wetted channel, particularly around a meander bend. Narrow single thread, confined channels are more hazardous than wider multi-thread channels if a recreational user cannot avoid a structure.

## RESULTS

Each structure was evaluated for its recreational safety using professional engineering judgment and the relative risk assessment model (Figure 2) developed by GeoEngineers (2011). The safety assessment also considered the recreational, access and geomorphic factors included in Table 2. Tables 3A and 3B below summarize the results of the safety assessment for each structure in Phase 1 and Phase 2 respectively, including structure location, structure characteristics and structure avoidance potential. Phase 1 structures in the middle reach are shown in Figure 4, and Phase 2 structures in the upper reach are shown in Figure 5.

Most of the Phase 1 and Phase 2 structures scored a moderate to high safety rating. This favorable safety rating reflects that most of the structures are primarily located along the channel edges with sight distances greater than 300 feet, have fair to good egress potential, have low to moderate strainer potential, and have adequate space in the channel to avoid them.

In the Phase 1 area (middle reach), the only structures that scored a low-moderate safety rating were the four habitat log structures located in a side channel. These structures span a large percentage of the side channel, which increases the difficulty in avoiding them. They do not receive a low safety rating because the side channel is less frequently travelled than the main channel and has a much lower discharge than the main channel. ELJs 17, 18, 19 and 20 received a moderate safety rating because of their moderate to moderate-high strainer potential, fair egress potential and relatively narrow channel width compared to the channel width upstream near ELJs 14, 15 and 16.

In the Phase 2 area (upper reach) ELJ 8 scored a moderate safety rating because of its low egress potential (steep vegetated and bedrock lined banks) but good avoidance potential as this ELJ is located on the inside of the channel bend with plenty of space in the channel to avoid it. ELJ 5 received a moderate safety rating because it spans approximately 50% of the channel and has a moderate-high strainer potential, but sight distance of nearly 600 feet and good egress potential. ELJ 15 also received a moderate safety rating because of its large size and location in the middle of the channel and thus a moderate strainer potential; however, it has fair egress potential, a long site distance of approximately 1,100 feet and adequate space in the channel to avoid it. The remaining Phase 2/upper reach ELJs received high to moderate-high safety ratings because of their low to low-moderate strainer potential, good egress potential, site distances between 300 and 1,000 feet, and a wide enough channel to avoid them.

## PROJECT RECOMMENDATIONS

Recommendations regarding public education, signage, and notification regarding structures in the Skookum-Edfro project are as follows:

- Through collaboration with DNR, LNNR will post highly visible warning signs on each structure except for the habitat log structures. WRIA1 co-managers have developed a uniform sign standard for projects within the watershed.
- Lummi Nation Natural Resources completed a DNR Public Safety Checklist for Large Woody Material Projects on May 23, 2016. On February 23rd the Lummi Nation Project Manager and Herrera Engineer met with DNR aquatic use permit specialists at the site to review the project components. No concerns were identified.
- Signage and/or warnings indicating ELJ structures are located in the area will be placed near public parking zones at the hatchery, in the vicinity of the Saxon Road Bridge (take-out), near each structure, and on internet web pages of recreational user groups.
- Lummi Nation Natural Resources will review land ownership and access agreements through WDNR and other stakeholders. Staff from LNNR will make adjustments if more public land use in the Skookum-Edfro project area becomes usable for recreation in the future.

TABLE 2. SAFETY CONSIDERATIONS (GeoEngineers 2011)

| | SAFETY FACTOR | DESCRIPTION |
|---|---|---|
| RECREATIONAL FACTORS | TYPE | WHITEWATER: KAYAK, RAFT, CANOE<br><br>FISHING |
| | PERIOD | WHITEWATER: APRIL THROUGH JUNE<br><br>FISHING: OCTOBER THROUGH FEBRUARY |
| | FREQUENCY | WHITEWATER: MODERATE (10-50 TRIPS PER YEAR)<br><br>FISHING: HIGH |
| | FLOW RANGE | WHITEWATER: 2,500- to 700-cfs<br><br>FISHING: 1,000- to 300-cfs |
| | SKILL LEVEL | WHITEWATER: Class II-III (BEGINNER TO MODERATE)<br><br>FISHING: MODERATE TO HIGH |
| ACCESS | ABILITY | GOOD |
| | LOCATIONS | PUT-IN: LARSON'S BRIDGE (RM 20.6)<br><br>TAKE-OUT: SAXON ROAD BRIDGE (RM12.8) |
| GEOMORPHIC FACTORS | VALLEY TYPE | BROAD, GLACIAL ORIGIN, WITH STEEP VALLEY WALLS |
| | CHANNEL TYPE | PRIMARILY RIFFLE WITH OCCASIONAL POOLS, MODERATELY CONFINED |
| | CHANNEL GRADIENT | MILD, 0.003 FT/FT (15 FT/MILE) |
| | CHANNEL STABILITY | STABLE, LITTLE CHANGE IN AERIAL RECORD |
| | NATURAL LWM FREQUENCY | LOGJAMS: 5.0/MILE<br>KEY PIECES: 22.5/MILE |

TABLE 3A. PHASE 1 (MIDDLE REACH) SAFETY ASSESSMENT SUMMARY

| | **LOCATION** | **STRUCTURE CHARACTERISTICS** | | **AVOIDANCE POTENTIAL** | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure ID per Figure 4** | Located along outside of bend? | Structure type | Strainer potential | Egress potential | Upstream sight distance (ft) | Structure distance to thalweg (ft) | Channel width (ft) | SAFETY RATING |
| **ELJ 14** | YES | FLOW DEFLECTION | LOW | HIGH | 1050 | 50 | 125 | HIGH |
| **ELJ 15** | NO | FLOW DEFLECTION | MODERATE-HIGH | FAIR | 850 | 35 | 180 | HIGH |
| **ELJ 16** | NO | FLOW DEFLECTION | LOW | FAIR | 615 | 20 | 175 | HIGH |
| **ELJ 17** | YES | FLOW DEFLECTION | MODERATE | GOOD | 1000 | <10 | 70 | MODERATE |
| **ELJ 18** | YES | MEANDER | MODERATE | GOOD | 1500 | <10 | 90 | MODERATE |
| **ELJ 19** | NO | FLOW DEFLECTION | MODERATE-HIGH | FAIR | 1100 | 40 | 110 | MODERATE |
| **ELJ 20** | NO | FLOW DEFLECTION | MODERATE-HIGH | FAIR | 1050 | 40 | 60 | MODERATE |
| **Habitat 1** | NO | HABITAT LOGS | MODERATE-HIGH | FAIR | 1310 | <10 | 50 | LOW-MODERATE |
| **Habitat 2** | NO | HABITAT LOGS | MODERATE-HIGH | FAIR | 1380 | 15 | 80 | LOW-MODERATE |
| **Habitat 3** | NO | HABITAT LOGS | MODERATE-HIGH | FAIR | 1580 | <10 | 85 | LOW-MODERATE |
| **Habitat 4** | NO | HABITAT LOGS | MODERATE-HIGH | FAIR | 1710 | <10 | 90 | LOW-MODERATE |

TABLE 3B. PHASE 2 (UPPER REACH) SAFETY ASSESSMENT SUMMARY

| | **LOCATION** | **STRUCTURE CHARACTERISTICS** | | **AVOIDANCE POTENTIAL** | | | | |
|---|---|---|---|---|---|---|---|---|
| **Structure ID per Figure 5** | Located along outside of bend? | Structure type | Strainer potential | Egress potential | Upstream sight distance (ft) | Structure distance to thalweg (ft) | Channel width (ft) | SAFETY RATING |
| **ELJ 1** | NO | FLOW DEFLECTION | MODERATE-HIGH | LOW | 410 | 40 | 140 | MODERATE |
| **ELJ 2** | NO | FLOW DEFLECTION | LOW | GOOD | 420 | 60 | 170 | MODERATE-HIGH |
| **ELJ 3** | YES | FLOW DEFLECTION | LOW-MODERATE | GOOD | 800 | 20 | 85 | MODERATE-HIGH |
| **ELJ 4** | YES | FLOW DEFLECTION | LOW-MODERATE | GOOD | 610 | 25 | 110 | MODERATE-HIGH |
| **ELJ 5** | NO | FLOW DEFLECTION | MODERATE-HIGH | GOOD | 580 | <10 | 105 | MODERATE |
| **ELJ 6** | YES | FLOW DEFLECTION | LOW-MODERATE | GOOD | 675 | 30 | 115 | MODERATE-HIGH |
| **ELJ 7** | YES | FLOW DEFLECTION | LOW-MODERATE | GOOD | 365 | 30 | 150 | MODERATE-HIGH |
| **ELJ 8** | NO | FLOW DEFLECTION | MODERATE | GOOD | 560 | 15 | 180 | MODERATE-HIGH |
| **ELJ 9** | NO | FLOW DEFLECTION | LOW-MODERATE | GOOD | 590 | 30 | 115 | MODERATE-HIGH |
| **ELJ 10** | NO | FLOW DEFLECTION | LOW | GOOD | 325 | 90 | 165 | HIGH |
| **ELJ 11** | NO | FLOW DEFLECTION | LOW-MODERATE | GOOD | 400 | 20 | 115 | MODERATE-HIGH |
| **ELJ 12** | NO | FLOW DEFLECTION | LOW-MODERATE | GOOD | 325 | 45 | 125 | MODERATE-HIGH |
| **ELJ 13** | NO | FLOW DEFLECTION | LOW-MODERATE | GOOD | 1040 | 20 | 150 | MODERATE-HIGH |
| **ELJ 14** | NO | FLOW DEFLECTION | LOW-MODERATE | GOOD | 1260 | 30 | 165 | MODERATE-HIGH |
| **ELJ 15** | NO | FLOW DEFLECTION | MODERATE | FAIR | 1100 | 20 | 195 | MODERATE |

## REFERENCES

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IAN B. MOSTRENKO
STATE OF WASHINGTON
36069
REGISTERED
PROFESSIONAL ENGINEER

## ENGINEER CERTIFICATION

I certify that I have read and do hereby approve this report.

Ian Mostrenko, P.E., Herrera Environmental Consultants

6/6/18
Date

# APPENDIX A

Appendix A1
Log spanning active channel in Habitat Log 4 at RM 14.1

Appendix A2
Woody gnarl ELJ 14 at upstream end of middle reach at RM 14.3.

Appendix A3
Habitat structure logs in middle reach of the project at RM 14.1

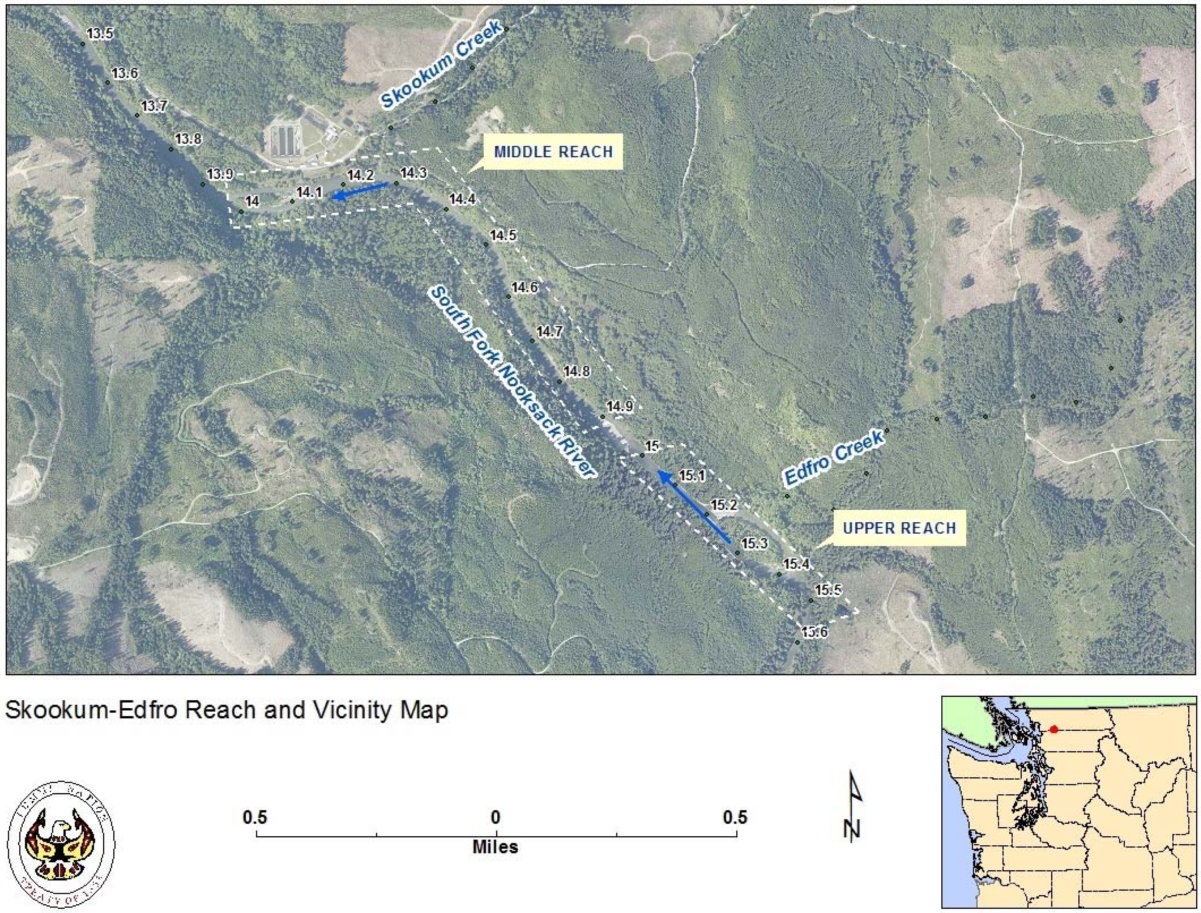



Figure 1. Site and vicinity map of the project area.

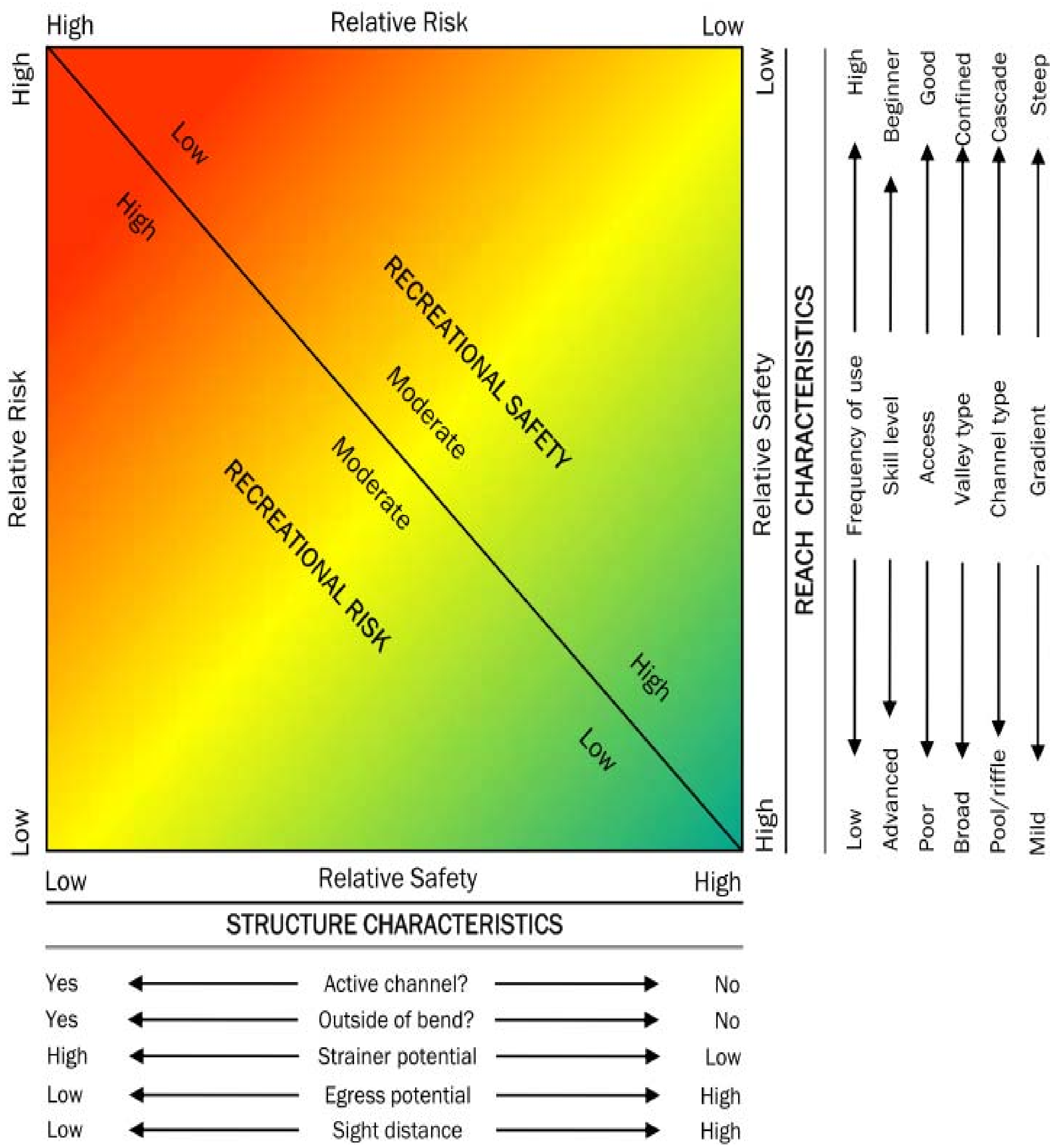



Figure 2. Relative risk assessment model. Modified from GeoEngineers (2011)

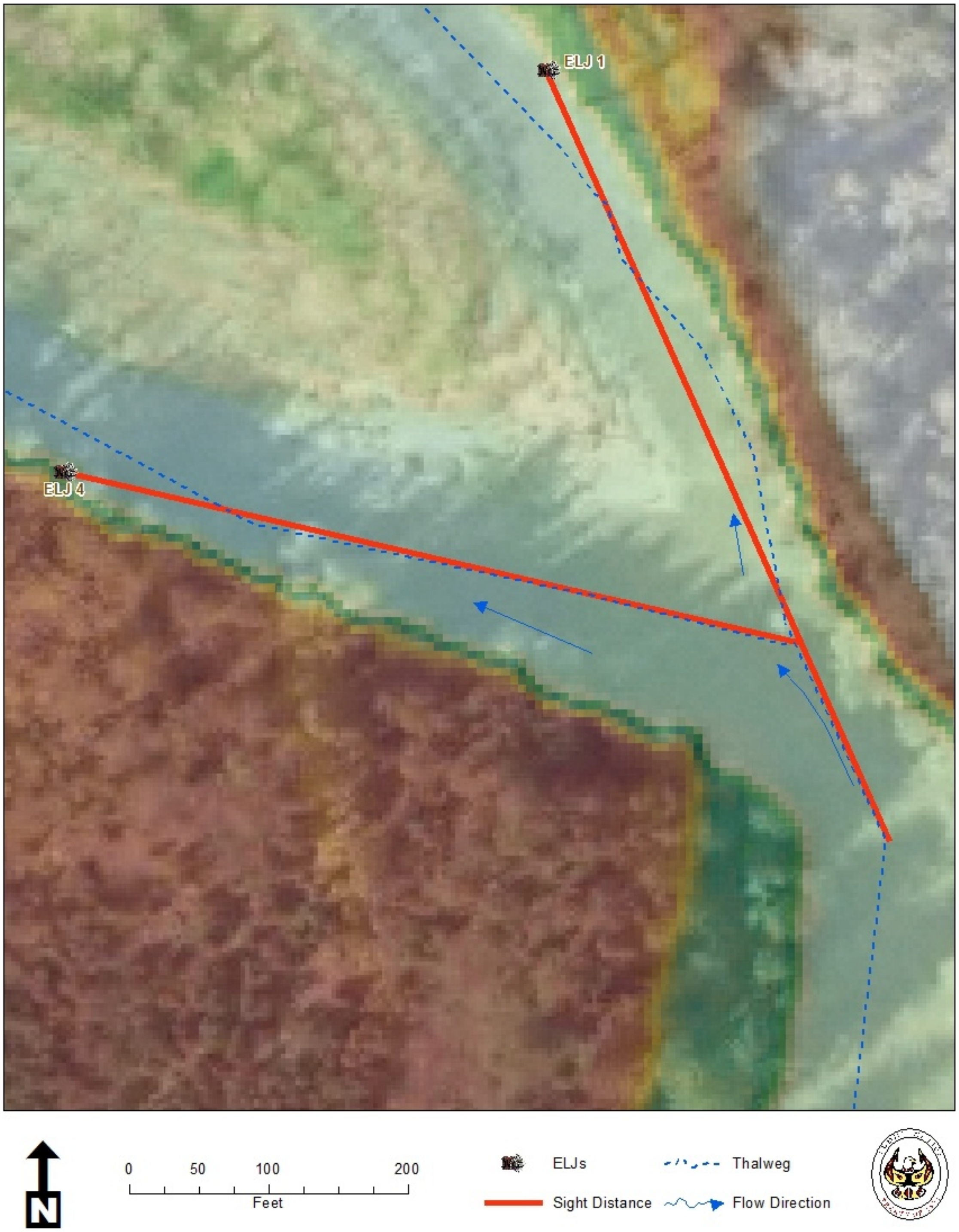
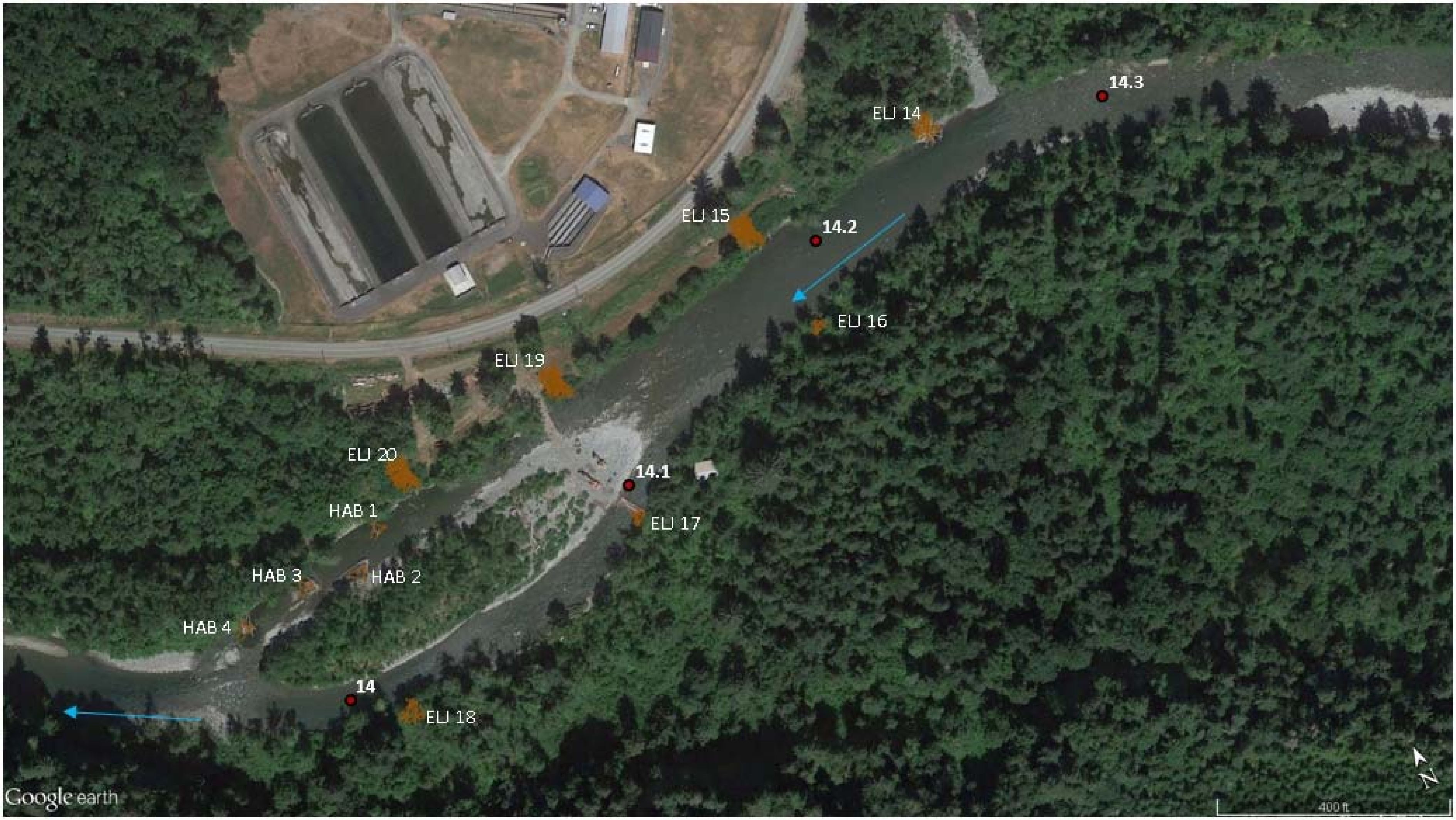



Figure 3. Sight distance example of two structures in the upper reach.




**Legend:** ELJ — Flow Direction

Habitat Logs — River Mile

**Middle Reach**
**Skookum-Edfro**
**Habitat Restoration Project**

Figure 4. Site map of the Phase 1 ELJs in the middle reach (completed) .


Figure 5. Site map of the Phase 2 ELJs in the upper reach.