BC Hydro

Puntledge River Project Water Use Plan

Gravel Replacement in the Puntledge River

Reference: PUNWORKS-1

Gravel Placement Project Definition Report

Study Period: 2013

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March 31, 2013

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Project No.300117

January 16, 2013

Esther Guimond
473 Leighton Avenue
Courtenay, BC
V9N 2Z5

Attention: **Esther Guimond, RPBio**
Fisheries Biologist

Dear Ms. Guimond:

Subject: **Puntledge River Spawning Habitat Modelling and Design – DRAFT Rev 2**

1 INTRODUCTION

Northwest Hydraulic Consultants Ltd. (NHC) is pleased to submit this modelling and design report for a proposed gravel pad to provide summer-run Chinook spawning habitat in the Puntledge River headpond, near Courtenay BC (Drawing 300117-001). The Puntledge River headpond, located between the Comox Lake impoundment dam and the diversion dam 3.7 km downstream, was historically the most important spawning area for summer-run Chinook salmon and steelhead. Following expansion of the hydro facilities in the 1950s, this habitat was altered through a combination of flooding, reduced velocities, and altered hydrology (Guimond, 2006). Artificial gravel recruitment can be an effective means to compensate past habitat losses (e.g. Burt, 2004).

The purpose of this report is to provide a summary of the site specific design for constructing spawning habitat for Chinook in the Puntledge River headpond. Project development tools included: site investigations; hydrotechnical analyses; interviews with Fisheries and Oceans Canada (DFO) staff; and review of data and experience from past similar projects. Numerical modelling was used to estimate the suitability of the habitats over the range of expected flows in the upper river, to estimate the tractive forces and stability of placed materials, and to develop final grading design elements. This design considers the recommendations and results of the previous NHC (2004) and Guimond (2006) reports.

The proposed gravel platform has a surface area of 2,000 m^2. The required spawning gravel volume is approximately 1,700 m^3 (3,100 tonnes). The gravel platform location is an upstream extension of the 2005 gravel placement project (Photo 1). The design surface elevation is 130 m; it was selected based on existing channel bathymetry and requirements for Chinook egg burial. Drawing 300117-001 provides a key map, location map, plan view, section, profile, and construction notes for the project.

Photo 1. The location of the proposed gravel pad is immediately upstream of the 2005 project.

A description of the hydraulic model and modelling techniques is provided in Section 2, and the fish habitat analysis and design is presented in Section 3. Section 4 provides a discussion of the construction, and Section 5 provides a summary and recommendations.

1.1 BACKGROUND

The Puntledge River system is one of the few rivers on the east coast of Vancouver Island to support both a summer- and fall-run Chinook salmon stock. Critical Chinook habitat was inundated by construction of the control and storage works associated with the expansion and rebuilding of BC Electric's (now BC Hydro) Puntledge Generating Station. The system consists of two dams. The Comox Lake Dam, constructed at the lake outlet, provides annual storage for maximization of energy from the system. The diversion dam supplies flow to the penstock. The critical spawning habitat for the summer-run Chinook extended downstream of the Comox Lake Dam to at least the Supply Creek confluence at the project site. The construction of the diversion dam altered these habitats through a combination of flooding and reduced velocities, loss of access, and altered hydrology.

In 2004, NHC conducted a study that used the hydrodynamic modelling computer program "River2D" to estimate the suitability of summer Chinook spawning habitats over a range of expected flows, and to provide a basis and rationale for the design and configuration of restored spawning habitat. The assessment measures included hydraulic parameters (depth and velocity) as well as measures of weighted habitat that was modelled using suitability relationships based on depth, depth-averaged velocity and substrate. The NHC (2004) report identified two locations within the headpond, referred to as the 'upper' and 'lower' sites, where gravel placement could provide suitable spawning habitat.

In 2005, a 4,750 m^2 gravel pad at an approximate elevation of 129.5 m was placed at the lower end of the 'lower site' identified in NHC (2004). Construction techniques and monitoring were summarized by Guimond (2006 & 2007). The site provided spawning habitat for up to 475 pairs, based on area-spawning relationships.

For this project, an area of 2,000 m^2 of Chinook spawning habitat every 5 years was provided as a restoration target by the Comptroller of Water Rights (BC Hydro, 2004). The design and configuration to meet this target was developed based on:

- Previous results at the site (NHC, 2004; Guimond, 2006; and Guimond, 2007);
- Numerical modelling analysis conducted for this project;
- Experience with similar projects on other rivers in the region;
- Biological input from DFO and the project biologist (Guimond, pers. comm.);
- Available project budgets; and,
- Construction logistics.

2 HYDRAULIC MODELLING

Two-dimensional (2D) numerical modelling is a tool for assessing hydraulic conditions for a specific state and river flow by providing an estimated representation of site hydraulics. River2D is a 2D depth-averaged finite element model that was developed at the University of Alberta with support from the Natural Sciences and Engineering Research Council of Canada (NSERC), DFO, Alberta Environmental Protection (AEP), and the United States Geological Survey (USGS). River2D estimates water surface elevations and horizontal depth-averaged velocities at specified locations in the river. This type of model is applicable where a representative geometric surface approximation is available and when the vertical component of flow is not significant.

River2D has an additional feature that has been customized by NHC for fish habitat evaluation or suitability, incorporating variables of depth, velocity and substrate/cover. The fish habitat module is based on the PHABSIM (Physical HABitat SIMulation), or weighted usable area (WUA) approach, which has been adapted to the triangular network required for the finite element model.

2.1 MODEL DEVELOPMENT

To predict flow conditions and consequently estimate WUA using the River2D model, four major steps were conducted. First, the channel characteristics (bed topography) were defined for the post-construction gravel pad bed. Second, computational meshes were generated for the post-construction channel configuration. The model was then used to predict steady-state flow conditions along the river channel for the design flow events under post-construction conditions. Finally, various habitat values, including weighted useable area, were calculated based on hydraulic conditions, and the assumed habitat suitability indices.

2.2 CHANNEL GEOMETRY

Riverbed bathymetry was developed from surveyed information provided by DFO (2005) following the 2005 gravel placement. The channel geometry is along 550 m of the river reach located approximately 0.8 km upstream of the Puntledge Diversion Dam. Similar to the 2004 Puntledge River modelling (NHC, 2004), the channel geometry was extended 80 m upstream from the end of the survey to improve model quality and stability. The proposed 2,000 m^2 gravel pad, at surface elevation 130 m, was included in the riverbed bathymetry. The modelled channel bed is shown in Figure 1.

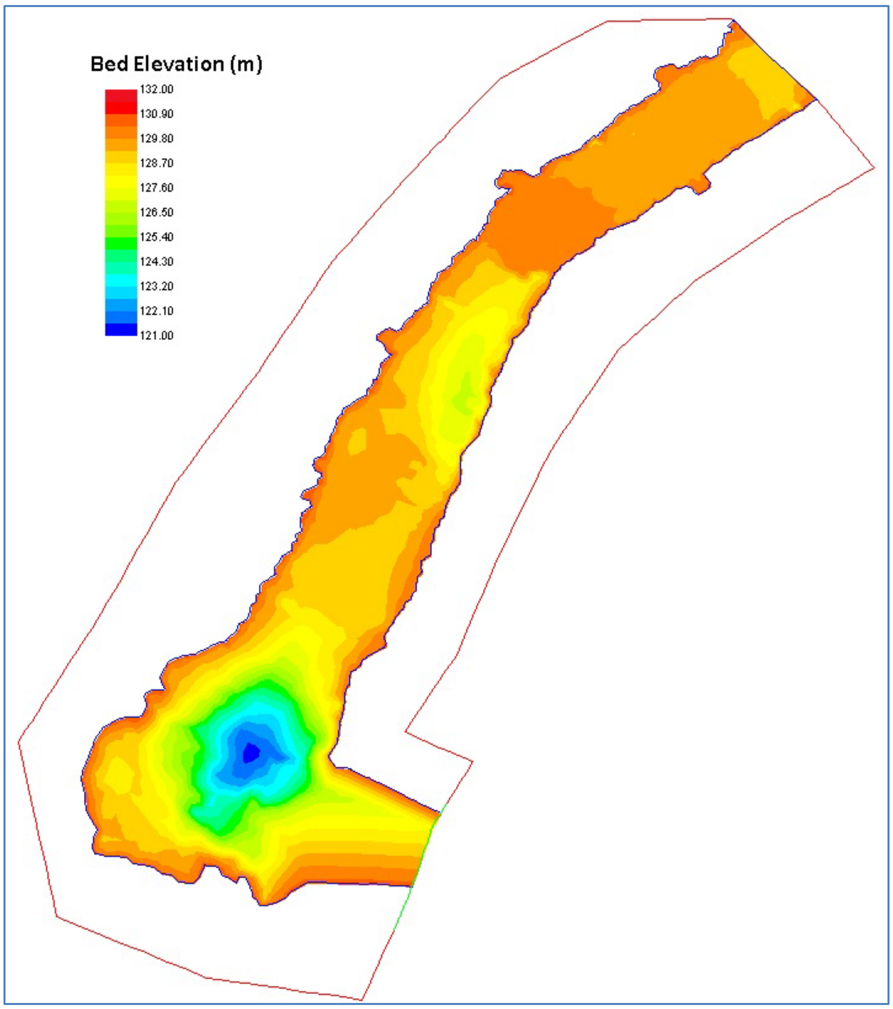


Figure 1. River2D Proposed Channel Bathymetry

2.3 Mesh Generation

Following channel geometry definition, a computational mesh required for numerical modelling was generated using the R2D Mesh pre-processor for the River2D numerical modelling. The modelling mesh defined the spatial and hydraulic characteristics of the channel bed as a series of nodes and elements.

A single mesh was created for all simulations. The mesh contained 5,479 nodes and 10,732 elements. The mesh consisted of triangular elements of 4.5 m^2 within the banks of the channel and finer elements of 2 m^2 within the area of the gravel pad. A larger triangular mesh was applied to the flood plain area to reduce computational time. To ensure that the modelled bathymetry accurately represented surveyed bathymetry, contours were compared to similar contours defined for the mesh elements and nodes; they exhibited good agreement.

2.4 Boundary Conditions

The upstream boundary conditions were set as steady state inflow discharges identified in Table 1. The downstream boundary was defined as a fixed water surface elevation, estimated using water surface elevations from broad-crested flows over the BC Hydro weir downstream of the site (NHC, 2004).

Table 1. River2D Simulations

Model Run	Flow (m^3/s)
1	15
2	30
3	60
4	100
5	140
6	180
7	260

2.5 Model Validation

A sensitivity analysis was completed because no data was available to calibrate the model. This included varying bed roughness by a factor of ± 10% at a 30 m^3/s discharge. The results of the sensitivity analysis are summarised in Table 2. In general, the model was found to be relatively insensitive to roughness.

Table 2. River2D Validation Data and Sensitivity Analysis

Model Run Flow (m^3/s)	Roughness Parameter Variability	WUA (m^2)	Percent Change (%)
	+10%	1120	0.4
30	No Change	1116	0
	-10%	1110	-0.5

3 Design

3.1 Habitat Characteristics

Summer-run Chinook salmon spawning habitat is the focus of this study. Delphi-derived spawning habitat criteria for summer-run Chinook salmon provided in the Water Use Plan (BC Hydro, 2004) were used in the habitat assessment. The criteria incorporated suitability for flow depth, velocity and sediment texture. The depth, velocity and substrate criteria are presented in Figure 2.

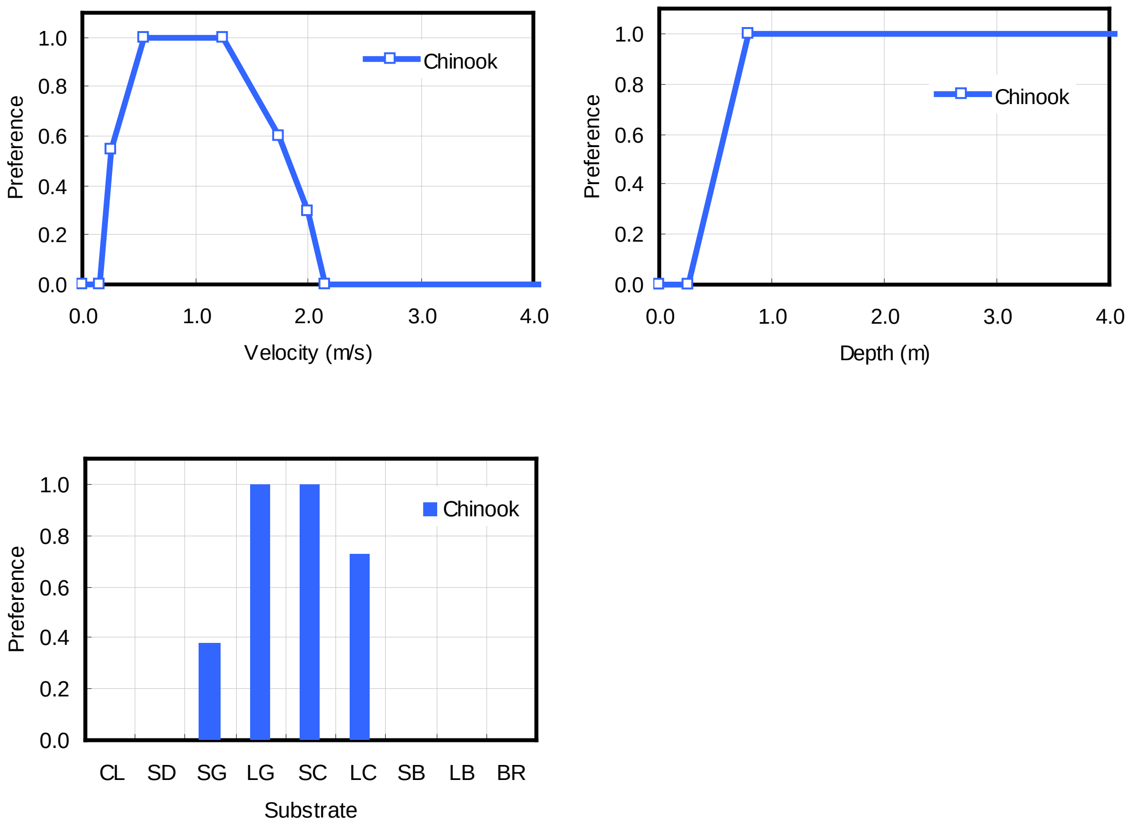


Figure 2. Chinook Spawning Habitat Suitability Criteria

3.2 HABITAT PARAMETERS

The hydrodynamic simulations provided depth and velocity hydraulic parameters at each node in the computational mesh. Within the spawning area, depth suitability between 0.0 and 1.0 was established by applying the species suitability criteria (Figure 2) for the specific depth at each node. Similarly, suitability for velocity was determined based on the species suitability criteria and specific velocity at each node. A substrate suitability factor of 1.0 was applied as the placed material is large gravel. The product of the three components is referred to as the composite suitability index (CSI) and ranges from 0.0 to 1.0. From this, the WUA was calculated for each node as an aggregate of the product of CSI and the area associated with the node. The total WUA for the specific species was the sum of WUA for all nodes within the proposed gravel pad area.

WUA for the proposed gravel pad under various flow rates were calculated for Chinook summer-run spawning salmon (Table 3).

Table 3. Modelled Weighted Useable Areas (WUA)

Model Run	Flow (m^3/s)	WUA (m^2)	WUA /Gravel Pad Area[1] (%)
1	15	1,026	51
2	30	1,116	56
3	60	771	39
4	100	194	10
5	140	38	2
6	180	18	1
7	260	0	0

The model results showed that the proposed gravel pad will provide Chinook spawning habitat for flows up to 100 m^3/s based on the CSI criteria in Figure 2. WUA is calculated using the combined suitability of depth, velocity and substrate over the pad. For the proposed gravel pad elevation of 130 m, depth of water was the limiting factor in the WUA calculations. Flow depths over the gravel pad at a discharge of 30 m^3/s ranged from 0.51 to 0.65 m, which corresponded to a depth suitability range of 0.49 to 0.73. While the depth of water above the spawning platform is limiting in suitability, a spawning pad elevation of 130 m provides the adequate depth of material for egg burial.

3.3 Gravel Stability and Specification

Gravel stability in a river is a function of many parameters including flow depth, flow velocity, bed slope, gravel size, gravel shape and gravel density. Hydraulic modelling results of the proposed gravel pad were used to calculate the minimum stable particle size for various flows using Sheild's equation (Table 4).

Table 4. Stable Particle Size (D_{50}) using Shield's Equation for the proposed gravel platform

Discharge (m^3/s)	Stable Bed Material Size D_{50} (mm)
15	3
30	7
60	15
100	22
140	31
180	33
260	41

The gravel specification previously specified in NHC, 2004 with a D_{50} of 75 mm would be stable at flows up to 260 m^3/s. Some fining of the smaller fraction of substrate and coarsening of the bed will likely occur over time, but the restored section surfaces will be hydraulically stable. Since the placement of the 2005 gravel, a maximum daily discharge of 258 m^3/s occurred in the reach below the diversion on January 13, 2010 (WSC

[1] Proposed gravel pad area of 2,000 m^2.

Gauge 08HB084). Following this event, sorting of material on the pad occurred; however, the material remained in the placement area. The gravel gradation used in 2005 is specified for this project. It was chosen for its stability during floods and suitability for spawning use by Chinook salmon and steelhead (Figure 3).

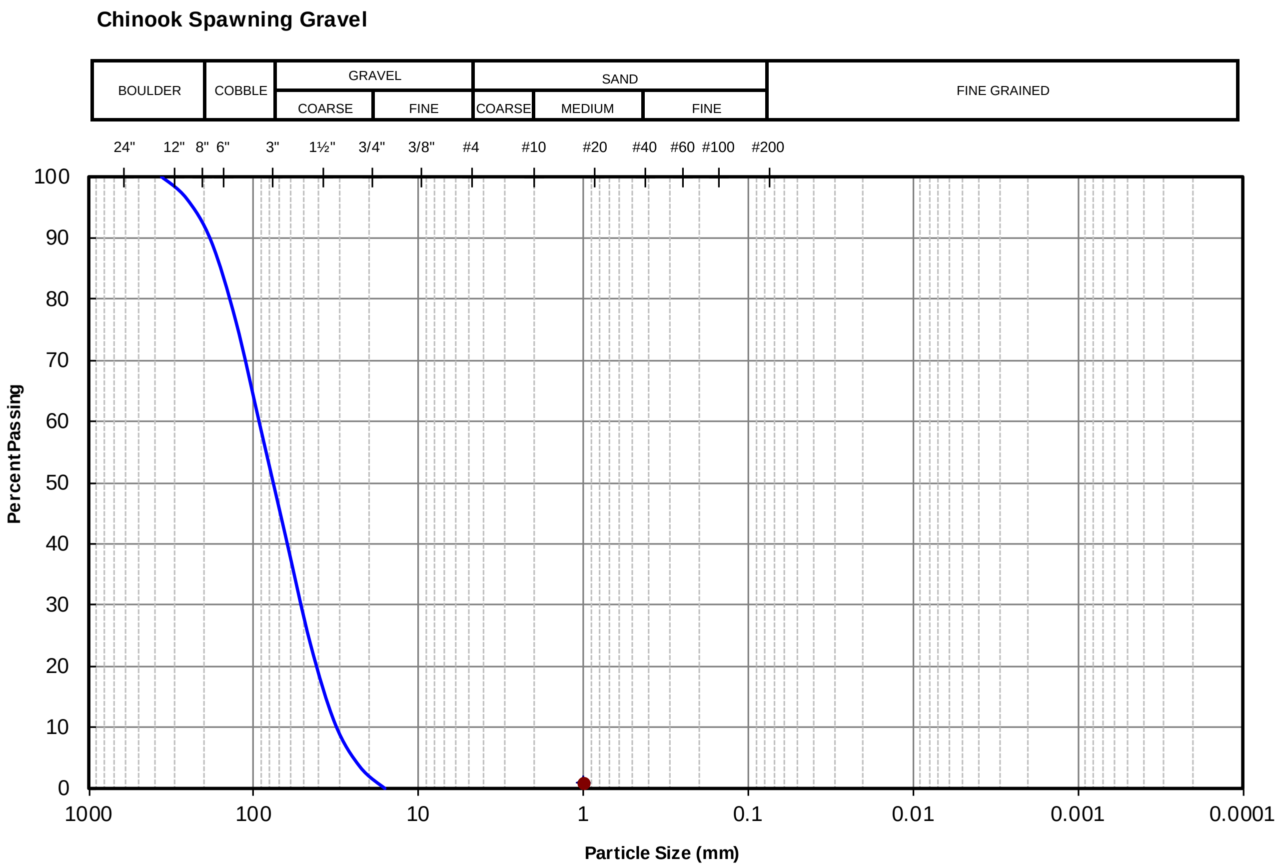


Figure 3. Gravel Specification (from NHC, 2004)

The spawning gravel should be washed to remove fine clay/silt particles before installing it in the river to reduce potential turbidity issues. In previous projects, the gravel was washed two times. The project owner may consider incorporating a fine sediment performance measure in the gravel supply tender contract.

3.4 Design Summary

The proposed gravel platform has a surface area of 2,000 m^2. The required spawning gravel volume is approximately 1,700 m^3. Using a conversion factor of 1.8 tonnes per cubic meter, the required mass is 3,100 tonnes.

The gravel platform design is an upstream extension of the 2005 gravel placement project. The design surface elevation is 130 m; it was selected based on existing channel bathymetry and requirements for Chinook egg burial. The average existing bed elevation within the gravel placement area is 129.2 m. The egg burial depths (as measured to the bottom of pocket) for spawning Chinook salmon is 0.50 m (DeVries, 1997). The specified gravel platform elevation (130 m) will provide adequate depth for egg burial. There will be a gradual transition from the proposed gravel pad to the pad constructed in 2005; the surface will be graded at a 10% slope.

Drawing 300117-001 provides a key map, location map, plan view, section, profile, and construction notes for the project.

4 CONSTRUCTION

This section provides guidance for constructing the project using experience gained from the similar spawning habitat project that was constructed at the site in 2005, as well as experience from other gravel installation (salmon habitat) and gravel removal (sediment management) projects in the region (e.g. Guimond, 2006; DFO, 2007; NHC, 2010; NHC, 2013).

The construction site is an environmentally sensitive area. An environmental management plan should be prepared to summarize the applicable environmental laws and best management practices. A qualified Fisheries biologist should be on site during all work in and near the river.

4.1 ACCESS

The preferred site access is the same route used for the 2005 project. Access is through the private residence at 4753 Forbidden Plateau Road, across the west end of the Courtenay (Smit Field) Airpark, and down the access trail that was previously developed. The access trail ends at the river 15 m downstream of the proposed gravel pad. Landowner permissions and gate keys will be required.

4.2 CONSTRUCTION OUTLINE

This suggested construction outline has been developed from the field review and from experience gained from similar projects. The outline is intended to provide a starting point for the construction team; adjustments will be required based on equipment availability, crew experience, weather, site conditions, and other factors.

A staging area should be developed at the east end of the airstrip. Tandem axle gravel trucks with pups should transport the specified spawning gravel material from the gravel pit and stockpile the material at the staging area. A large hydraulic excavator (25 to 30 tonne class) should be used to reload the gravel into an articulating off-road haul truck (30 tonne class). The haul truck should drive down the access trail, turn around at the bottom, and backup/end-dump in the river. A mid-size hydraulic excavator (20 tonne class) should place and shape the gravel in the river. The stockpiled material must be delivered at approximately the same rate as it is reloaded and hauled to the river.

The following placement outline is intended to limit sediment input to the river. Initially the haul truck and excavator should be used to construct a gravel 'road' 0.75 m above the water surface from the left bank to 15 m from the right bank; the road should be located at the downstream end of the new pad and it should be perpendicular to the flow. The equipment should then be used to construct a road upstream from the end of the perpendicular spur. The second road should be parallel to the bank and end at the upstream extent of the gravel pad. The center of the 'L' shape (towards the left bank) should then be filled in. For the final step the excavator should spread the 'road' towards the right bank.

Water turbidity should be monitored approximately 100 m downstream of the site and at the municipal water intake. The rate of gravel placed should be slowed or temporarily halted if pre-determined turbidity thresholds are exceeded. Work should proceed when the turbidity drops below the thresholds. Modifications to the placement sequence may be required to reduce the suspended sediment loading to the river.

All placed gravel should be graded roughly to elevation 130 m. The finished surface should be left hummocky with variations in the surface of +/- 0.3 m.

All terrestrial areas disturbed by construction should be graded smooth and revegetated as per the revegetation plan (by others).

4.3 SCHEDULE

There is a municipal water intake for the cities of Courtenay and Comox located at the BC Hydro diversion dam approximately 1.1 km downstream of the site. BC Hydro typically closes the diversion for seasonal maintenance in August, during which time the municipal water is extracted by pumps much further downstream near the Puntledge fish hatchery. The spawning gravel project construction should be timed to coincide with the diversion dam maintenance shut down in September because:

1. There will be reduced turbidity at the municipal water intake because of increased settlement time. The diversion dam is 1.1 km downstream of the construction site, while the alternate municipal intake near the fish hatchery is 7 km downstream;
2. The work will be in the 'fish work window'; and,
3. Puntledge River flows are usually at the annual lowest.

The duration of the in-river work using the access, equipment, and construction sequence suggested above should be on the order of 30 hours, assuming a delivery and placement rate of approximately 100 tonnes per hour. The most likely potential delays are turbidity-related work slowdowns.

5 SUMMARY AND RECOMMENDATIONS

A restoration target area of 2,000 m^2 of Chinook spawning habitat every five years was provided as a goal by the Comptroller of Water Rights (BC Hydro, 2004). The design and configuration to meet this target was developed based on:

- Previous results at the site (NHC, 2004; Guimond, 2006; and Guimond, 2007);
- Numerical modelling analysis conducted for this project;
- Experience with similar projects on other rivers in the region;
- Available project construction budgets; and,
- Construction logistics.

The channel bathymetry survey that was used for this analysis was conducted in 2005. There have been several high flow events since the survey was conducted, including a significant flood in January 2010. Current channel conditions may be different from the survey; however, the model will not reflect (if applicable) these differences.

The proposed gravel pad has a surface area of 2,000 m^2 at an elevation of 130 m. It will provide adequate summer-run Chinook spawning habitat over a range of flows from 15 to 100 m^3/s, and meet requirements for egg burial depths. The gravel gradation is the same as the 2005 project. The gradation falls in the habitat suitability index specifications, has been used at the site by Chinook salmon, and has been hydraulically stable during floods. The volume of spawning gravel for the project is approximately 1,700 m^3 (3,100 tonnes). The gravel gradation adopted for project is stable for flood flows up to 260 m^3/s. The gradation was specified because of its stability and suitability for Chinook and steelhead spawning.

The construction site is an environmentally sensitive area. An environmental management plan should be prepared to summarize the applicable environmental laws and best management practices. A qualified Fisheries biologist should be on site during all work in and near the river.

Construction should be undertaken during the BC Hydro diversion dam maintenance shutdown to decrease the risk of construction delays caused by exceeding drinking water turbidity thresholds.

Obtaining environmental permits, reviewing turbidity thresholds and other parameters, and coordinating construction with BC Hydro and other stakeholders is required for the next stage of the project.

Sincerely,

northwest hydraulic consultants ltd.

original signed by

Joanna Glawdel, M.A.Sc., EIT
Hydrotechnical Engineer

original signed by

Graham Hill, P.Eng.
Project Engineer

Enclosures:

Drawing 300117-001

6 REFERENCES

BC Hydro. 2004. *Puntledge River Project Water Use Plan*. Revised for the Acceptance by the Comptroller of Water Rights. December 1, 2004.

Burt, D. 2004. *Restoration of the Lower Campbell River, a Review of Projects to 2003 and a Plan for Future Works*.

Fisheries and Oceans Canada (DFO). 2007. *Campbell River Mainstem Spawning Gravel 2006 First Island.* Prepared by S. Anderson.

Fisheries and Oceans Canada (DFO). 2005. *Puntledge River Supply Creek Project Gravel Placement.* Surveyed by Fisheries and Oceans Canada, Oceans, Habitat and Enhancement – SCD. Dated November 7, 2005.

Guimond, E. 2006. *Summer Chinook Spawning Habitat Restoration in the Puntledge River Headpond 2004 – 2005.* Prepared for Fisheries and Oceans Canada. BC Hydro file no. 04.PUN.01.

Guimond, E. 2007. *Puntledge River Headpond Gravel Placement Post-Construction Monitoring 2006 – 2007*. Prepared for Comox Valley Project Watershed. BC Hydro file no. 06.PUN.03.

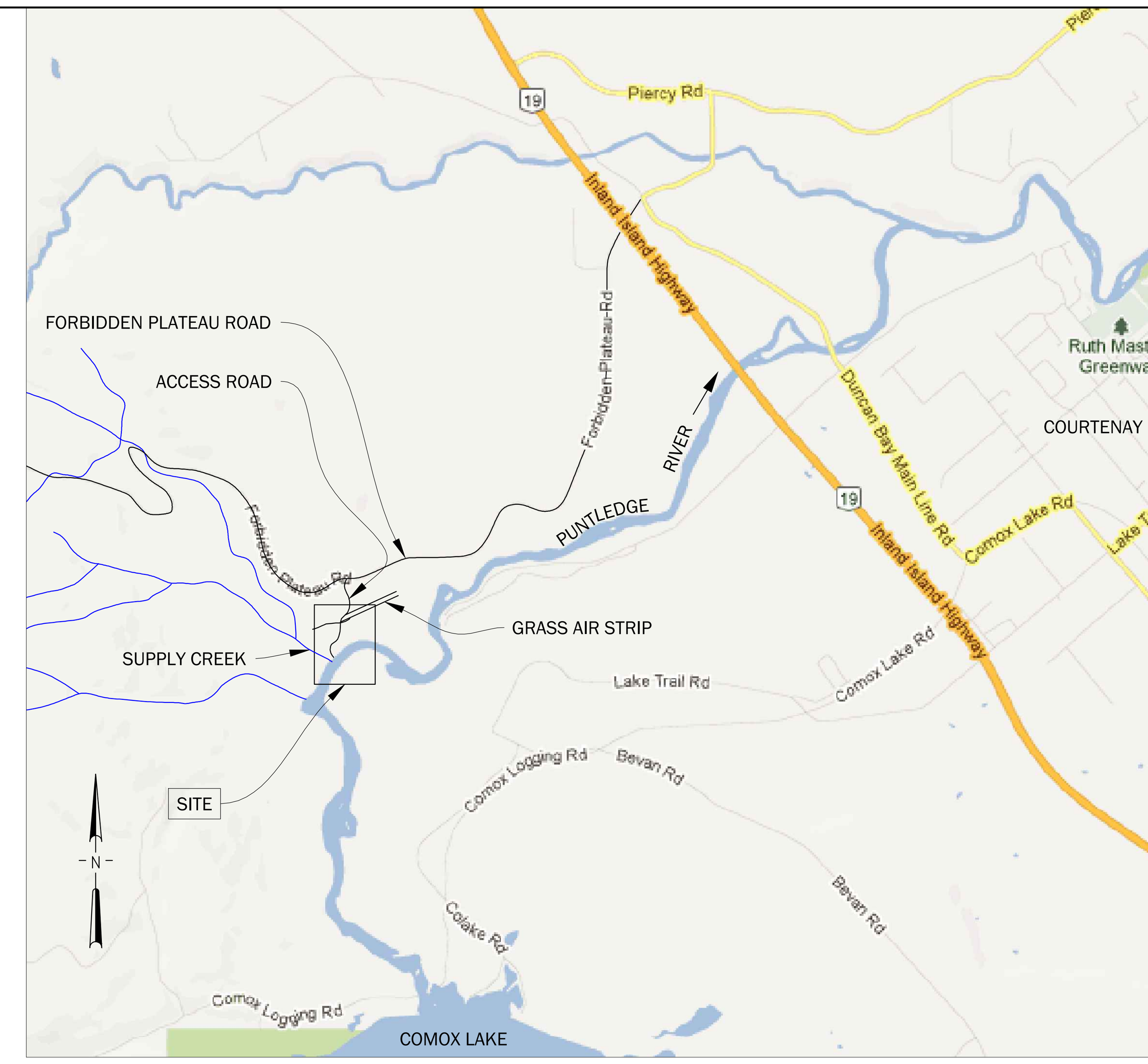
DeVries, P. 1997. *Riverine salmonid egg burial depths: review of published data and implications for scour studies.* Can. J. Fish. Aquat. Sci. Vol. 54. Pg. 1685-1697.

Northwest Hydraulic Consultants Ltd. 2004. *Puntledge River Summer Chinook Spawning Habitat Restoration Design and Numerical Modelling*. Report prepared for Fisheries and Oceans Canada.

Northwest Hydraulic Consultants Ltd. 2010. *Campbell River Gravel Placement 2009: Site 7-II.* Report prepared for the Campbell River Salmon Foundation. BC Hydro file no. 09.CBR.01.

Northwest Hydraulic Consultants Ltd. 2013. *Campbell River Gravel Placement 2012: Site 9.* Report prepared for the Campbell River Salmon Foundation. BC Hydro file no. 11.CBR.03.

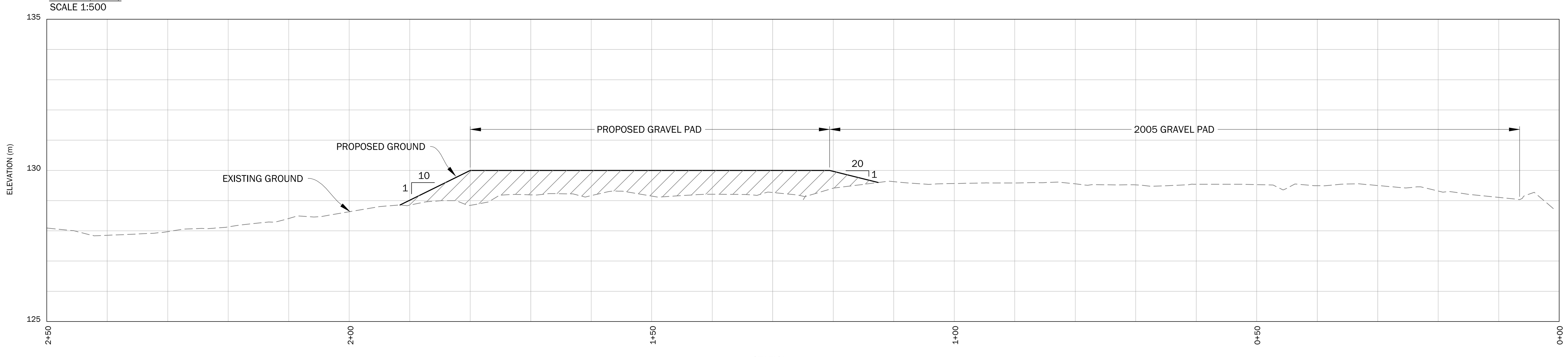
KEY MAP
NTS



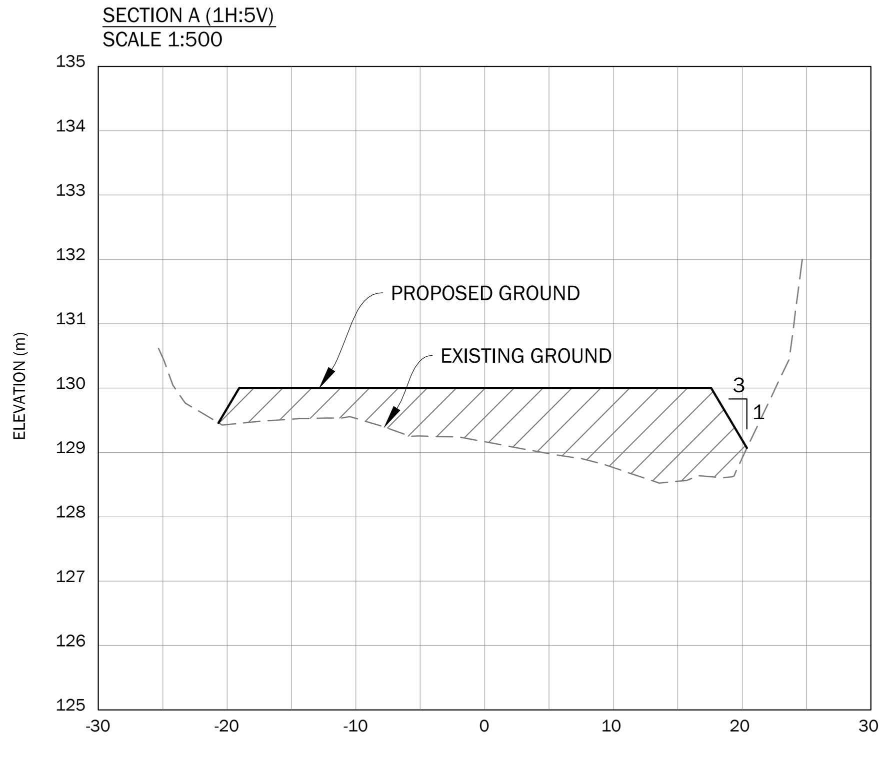
LOCATION MAP
NTS

DRAFT
NOT FOR CONSTRUCTION

PROFILE (1H:5V)
SCALE 1:500



SECTION A (1H:5V)
SCALE 1:500

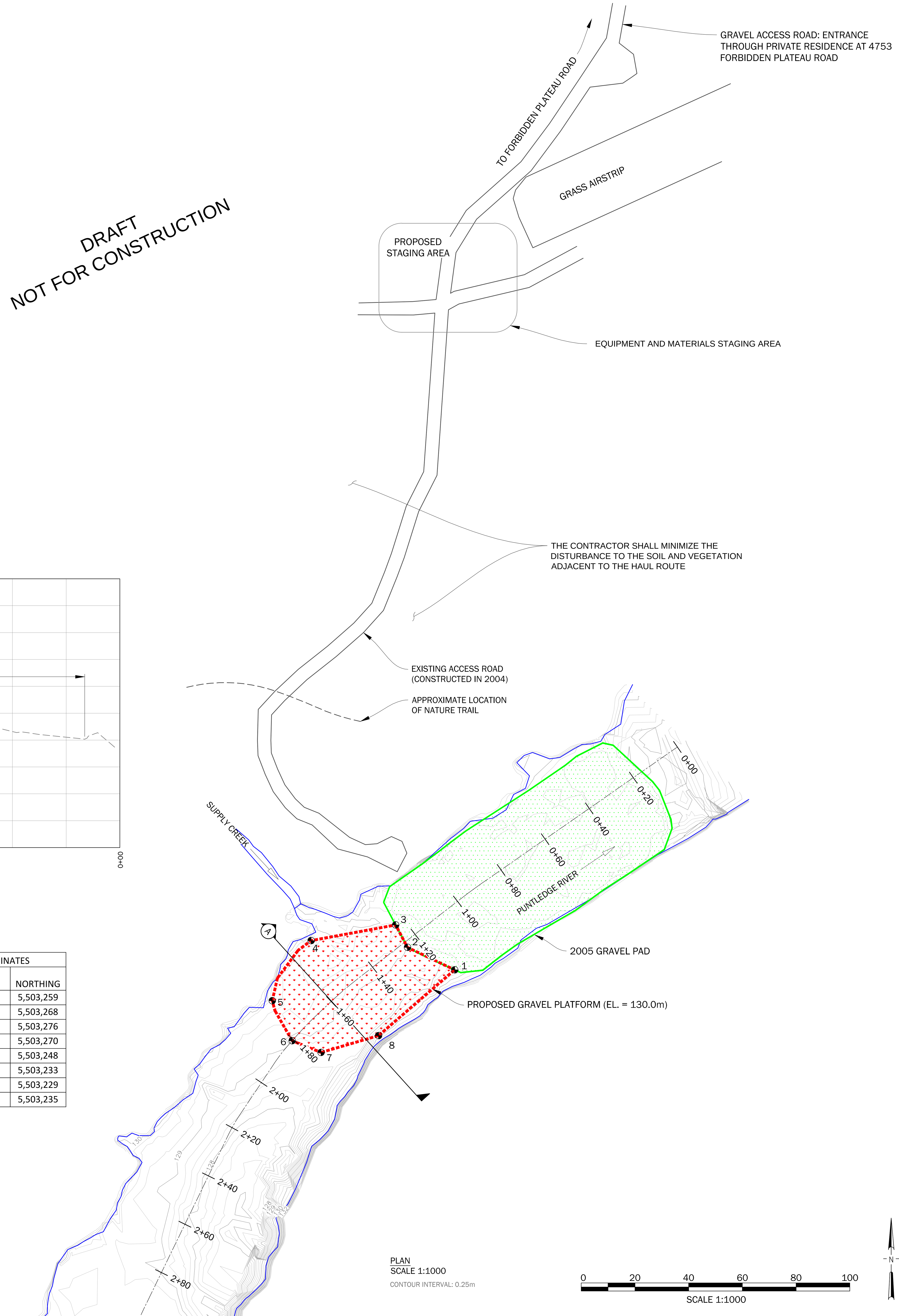


GENERAL NOTES:

1. THE SITE SURVEY WAS PROVIDED BY BC HYDRO AND FISHERIES AND OCEANS CANADA (DFO). THE COORDINATES ARE UTM ZONE 10, AND THE VERTICAL DATUM IS APPROXIMATELY GEODETIC. THE BC HYDRO SURVEY DATE IS UNKNOWN. THE DFO SURVEY WAS CONDUCTED IN SEPT 2005. THE DFO DRAWING NUMBERS ARE 31-123-01, -02, -03 AND -04.
2. ALL UNITS ARE IN METERS UNLESS OTHERWISE INDICATED.
3. THE SPAWNING GRAVEL SHALL MEET THE SPECIFICATIONS PROVIDED BY THE PROJECT ENGINEER. THE MATERIAL SHALL BE INSPECTED AND APPROVED BY THE ENGINEER PRIOR TO DELIVERY TO THE SITE.
4. THE AVERAGE SPAWNING GRAVEL PLATFORM SURFACE ELEVATION SHALL BE AT 130.0m. IRREGULAR UNDULATIONS (+/- 0.3m) SHOULD BE LEFT IN THE SURFACE TO ENHANCE HYDRAULIC VARIABILITY.
5. THE WORK ZONE IS AN ENVIRONMENTALLY SENSITIVE AREA. BEST MANAGEMENT PRACTICES SHALL BE FOLLOWED AT ALL TIMES; REFER TO THE ENVIRONMENTAL MANAGEMENT PLAN.
6. AT THE END OF THE PROJECT THE ACCESS ROADS AND EQUIPMENT AND MATERIALS STAGING AREA MUST BE RESTORED TO PRE-PROJECT CONDITIONS. ALL THE GRAVEL SHALL BE REMOVED FROM THE SURFACE, DAMAGED AREAS SHALL BE REPAIRED WITH SOIL AND REVEGETATED WITH NATIVE PLANTS AND/OR A GRASS SEED MIXTURE WHERE REQUIRED.

SPOT COORDINATES

POINT No.	EASTING	NORTHING
1	348,242	5,503,259
2	348,225	5,503,268
3	348,220	5,503,276
4	348,189	5,503,270
5	348,174	5,503,248
6	348,182	5,503,233
7	348,192	5,503,229
8	348,214	5,503,235



PLAN
SCALE 1:1000
CONTOUR INTERVAL: 0.25m

0 20 40 60 80 100
SCALE 1:1000

Revisions:			
No:	Description:	By:	Date:

Scale:	AS SHOWN
Designed By:	JXG
Drawn by:	CSM
Reviewed By:	GRH
Date:	16 JAN 2012
Project No:	300117

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PUNTLEDGE RIVER SPAWNING HABITAT

GRAVEL PLATFORM DESIGN
PROJECT LOCATION
PLAN, PROFILE AND SECTION

Drawing No: 300117-001 SHEET 1 OF 1 Rev: 0

nhc
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