DISTRICT OF SQUAMISH
PROJECT #: 18P-00095-00

SQUAMISH RIVER DIKE UPGRADE UPPER JUDD (JIMMY-JIMMY) SLOUGH

SLOUGH INFLOW CULVERT PRELIMINARY DESIGN REPORT

JANUARY 21, 2020

QUALITY MANAGEMENT

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2020-01-21

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Bound Separately:

1 BACKGROUND AND OBJECTIVES

1.1 PROJECT DESCRIPTION

Judd Slough (also referred to as Jimmy-Jimmy Slough) is located within the community of Brackendale in the District of Squamish. The slough was formerly a sidechannel of the Squamish River which was isolated hydraulically when the dike was constructed. The District is interested in providing a culvert at the north end of Judd Slough to provide inflow for improvement of spawning habitat within the Slough. Fish passage would continue to occur at the south end when the outlet gates are open. There is an existing culvert which is reported to have been deactivated following the 1991 flood by collapsing the outlet[1]. There are anectodal records of seepage observed on the landside of the culvert during a recent flooding event.

A feasibility study has been completed by WSP[2]. The purpose of this document is to provide a conceptual design for the culvert and describe the major elements, including the headwall, culvert body, control gates and instrumentation. An operating strategy for the culvert control gates is also provided.

[1] "Squamish River Dike Raising – Upper Judd Slough Conceptual Design Brief", Kerr Wood Leidal Consulting Engineers, June 1, 2017

[2] "Squamish River Dike Upgrade Upper Judd (Jimmy-Jimmy) Slough: Slough Inflow Culvert Feasibility Memorandum", WSP, September 9, 2019.

2 BASIS OF DESIGN

2.1 DESIGN FLOW

Based on the feasibility study, the culvert will be designed for a flowrate of 3.2 m^3/s.

2.2 CONFIGURATION

The proposed inlet structure consists of a box culvert with a central sluice gate chamber containing two sluice gates.

Having two sluice gates provides redundancy for flood protection. If one of the gates leaks or fails to close, the other gate will provide full protection. Having two sluice gates also provides the opportunity for worker entry into the sluice gate chamber for maintenance.

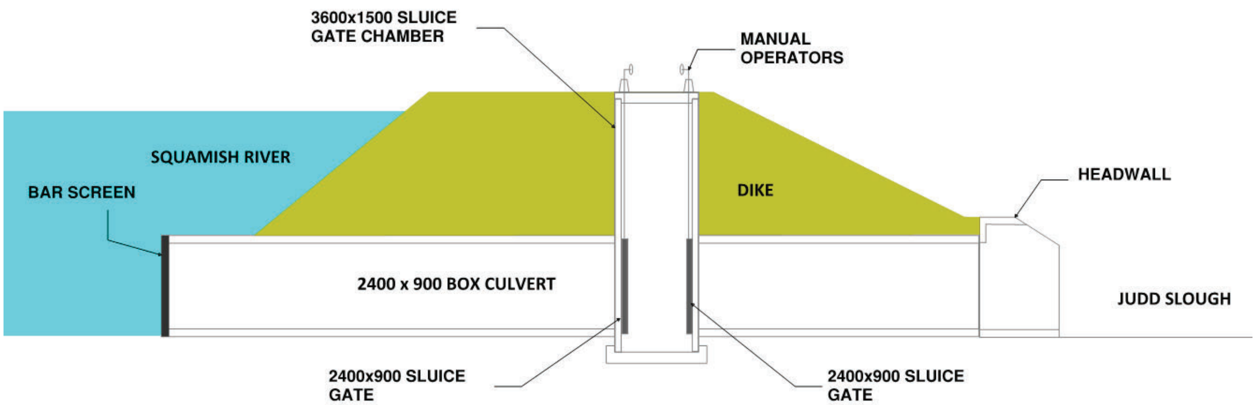


Figure 2-1: Proposed culvert configuration

2.3 GATE OPTIONS

Three options were considered for the control gate. A discussion of these options follows.

2.3.1 MANUAL SLUICE GATE

A manual sluice gate provides the most basic form of control. The gates would be opened and closed manually on-site. Operation of the culvert would be seasonal, and would depend on weather forecast.

2.3.2 MOTORIZED SLUICE GATES

Motorized control would allow for automation and remote operation of the gates. Automation may allow the District to extend the operating season of the sluice gate.

Fisheries and Oceans Canada (DFO) has proposed the option of providing attraction flows for spawning in the Slough during October. Because October tends to be a rainy month, the culvert sluice gates may need to be opened and closed frequently to ensure flood protection. This process would be operationally challenging without motorized control.

A sluice gate with a motorized actuator could be opened and closed remotely, or automated at a future date based on river levels, Slough levels and possibly weather forecast. A BC Hydro service connection would be required. There are overhead powerlines on Axen Road within the Squamish First Nation Wawaik'um Reserve. The powerlines are approximately 200 metres from the proposed sluice gate.

2.3.3 SELF-REGULATING TIDE GATE

Self-regulating tide gates rely on floats, spring-loaded hinges and hydraulic pressure differential to open and close without the requirement for power. These devices are designed to allow outflow and inflow during low water levels, and to stop flow during high river or tide levels.

There are many types of self-regulating tide gates. For purposes of this discussion, this report assumes a side-hinged tide-gate with a float and spring operating device. Example products are:

- Golden Harvest Model GH850, or
- Nehalem Marine Side-Hinged Tide Gate with Muted Tidal Regulator.

Side-hinged tide-gates have the advantage of providing minimal constriction to flow, allowing the required flowrate through the inlet culvert.

The gates allow for a manual override, allowing the gate to be forced the gate to a closed position. The manual override feature allows the District's operations personnel to operate the gate seasonally, similar to the manual sluice gate. The main advantage of this type of gate is that it provides a safeguard in the event of high river levels during the culvert's operating season.

2.3.4 DISCUSSION

Based on discussions with Fisheries and Oceans Canada[3], the sluice gates would be operated seasonally for 2-3 months per year. Operation during July and August would be with the intention of scouring sediments to expose gravels. Operation during October, if feasible, would be for generating attraction flows for spawning.

Self-regulating tide gates were ruled out for Judd Slough for the following reasons:

- A side-opening gate would require a much larger chamber, which would be challenging and costly from a construction perspective.
- The gates are mechanically complex from an operations and maintenance perspective.
- The gates cannot be opened or closed remotely based on weather forecast, which makes them operationally equivalent to a manual sluice gate.

To limit project costs, manual sluice gates are proposed, with full provisions to install motorized actuators in the future.

[3] E-mail from Dave Nanson, dated February 19, 2019

2.4 SCOUR PROTECTION

At the upstream end, protection will be provided by the 1.0 m thick rip-rap Class 250 rip-rap apron apron on the dike face. The channel protection apron downstream will be designed based on the United States Department of Transportation Federal Highway Administration Hydraulic Engineering Circular #14, and best practices.

The channel protection design will consider the following worst-case conditions:

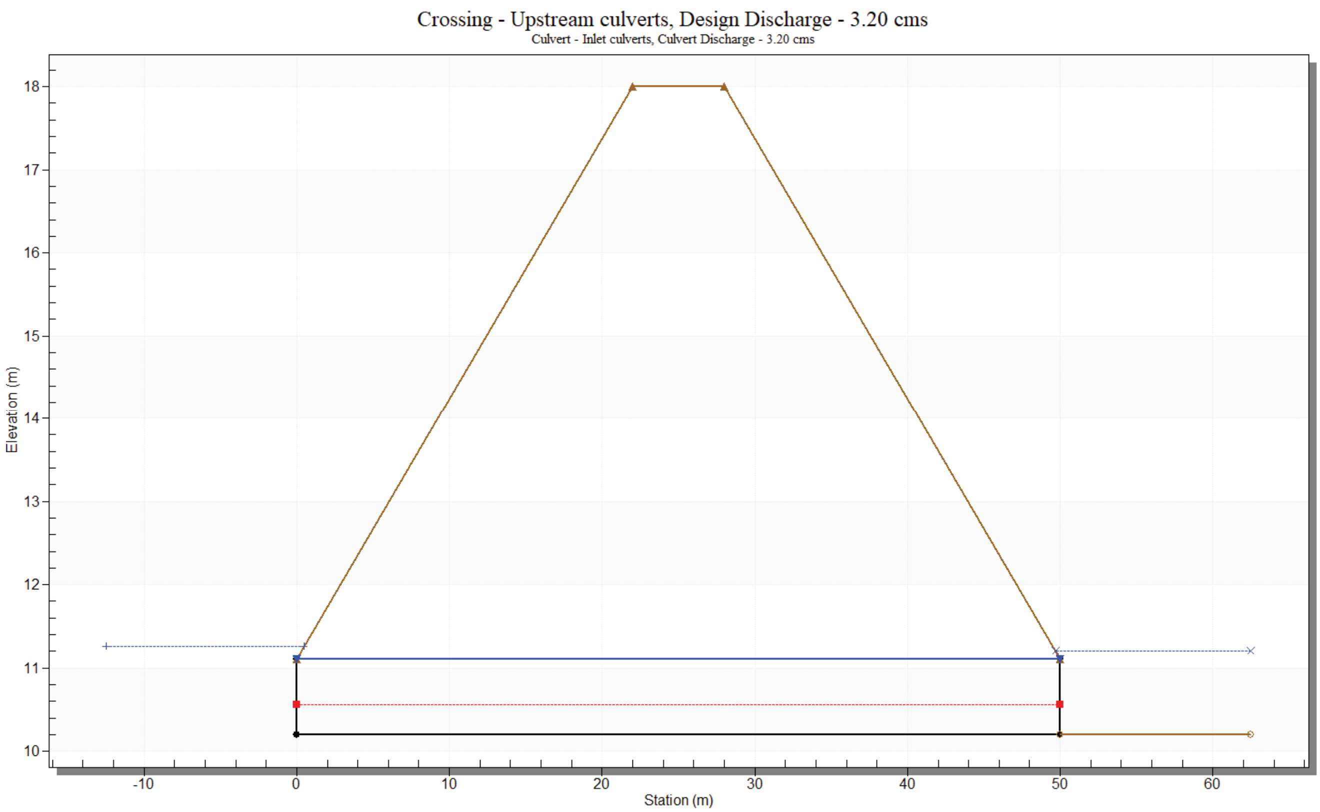
a) Inlet-controlled flow when the control gates are first opened, allowing water to quickly flow into an empty Slough, with an upstream water level of 11.5 m (0.5 m higher than the average water level for July).

b) Steady flow condition with upstream water level at 12.5 m (this is the highest upstream water level observed in July or August between 2011 and 2017.

2.5 SIZE AND SHAPE

The proposed system consists of a 2400 x 900 mm concrete box culvert. The culvert flow profile was modelled using the USDOT HY-8 software package. A Manning's roughness value of n=0.012 was assumed for the culvert.

A printout of the flow profile is shown in the figure below. The software estimates a required headwater level of 11.20 m for the design flow of 3.2 m^3/s. The water level would be 0.3 m above the proposed culvert crown.



2.6 SLUICE GATE

2.6.1 DESIGN PRESSURE

Based on WSP's Issued for Construction Drawings for the Squamish River Dike Raising—Upper Judd Slough, the dike crest elevation at the proposed culvert location is approximately 17.5 m. The proposed culvert invert elevation at the inlet is 10.5 m, which corresponds roughly with the waterside dike toe elevation. The sluice gate would be required to resist a seating head of 17.4 – 10.5 = 6.9 m.

2.6.2 SLUICE GATE OPERATOR

The proposed sluice gate will be operated manually from above the chamber at the top of dike level.

2.6.3 SIZE

The proposed sluice gate will be approximately 2400 mm wide by 900 mm tall to suit the culvert size.

2.7 CONSTRUCTION SEQUENCING

2.7.1 FISHERIES WINDOW

Based on the Ministry of Environment's Guidelines for Reduced Risk Instream Work Windows, Lower Mainland Region, dated March, 2006, any instream works would be best completed in the month of August.

2.7.2 FLOOD PROTECTION

Installation of the new culvert and removal of the existing culvert will require excavation within the dike. Consideration is required to maintain flood protection during construction. The average water level in the Squamish River follows a typical seasonal curve, with maximum average water levels in June/July, and minimum water levels in January. However, flooding is dominated by peaking due to rainfall events (see Figure 2-2). Full flood protection will be required whenever there is precipitation in the forecast.

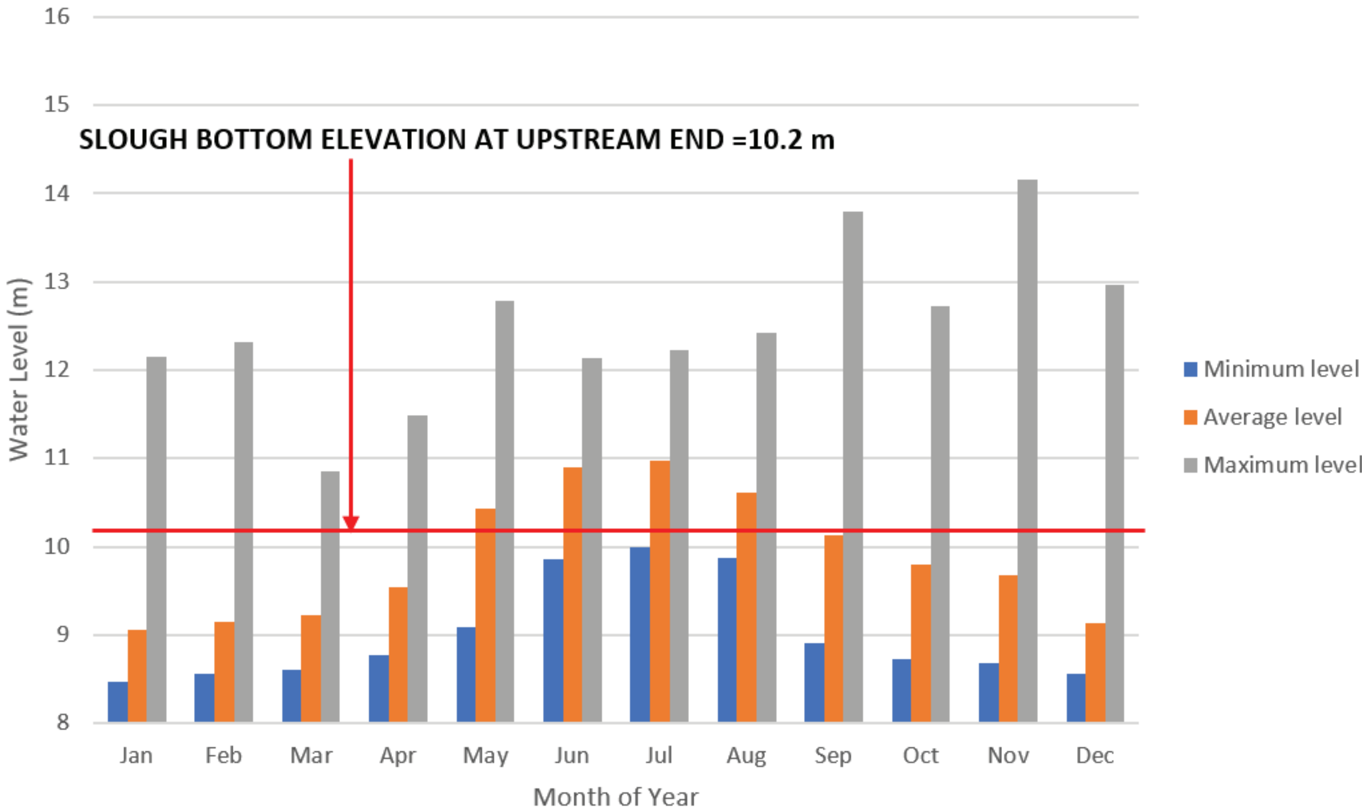


Figure 2-2: Estimated Historical Squamish River water levels upstream of the Slough inlet (Squamish River Level at Brackendale Environment Canada Reading + 7.85 m) between 2011 and 2017. The data was calibrated to the project location using surveyed water levels taken on five separate dates in 2019.

Limitations in the Specifications will include the following:

- All in-stream work shall be done during August, including placement and removal of cofferdams.
- The excavation of the dike shall be phased to maintain flood protection. Excavation shall be phased to maintain a minimum dike crest width of 4 metres at all times, except as authorized for a short period (less than 10 days).
- Equipment shall be available on-site, subject to an emergency response plan demonstrating the dike can be restored to a minimum 4 m width with less than 12 hours notice. The dike shall be restored immediately if there is a significant storm event forecast in the watershed while the dike is compromised by excavation.

2.7.3 POSSIBLE SEQUENCING

The ultimate choice of construction methodology will be the decision of the Contractor selected for the work. A work sequence is illustrated in Appendix A, showing a possible approach for constructing the works while minimizing risk to flood protection.

Stage 1: Construction of the sluice gate chamber

Constructing the proposed sluice gate chamber first allows for installation of the culvert on the landside without compromising flood protection. During construction, the river level is expected to be at around 11.0 m geodetic, which is approximately 1.5 m above the proposed base of excavation. The sluice gate chamber could be constructed in a number of ways including:

- *Caisson-style installation*: The chamber is installed in-place without the base, excavating material from the centre. A working surface is poured at the base using underwater "tremie mix" concrete, providing a dry working area for construction of the chamber base. This type of installation requires no sideslopes, and is ideal for construction below the groundwater table, since the soil is supported by the chamber itself. However, the presence of large cobbles or boulders can slow this process down.
- *Open cut installation*: To install the chamber by open-cut, dewatering may be required prior to excavation below the water table to avoid sloughing.

The sluice gate openings would be covered during installation with a suitable temporary material such as plywood with timber bracing to hold back soil and reduce movement of water through the chamber.

Stage 2: Install sluice gates

The sluice gates would be installed and closed to provide protection during subsequent steps.

Stage 3: Construction of the landside culvert and headwall

Once the chamber is constructed, the downstream culvert and headwall could be constructed without compromising flood protection. The existing culvert would be removed during construction of the new culvert. During this stage, the sluice gate chamber will experience soil pressure from the dike on the riverside, without any soil support on the landside. The contractor may need to support the chamber during this stage of construction to prevent sliding or overturning due to unbalanced soil pressures.

Stage 4: Construction of the cofferdam

A cofferdam would be constructed in early August—at the beginning of the fisheries least-risk window. The cofferdam would be constructed to an elevation of 12.5 m geodetic (approximately 2-2.5 m above the existing grade at the dike toe). The proposed elevation of 12.5 m geodetic corresponds to the highest river level recorded in August between 2011 and 2017. Construction of a cofferdam will require removal of rip-rap at the interface between the dam and the dike face.

Stage 5: Install riverside culvert and install sluice gates

The riverside culvert consists of approximately nine 2.4 m length box culvert sections. Installation of the riverside culvert will involve the following activities:

- dewatering within isolated area,
- removal of the existing rip-rap,
- excavation and removal of existing culvert,
- placement of bedding layer,
- installation of culvert,
- backfill with approved dike fill, and
- restoration of rip-rap.

The work would be scheduled over a non-stop 2-week work period in early August, when there are no storm events in the long-term forecast.

Step 6: Remove cofferdam

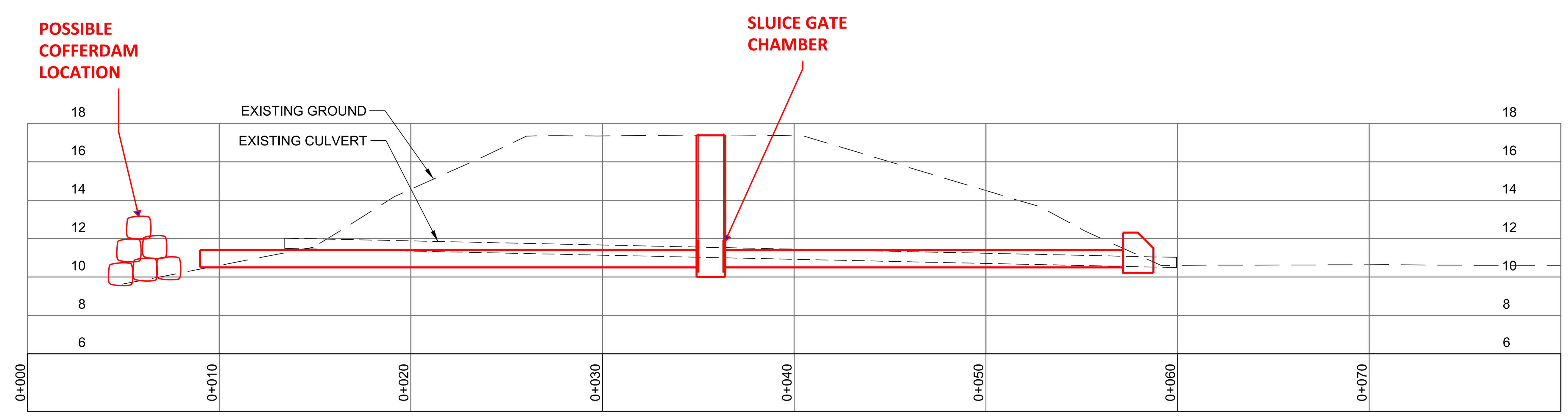
Once the dike is restored and the sluice gates are installed, the cofferdam can be removed.

Step 7: Complete sluice gate chamber

Completion of the sluice gate chamber construction would include:

- Installation of chamber lid and access hatch
- Any interior grouting/sealing as required
- Installation of manual operators

APPENDICES



PROFILE
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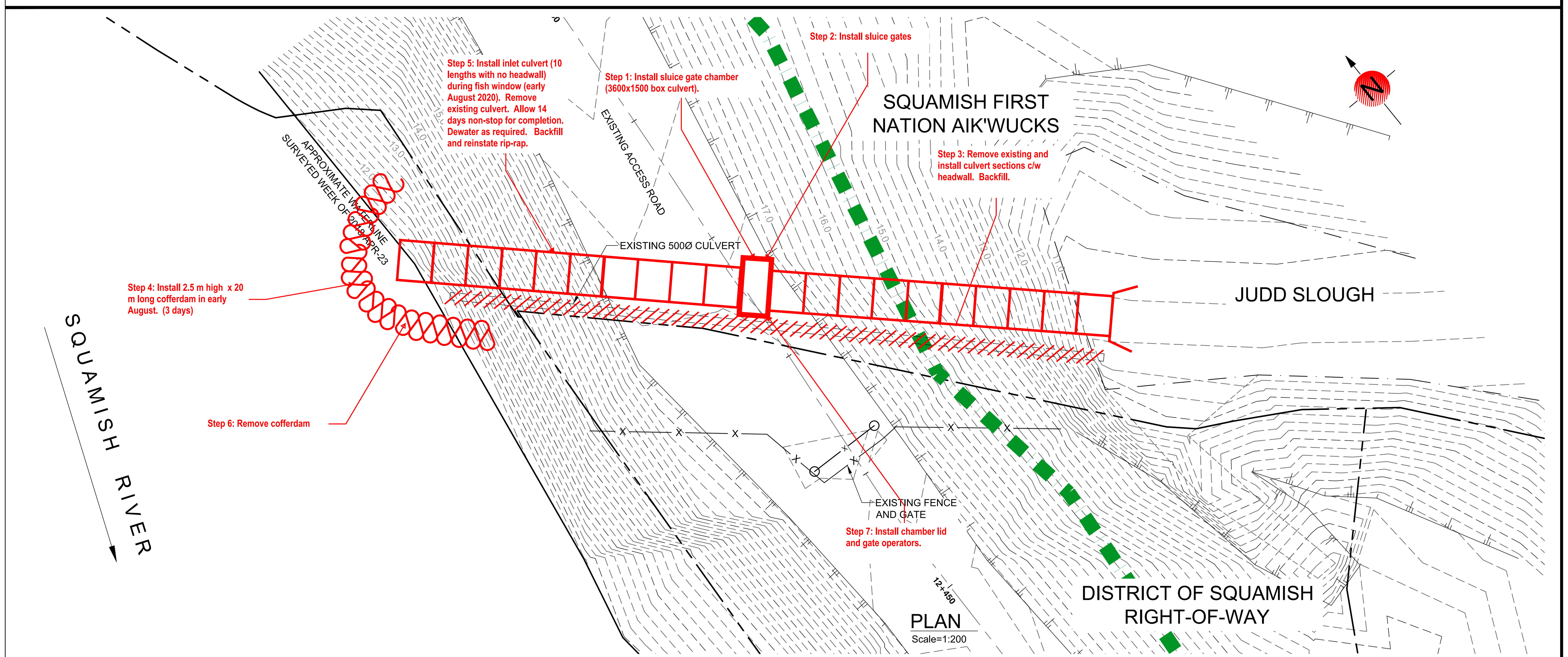


PLAN
Scale=1:200

NOTES:

1. DO NOT COMPROMISE FLOOD PROTECTION DURING CONSTRUCTION. SUBMIT PLAN FOR PROVIDING TEMPORARY PROTECTION AND ISOLATING WORK AREA FROM FLOWS IN THE SQUAMISH RIVER DURING CONSTRUCTION.

1:200 @ ANSI D 0 2 4 6 8 10 12 14 16 18 20 m

Revision	Amendment	Approved	Revision Date
A	PRELIMINARY DESIGN	KK	2019/11/07

wsp
North Vancouver Office
604-990-4800
210-889 Harbourside Drive
North Vancouver BC
V7P 3S1, Canada

Designed	Approved	Approved Date
K.KONICEK	S.KRAS	2019/11/07
Drawn	**Scales**	
E.KARAIM	AS SHOWN	

Project
DISTRICT OF SQUAMISH
SQUAMISH RIVER DIKE RAISING
UPPER JUDD SLOUGH

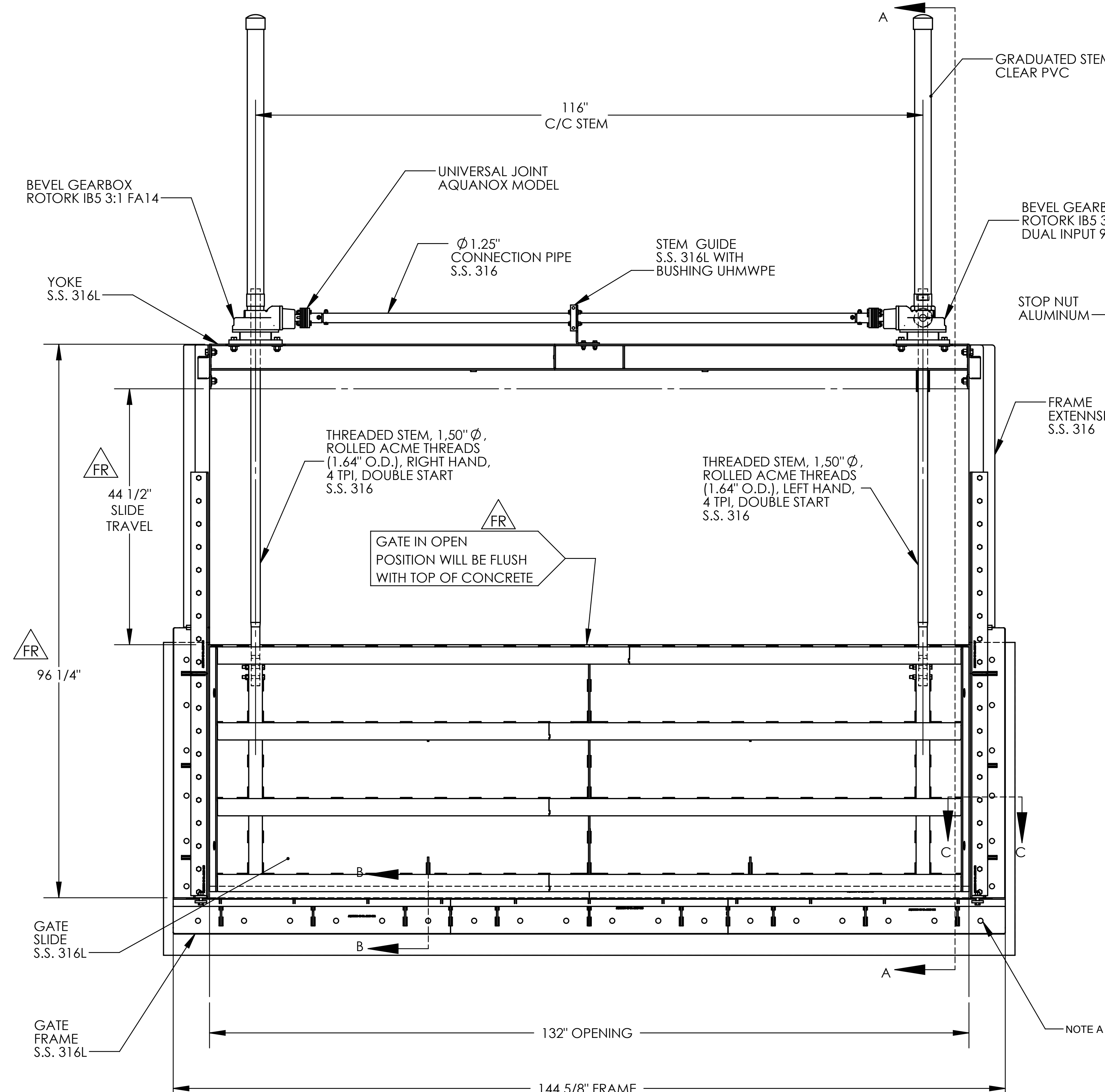
Sheet
POSSIBLE PHASING OF CONSTRUCTION AND PRELIMINARY PLAN

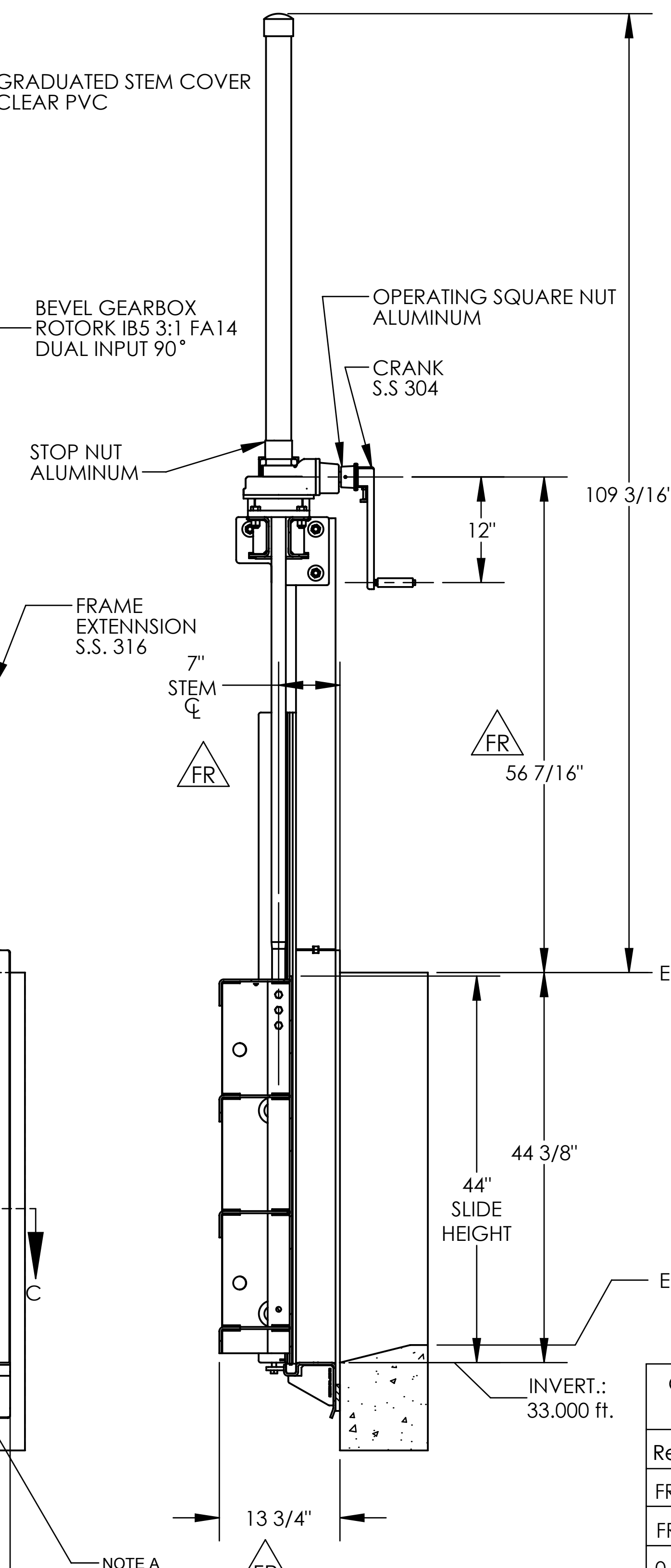
Project No.	Sheet. No.	Revision
D-036F2.00	C500	A

Original Sheet Size ANSI D [22"x34"] Plot Date 2019-12-20 at 1:55:29 PM Path M:\SQUAMISH DISTRICT OF\D-036F2.00\(C) Civil\D-036F2.00 Design Culvert.dwg C500

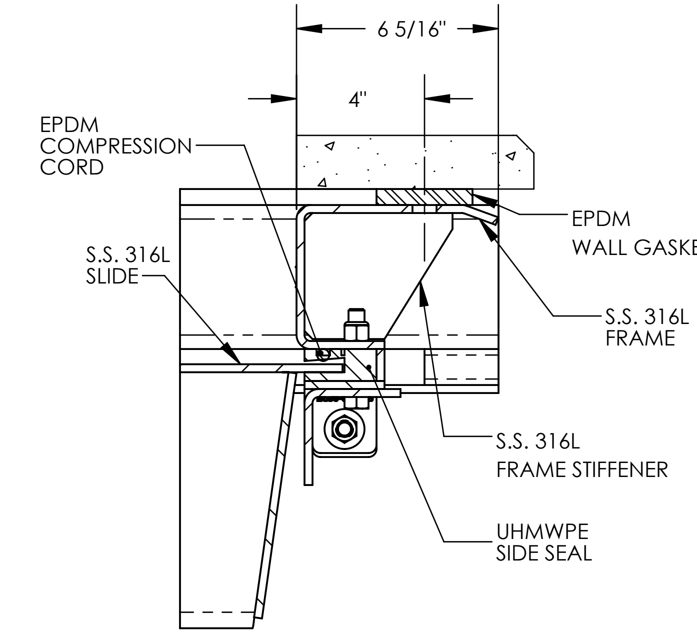
Fontaine Aquanox VANNES MURALES WATER CONTROL GATES

Stainless Steel Channel Gates - Series 25

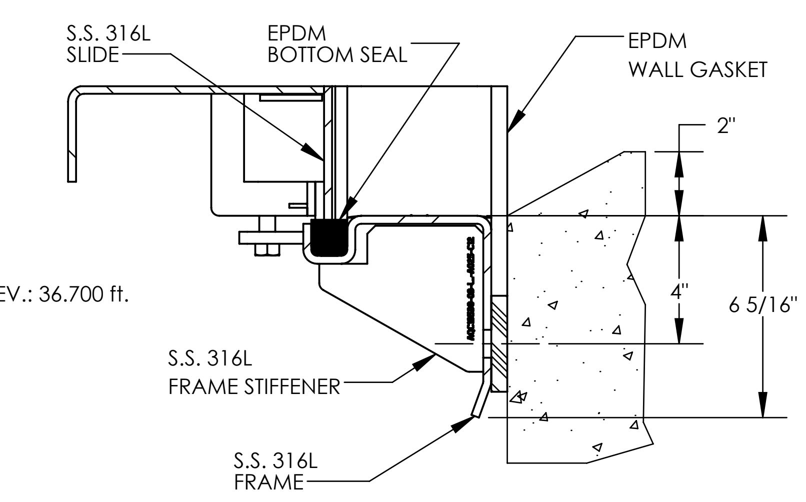




SECTION A-A



SIDE SEAL CROSS SECTION C-C



BOTTOM SEAL CROSS SECTION B-B

NOTE A: ANCHORS NOT SUPPLIED.
MECHANICAL: HILTI KWIK BOLT 3 OR BETTER, 5/8" [16mm] DIA.X 4.0" [102mm] EMBEDMENT IN 2000 PSI [14 Mpa] CONCRETE.
ADHESIVE: HILTI HVA OR BETTER, 5/8" [16mm] DIA.X 5.0" [127mm] EMBEDMENT IN 2000 PSI [14 Mpa] CONCRETE.
QTY: 30
FR

General Notes
1. Drawing is not to scale

Rev.	Date	Desc.
FR	2018/03/16	EC - BOTTOM OF GATE POSITION ADDED
FR	2018/03/07	CS- GATE CHANGED FROM SERIES 40 TO SERIES 25
0	2018/01/17	YM

ISE
ISE Métal Inc. - Sherbrooke, QC, Canada
www.iseaquanox.com - 819-769-0157

Project no.: 13539

Bradenton, FL

Bradenton WTF Improvements

Item 3: 20-G-1, 20-G-2

Model no.: 403-Y2X-132-44-A-CW-5

Qty: 2

Drawing no.: D13539-03-403Y2X13244ACW5

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