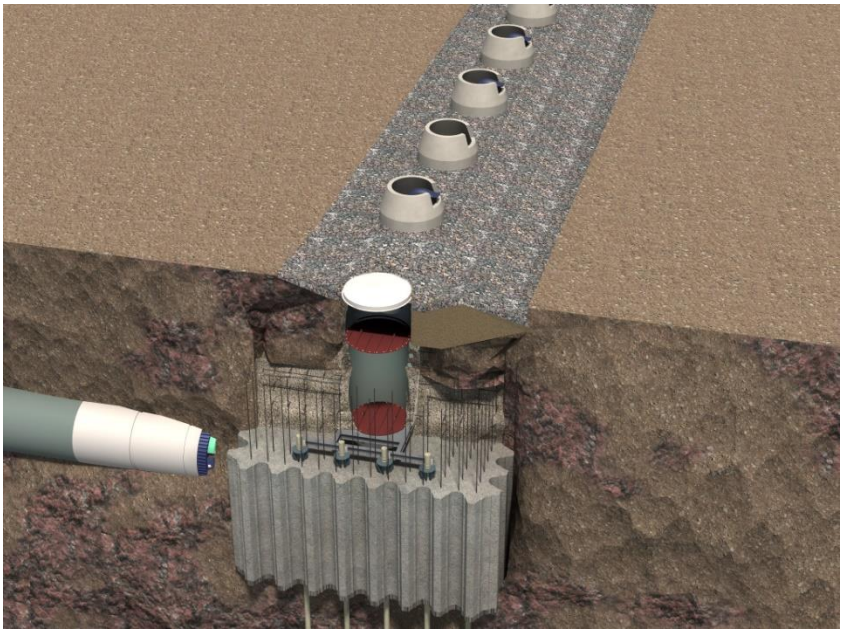
APPENDIX L
HABITAT ASSESSMENT

L.1: Habitat Assessment

Annacis Island WWTP New Outfall System

Vancouver Fraser Port Authority
Project and Environmental Review Application



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PORT METRO VANCOUVER
HABITAT ASSESSMENT

ANNACIS ISLAND WASTEWATER TREATMENT PLANT
NEW OUTFALL SYSTEM

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December 29, 2017

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1.0 PROJECT OVERVIEW

The Greater Vancouver Sewerage and Drainage District (Metro Vancouver) is currently expanding the Annacis Island Wastewater Treatment Plant (Treatment Plant) to increase secondary-treatment hydraulic capacity. A new diffuser outfall within Annieville Channel of the Main Arm of the Fraser River (Project) is required to replace existing outfall facilities.

This report is a Habitat Assessment in accordance with information requirements of the Project and Environmental Review Process administered by Port Metro Vancouver.

1.1 Project Title

The Project title is:

Annacis Island Wastewater Treatment Plant
New Outfall System

1.2 Project Location

The Project is located between the Annacis Island Waste Water Treatment Plant and the southern shoreline of Annacis Island, with the outfall terminating within Annieville Channel of the Fraser River, immediately downstream of the north pier of the Alex Fraser Bridge, Delta, British Columbia (Figure 1). The geographical coordinates of the approximate centre of the design footprint of the Project are 49°9'30.99" N latitude and 122°56'51.38" W longitude.

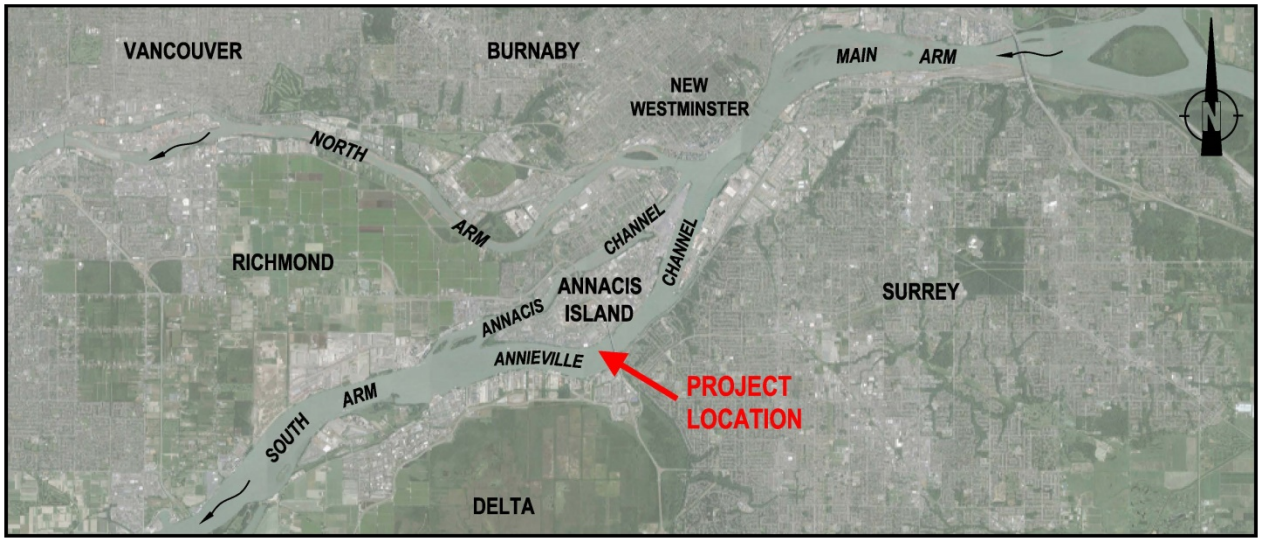

Figure 1. Project Location

2.0 PROJECT DESCRIPTION

Metro Vancouver is currently expanding the Annacis Island Wastewater Treatment Plant (Treatment Plant) to increase secondary-treatment hydraulic capacity. The Treatment Plant currently discharges an average of approximately 483 million litres per day (MLD) of secondary-treated effluent into the Fraser River through the existing outfall to a distance of 160 metres (m) off the southern shoreline of Annacis Island, immediately downstream of the Alex Fraser Bridge. The current peak wet-weather capacity of the Treatment Plant is 1089 MLD. Sewage consists of industrial, commercial and domestic wastewaters.

The Treatment Plant is currently being expanded to increase the hydraulic capacity of secondary treatment. This Stage V expansion will increase the average annual capacity to 732 MLD with a peak wet-weather capacity of 1632 MLD. A new outfall is required as the existing outfall system is unable to sufficiently dilute effluent, particularly during slack tide and low discharge in the river, and lacks sufficient hydraulic capacity to discharge estimated increased flows during high water in the river.

The new outfall will commence at the Treatment Plant and terminate at the edge of the north boundary of the navigation channel within Annieville Channel. The outfall will consist of a 4.2 m diameter pipe extending below ground from the Treatment Plant to a riser located in the river. Diffuser manifold pipes will extend approximately 120 to 150 m upstream and downstream from the riser, for a total of 240 to 300 m, aligned approximately parallel with and immediately shoreward of the northern margin of the navigation channel. These pipes will be buried at a relatively shallow depth; multiple diffusers will rise from the pipes into the water column.

The Project includes several components between the Chlorine Contact Tank (CCT) level control structure on the Treatment Plant site to the outfall diffuser located in the Fraser River (Figure 2):

- a Level Control Structure (LCS) with new level control gates and connection to the exiting CCT;
- an Effluent Shaft which connects the LCS to the Effluent Tunnel;
- an Effluent Tunnel mined at a depth of approximately 30 m between the Effluent and Outfall Shafts;
- an Outfall Shaft for launching the tunnel boring machine (TBM) to excavate the two tunnels, and provide for a future Effluent Pump Station;
- an Outfall Tunnel mined at a depth of approximately 30 meters between the Outfall and Riser Shafts;
- a River Riser structure located in the Fraser River connecting the Outfall Tunnel to the Diffuser Manifold; and,
- a Diffuser Manifold buried in the river bed with risers extending to approximately 1 metre above the river bed.

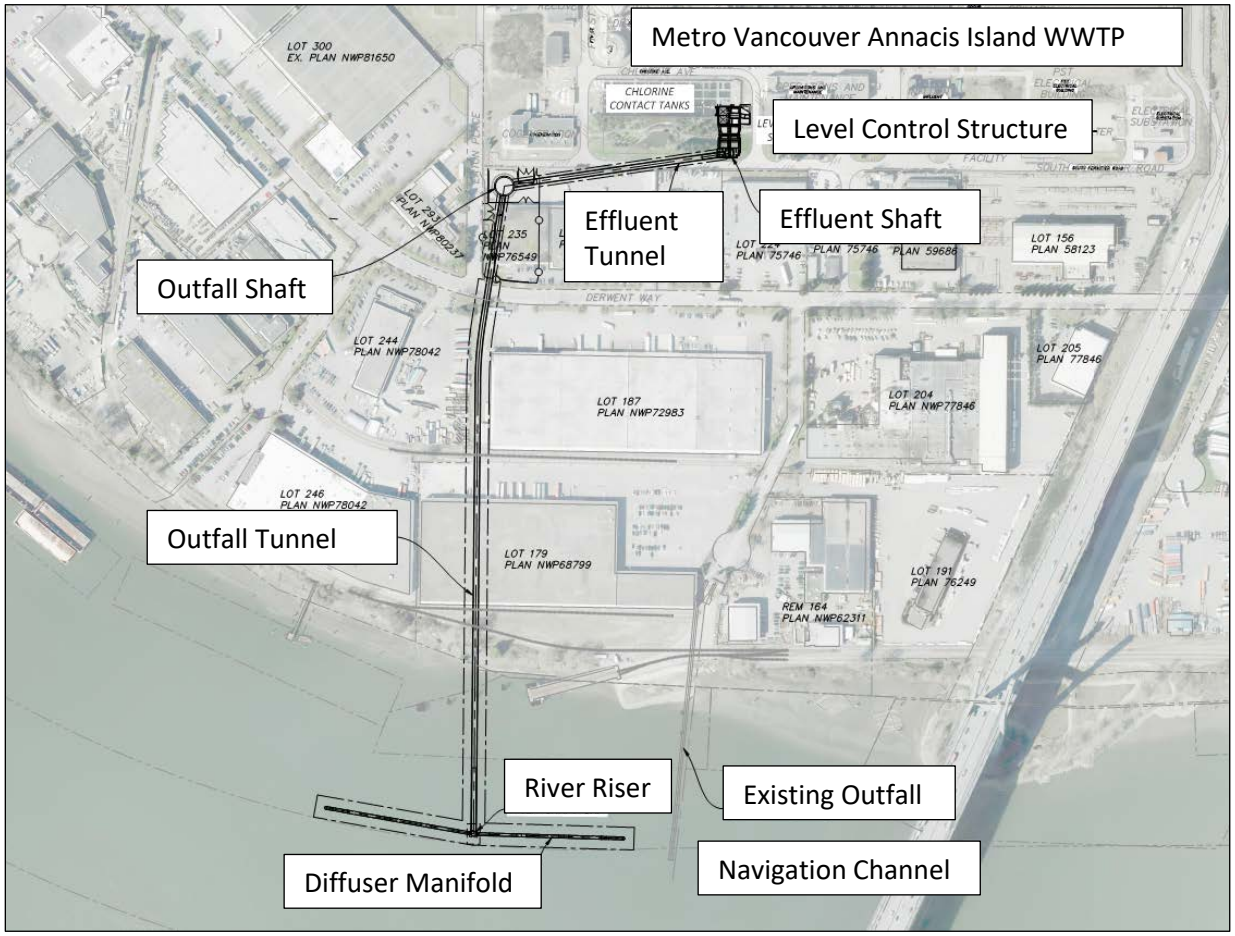

Figure 2. Project Components

Components of the Project are depicted by the following design drawings (CDM Smith Canada ULC; Appendix A):

- Drawing No. A10 X-G-001 “Hydraulic Profile New Outfall System” (Nov.2017);
- Drawing No. A10 X-G0101 “A10 – General Site Works NOS Aerial Map” (Nov.2017);
- Drawing No. A10 X-C0101 “Right of Way Key Plan” (Nov.2017);
- Drawing No. X-A61C0028 “Lot 236 Plan and Isometric” (Nov.2017);
- Drawing No. X-A61C0029 “Lot 187 Plan and Isometric” (Nov.2017);
- Drawing No. X-A61C0030 “Lot 179 Plan and Isometric” (Nov.2017);
- Drawing No. X-A61C0031 “Waterfront Lot Plan” (Nov.2017);
- Drawing No. A61C0001 “A61 – General Site Works Site Plan Sheet Key Map 2” (Nov.2017);
- Drawing No. A61C0002 “A61 – NOS Tunnel Plan and Profile 1” (Nov.2017);
- Drawing No. A61C0003 “A61 – NOS Tunnel Plan and Profile 2” (Nov.2017);
- Drawing No. A61C0004 “A61 – NOS Tunnel Plan and Profile 3” (Nov.2017);
- Drawing No. A61C0005 “A61 – NOS Tunnel Plan and Profile 4” (Nov.2017);
- Drawing No. X-A10C007 “Civil Works – Site Plan Construction Access and Fencing” (Nov.2017);

- Drawing No. X-A10C008 “Civil Works – General Arrangement Construction Staging Area – 1” (Nov.2017);
- Drawing No. X-A61S0081 “Riser Shaft Construction Sequence 1” (Nov.2017);
- Drawing No. X-A61S0082 “NOS Riser Shaft Construction Sequence 2” (Nov.2017);
- Drawing No. X-A61S0083 “Riser Shaft Construction Sequence 3” (Nov.2017);
- Drawing No. A61C0052 “A61 – NOS River Riser Plan Top Level” (Nov.2017);
- Drawing No. A61C0053 “NOS River Riser Section” (Nov.2017);
- Drawing No. A61C0070 “A61 – NOS Diffuser Manifold River Plan” (Nov.2017);
- Drawing No. A61C0071 “A61 – NOS Diffuser Manifold Sections 1 of 3” (Nov.2017);
- Drawing No. A61C0072 “A61 – NOS Diffuser Manifold Sections 2 of 3” (Nov.2017);
- Drawing No. A61C0073 “A61 – NOS Diffuser Manifold Sections 3 of 3” (Nov.2017); and,
- Drawing No. A61C0074 “Diffuser Manifold Details 1” (Nov.2017).

Construction methodologies for each of the Project components are as follows.

2.1 Level Control Structure

The Level Control Structure will be a new reinforced concrete structure attached to and at the same elevation as the existing Chlorine Contact Tanks. The new LCS will consist of a Distribution Channel Area, Flexible Connection Channel, Level Control Gate Area, and Effluent Shaft Top Structure Area. Construction of the LCS will require shallow excavations and conventional reinforce concrete structure construction.

2.2 On-Land Shafts

The on-land shafts (Effluent and Outfall Shafts) will likely be constructed using slurry panels for temporary excavation support. Slurry panels are constructed by excavation of vertical trenches followed by backfilling with concrete to create a vertical panel. Once the slurry panels are completed to form a water tight, circular shoring system, native soils will be excavated from within the shoring, stockpiled on site, and disposed at a permitted upland site. A 1 metre thick cast-in-place concrete lining will be placed to form the permanent structure.

2.3 Outfall Conveyance Tunnels

The installation of the outfall conveyance tunnels will utilize a trenchless methodology, specifically pressurized-face tunnelling using a TBM. The top to the tunnel will be located at a depth of 30 m below land surface and more than 20 m beneath intertidal and nearshore subtidal river bottom, terminating at the location of the river riser.

Conveyance tunnel excavation will be performed with either a slurry pressure balance (SPB) TBM or an earth pressure balance (EPB) TBM. 254 mm thick concrete liner segments will be installed concurrently with tunneling to form the permanent tunnel lining. Activities associated with tunnel excavating include delivery and storage of pre-cast tunnel lining segments; grout and ground conditioning materials; process and ventilation pipe; tunnel train rails or conveyors;

processing of TBM slurry (SPB) or removal of tunnel spoil from the shaft (EPB); and temporary storage of the excavated material on site prior to disposal at a permitted upland site.

The conveyance tunnels will be located within denser Fraser River sand deposits. These deposits have been identified through geotechnical investigation as sufficiently competent material to ensure the new outfall system is functional following design ground motions corresponding to a return period of 2,475 years, the equivalent of a nearby 6.5 to 7.5 Richter scale magnitude earthquake, or an offshore subduction zone 7.0 to 8.0 magnitude earthquake.

2.4 River Riser

The construction methodology for the river riser is presented by Drawing Nos. X-A61S0081 through to X-A61S0083 (Appendix A). The river riser will be installed in isolation of Fraser River waters. This will be achieved through installation of a cofferdam. The cofferdam will extend from the river bed through the water column, above the high-water elevation. The cofferdam will be composed of metal pipe piles and sheet piles; piles will be installed using a vibratory hammer. Completion of the river riser involves removal of river sediments, installation of foundation piling, and backfilling the excavation with concrete encasing a 3.8 metre diameter vertical riser pipe. Once the river riser is completed, the cofferdam will be removed.

2.5 Diffuser Manifold

The diffuser manifold will be installed through dredging a shallow trench in the river bed. It is anticipated that temporary shoring will be utilized to mitigate sloughing of bank sediments into the trench. Drawing No. A61C0073 (Appendix A) provides details regarding a diffuser manifold with shoring.

Dredging will be conducted using a clamshell dredge (i.e. a crane equipped with a clamshell bucket). A clamshell dredge is selected, in part, due to its ability to precisely excavate to the limits delineated by the design. Hydraulic dredges, such as cutterhead suction and hopper dredges, tend to over-excavate, especially where sand is the dominant sediment. The use of a clamshell limits impacts on the river bed associated with construction.

The crane with bucket will be operated from a floating spud-derrick. The bucket is operated through a series of cables fitted to the crane. Dredged material is deposited onto a barge. It is anticipated that a portion of the dredged material will be utilized to restore the river bottom (sediment and elevation) upon completion of the installation of the manifold.

3.0 PROJECT SCHEDULE

Construction of the Project is proposed to commence January 2019, the anticipated date of the commencement of operation of the outfall is August 2021, and completion of the entire Project is expected in early 2022.

A bar chart schedule showing the anticipated duration of construction activities is presented in Figure 3 based on an anticipated start of construction date in January 2019. The tunnel construction activities are shown in orange, on-land shaft construction activities in teal, in-river

construction activities in purple, and the construction activities associated with completion of shaft lining, LCS and connection to the CCTs in green.

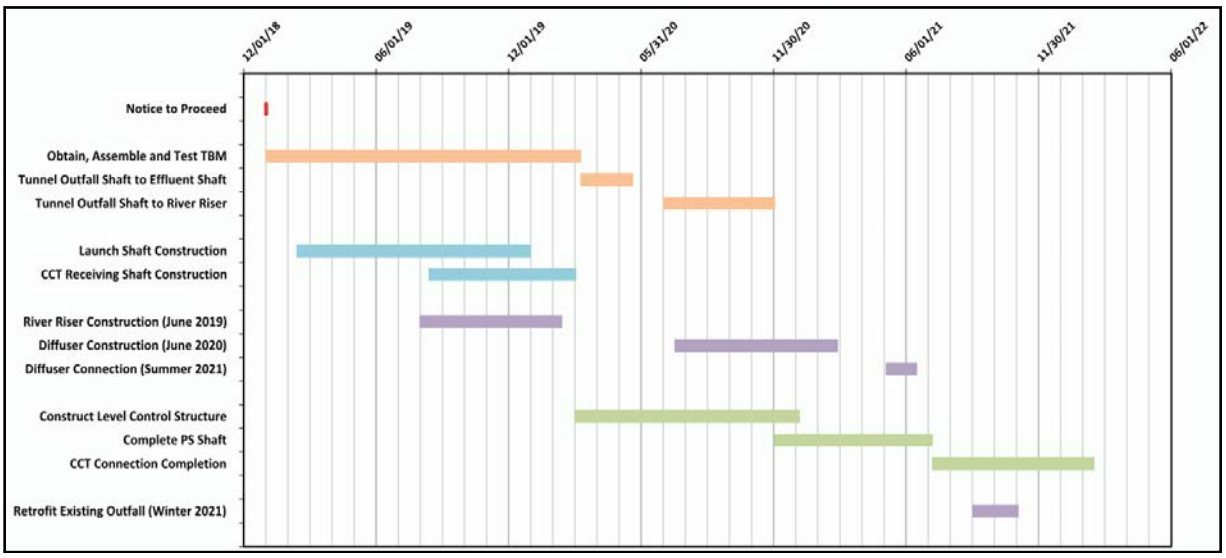

Figure 3. Construction Schedule

The first two in-river seasons (river riser and diffuser construction) will be restricted to the timing window for inwater works of least risk to fish, specifically June 16 through to February 28 (Fisheries and Oceans Canada 2017a).

The second two in-river seasons/activities (diffuser connection and existing outfall rehabilitation) do not involve any disturbance to fish or fish habitat at the river bed, other than short-term, temporary anchoring of spud barges. Although it would be preferable to perform these activities later in the fish window when river flows are lowest, the contractor will be allowed to perform these activities outside the in-river work window as necessary to limit the overall duration and impact of the construction activities.

4.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 Existing Infrastructure

Annacis Island Waste Water Treatment Plant

The Annacis Island Wastewater Treatment Plant is located on the southern part of Annacis, with the existing effluent discharge off the southern shoreline of the island, within Annieville Channel of the Fraser River. The Treatment Plant provides secondary treatment to wastewater for over 1 million residents in 14 municipalities (Metro Vancouver 2017).

The existing outfall is aligned along and immediately downstream of the South Surrey Interceptor. The outfall is comprised of three pipes (two 1676 millimetre (mm) OD pipes and one 1219 mm OD pipe) that extend 165 m into Annieville Channel from the north bank of Annacis Island. Secondary-treated effluent is discharged through seven sets of steel risers that are situated between 105 and 165 m from the north bank (Northwest Hydraulic Consultants Ltd. 2015). The risers consist of 450 mm diameter, 6.1 m high pipes; the top of these pipes are approximately flush with the bed of the channel. There is limited scour protection around the pipes.

The South Surrey Interceptor occurs approximately 500 m downstream of the Alex Fraser Bridge, approximately 190 m upstream of the proposed outfall diffuser. It is a conduit for influent that enters the Treatment Plant. It was constructed in 1974. The Interceptor consists of two 48 inch outside diameter (OD) cement-lined steel pipes and a 36 inch OD steel pipe in an excavated trench that is backfilled with native river bed material. The pipes occurred from 6.0 to 6.4 m below the bed of the river at the time construction was complete.

Riprap scour protection has been added atop the pipes on several occasions, the first time in 1984, and the last time in 1995.

Industrial/Commercial Development

Annacis Island was the first industrial park opened (1955) in Canada (Quasar Design & Data Management Inc. 2017) The 1,200 acre island hosts 430 companies employing more than 10,300 people (Delta Chamber of Commerce 2017). It has both highway and rail access, and has a barge loading facility along its southern shoreline.

Alex Fraser Bridge

The Alex Fraser Bridge occurs upstream of the proposed diffuser outfall. It was constructed in 1984. It is part of Highway 91; the highway has ramp access to Annacis Island.

The bridge has a span of 464 m. The alignment of the bridge is approximately 30 degrees to the alignment of Annieville Channel; the effective waterway opening is 370 m. The channel width upstream and downstream of the bridge is 450 m and 800 m, respectively. The bridge forms a significant constriction to flows within the channel.

The two bridge towers are protected against ship collisions by large sand islands that are armoured with riprap. The islands extend into flows, forming short guide banks. A conspicuous back eddy occurs downstream of the north island, facilitating deposition of sediments and collection of woody debris shoreward of the proposed diffuser outfall location.

Southern Railway Railcar Barge Terminal

The design alignment of the conveyance tunnel engages the distal half of the moorage basin of Southern Railway's railcar barge terminal. The moorage basin is dredged on a regular basis to maintain the design depth of the basin, specifically 6.0 m below chart datum (Pedersen 2005).

4.2 Existing Channel Bed

Intertidal

Intertidal flats occur as a narrow fringe within the design alignment of the effluent pipe. Sediments consist of silts to fine sands. The riverward margin of intertidal flats are demarcated by the moorage basin of Southern Railway's railcar barge terminal.

The flats are particularly wide downstream and upstream of the design alignment of the pipe, as a result of the hydraulic shadows associated with moored chip barges and the north sand island of the Alex Fraser Bridge, respectively. Sediments at lower elevations of the flats are

predominantly silts and fine sands; coarser sands are prevalent at and about the high water elevation where waves frequently break upon bottom sediments.
Intertidal marsh occurs as discontinuous patches along the higher margins of the flats. Characteristic species include spikerush (*Eleocharis palustris*), articulated rush (*Juncus articulatus*), Lyngby's sedge (*Carex lyngbyei*), reed canarygrass (*Phalaris arundinacea*), bentgrass (*Agrostis stolonifera*), American bugleweed (*Lycopus americanus*), knotweed (*Polygonum* sp.), and aster (*Aster* sp.).

Subtidal

The bed elevation at the design location of the diffuser outfall is approximately 10 m below chart datum. Since the construction of the Alex Fraser Bridge, the bed elevation at the design outfall location has varied up to 2 m (Northwest Hydraulic Consultants Ltd. 2015).

The formation and migration of dunes on the channel bottom at and about the location of the outfall diffusers is likely accountable for this variability in bed elevations. Dunes have been observed at the location of the diffusers across a range of observed flows (Northwest Hydraulic Consultants Ltd. 2015). They are transient in nature, with the largest dunes being prevalent during low river discharge, and the smallest dunes associated with high river discharge.

Bottom sediments consist of a range of fine to coarse sands (Golder Associates Ltd. 2017a). These sands are readily transported by flows characteristic of the proposed outfall location, facilitating the formation of dunes observed throughout those parts of the channel within and in proximity to the outfall location (Northwest Hydraulic Consultants Ltd. 2015).

4.3 Hydrology, Hydraulics and Salinity

The Fraser River has a snowmelt-dominated flow regime, with the discharge typically rising in April, peaking between May and July, and then receding during the autumn and winter months (Northwest Hydraulic Consultants Ltd. 2015). The long-term mean flow at Mission is 3200 m^3/s (Northwest Hydraulic Consultants Ltd. 2015). The discharge at Mission for the 20-year return period is estimated at 13,700 m^3/s (Northwest Hydraulic Consultants Ltd. 2015). Monthly average flows from 1965 to 1992 at the Port Mann Pump Station, upstream of Annacis Island, ranged from 1030 m^3/s in winter to 11,900 m^3/s during freshet in early summer (Water Office 2017). The distribution of flows amongst the branches of the lower Fraser River was measured by Public Works Government Services Canada in May-June 2002. (Northwest Hydraulic Consultants Ltd. 2015). The measurements revealed that Annieville Channel carried 80 percent of the flow measured at New Westminster, upstream of the trifurcation of the main stem of Fraser River into the North Arm, Annacis Channel and Annieville Channel.

The variation in mean velocities for the simulated 2012 flood condition at the design location of the outfall, coinciding to a 20-year return period event, ranged from 1.2 m/s to 2.5 m/s (Northwest Hydraulic Consultants Ltd. 2015).

The design location of the outfall occurs within the lower part of the Fraser River estuary. The oceanographic characteristics of the lower part of the estuary are strongly affected by the quantity, quality, and timing of freshwater discharge and by the tides and winds of the Strait of

Georgia (Adams and Williams 2004). Fresh waters of the river are less dense than the salt waters of the strait. As a result, a halocline occurs within the lower estuary.

During a flood tide, salt waters tend to flow upstream beneath the downstream-flowing fresh waters until an equilibrium of vertical pressures is reached (Tamburi and Hay 1978). A curved interface is formed between salt and fresh waters when this equilibrium is reached, forming a salt wedge. The interface touches the bottom when the salt water reaches a point of zero velocity. The position of the salt wedge varies with both tide and freshwater discharge.

The position of the salt wedge occurs upstream of the Alex Fraser Bridge when freshwater discharge is low, typically during winter (Tamburi and Hay 1978). During freshet, from May through to early July, when discharge is highest, the upstream-most position of the salt wedge is often at the delta front (Tamburi and Hay 1978).

4.4 Fish and Fish Habitats

Fisheries Act

The *Fisheries Act* is referenced as a guide to identify species and habitats of management concern, in particular those that support fisheries. The *Act* contains language specific to the protection of fish and fish habitat, and language specific to the discharge of treated effluent. Fish species that have been categorized as species at risk, at both the provincial and federal levels, are identified. They are further considered as species at risk in a separate section specific to this subject.

The *Fisheries Act* prohibits "serious harm to fish" that are part of or support a commercial, recreational or Aboriginal fishery.

> "Serious harm to fish is the death of fish or any permanent alteration to, or destruction of, fish habitat".
>
> As per the *Fisheries Act*, fish include "(a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals".
>
> Fish that are part of a fishery are "fish that may be fished as part of a commercial, recreational or Aboriginal fishery".
>
> Fish that support a fishery are "fish that contribute to the productivity of a commercial, recreational or Aboriginal fishery".
>
> Fish habitat means "spawning grounds and any other areas, including nursery, rearing, food supply and migration areas, on which fish depend directly or indirectly in order to carry out their life history processes".

The *Fisheries Act* prohibits "the deposit of a deleterious substance of any type in water frequented by fish or in any place under any conditions where the deleterious substance or any

other deleterious substance that results from the deposit of the deleterious substance may enter such water".

Deleterious substance means, in part,

"(a) any substance that, if added to any water, would degrade or alter or form part of a process of degradation or alteration of the quality of that water so that is rendered or is likely to be rendered deleterious to fish or fish habitat or the use by man of fish that frequent that water, or
(b) any water that contains a substance in such quantities or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it would, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or the use by man of fish that frequent that water".

The Wastewater Systems Effluent Regulations of the *Fisheries Act*, "apply in respect of a wastewater system that, when it deposits effluent via its final discharge point, deposits a deleterious substance".

The Regulations contain mandatory effluent conditions for specific deleterious substances contained within municipal effluent to be achieved through secondary wastewater treatment. As per the Regulations, effluent conditions according to each of these substances are as follows:

- carbonaceous biochemical oxygen demanding matter – the average carbonaceous biochemical oxygen demand does not exceed 25 milligrams/litre (mg/L);
- suspended solids – the average concentration of suspended solids does not exceed 25 mg/L;
- total residual chlorine - the average concentration of residual chlorine does not exceed 0.02 mg/L, if chlorine in any form is used in the treatment of wastewater; and
- un-ionized ammonia – the maximum concentration of un-ionized ammonia, expressed as nitrogen, is less than 1.25 mg/L at 15 degrees Celsius (^{o}C) +/- 1^{o}C.

Also, effluent can only be discharged if it is not acutely lethal to rainbow trout as determined by standard toxicity test methods specified in the Regulations.

Subsections (1) and (2) of Section 35 of the *Fisheries Act*, with regard to "serious harm to fish" and "exception", respectively, are administered by Fisheries and Oceans Canada. "Exception" presents circumstances whereby "serious harm to fish" may occur, including works, undertakings or activities carried on in accordance with regulations of the *Fisheries Act*.

Subsections (3) and (4) of Section 36 of the *Fisheries Act*, with regard to "deposit of deleterious substance prohibited" and "deposits authorized by regulation", and the Wastewater Systems Effluent Regulation, are administered by Environment and Climate Change Canada.

Fish Species and Habitats

Fish and fish habitats addressed within this section support commercial, recreational or Aboriginal (CRA) fisheries and/or have been categorized as species at risk.

Salmon

Seven (7) species of salmon (*Oncorhynchus* spp.) occur within the lower Fraser River, specifically: chinook salmon (*O. tshawytscha*); chum salmon (*O. keta*); coho salmon (*O. kisutch*); pink salmon (*O. gorbuscha*); sockeye salmon (*O. nerka*); cutthroat trout (*O. clarkii clarkii*); and, steelhead (*O. mykiss*) (Water and Land Use Committee 2006). Adult salmon migrate upstream annually to spawn, and juvenile salmon migrate downstream annually to and through the estuary and ultimately to the sea.

Salmon have been and continue to be important to First Nations for food, social and ceremonial purposes (Fisheries and Oceans Canada 2017b). Tens of thousands of recreational fishers engage in catch and release and retention fisheries throughout British Columbia, a large part of which occur within the Fraser River (Fisheries and Oceans Canada 2017b). Fraser River stocks support several commercial fisheries.

Juvenile downstream migration is associated with spring freshet, which brings flow, sediment, and nutrients to peripheral areas of the active channel (Rempel *et al.* 2012); smolt downstream migration appears to be dependent upon adequate river current (Bjornn and Reiser 1991). Migration occurs rapidly on time scales of days to weeks, with interspecific variability in time required to reach the river mouth (Melnychuk *et al*. 2010). Migration rates also vary with run type, distance from the ocean, date, and fish size (Carter *et al.* 2009).

Juvenile salmon generally move along the shoreline at depths between 0.1 m and 2.0 m (Southard *et al.* 2006).

Juvenile downstream migration is considered a sensitive life stage as localized impacts to the survivorship of juvenile salmon may disproportionately affect specific runs of adult salmon.

Chinook Salmon (*O. tshawytscha*)

The chinook salmon is the largest of the Pacific salmon. A large number of populations characterize Fraser River chinook salmon (Fisheries and Oceans Canada 1999). Fraser chinook stocks are divided into four major geographical complexes. The complexes include the upper Fraser River system (upstream of Prince George), middle Fraser system (downstream of Prince George, excluding the Thompson River), the Thompson River system, and the lower Fraser system , which is largely defined by Harrison River fish (Fisheries and Oceans Canada 1999).

The geographical complexes fit into three seasonal spawning runs. The spring run moves through the lower Fraser River before July 15. Summer chinook migrate through the lower Fraser River between July 15 and September 01. The fall run is largely represented by Harrison River and Chilliwack River chinook that enter the lower Fraser River after September 01 (Fisheries and Oceans Canada 1999). The majority of spawners are 3, 4 and 5 years in age (Fisheries and Oceans Canada 1999).

Spawning typically occurs between August and December (Fisheries and Oceans Canada 1999). Spawning occurs upstream of the area of tidal influence in the river. The Harrison River population represents spawning within the lowest part of the watershed. Most spawning, in contrast, occurs within the middle and upper regions of the watershed (Fisheries and Oceans Canada 1999).
Fry emerge from March through June (Schmidt *et al.* 1979; Fraser *et al.* 1982). Upon emergence, chinook fry slowly migrate downstream (Mattson 1962; Reimers 1968; Lister and Genoe 1970), largely utilizing the lower Fraser River for rearing.

Based on the length of freshwater rearing, chinook fry may follow one of three life history strategies (Fraser *et al.* 1982), specifically:

- "immediate-type", where fry migrate directly to the estuary upon emergence;
- "ocean-type", where fry reside in freshwater from approximately 60 to 150 days before migrating seaward; and,
- "stream-type", where fry reside in freshwater for a year or more before migrating seaward.

Since Fraser *et al.* (1982), the immediate-type has been grouped in with the ocean-type life history strategy (Anonymous 2011). It is now considered a variation of the "ocean-type".

The estuary, that portion of the lower Fraser River, from Mission downstream to the delta front, where maritime influence is prevalent, provides important rearing habitat for juvenile chinook. Juvenile fish utilize a variety of habitat types, including non-natal streams, sloughs, nearshore shallows, and tidal flats, marshes and channels (Dunford 1975; Levy *et al.* 1979; Delaney and Olmstead 1981; Levy and Northcote 1982; P.A. Harder and Associates Ltd. 1988; Murray and Rosenau 1989;).

The age of chinook on spawning grounds within the Fraser River system is typically 4 years (Healey 1991). This is the most abundant age class for male and female ocean-type and male stream-type fish. Five (5) years is the most abundant age class for stream-type females (Healey 1991).

Chum Salmon (*O. keta*)

Chum salmon is the second largest Pacific salmon species (Salo 1991). The largest run of chum in British Columbia occurs in the Fraser River (Grant and Pestal 2009a). Two conservation units have been identified for chum based on life history and lineage (Grant and Pestal 2009a), specifically the Lower Fraser River, and the Fraser Canyon.

Chum salmon are managed as a single run with adult upstream migration occurring between September and December (Grant and Pestal 2009a). Prior to upstream migration, adults may delay at the mouth of the river for up to four weeks (Palmer 1966).

Fraser River adult chum salmon spawn in approximately 110 streams, including the Fraser River mainstem. Over 90 percent of the total production results from major tributaries (Grant and Pestal 2009a). The Harrison/Chehalis/Weaver, the Chilliwack/Vedder, and the Stave watersheds sustain the largest of the Fraser River stocks (Grant and Pestal 2009a). All Fraser River spawning occurs downstream of the Fraser Canyon (Grant and Pestal 2009a). Spawning occurs

between late September and January, peaking in late October (Grant and Pestal 2009a). Spawning in small tributaries typically lasts for two to three weeks whereas in large tributaries spawning can last up to several months (Grant and Pestal 2009a).

Fry typically emerge in February, and subsequently migrate seaward from February through June, with most of the migration during March and April (Todd 1966; Grant and Pestal 2009a).

The Fraser River estuary provides important rearing habitat for juvenile chum salmon. Juveniles may be found within the estuary between March and July. Juvenile fish utilize a variety of habitat types, including nearshore shallows, sloughs, and tidal flats, marshes and channels (Dunford 1975; Levy *et al.* 1979; Delaney and Olmstead 1981; Levy and Northcote 1982; P.A. Harder and Associates Ltd. 1988).

The age of individuals returning to spawn in natal streams ranges from 3 to 5 years (Beacham and Murray 1987).

Coho Salmon (*O. kisutch*)

Coho salmon utilize most coastal streams in British Columbia (Fisheries and Oceans Canada 2013a). Several populations of coho salmon occur in the Fraser River, including the interior Fraser River population. This population is genetically distinct from the lower Fraser River population (COSEWIC 2002).

The interior Fraser River population is designated as "threatened" by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) (Government of Canada 2017a). It is not listed on Schedule 1 of the federal *Species at Risk Act* (SARA) (Government of Canada 2017a). Schedule 1 is the official list of species at risk in Canada.

Coho salmon do not display discrete seasonal runs like other salmon species and, as such, populations of coho of the lower Fraser River are managed as a single entity (Pacific Salmon Treaty 2014).

Coho salmon begin their migration through the lower Fraser River to natal streams between late August and mid-October (Fisheries and Oceans Canada 2015). Spawning occurs between November and January (McPhail 2007). Preferred spawning habitat includes riffles in small streams and the side channels of larger rivers (Interior Fraser Coho Recovery Team 2006). Depth of water (<0.3 metre), gravel diameter (<0.15 metre) and high dissolved oxygen concentrations are all important spawning habitat requirements.

Fry emerge from the gravel the following spring and take refuge in streams (McPhail 2007). Coho fry rarely occur within the lower Fraser River (Fraser *et al*. 1982). Coho typically exhibit a stream-type life history with individuals typically residing in freshwater streams for one year before migrating to the ocean as smolts (McPhail 2007).

Downstream migration of smolts typically occurs between April and late June with peak migration between early May and early June (McPhail 2007). Coho smolts have been captured within the lower estuary from late April through to mid-June, and off Roberts Bank and Sturgeon Bank from mid-May until late August (Fisheries and Marine Service 1975). Utilization of habitats in the lower Fraser River by juvenile coho occurs primarily between March and August,

with the main channel and estuary providing important rearing habitat for juveniles during their downstream migration (Kistritz and Scott 1992). Coho smolts utilize habitat similar to that of juvenile chinook (Rosberg and Byers 1985; Rosberg and Millar 1987).

Adult fish return to natal streams to spawn after spending up to 18 months in coastal inland waters (McPhail 2007).

Pink Salmon (*O. gorbuscha*)

Pink salmon is the most numerically abundant salmon species in BC (Healey 1993) with spawning runs occurring in most rivers and streams along the coast (Riddell and Beamish 2003). Pink salmon are known to spawn closer to the ocean than other Pacific salmon species and are unable to navigate barriers such as waterfalls or cascades (Grant and Pestal 2009b). However, within the Fraser River system, pink salmon do migrate to the Thompson and Bridge river systems, approximately 300 kilometres (km) upstream from the delta front, with individuals reaching the Quesnel River on occasion, representing a migration distance of approximately 690 km (McPhail 2007).

Pink salmon differ from other Pacific salmon species in that they have a fixed two-year life cycle (Grant and Pestal 2009b; McPhail 2007). In odd years, the Fraser River supports the largest run of pink salmon in BC (Grant and Pestal 2009b), with the majority of spawning occurring in the lower river, within tributary watercourses of the estuary to the Fraser Canyon (Fisheries and Oceans Canada 1995). Pink stocks are broadly categorized into early and late runs (McPhail 2007). Early-run pink salmon spawn in upstream tributaries and main stem shoals and bars, while late-run adults typically spawn in tributaries below Hope, particularly in the Harrison and Chilliwack rivers (Fisheries and Oceans Canada 1995; Riddell and Beamish 2003). Most Fraser River pink salmon return to their natal streams during September to October (Grant and Pestal 2009b).

Fry emerge from gravels in early spring between 3 to 5 months after hatching (McPhail 2007). Once surface swimming begins, pink salmon fry quickly migrate downstream. This downstream migration begins as early as late February in the Fraser and lasts until May; the main migration occurs in mid-April (Fisheries and Oceans Canada 1995). Juveniles reach the Fraser River estuary about May and disperse to southern areas of the Strait of Georgia (Grant and Pestal 2009b).

Sub-adults rear in the ocean for approximately 12 to 18 months before beginning their upstream migration to natal streams (McPhail 2007).

Sockeye Salmon (*O. nerka*)

Sockeye salmon is the second most abundant salmon species in British Columbia with approximately 900 unique stocks occurring in the province (Henderson and Graham 1998). The Fraser River is the largest producing system for sockeye salmon in British Columbia (Henderson and Graham 1998).

Adult sockeye migrate through the lower Fraser River between June and November (Cooke *et al.* 2004). Individual Fraser River sockeye salmon populations have particular times for returns or runs (Gable and Cox-Rogers 1993), specifically:

- early Stuart run (June);
- early summer run (July);
- mid-summer run (August); and
- late run (September to November).

The late run includes the Cultus Lake population. This population is designated as "endangered" by the Committee on the Status of Endangered Wildlife in Canada (Government of Canada 2017b). It is not listed on Schedule 1 of the federal *Species at Risk Act* (SARA) (Government of Canada 2017b). Schedule 1 is the official list of species at risk in Canada.

Late run individuals often delay at the river mouth for up to several weeks before migrating upstream; the early and summer runs typically travel upstream without delay (Cooke *et al.* 2004). Since 1995, upstream migrations have been occurring up to six weeks earlier than historically observed (Cooke *et al.* 2004; Johannes *et al.* 2011; Martins *et al.* 2011).

Spawning occurs in Fraser River tributaries between September and December (British Columbia Conservation Data Centre 2016). Sockeye salmon have two typical life history strategies, lake-type and river-type (Johannes *et al.* 2011). River-type sockeye comprise less than 1 percent of the Fraser River sockeye population

The incubation period for sockeye eggs is six to nine weeks (British Columbia Conservation Data Centre 2016). Alevins remain in the gravel after hatching for two to three weeks prior to emerging (British Columbia Conservation Data Centre 2016). River-type individuals migrate downstream immediately after emerging and remain in the lower Fraser River and estuary for two to six months, rearing in creek mouths, sloughs and side channels (Johannes *et al.* 2011). Lake-type individuals spend a year or more in freshwater lakes before migrating downstream (Hoos and Packman 1974), spending between seven and ten days in the lower Fraser River (Johannes *et al.* 2011) before moving seaward. Downstream migration of juvenile sockeye, of both types, occurs largely from April through May (Johannes *et al.* 2011).

Sockeye salmon remain in ocean conditions for one to four years (Henderson and Graham 1998), with return runs exhibiting a four year cycle in abundance (Henderson and Graham 1998; Fisheries and Oceans Canada 2013b).

Coastal Cutthroat Trout (*O. clarkii clarkii*)

Coastal cutthroat trout occur along much of the Pacific Northwest coast and is broadly distributed throughout coastal British Columbia (Costello 2008). Coastal cutthroat trout are known to occupy a wide range of habitats including small streams, large rivers, bogs, sloughs, ponds, large lakes, coastal lagoons, estuaries and ocean beaches (Slaney and Roberts 2005).

Lower Fraser River populations display diverse life history traits and migratory behaviour (Slaney and Roberts 2005). Four life history forms exist, with all forms being supported within the lower Fraser River (Slaney and Roberts 2005). Specifically, these life history forms are:

- resident populations inhabiting small headwater streams (non-migratory);
- fluvial populations that undergo in-river migrations between small tributaries and large mainstem foraging areas;

- adfluvial populations that migrate between lakes and streams for spawning and or foraging purposes; and
- anadromous populations that migrate to the ocean for less than a year before returning to freshwater.

It is predicted that coastal cutthroat trout operate via migratory cycles, with not all individuals in a population restricted to a single cycle (Slaney and Roberts 2005).

Resident coastal cutthroat trout populations reside in the tributaries of the lower Fraser River. Anadromous sea-run populations occur throughout the lower Fraser River system (McPhail 2007). Anadromous trout typically enter freshwater spawning streams during late fall through to early winter (Scott and Crossman 1973), in advance of spawning from December through to May (Trotter 1989). Peak spawning occurs during February (Trotter 1989).

Anadromous trout spend 1 to 4 summers in freshwater before migrating to the ocean. Details of the downstream migration patterns of coastal cutthroat trout in the Fraser River are not well known. In other large Pacific Northwest rivers (e.g. Columbia River), downstream movements of coastal cutthroat trout were greatest during an outgoing tide (Zydlewski *et al.* 2008). Similar to other salmonids, downstream movements also appeared to be influenced by diel cycle, with movements peaking during the hours just after sunrise and just after sunset. In the Columbia River, migrating coast cutthroat trout were observed travelling near the shore, although several individuals were observed to cross the shipping channel and travel in the main channel for several hours (Zydlewski *et al.* 2008).

Coastal cutthroat trout throughout British Columbia is blue-listed by the Province of British Columbia (British Columbia Conservation Data Centre 2017a).

Steelhead Trout (*O. mykiss*)

Steelhead trout is the anadromous form of rainbow trout. Three (3) races of steelhead trout occur within the Fraser River system, specifically coastal-winter, coastal-summer and interior-summer (Anonymous 1998).

Coastal-winter steelhead migrate through the Fraser River to spawning habitats of tributaries from November through to April (Anonymous 1998). Approximately 21 streams of the lower Fraser River support spawning by steelhead (Anonymous 1998).

Only 3 summer runs of coastal-summer steelhead are supported by the Fraser River, namely stocks associated with the Coquihalla River, Chehalis River and Silverhope Creek. Winter runs are also associated with these watercourses. Summer fish ascend streams to spawn from April through to July (Anonymous 1998).

Interior-summer steelhead are organized according to three subcatchments of the Fraser River, specifically the Thompson River, Chilcotin River and west Fraser tributaries (Anonymous 1998).

Movement into the lower Fraser River for Thompson and Chilcotin stocks peaks in early fall (Anonymous 1998). Fish of both stocks often overwinter in larger watercourses before moving upstream to spawn (Anonymous 1998).

West Fraser tributaries steelhead migrate through the Fraser River during fall, with fish overwintering in the mainstem of the Fraser River before moving into spawning tributaries during February through to May (Anonymous 1998).

Fry emerge in late spring or early fall (Quinn 2005). Steelhead typically reside in freshwater from 1 to 3 years before migrating to sea. They typically spend 1 to 3 years at sea before returning to spawn (Quinn 2005). Adults may survive to spawn 2 or more times (Quinn 2005).

Char

Dolly Varden (*Salvelinus malma*)

Dolly Varden is divided into two district forms, specifically the northern form and the southern form, with a third form potentially associated with the Bering Sea (COSEWIC 2010). Little is known about Dolly Varden populations in the lower Fraser River; as such, information from other BC populations is applied to the description for lower Fraser River.

Three life history strategies are utilized by Dolly Varden in BC (McPhail 2007), specifically anadromous, stream-resident, and adfluvial. Anadromous individuals migrate between freshwater and ocean conditions, spending much time in estuaries (McPhail 2007). Stream-residents reside in rivers and streams for their entire lives, and adfluvial individuals reside in lakes for most of their life and spawn in streams (McPhail 2007). Both mature and immature anadromous Dolly Varden have been recorded migrating between freshwater and ocean conditions (McPhail 2007), and as such migration may not be strictly related to reproductive processes but may also be related to feeding opportunities (British Columbia Ministry of Fisheries 1999).

Stream-resident Dolly Varden typically spawn locally whereas anadromous and adfluvial populations migrate upstream to spawning sites (McPhail 2007). Although adfluvial populations have not been directly studied, observations suggest these individuals migrate short distances to spawn (i.e. less than 1 kilometre) (McPhail 2007). Anadromous populations migrate to spawning streams between May and December (British Columbia Conservation Data Centre 2016).

In southern BC, Dolly Varden spawning typically occurs during the fall (McPhail 2007). Anadromous adults, after spawning, overwinter in lakes and move back downstream in spring (McPhail 2007). Fry emerge from gravels from April to May (McPhail 2007).

Stream-resident juveniles prefer shallow, slow moving areas with adequate cover such as pools and side channels (McPhail 2007). Anadromous fry initially stay close to river margins and move into areas of higher water velocities by mid-summer (McPhail 2007). Anadromous parr may migrate to the lower stream reaches in spring and return upstream in late summer to fall (McPhail 2007). These individuals remain in freshwater for three to four years before migrating to estuarine and marine environments (British Columbia Ministry of Fisheries 1999).

Dolly Varden reach sexual maturity between three and six years (McPhail 2007; British Columbia Conservation Data Centre 2016), although for most individuals this occurs after the fifth growing season (McPhail 2007). Southern form adults may spawn every year after reaching

maturity (British Columbia Ministry of Fisheries 1999). The life span of Dolly Varden is estimated to be ten to twelve years (British Columbia Conservation Data Centre 2016).

Bull Trout (*S. confluentus*)

Populations of bull trout are divided into five geographical units (COSEWIC 2012a), specifically:

- south coast British Columbia populations;
- western Arctic populations;
- upper Yukon populations;
- Saskatchewan – Nelson rivers populations; and,
- Pacific populations.

The lower Fraser River population is included within the south coast British Columbia populations. Bull trout comprising south coast British Columbia populations has been designated as a species of "special concern" (Government of Canada 2017c). It is not listed on Schedule 1 of SARA (Government of Canada 2017c). It is not listed on Schedule 1 of SARA (Government of Canada 2017c). Schedule 1 is the official list of species at risk in Canada. Bull trout throughout British Columbia is blue-listed by the Province of British Columbia (British Columbia Conservation Data Centre 2017a).

Four life history strategies are utilized by bull trout in BC (McPhail 2007), specifically anadromous, stream-resident, adfluvial and fluvial. The anadromous form is restricted to southwestern British Columbia (McPhail 2007), an area likely analogous to the geographical area inhabited by the south coast populations identified by COSEWIC (2012a).

Anadromous individuals move between freshwater and the ocean. The entire life history of stream-residents occur within small rivers and streams. Adfluvial individuals occur within lakes and the lower reaches of associated large rivers, migrating to streams to spawn (McPhail 2007). The fluvial form resides in large river systems, embarking on extensive migrations to spawn in smaller tributary rivers (McPhail 2007).

Bull trout spawn from September to October (McPhail and Baxter 1996). Fluvial individuals commence their migration to spawning grounds during late August (McPhail 2007). Adfluvial individuals commence their migration in late summer to early fall (McPhail 2007). The migration patterns of anadromous individuals are poorly documented; bull trout may display a migration similar to its very close relative, Dolly Varden; anadromous Dolly Varden migrate to spawning streams between May and December (British Columbia Conservation Data Centre 2016).

In the wild, fry emerge approximately 220 days after egg deposition (Fraley and Shepard 1989). Fry are day active and closely associated with shallows along the margins of streams and rivers. The rearing phase of bull trout is typically 2 to 4 years (McPhail 2007).

Bull trout reach sexual maturity between 3 and 8 years (McPhail and Murray 1979; Fraley and Shepard 1989; Rieman and McIntyre 1996). Bull trout spawn more than once, however, in contrast to Dolly Varden that spawn every year (British Columbia Ministry of Fisheries 1999),

they may not spawn every year (Pollard and Down 2001; Johnston and Post 2009). The typical life span is unknown, but a maximum age of 24 years has been recorded (COSEWIC 2012a).

Smelt

Eulachon (*Thaleichthys pacificus*)

Eulachon is an anadromous smelt occurring along the Pacific coast of North America from Alaska to southern California (McPhail 2007). Eulachon spends over 95 percent of its life at sea (COSEWIC 2011), and spawns in the lower reaches of typically glacier-fed rivers that experience spring freshets (McPhail 2007). Within British Columbia, eulachon occurs in at least 38 rivers (COSEWIC 2011), but spawns in only 12 to 20 rivers including the lower Fraser River (McPhail 2007).

Eulachon spawns in the lower Fraser River in April and May (McPhail 2007). Most spawning occurs between Mission and Chilliwack (approximately 60 to 120 km upstream), where the substrate changes from silt and sand to gravel (McPhail 2007). Further downstream, near the confluence of the Fraser and Pitt rivers, eulachon spawning habitat is characterized by substrates of fine-to-medium sands and coarse sands with pebbles, depths of 5 to 10 m, and maximum current speeds of 0.3 to 0.7 m per second (m/s) (Plate 2009). Spawning locations downstream of Mission are determined by the availability of appropriate spawning substrate. Locations targeted by Fisheries and Oceans Canada for eulachon egg and larval out-drift sampling in recent years include Deas Island, Tilbury Island, New Westminster, Barnston Island, Iona Island, the upper North Arm, and the lower Pitt River area (McCarter and Hay 2003). Spawning stock biomass during sampling from 1995 to 2012 was typically much higher in the South Arm than in the North Arm (Fisheries and Oceans Canada 2014a).

Adult eulachon use migration corridors within the river to reach spawning locations. Migration corridors occur in side channels and the main channel of the river, including near structures such as bridges (Plate 2009). Eulachon appear to congregate in estuaries prior to migrating upriver to spawning locations (McPhail 2007).

Juvenile eulachon appear to disperse into marine waters within their first year of life. The juvenile migration portion of the eulachon life cycle is poorly understood (McPhail 2007).

Eulachon are an important, energy-rich prey species in the springtime for marine and freshwater fishes, mammals and birds (COSEWIC 2011). Timing of the eulachon run coincides with otherwise seasonally low prey availability, and predation is heavy during pre-spawning aggregations in the lower reaches of rivers (COSEWIC 2011).

Eulachon populations have declined along the Pacific coast of North America in recent decades (McPhail 2007). Eulachon throughout British Columbia is blue-listed by the Province of British Columbia (British Columbia Conservation Data Centre 2017a). The Fraser River population has been designated “endangered” by the Committee on the Status of Endangered Wildlife in Canada (Government of Canada 2017d). It is not listed on Schedule 1 of SARA (Government of Canada 2017c). Schedule 1 is the official list of species at risk in Canada.

Sturgeon

White Sturgeon (*Acipenser transmontanus*)

White sturgeon is a large freshwater fish whose marine distribution spans the Pacific Coast of North America from Alaska to California. Spawning populations are known only from the Sacramento-San Joaquin, Columbia, and Fraser river systems. Within the Fraser River system, white sturgeon occurs within the estuary to upstream of Prince George, as well as in the Nechako River from its confluence with the Fraser River to upstream of Vanderhoof. White sturgeon also occurs in large lakes associated with these two rivers (McPhail 2007).

White sturgeon spawn in June and July in the Fraser River between Hope and Chilliwack (McPhail 2007). Sturgeon do not spawn every year, and spawning migrations are not conspicuous due to the length of the spawning season and small number of spawners (McPhail 2007).

Late juvenile (over two years) and adult white sturgeon habitat is typically located in large rivers, large natural lakes, and large reservoirs (COSEWIC 2012b). River habitat is typically characterized by deep waters with backwater and eddy flow characteristics, adjacent to heavy flows, with a sand and fine gravel substrate (Fisheries and Oceans Canada 2014b). Within the Fraser River, adult white sturgeon are present in the main channel for much of the year, moving upstream to spawn and downstream to exploit seasonal food availability (Nelson *et al.* 2004). Downstream of Mission, the substrate is characterized by sandy silt, with water depths of 10 to 20 m and turbid water (Nelson *et al*. 2004). Adult sturgeon spend the winter (October to March) in a low-activity state in deep, low-velocity locations (Nelson *et al*. 2004). Adults occasionally occur within brackish waters of the lower estuary and may spend extended periods in the marine environment (McPhail 2007).

Little is known about juvenile (less than two years) white sturgeon habitat in British Columbia, but evidence suggests that juveniles are typically associated with areas of slow to moderate water velocities, in areas such as the lower reaches or confluence points of tributaries, large backwaters, side channels, and sloughs (Lane and Rosenau 1995). Water depth and substrate are varied (Lane and Rosenau 1995). Juveniles leave these areas, most likely for the main channel, once water temperatures fall below 13 to 15 °C (Lane and Rosenau 1995).

Juvenile white sturgeon have been documented to occur in proximity to the outfall location (Glova *et al.* 2008; Glova *et al.* 2009). Significant catches of juvenile (> 5 individuals) occurred immediately downstream of the north sand island tower footing of the Alex Fraser Bridge, and at and about the confluence of Annacis and Annieville channels, in proximity to Purfleet Point, and Don and Lion islands. Juvenile sturgeon occurred predominantly nearshore.. The bulk of sampling in 2007-08 occurred during September through November 2007 (Glova *et al.* 2008), while sampling in 2008 occurred during June, July and September 2008 (Glova *et al.* 2009).

The lower Fraser River population of white sturgeon is red-listed by the Province of British Columbia (British Columbia Conservation Data Centre 2017a). The population has been designated “threatened” by the Committee on the Status of Endangered Wildlife in Canada (Government of Canada 2017e). It is not listed on Schedule 1 of SARA (Government of Canada 2017e). Schedule 1 is the official list of species at risk in Canada. Loss of habitat quality and

quantity is identified by the federal Recovery Strategy (Fisheries and Oceans Canada 2014b) as posing a high relative risk to this population and its habitat.

Green Sturgeon (*Acipenser medirostris*)

Green sturgeon occurs along the entire coast of British Columbia (Fisheries and Oceans Canada 2016). Green sturgeon may be more abundant within coastal waters of northwestern Vancouver Island than elsewhere in coastal British Columbia (Erickson and Hightower 2007).

Green sturgeon are rarely encountered in the Fraser River, with three confirmed reports at and about McMillan Island associated with the Albion Test Fishery (Logan 2013), and three likely and three possible associated with sport fishers and researchers (Nelson 2013). There is no evidence of green sturgeon spawning in the Fraser River (Moyle 2002).

If green sturgeons occur within the Project area, they would occur as sub-adults or adults. Sub-adults and adults may occur on non-natal estuaries for periods of several months (Adams *et al.* 2007; Lindley *et al.* 2011). Feeding may not occur during these periods, as such green sturgeon captured had empty stomachs (Adams *et al.* 2007). Residence within estuaries may be attributable to physiological requirements, such as osmoregulation (Sulak and Randall 2002).

It is unlikely that green sturgeons within the Project area, where the salt wedge is transitory, are not feeding. The osmoregulatory system of such fish should be sufficiently advanced to allow fish to readily pass from brackish to fresh waters. If indeed such fish are feeding, their feeding ecology should be similar to that of white sturgeon (COSEWIC 2004).

Green sturgeon is red-listed by the British Columbia Conservation Data Centre (2017b). It has been designated as a species of "special concern " by the Committee on the Status of Endangered Wildlife in Canada (Government of Canada 2017f). It is listed on Schedule 1 of SARA as a species of "special concern" (Government of Canada 2017f). Schedule 1 is the official list of species at risk in Canada.

4.5 Wildlife and Wildlife Habitats

The description of wildlife and their habitats is restricted to mammals and birds that are anticipated to occur in proximity to the design location of the outfall.

Terrestrial wildlife habitats in proximity to the outfall include anthropogenic features (e.g. Alex Fraser Bridge, rail line), a narrow fringe of riparian woodland, and the upland margin of intertidal marsh. These habitats occur within and adjacent to the operational footprints of a rail line, a barge loading facility, and the Alex Fraser Bridge.

Aquatic wildlife habitats in proximity to and within the design location of the outfall include intertidal flats, the water's surface, and the water column of Annieville Channel.

Mammals

Marine Mammals

Marine mammals expected to occur in Annieville Channel include Steller sea lion (*Eumetopias jubatus*) and Harbour seal (*Phoca vitulina*). California sea lion (*Zalophus californianus*) congregate at Sandheads near Steveston, Richmond, and may occasionally travel up the Fraser River into Annieville Channel.

Steller sea lions spend the majority of time in marine waters or at terrestrial rookeries and haul-out sites, but occasionally enter freshwater environments (COSEWIC 2013). Use of the lower Fraser River by this species includes feeding congregations in the river during spring eulachon runs (Bigg 1985) and occasional rafting behaviour up to 35 km upstream of the mouth of the river (Olesiuk 2011). Elsewhere in British Columbia, Steller sea lion have been observed to congregate in the estuaries to feed on pre-spawning adult salmon (Bigg *et al*. 1990).

Harbour seals occur in all coastal waters, some lakes, and many rivers, including the Fraser River upstream to Hell's Gate (Ford 2014). Preferred haul-out sites include tidal mud flats, sand bars, reefs, and log booms (Ford 2014). Harbour seals are essentially non-migratory, but move locally in association with tides, food, reproduction, and season (Ford 2014). The species is a generalist predator, consuming a range of fishes, invertebrates, and birds (Ford 2014). Within rivers and estuaries during summer and fall, pre-spawning adult salmon can form a significant portion of the harbour seal diet (Ford 2014).

California sea-lions occur in British Columbia between late fall and spring, co-occurring with Steller sea lions at haul-outs or in rafts at the water surface. Most British Columbia occurrences are on the west coast of Vancouver Island and in the Strait of Georgia (Ford 2014). California sea lion is an opportunistic predator, consuming a wide range of fishes and invertebrates according to local availability. Food items occurring within the Fraser River are primarily fish, including but not limited to salmon and eulachon (Ford 2014). Feeding congregations and upriver rafting behaviour occurs in association with these behaviours in Steller sea lions, as this species was observed in April 1984 approximately 50 km up the Fraser River (Bigg 1985).

Non-marine Mammals

Ten (10) native mammal species likely occur within and in proximity to the design location of the outfall.

Coyote (*Canis latrans*) is a terrestrial, mainly crepuscular and nocturnal predator that is typically associated with open or relatively treeless areas, but which has become common in urban areas, including riparian areas, parks, vacant lots, and roadside strips (Hatler *et al.* 2008). Evidence of coyote presence has been detected by Envirowest along the Fraser River within 5 km of the outfall (Fairhurst 2017). Coyote resting sites are located in open areas or beneath trees or other structures. Maternal denning habitat includes, among other habitats, dense thickets (Hatler *et al.* 2008). Typical prey items are small to medium-sized mammals, but coyote also opportunistically consumes fruits and seeds, invertebrates, reptiles, amphibians, birds and their eggs and young, aquatic organisms (e.g. fish, tadpoles, and crayfish), domesticated animals, and garbage (Hatler *et al.* 2008). Habitat use by coyote in proximity to the outfall may include

resting, foraging, and traveling in the rail corridor, and resting, foraging, and denning within vegetated riparian areas.

Raccoon (*Procyon lotor*) is a terrestrial, mainly nocturnal and crepuscular, opportunistic omnivore that is typically associated with forested areas near water, but which occurs at high densities in relatively unforested urban areas such as the Lower Mainland (Hatler *et al.* 2008). Raccoon has been detected by Envirowest along the Fraser River within 5 km of the Project area (Fairhurst 2017). Locations used by urban raccoons for daily resting and maternal denning are associated with buildings and other anthropogenic structures such as culverts and debris piles; naturally occurring locations used in wooded areas include tree cavities and hollow logs. Foraging habitat is typically associated with water (wetlands, riparian areas, beaches and estuaries). Typical food items include carrion, garbage, nuts, grains, fruits, and small animals (e.g. invertebrates, fish, amphibians, reptiles, small mammals, and bird eggs and young) (Hatler *et al.* 2008). Habitat use by raccoon in proximity to the outfall may include foraging in all terrestrial areas, and denning amongst anthropogenic structures, such as buildings.

North American river otter (*Lontra canadensis*) is a semiaquatic, mainly nocturnal carnivore that occurs within and about rivers and estuaries, as well as streams, ponds, lakes and marshes (Hatler *et al.* 2008). Evidence of otter presence has been detected by Envirowest along the Fraser River within 5 km of the outfall (Fairhurst 2017). Locations used for daily resting and maternal denning include abandoned lodges and burrows of beavers and other animals, natural cavities (e.g. under roots of large trees or in hollow logs), and within the voids of large boulder rubble. Foraging locations include slow-moving water (beaver ponds, eddies, backwater sloughs, and pools). Fish are the primary prey of river otter; other prey items include waterbirds, small mammals, amphibians, reptiles, and invertebrates (Hatler *et al.* 2008). Habitat use by river otter within and in proximity to the design location of the outfall may include foraging in and alongside the river channel, and denning in bank riprap.

Ermine (*Mustela erminea*) is a small terrestrial, mainly nocturnal carnivore occurring in habitats dominated by trees and shrubs and forest edges, including riparian areas; habitat preferences appear to favour young forests. Locations used for daily resting and maternal denning include rodent burrows and cavities within rock or debris piles, trees, or logs. Prey items are primarily small mammals (mainly voles and lemmings), but also include native and domesticated birds (including eggs and nestlings), amphibians, fish, and invertebrates (Hatler *et al*. 2008). Habitat use by ermine in proximity to the outfall may include denning in bank riprap, and foraging along the margins of the river channel.

Mink (*Neovison vison*) is a small semiaquatic, mainly nocturnal carnivore occurring near water (Hatler et al. 2008). Mink has been detected by Envirowest along the Fraser River within 5 km of the outfall (Fairhurst 2017). Locations used in freshwater (non-coastal) habitats in British Columbia for daily resting and maternal denning include natural cavities (in hollow logs or stumps, under tree roots, in debris piles, or among rock rubble), abandoned lodges and burrows of beavers and other species, and amongst anthropogenic structures (e.g. areas below buildings, bridges and wharfs, or in boats). Foraging in freshwater habitats is primarily near shorelines except in areas where water features are abundant on a landscape level. Foraging locations include the water and riparian areas of ditches, streams, and rivers; wetlands; and shores of ponds and lakes characterized by significant cover by aquatic and marsh vegetation or terrestrial plants and a structurally complex near-ground environment (e.g. boulders, exposed tree roots, or woody debris). Prey items include small mammals, birds, amphibians, reptiles, and invertebrates

(Hatler *et al*. 2008). Habitat use by mink in proximity to the outfall is expected to include denning in bank riprap, and foraging along the margins of the river channel.

Striped skunk (*Mephitis mephitis*) is a terrestrial, mainly nocturnal opportunistic omnivore that in British Columbia typically occurs in edge habitats, wetlands, meadows, riparian areas, and around streams, lakes and ponds, but is also common in urban areas. Locations used for daily resting during spring and fall, and for maternal denning, include spaces in or under hollow trees and logs, in rock and debris piles, skunk or other mammal burrows, and anthropogenic structures such as buildings or culverts. Winter dens, often used communally, are typically located in burrows or under buildings. Foraging occurs above ground and sometimes includes wading in shallow water. Food items are primarily insects, but also include small mammals, bird eggs and nestlings, amphibians, crayfish, carrion, fruits, garbage, and grain crops (Hatler *et al*. 2008). Habitat use by striped skunk in proximity the outfall is expected to include foraging in terrestrial areas, and denning amongst anthropogenic features including bank riprap.

American beaver (*Castor canadensis*) is an aquatic, crepuscular, herbivorous rodent associated with lakes, ponds, marshy areas and slow-flowing streams with abundant woody plants (Nagorsen 2005). American beaver has been detected by Envirowest along the Fraser River within 5 km of the Project area (Fairhurst 2017). Overwintering, breeding and resting occur in lodges constructed from peeled sticks and mud, or in excavated burrows in banks or along streams. Travel occurs primarily by water and foraging occurs on land. Food items include the leaves, twigs and bark of herbaceous and woody plants (Nagorsen 2005). Habitat use by beaver within and in proximity to the design location of the outfall is expected to include foraging within riparian woodland and area and travel throughout the river channel.

Common muskrat (*Ondatra zibethicus*) is an aquatic, mainly nocturnal, omnivorous rodent associated with small lakes, ponds, marshes, slow streams, sloughs, drainage ditches, dikes, and brackish estuaries. Dwellings comprise either excavated burrows in slough, ditch, dyke, stream or lake banks, or lodges constructed of roots and stems. Foraging occurs in water and food items include aquatic plants' stems, leaves, shoots, roots and tubers; other food items include agricultural crops, invertebrates, and young birds. Habitat use by muskrat within and in proximity to the design location of the outfall is expected to be limited to foraging within a constructed marsh located upstream of the outfall, at and about the pier footing of the Alex Fraser Bridge, and to dispersal through the aquatic environment during spring and summer.

North American deermouse (*Peromyscus maniculatus*) is a terrestrial, nocturnal, omnivorous small rodent with broad habitat associations that include shrub thickets and grassy areas as found in the vicinity of the Project. Denning occurs in tree cavities or nest boxes; under logs, stumps, and woody debris; or at the base of trees. Food items include tree seeds, shrubs, grasses, and invertebrates (Nagorsen 2005). Habitat use by deermouse in proximity to the outfall is expected to include denning within vegetated riparian areas and foraging within riparian areas, including the rail corridor.

Cinereus shrew (*Sorex cinereus*) is a terrestrial, small insectivore with broad habitat associations including forests, meadows, avalanche slopes, riverbanks, lakeshores, bogs, and birch-willow thickets. Activity occurs throughout the day but peaks at night (Nagorsen 1996). Nests are located under logs, between rocks, or in burrows (Eder and Pattie 2001). Food items include a wide variety of invertebrates, as well as fungi (Nagorsen 1996). Habitat use by cinereus shrew in

proximity to the outfall is expected to include nesting and foraging within vegetated riparian areas.

Impacts to these species caused by proposed works are not anticipated, as their habitat use is limited primarily to terrestrial areas and/or portions of the river proximal to the riverbank.

Birds

Terrestrial Habitats

Bird nesting is expected to occur in proximity to the design location of the outfall, upon anthropogenic structures (e.g. buildings, towers, superstructure of the Alex Fraser Bridge), on the ground at and about the rail and the pier footing of the Alex Fraser Bridge, within riparian woodlands, and within the upland fringes of intertidal marshes.

Birds characteristic of this section of the Fraser River that nest on anthropogenic structures include glaucous-winged gull (*Larus glaucescens*), violet-green swallow (*Tachycineta thalassina*), cliff swallow (*Petrochelidon pyrrhonota*), barn swallow (*Hirundo rustica*), European starling (*Sturnus vulgaris*), and rock pigeon (*Columba livia*). Glaucous-winged gull, European starling, and rock pigeon are year-round residents in the Lower Mainland (the latter two being non-native species), whereas the three swallow species are seasonal residents during the nesting season (eBird Canada 2017). Glaucous-winged gull is known to nest on rooftops, whereas the other species nest on other building surfaces (Davidson *et al*. 2015).

Locally typical birds that can be expected to nest within and along the edges of the riparian woodland include bald eagle (*Haliaeetus leucocephalus*), mallard (*Anas platyrhynchos*), northwestern crow (*Corvus caurinus*), downy woodpecker (*Picoides pubescens*), Anna's hummingbird (*Calypte anna*), tree swallow (*Tachycineta bicolor*), black-capped chickadee (*Poecile atricapillus*), bushtit (*Psaltriparus minimus*), song sparrow (*Melospiza melodia*), white-crowned sparrow (*Zonotrichia leucophrys*), spotted towhee (*Pipilo maculatus*), American robin (*Turdus migratorius*), Wilson's warbler (*Cardellina pusilla*), yellow-rumped warbler (*Setophaga coronata*), yellow warbler (*Setophaga petechia*), and house finch (*Haemorhous mexicanus*). All of these species are year-round residents in the Lower Mainland, with the exception of yellow warbler, which is a seasonal resident during the nesting season (eBird Canada 2017). Cavity-nesting species include downy woodpecker, tree swallow, and black-capped chickadee. Tree-nesting species that are not cavity-nesters include bald eagle, northwestern crow, Anna's hummingbird, bushtit, American robin, yellow-rumped warbler, and house finch. Shrub-nesting species include Anna's hummingbird, song sparrow, Wilson's warbler, and yellow warbler. Ground-nesting species include mallard, white-crowned sparrow, spotted towhee, and Wilson's warbler (Davidson *et al.* 2015).

Locally typical birds that nest on open ground include spotted sandpiper (*Actitis macularius*) and killdeer (*Charadrius vociferus*). Both species occur within the Lower Mainland year-round, but spotted sandpiper is most common during the nesting season (eBird Canada 2017). Spotted sandpiper nests near shorelines within semi-open habitat, whereas killdeer nests in gravelly open areas (Davidson *et al.* 2015).

Locally typical birds that nest in marsh vegetation along the riverbank include marsh wren (*Cistothorus palustris*) and red-winged blackbird (*Agelaius phoeniceus*). Both species are year-round residents in the Lower Mainland (eBird Canada 2017).

Aquatic Habitats

River-foraging birds characteristic of this section of the Fraser River, whose foraging habitat includes the aquatic portion of the Project footprint, include raptors, dabbling ducks, diving ducks, geese, seabirds, herons, and shorebirds. The primary raptor expected to fish within the vicinity of the Project is bald eagle. Typical dabbling ducks include mallard, green-winged teal (*Anas crecca*), American wigeon (*Anas americana*), northern pintail (*Anas acuta*), and gadwall (*Anas strepera*). Typical diving ducks include common goldeneye (*Bucephala clangula*), bufflehead (*Bucephala albeola*), common merganser (*Mergus merganser*), and hooded merganser (*Lophodytes cucullatus*). Typical geese include Canada goose (*Branta canadensis*). Typical seabirds include glaucous-winged gull and double-crested cormorant (*Phalacrocorax auritus*). Typical herons include great blue heron (*Ardea herodias* ssp. *fannini*). Typical shorebirds include greater yellowlegs (*Tringa melanoleuca*).

The above-water foraging habitat for aerial insectivores also extends into the Project footprint within the river. Locally nesting bird species including violet-green swallow, cliff swallow, barn swallow, and tree swallow hunt insect prey over the river surface.

4.6 Species at Risk

Species of management concern are identified in the context of provincial and federal ranking systems. Provincial rankings are undertaken by the British Columbia Conservation Data Centre (CDC). Federal rankings are undertaken by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC),

Provincial Rankings

The provincial ranking system applies to species and ecological communities that have been assessed by the CDC. The CDC also publishes a list of ecological communities-at-risk in order to prioritize ecological communities for conservation. The CDC maintains dynamic tracking lists of native species and ecological communities that occur within British Columbia, and assigns each species and ecological community a Conservation Status Rank indicating the level at which they are at risk of being lost

The CDC rankings serve two purposes: first, they assist in the setting of conservation priorities and provide a simplified view of the conservation status of species and ecological communities. Second, they help identify species and communities to be considered for formal designation as Endangered or Threatened under the *Wildlife Act* (British Columbia Ministry of Environment 2016a).

Based on their Conservation Status Ranks, the CDC assigns species and ecological communities to the provincial Red, Blue or Yellow lists. The Red list is defined as a list of "ecological communities, indigenous species and subspecies in British Columbia that are at the greatest risk of being lost" (British Columbia Ministry of Environment 2016b). The Blue list is defined as a

list of “ecological communities, indigenous species and subspecies in B.C. that are of special concern (formerly vulnerable)” (British Columbia Ministry of Environment 2016b). The Yellow list is defined as a list of “ecological communities and indigenous species in B.C. that are at the least risk of being lost” (British Columbia Ministry of Environment 2016b).

Federal Rankings

The Canada *Species at Risk Act* (SARA) was proclaimed with the specific intent of protecting wildlife species-at-risk in Canada. Within SARA, COSEWIC was established as an independent body of experts responsible for identifying and assessing species considered to be at risk. COSEWIC currently addresses all native mammals, birds, reptiles, amphibians, fish, arthropods, molluscs, vascular plants, mosses and lichens (COSEWIC 2016).

The identification and assessment of species considered to be at risk is the first step towards protecting species-at-risk. Species that have been designated by COSEWIC may qualify for legal protection and recovery under SARA. It is the responsibility of the federal Minister of Environment and Climate Change (the Minister responsible for SARA) to assign legal protection of species designated by COSEWIC. This involves listing the species in Schedule 1 of SARA. Species included in Schedules 2 and 3 are candidates for inclusion in Schedule 1, following further assessment.

Schedule 1 of SARA formally designates species as being Extirpated, Endangered, Threatened, or of Special Concern. Schedule 2 and Schedule 3 include species that have been tracked by COSEWIC prior to the proclamation of SARA, yet require reassessment using the latest assessment criteria before being listed on Schedule 1.

Section 32 of SARA protects individuals of Schedule 1-listed Extirpated, Endangered and Threatened wildlife when they are aquatic species included in the Federal *Fisheries Act* or migratory birds protected by the *Migratory Birds Convention Act, 1994*, or when they are on federal lands or have been subject to an order made by the Governor in Council. An ‘individual’ is defined by Section 2 of SARA as “an individual of a wildlife species, whether living or dead, at any developmental stage and includes larvae, embryos, eggs, sperm, seeds, pollen, spores and asexual propagules.”

Section 33 of SARA protects the residences of Schedule 1-listed Endangered and Threatened wildlife species when they are aquatic species or migratory birds protected by the *Migratory Birds Convention Act, 1994*, or when they are on federal lands or have been subject to an order made by the Governor in Council. A ‘residence’ is defined by Section 2 of SARA as “a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating.”

Section 36 of SARA provides for protections outlined above for federally listed species to certain provincially listed species-at-risk on federal lands. These species are currently limited to sea otter (*Enhydra lutris*), Vancouver Island marmot (*Marmota vancouverensis*), burrowing owl (*Athene cunicularia*), and American white pelican (*Pelecanus arythrorhynchos*).

Section 58 of SARA protects critical habitat of Schedule 1-listed Endangered and Threatened species, and some Extirpated species. Section 2 of SARA defines 'critical habitat' as "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species." Protection of critical habitat is provided on federal land, off federal land for aquatic species and migratory birds included in Schedule1 of the SARA, and off federal land where ordered by the competent minister.

Assessment Criteria

A list of species of management concern possibly occurring within the proposed works area was generated by reviewing species-at-risk listed by the CDC as occurring within the Metro Vancouver Regional District. The initial list was refined to include only those species listed by the CDC as occurring in the CWH or CDF biogeoclimatic zone. When subzone associations were specified by the CDC, the list was refined to exclude species that do not occur in the subzone describing Annacis Island (CWHxm1) or immediate surrounding areas (CDFmm or CWHdm) (British Columbia Ministry of Environment 2016c). The list was further refined to exclude species restricted to broad habitat types (e.g. old-growth forest) that do not occur within the Project area (British Columbia Ministry of Environment 2016c). Finally, the list was refined to include only species-at-risk whose habitat requirements at critical life stages (e.g. breeding, nesting/denning, or hibernating, for animals; or germination, flowering, and seed dispersal for plants) were met by existing environmental conditions within and in proximity to the Project area, specifically intertidal and subtidal habitats along the south shoreline of Annacis Island extending along the Annieville Channel.

CDC-documented element occurrences of species-at-risk and ecological communities-at-risk were queried within 5 km of the Project, using the provincial online mapping tool (British Columbia Ministry of Environment 2016c, Klinkenberg 2016a) for historical and publicly available occurrences. Anecdotal and museum records of species-at-risk occurrences within the 10 km radius were investigated for species for which CDC element occurrences do not exist within that radius (eBird Canada 2015, Klinkenberg 2016b). For species and ecological communities mapped by the CDC, whose distributions are well known due to systematic provincial or federal survey efforts or citizen science initiatives, these occurrence records were used to determine whether species-at-risk or ecological communities-at-risk have previously been recorded at or near the Project area, and to corroborate assessments of the likelihood of these elements occurring within the Project area.

Assessment Findings

A total of 14 non-sensitive species of management concern have been identified by the CDC to occur within 5 km of the Project. These species include 1 fish, 3 mammals, 1 arachnid, 1 amphibian, 1 insect, and 7 plants. CDC identified species are included as Table 1.

Table 1. CDC Species of Management Concern Occurring within 5 kilometres of the Project				
Common Name	**Scientific Name**	**SARA Schedule 1**	**CDC**	**Project Area Occurrence**
Fish				
White sturgeon (lower Fraser River population)	*Acipenser transmontanus pop. 4*	Not Included	Red	Likely
Mammals				
Pacific water shrew	*Sorex bendirii*	Endangered	Red	Unlikely
Olympic shrew	*Sorex rohweri*	Not included	Red	Unlikely
Southern red-backed vole, *occidentalis* subspecies	*Myodes gapperi occidentalis*	Not included	Red	Unlikely
Arachnids				
Georgia basin bog spider	*Gnaphosa snohomish*	Not included	No Status	Unlikely
Amphibians				
Northern red legged frog	*Rana aurora*	Special Concern	Blue	Unlikely
Insects				
Dun skipper	*Euphyes vestris*	Threatened	Red	Unlikely
Plants				
Vancouver Island Beggarticks	*Bidens amplissima*	Special Concern	Blue	Unlikely
Green-fruited sedge	*Carex interrupta*	Not included	Blue	Unlikely
Three-flowered waterwort	*Elatine rubella*	Not included	Blue	Unlikely
Flowering quillwort	*Lilaea scilloides*	Not included	Blue	Unlikely
False-pimpernel	*Lindernia dubia* var. *anagallidea*	Not included	Blue	Unlikely
Streambank lupine	*Lupinus rivularis*	Endangered	Red	Unlikely
Pointed rush	*Juncus oxymeris*	Not included	Blue	Unlikely

The outfall is located within Annieville Channel. The design does not engage terrestrial and intertidal environments of the channel. Mammals, arachnids, amphibians, insects and plants documented by the CDC to occur within a 5 kilometre radius of the Project are not expected to be directly engaged by the Project. Construction activities will not physical impact terrestrial and intertidal environments.

White sturgeon (lower Fraser River population) has been documented to utilize the Annieville Channel, and can be expected to occur within the Project footprint.

Two (2) fish species listed by the Province of British Columbia are not included in the CDC database to occur within a 5 kilometre radius of the design location of the outfall. These are coastal cutthroat trout and eulachon. They are absent in the database despite known occurrences of these species within Annieville Channel and other aquatic features of the Fraser River.

Bull trout and green sturgeon, also listed by the Province, are also not included in the database. This may be attributable to a lack of data specific to Annieville Channel and other aquatic features of the Fraser River, or that they may not occur within these areas.

5.0 IMPACTS AND MITIGATION

5.1 Design

Design impacts are permanent impacts. The design displaces surficial sands of the river bed. These impacts are largely attributable to the river riser, and diffuser manifold and associated riprap (see Drawing Nos. A61C0071 through to A61C0073; Appendix A).

Impacts to the river bed by riprap would be transitory in nature. It is anticipated that most of the riprap would be buried by sand through deposition associated with freshet. During other times of the year, this sand would be progressively eroded by currents, eventually exposing previously buried riprap. Typically, the diffusers and a narrow strip of riprap would be exposed above the river bed.

Dredging of the navigation channel, adjacent to the design location of the outfall, would also affect the extent of impacts. Dredging occurs when the river bed elevation is above the minimum depth elevation for navigation. The residual impact to surficial sand of the river bottom attributable to displacement of riprap will not be more than 1100 m^2. It will typically be less than 1100 m^2 due to the deposition and persistence of sediments.

Fish and Fish Habitats

Juvenile salmon generally occur within the upper 2 m of the water column (Southard *et al.* 2006), and along the shoreline, and would not be affected by changes in the river bed at the design location of the outfall.

Adult Pacific salmon, particularly coho, chinook, sockeye, pink and chum salmon, and steelhead and anadromous coastal cutthroat trout and bull trout, are unlikely to stage at the design location of the outfall during upstream migration. The outfall likely falls along the margins of the migratory corridor to upstream spawning habitats. Changes to the river bottom at this location would not markedly affect adult Pacific salmon.

Resident coastal cutthroat trout and fluvial bull trout, and prospectively adfluvial (Pitt Lake) Dolly Varden and bull trout, likely move throughout the immediate shoreline environment, where preferred prey, such as larval and juvenile fish, occur. It is highly unlikely that the design river bottom provides foraging opportunities for char and trout. Changes to the river bottom would not markedly affect these fish.

Eulachon do not spawn at the design location of the outfall. The outfall likely falls along the margins of the migratory corridor to upstream spawning habitats. Changes to the river bottom at this location would not markedly affect eulachon.

Green sturgeon is an infrequent visitor to the Fraser River. Forays into the river are likely directly associated with feeding; the eulachon migration may draw this fish into the river, in particular to reaches of the river further upstream of the Project area where eulachon spawn. Changes to the river bottom at this location would not markedly affect green sturgeon.

Adult white sturgeon occur throughout Annieville Channel, and likely occur periodically within the design footprint of the riser and diffuser manifold. White sturgeon within the lower Fraser

River feed upon invertebrates and fish, including eulachon and the spent spawners of Pacific salmon (Fisheries and Oceans Canada 2014b). Eulachon are a conspicuous prey item at the design footprint of the river riser and the diffuser manifold (Fisheries and Oceans 2014b), while spent spawners of Pacific salmon are an important prey item further upstream within the Fraser and Pitt rivers. Bottom fish that are likely prey for adult sturgeon, such as juvenile starry flounder (*Platichthys stellatus*), that move in with the salt wedge, likely occur at the design location of the river riser and diffuser manifold. The availability of important prey, in particular eulachon, is largely independent of the state of the river bottom. It is unlikely that the change in the bottom will affect the availability of important prey for adult sturgeon.

The nearshore subtidal and intertidal areas between Annacis Island and the design location of the outfall are characterized by relatively slower flows and fine sediments known to be preferred habitat of juvenile white sturgeon (Glova *et al.* 2008; Glova *et al.* 2009).

River bottom elevations at and about the location of the dredge pocket are approximately 10 m below chart datum. Catches of juvenile sturgeon presented by Glova *et al.* (2008) largely occurred at depths less than 10 m. For Glova *et al.* (2009), catches occurred largely at depths less than 15 m. Sampling depths for these studies were not referenced to tidal height. It is unlikely that sampling occurred during local low water, with the majority of catches likely occurring at depths less than 10 m below chart datum. In this regard, the design location of the riser and diffuser manifold is likely utilized to a lesser extent than shallower, more landward bottom habitats of Annieville Channel.

Glova *et al.* (2008) did not catch sturgeon at bottom salinities greater than 0.6 part per thousand. Glova *et al.* (2009) did not report salinities. Young juvenile sturgeons are intolerant of saline waters (Amiri *et al.* 2009). The salt wedge extends up to the existing outfall during low river discharge. This would pre-empt juvenile sturgeon during at least part of the year at and in proximity to the design location of the new outfall.

Juvenile sturgeon feed upon benthic invertebrates, small fish and fish eggs (Scott and Crossman 1973; McCabe *et al.* 1993). Displacement of small fish by a change in bottom substrate, from sand to riprap, is not likely to affect the availability of such fish. Most small fish will be associated with nearshore environments, at depths considerably shallower than the design depth of the new outfall. It is likely that fish eggs as food at the design location of the outfall is restricted to drift of eulachon eggs from upstream spawning habitats. The availability of fish and fish eggs as food would not be affected by changes to the river bottom attributable to the design of the outfall.

Design riprap would displace habitat for benthic invertebrates. Benthic invertebrates are likely a food resource at the design location of the outfall; however, this resource is likely limited, as bottom sediments (i.e. sands 0.063mm to 2.00mm; Golder Associates Ltd. 2017b) that serve as habitat are transitory (see Northwest Hydraulic Consultants Ltd. 2015). This significantly constrains the establishment and persistence of benthic invertebrates. Sieve analysis of 3 samples of surficial sand (conducted by Envirowest Consultants Inc.), each approximately 20 litres, did not reveal living invertebrates. Pupal cases of chironomids were the only signs of invertebrates. Golder Associates Ltd. (2017c), for a sample location downstream of the design location of the diffuser manifold, along the northern margin of the navigation channel within Annieville Channel, documented invertebrates at a density of 238 individuals per m^2. Five (5) were represented, comprised of 2 tubificid worm species, 2 chironomid species, and identified

bivalves. The mesh sizes utilized to sieve the invertebrates from the sediments was 0.25mm and 0.50mm; all invertebrates were captured by the 0.50mm sieve.

Any assessment of prospective impacts of a development project on sturgeon is dependent upon existing information, including accounts of the life history of sturgeon within the Fraser River. The assessment of the design impacts of the outfall is founded upon this information. In consideration of the scope of the Project, this information appears adequate to conduct such an assessment.

Fisheries and Oceans Canada (2014b) presents important habitats for non-SARA listed middle and lower Fraser River populations. Important habitats for these populations are presented. The important habitats identified for the non-SARA listed populations of white sturgeon have no legal meaning or bearing under SARA (Fisheries and Oceans Canada 2014b).

The appendix provides maps of important habitats for lower Fraser River white sturgeon. The important habitats are delineated by polygons. A polygon encapsulates all of Annacis Channel, most of Annieville Channel, downstream within the Main Arm to a point defined by Duck Island and its associated causeway. All bottom elevations of the waterways are represented.

The polygon identifies an area "known to be used extensively for spring and summer to fall feeding habitats" (Fisheries and Oceans 2014b). The only studies referenced for the delineation of the polygon are Glova *et al.* 2008 and Glova *et al.* 2009; these studies are limited in their scope and cannot entirely represent the delineation of the polygon. In the absence of published reports, it can only be assumed that the delineation of the polygon is dependent upon unpublished data that has not been identified.

Impacts to surficial sand on the river bed (no greater than 1100 m^2) would not impair the life history stages of white sturgeon and other fish species of management concern. Affected habitat is represented throughout the Fraser River estuary, including Annieville Channel, Annacis Channel, and other water features associated with Annacis Island (as identified in the polygon for white sturgeon habitat encapsulating Annacis Island). The scale of impact is small, with the maximum design footprint of the outfall encompassing approximately 0.01 percent of the 8,156,600 m^2 of river bottom occurring within the sturgeon polygon presented by Fisheries and Oceans Canada (2014b).

Wildlife and Wildlife Habitats

There are no impacts to wildlife species and their habitats attributable to the design of the river riser, diffuser manifold and associated rip rap.

Species at Risk

Prospective impacts to white sturgeon and green sturgeon, red-listed by the Province of British Columbia, and to bull trout, coastal cutthroat trout and eulachon, blue-listed by the Province, are presented under the header "Fish and Fish Habitats".
Impacts attributable to the design of the river riser, diffuser manifold and associated rip rap to other species at risk are not anticipated.

5.2 Construction

Construction of the Project would employ Fisheries and Oceans Canada's measures to avoid causing harm to fish and fish habitat (Fisheries and Oceans Canada 2017c). Best management practices and standards for the protection of the environment would also be applied (British Columbia Ministry of Environment and Fisheries and Oceans Canada 2017).

A Construction Environmental Management Plan (CEMP) is submitted as part of the Project and Environmental Review (PER) Application. The table of contents for the CEMP is as follows:

The contractor is required to submit to Metro Vancouver an Environmental Protection Plan (EPP) prior to the commencement of construction of the Project. The contractor is required to comply with the CEMP, the EPP and performance based environmental standards contained with Contract Section 01355 – Environmental Protection.

Fish and Fish Habitats

Outfall Conveyance Tunnels

The incorporation of a trenchless methodology avoids impacts to the riparian, intertidal marsh, intertidal mudflat, and nearshore subtidal river bottom fish habitats. The upland access portal would be located within the developed landscape of the industrial park of Annacis Island; natural features would not be impacted.

Impacts to fish species and their habitats are not anticipated.

River Riser

It is anticipated that underwater pressures associated with the installation of the metal pipe and sheet piles with a vibratory hammer would be below the Fisheries and Oceans Canada's 30kpa threshold (Vagle 2003; Buehler *et al.* 2015) to prevent harm to fish. The coffer dam would be installed during the timing window for inwater works of least risk to fish (June 16 through to February 28) (Fisheries and Oceans Canada 2017a); work within the coffer dam could occur at any time throughout the year as the works would be isolated from Fraser River waters. The riser would be connected to the outfall pipe within the coffer dam. Details regarding the coffer dam are presented by the above referenced drawing and by Drawing No. A61 C0052 "A61 – NOS, Riser Shaft Plan Top Level" (Appendix A).

The interior of the coffer dam would be inspected for fish upon completion of installation. Any fish encountered would be salvaged and released to open waters of Annieville Channel.

It is highly unlikely that fish will be struck during installation of piles. Fish will engage in avoidance behaviour during installation of piles.

Impacts to the river bed related to the installation of the riser are extremely localized and temporary. The construction footprint of the riser falls within the design footprint of the riser and diffuser manifold.

Diffuser Manifold

The installation of the diffuser manifold with shoring mitigates the area of river bed temporarily impacted by dredging; the temporary impact is approximately 12,750 m^2 (Figure 3). Dredging beyond the design footprint of the diffuser manifold is mitigated by the restoration of native sediments. Temporary disturbance of sediments would be further mitigated by the annual deposition of sediments associated with freshet.

Dredging would be conducted using a clamshell dredge (i.e. a crane equipped with a clamshell bucket). A clamshell dredge is selected, in part, due to its ability to precisely excavate to the limits delineated by the design. Hydraulic dredges, such as cutterhead suction and hopper

dredges, have a tendency to over-excavate, especially where sand is the dominant sediment. The use of a clamshell limits impacts on the river bed associated with construction.

The crane with bucket would be operated from a floating spud-derrick. The bucket is operated through a series of cables fitted to the crane. Dredged material is deposited onto a barge. It is anticipated that a portion of the dredged material would be utilized to restore the river bottom (sediment and elevation) upon completion of the installation of the manifold.

It is anticipated that material not used to restore the river bed at and about the riser and diffuser manifold would be disposed at sea (Disposal-at-Sea Permit) or barged to an off-loading facility and disposed at a permitted upland site. Dredging would be conducted during the timing window for inwater works of least risk to fish (June 16 through to February 28) (Fisheries and Oceans Canada 2017a). The inwater timing window is specific to the mitigation of impacts to downstream migrating juvenile salmonids. Incidentally, the work window also protects upstream migrating eulachon; this species is typically migrating through Annieville Channel from March through to May. Likewise, late juvenile and adult white sturgeon feeding upon eulachon during spring and summer (April 01-August 01; Fisheries and Oceans Canada 2014a) are also protected.

Extraordinary mitigation measures for the containment of sediment plumes attributable to dredging, such as silt curtains, are not proposed for dredging activities. Silt curtains cannot be maintained in place due to fluvial and tidal currents. Other means of containment, such as steel sheet pile, are cost-prohibitive and not appropriate for the scale of dredging proposed. Measures to implement such containment would dramatically exceed the scope of work associated directly with dredging.

Elevated turbidity and total suspended solids associated with sediment plumes are typically transitory and temporary (Water and Land Use Committee 2006). If juvenile salmon encounter a sediment plume, they will express avoidance behaviour (see ECORP Consulting, Inc. 2009). Prospective impacts to juvenile salmon are mitigated through restriction of dredging to the inwater work window (Water and Land Use Committee 2006).

Adult salmon, Dolly Varden char and bull trout will be in the river outside of the inwater work window. It is anticipated that salmon and char will express avoidance behaviour in response to the operation of the clamshell. They will also express avoidance behaviour associated with the sediment plume generated by dredging activities.

Dredging with a clamshell during late summer through to late winter has the potential to entrain adult and juvenile white sturgeon as they predominantly reside on the river bottom. The prospective impacts of dredging on all species of sturgeon, let alone white sturgeon, have been poorly studied. When such studies have been conducted, the focus has been upon the potential impacts of hydraulic dredging. The impacts of mechanical dredging, as represented by clamshell dredging, have not been studied in the Fraser River.

A perspective regarding the risk of harm or death of white sturgeon due to mechanical dredging may be derived from data pertaining to interactions between dredging and other species of sturgeon. Data pertaining to mortalities attributable to entrainment by mechanical dredging are provided by the US Army Corps of Engineers Sea Turtle Data Warehouse (2013) for the Atlantic and Gulf coasts. The data spans 18 years, from 1995 to 2013. Forty-two (42) sturgeon (3 Gulf

sturgeon (*A. oxyrinchus desotoi*), 11 shortnose sturgeon (*A. brevirostrum*), and 34 Atlantic sturgeon (*A. oxyrinchus oxyrinchus*)) were taken during dredging. Five sturgeon survived their encounters with the dredges (2 shortnose sturgeon and 3 Atlantic sturgeon). The majority of mortalities were associated with hopper dredging (3 Gulf sturgeon, 5 shortnose sturgeon and 24 Atlantic sturgeon). Four (4) sturgeon (1 shortnose and 3 Atlantic sturgeon) were entrained by mechanical dredging. The Atlantic Sturgeon Status Review Team calculated a minimum entrainment of 0.6 Atlantic sturgeon per year, based strictly on hopper dredging operations and an assumption that dredging efforts were relatively similar among years (US Army Corps of Engineers Sea Turtle Data Warehouse 2006). As can be deduced from the US Army Corps of Engineers Sea Turtle Data Warehouse (2013) data, the rate of sturgeon entrainment by mechanical dredging appears to be substantively less than entrainment associated with hopper dredging.

COSEWIC (2012b) does not identify dredging as a threat to sturgeon in terms of mortalities induced by the act of dredging. In this regard, and in consideration of US Army Corps of Engineers Sea Turtle Data Warehouse (2013) data and the scale and scope of dredging, it is unlikely that dredging would result in the death of white sturgeon.

Wildlife and Wildlife Habitats

Outfall Conveyance Tunnels

The incorporation of a trenchless methodology avoids impacts to the riparian, intertidal marsh, intertidal mudflat, and nearshore subtidal river bottom fish habitats. The upland access portal would be located within the developed landscape of the industrial park of Annacis Island; natural features would not be impacted.

Impacts to wildlife species and their habitats are not anticipated

River Riser

The installation of sheet and pipe piles has the potential to impact nesting by bald eagle due to this species' proximity to the location of works, large territory size, and extensive use of the river channel and associated habitats. Several bald eagle nests occur on and near Annacis Island, including locations at Purfleet Point, west of Highway 91 along Annacis Channel, and along Annieville Channel east of the Alex Fraser Bridge. The latter nest is located in the crown of a black cottonwood tree approximately 1.8 km upstream of the Project. Noise disturbance during installation of piles is considered to have the highest likelihood of causing disturbance to bald eagle nesting; potential sources of visual disturbance are outside the provincially recommended noise buffers for nests of this species.
Noise disturbance during installation of sheet piles may also impact nesting and foraging activity by shorebirds (spotted sandpiper and killdeer) in the vicinity of works, as both species are easily flushed by visual and noise disturbances, including those occurring at a distance.

It is unlikely that the installation of piles will impact nesting by other bird species. Impacts to foraging activity by birds are expected to be limited to shorebirds, and perhaps to mallard duck. Impacts to foraging activity by glaucous-winged gull are not anticipated as most foraging within and in proximity to the Project area occurs during the upstream migration of eulachon; the period

of migration for eulachon is encapsulated by the closure of inwater works in the Fraser River at this location.

Prospective impacts to bald eagle, spotted sandpiper and killdeer are to be considered in the context of other marine activities that occur in proximity to the Project area. Southern Railway operates a railcar barge facility immediately north of the design locations of the river riser and diffuser manifold. Active chip scow transport and moorage occurs within the navigation channel and proximal water lots. Marine traffic is a constant activity within the navigation channel. Nesting and foraging activities by bald eagle, spotted sandpiper and killdeer are likely habituated to existing marine activities in proximity to the Project area.

Prospective impacts to marine mammals would be largely limited to the acoustics associated with the vibratory hammer installation of the metal pipe and sheet piles. However, it is unlikely that acoustics associated with the use of a vibratory hammer will exceed thresholds that cause marine mammals to be harmed or be compelled to alter their behaviour. It is highly unlikely that marine mammals would be struck by marine equipment or materials during the installation and decommissioning of the coffer dam.

The occurrence of marine mammals outside of the timing window for inwater works of least risk to fish would be largely limited to the upstream migration of adult salmon. Adult salmon would largely use the centre of Annieville Channel for migration. It is not anticipated that marine mammals would occur directly within the construction footprint of the riser.

It is worthy to note that protection of these marine mammals from harm is provided by the Marine Mammal Regulations SOR/93-56 of the *Fisheries Act*.

Non-marine mammals will not be unduly impacted by pile driving activities. Most will simply exhibit avoidance behaviour during the implementation of works.

Diffuser Manifold

Dredging associated with the installation of the diffuser manifold is described in the previous section “Fish Species and Habitats”.

Visual disturbance is likely the notable impact on wildlife. Nesting and foraging activity by shorebirds (spotted sandpiper and killdeer) may be impacted. Both species will likely be flushed by the operation of the dredge and move elsewhere within Annieville Channel. Impact to other birds, such as mallard and gull, is not likely; these species are habituated to industrial activities within Annieville Channel. Nesting by eagles will likely not be affected as the activity as the visual disturbance is outside the provincially recommended buffer for this species. Nesting and foraging activities of other bird species will not likely be unduly affected.
Prospective impacts to wildlife species and habitat attributable to the installation of the riser are limited to marine mammals. Such impacts would, in turn, be largely limited strikes attributable to the operation of the clam shell dredge. However, it is highly unlikely that marine mammals would be struck by marine equipment or materials during the installation and decommissioning of the coffer dam.

The occurrence of marine mammals outside of the timing window for inwater works of least risk to fish would be largely limited to the upstream migration of adult salmon. Adult salmon would

largely use the centre of Annieville Channel for migration. It is not anticipated that marine mammals would occur directly within the construction activities associated with the installation of the diffuser manifold.

It is worthy to note that protection of these marine mammals from harm is provided by the Marine Mammal Regulations SOR/93-56 of the *Fisheries Act*.

Non-marine mammals will not be unduly impacted by pile driving activities. Most will simply exhibit avoidance behaviour during the implementation of works.

Species at Risk

Prospective impacts to white sturgeon and green sturgeon, red-listed by the Province of British Columbia, and to bull trout, coastal cutthroat trout and eulachon, blue-listed by the Province, are presented under the header "Fish and Fish Habitats".

Outfall Conveyance Tunnels

The incorporation of a trenchless methodology avoids impacts to the riparian, intertidal marsh, intertidal mudflat, and nearshore subtidal river bottom habitats. The upland access portal would be located within the developed landscape of the industrial park on Annacis Island; natural features would not be impacted.

Impacts to species at risk, including white sturgeon, attributable to the construction of the conveyance tunnels are not anticipated.

River Riser

Impacts to species at risk other than white sturgeon attributable to the construction of the river riser are not anticipated. Impacts to white sturgeon are unlikely.

Diffuser Manifold

Impacts attributable to the construction of the diffuser manifold species at risk other than white sturgeon are not anticipated. The prospect of impacts to white sturgeon is low.

5.3 Operation

The waste water treatment process, and associated effluent quality, is not anticipated to markedly change as part of the overall upgrade of the Treatment Plant. Based upon a review of 2014 effluent and toxicity data (Greater Vancouver Sewerage and Drainage District 2015) conducted as part of the Stage 1 Environmental Impact Statement (Stage 1 EIS) (Golder Associates Ltd. 2016) for the Project, the Treatment Plant effluent meets Wastewater Systems Effluent Regulations limits and is not acutely toxic. Tri-Star Environmental Consulting (2015) also reported that the effluent was not acutely lethal based on standardized acute toxicity testing undertaken on Treatment Plan effluent sampled between 2009 and 2012.

Key findings of a Stage 2 Environmental Impact Statement (Golder Associates Ltd. 2017d), completed in accordance with the Municipal Wastewater Regulation of the *Environmental Management Act*, are as follows.

- "Adverse effects on aquatic life and impairment of other receiving environment uses identified for the study area (i.e., secondary recreational contact, wildlife use, agricultural use) are not expected based on the assessment of predicted concentrations at the edge of the IDZ" (Initial Dilution Zone) "and far-field nodes in the Fraser River."
- "Adverse effects on wildlife and people consuming fish from the Fraser River are not expected because concentrations of PBT constituents in the effluent and IDZ are not increasing due to the Project."
- "Secondary treated whole effluent at the point of discharge is not expected to be acutely lethal to aquatic life and conditions within the IDZ would likewise not be expected to be acutely lethal to aquatic life."

The IDZ is the three-dimensional zone around the point of discharge where mixing of the effluent and receiving water occurs. For a large water body, the IDZ is commonly defined as a cylindrical body of water around the outfall, with a lateral radius the lesser of 100 m from the outfall or 25 percent the width of the receiving water body, and extending upwards through the water column to the surface.

Fish and Fish Habitats

It is worthy to note that juvenile sturgeon have been caught within the IDZ of the existing outfall (Glova *et al.* 2008; Glova *et al.* 2009). The numbers of juvenile sturgeon within the IDZ and elsewhere along the shorelines of Annacis Island were the highest of sample locations downstream of the Mission Bridge (Highway No.11), suggesting the effluent does not deter use of the nearshore environments of Annieville Channel by juvenile sturgeon.

The Treatment Plant effluent meets Wastewater Systems Effluent Regulations limits and is, as such, is deemed not acutely toxic. In the context of the *Fisheries Act*, impacts to CRA fish are adequately mitigated.

Wildlife and Wildlife Habitats

Wildlife and associated habitats within the operational footprint of the Project occur largely within the IDZ of the existing outfall. As wildlife resource values are concurrent with the existing IDZ, it is unlikely that wildlife and associated habitats will be impacted by the discharge of effluent.

Species at Risk

Prospective impacts to white sturgeon and green sturgeon, red-listed by the Province of British Columbia, and to bull trout, coastal cutthroat trout and eulachon, blue-listed by the Province, are presented under the header "Fish and Fish Habitats".

Impacts to other species at risk are not anticipated.

6.0 ENVIRONMENTAL MONITORING

6.1 Construction

As described in Section 5.2, a CEMP is submitted as part of the PER Application. The CEMP provides a basis for the development of the site or activity-specific EPP to be prepared by the construction contractor. The EPP accounts for the contractor's selected construction practices and mitigation strategies prior to the start of construction. Contract Section 01355 – Environmental Protection requires the EPP to address all environmental monitoring requirements for all activities that may adversely impact environmental resources.

6.2 Operation

Receiving environment monitoring will be conducted upon the discharge of effluent as part of Metro Vancouver's existing effluent sampling program and its' Annual Receiving Environment Monitoring (REM) program. The Stage 2 EIS prepared for British Columbia Ministry of Environment by Golder Associates Ltd. presents recommendations for consideration in modifying the existing programs where necessary to adapt to the project and EIS findings. The Stage 2 EIS is included as Appendix K.2 to the PER Application.

7.0 SUMMARY AND ASSESSMENT OF IMPACTS

Impacts to fish and fish habitat, wildlife and wildlife habitat, and species at risk are addressed specifically in the context of those species that are likely to occur within the design, construction and operation footprints of the Project.

Design related impacts are permanent. The design of the river riser, and diffuser manifold and associated riprap would displace surficial sands of the river bed. The long term impacts on the river bottom, however, would vary. The bed elevation of the river bed will vary dependent upon maintenance dredging of the adjacent navigation channel. The anticipated residual impact to river bottom, specifically surficial sand, is expected to not exceed 1100 m^2.

Impacts to surficial sand on the river bed would not impair the life history stages of fish species, wildlife species and species at risk. Affected fish habitat, and habitat for a single species at risk (i.e. white sturgeon) is represented throughout the lower Fraser River, including Annieville Channel, Annacis Channel, and other water features associated with Annacis Island. The scale of impact on fish species and species at risk is not of consequence, especially in consideration of the abundance of similar habitat available to these species in proximity to the design location of the outfall. Wildlife habitat and habitat for other species at risk is not affected.

Construction related impacts are temporary. These impacts are mitigated through special measures that would be implemented during construction of the conveyance tunnels, river riser and diffuser manifold. Dredging required to facilitate construction of the diffuser manifold would impact approximately 12,750 m^2 of river bottom. Most of this impact is temporary, and would largely be offset through restoration of the affected river bed, outside of the design impact of the outfall, to the pre-impact condition (sediment and elevation). Temporary impacts associated with the construction of the outfall would not substantively affect fish species, wildlife species and species at risk.

The operation of the outfall is defined by the discharge of secondary treated effluent. Effluent quality is not anticipated to change with the upgrade of the Treatment Plant. Analytical characterization and toxicity testing of the Treatment Plant effluent has demonstrated that effluent quality meets Wastewater Systems Effluent Regulations limits and is not acutely toxic; in the context of the *Fisheries Act*, impacts to CRA fish, including those fish that are listed as species at risk by the Province of British Columbia, are adequately mitigated.

Key findings of a Stage 2 Environmental Impact Statement, based upon conservation assumptions, indicated that adverse effects on aquatic life and impairment of other uses, such as wildlife use, are unlikely at the edge of the Initial Dilution Zone (IDZ) and far-field nodes within the Fraser River. Effluent at the point of discharge and Conditions within the IDZ are not expected to be acutely toxic to aquatic life.

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APPENDIX A
DESIGN DRAWINGS

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metro vancouver

Greater Vancouver Regional District • Greater Vancouver Water District
Greater Vancouver Sewerage and Drainage District • Greater Vancouver Housing Corporation

4330 Kingsway, Burnaby, BC, Canada V5H 4G8 604-432-6200 www.metrovancouver.org

GREATER VANCOUVER SEWER AND DRAINAGE DISTRICT

ANNACIS ISLAND WASTEWATER TREATMENT PLANT NEW OUTFALL SYSTEM CONSTRUCTION SERVICES FOR THE OUTFALL

RFP NO. 18-0001

ISSUED FOR PERMIT DRAWING SET

NOVEMBER 2017

2017-10-17 15:22 SOUNDARRAJANA C:\cdmvm\soundarrajana\d2821585\A00 X-G-001 - PERMIT.dwg
xref files:

SHEET INDEX

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	A00 X-G003	DRAWING INDEX - 1
	A10G0031	GENERAL LOCATION AND VICINITY MAP
	A10 X-G001	HYDRAULIC PROFILE NEW OUTFALL SYSTEM
	A10 X-G0101	A10 - GENERAL SITEWORKS NOS AERIAL MAP
SITE PLAN AND BUILDINGS, STRUCTURES & EQUIPMENT, AND LOT GRADING & UTILITIES		
	A10 X-C0101	RIGHT OF WAY KEY PLAN
	X-A61C0028	LOT 236 PLAN AND ISOMETRIC
	X-A61C0029	LOT 187 PLAN AND ISOMETRIC
	X-A61C0030	PLAN LOT 179 VOLUMETRIC RIGHT OF WAY
	X-A61C0031	WATER FRONT LOT PLAN
	A61C0001	A61 - GENERAL SITE WORKS, NOS SITE PLAN KEY MAP
	A61C0002	A61 - TUNNEL PLAN & PROFILE 1
	A61C0003	A61 - TUNNEL PLAN & PROFILE 2
	A61C0004	A61 - TUNNEL PLAN & PROFILE 3
	A61C0005	A61 - TUNNEL PLAN & PROFILE 4
	X-A10C007	CIVIL WORKS - GENERAL SITE CONSTRUCTION ACCESS AND STAGING
	X-A10C008	CIVIL WORKS - OUTFALL SHAFT SITE CONSTRUCTION ACCESS AND STAGING
	X-A61S0081	RIVER RISER CONSTRUCTION SEQUENCE 1
	X-A61S0082	RIVER RISER CONSTRUCTION SEQUENCE 2
	X-A61S0083	RIVER RISER CONSTRUCTION SEQUENCE 3
MARINE STRUCTURES		
	A61C0070	DIFFUSER MANIFOLD RIVER PLAN
	A61C0077	EXISTING OUTFALL PLAN
	A61C0078	EXISTING OUTFALL SECTION & DETAILS
	A61C0052	RIVER RISER PLAN TOP LEVEL
	A61C0053	RIVER RISER SECTION
	A61C0071	DIFFUSER MANIFOLD SECTION 1
	A61C0072	DIFFUSER MANIFOLD SECTION 2
	A61C0073	DIFFUSER MANIFOLD SECTION 3
	A61C0074	DIFFUSER MANIFOLD DETAILS
LIGHTING PLAN		
	A50E4721	LAYOUT LEVEL CONTROL STRUCTURE (LCS) AREA 50 - POWER AND LIGHTING PLAN
	A61E5212	LAYOUT OUTFALL SHAFT AREA 61 - POWER AND LIGHTING PLAN

ISSUED FOR PERMIT REVIEW
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CDM Smith
1001-4710 Kingsway
Burnaby, BC V5H 4M2
Canada
Phone: 604-431-0242

Professional Seal

Issue	Date	Desn	Dr'n	Chkd	App'd	Description
P1	NOV. 2017	AK	VR	BJF	JNC	ISSUED FOR PERMIT REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER WATER DISTRICT AND SEWERAGE & DRAINAGE DISTRICT

Design: AK
Drawn: VR
Checked: BJF
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

DRAWING INDEX

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DISTRICT FILE S-1933
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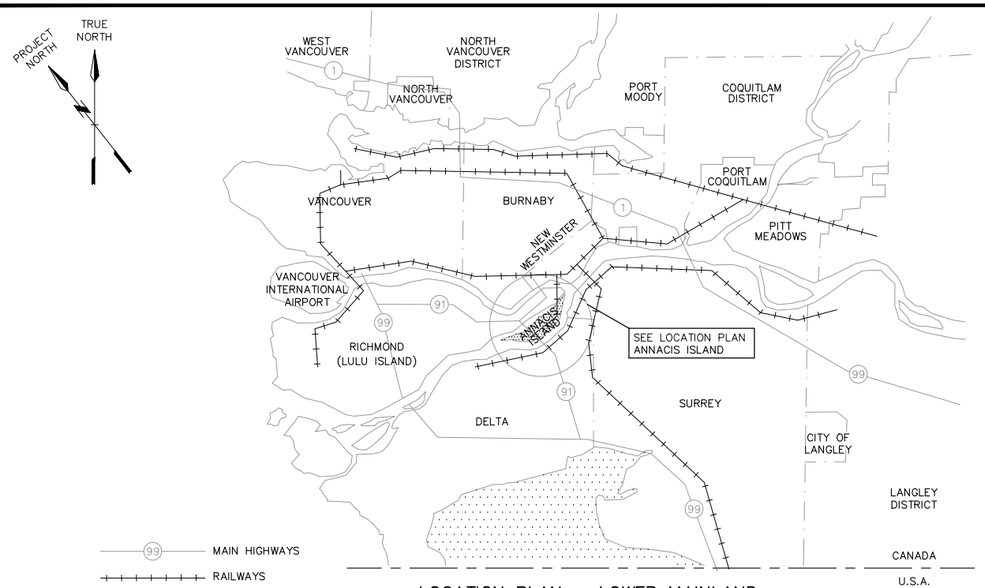

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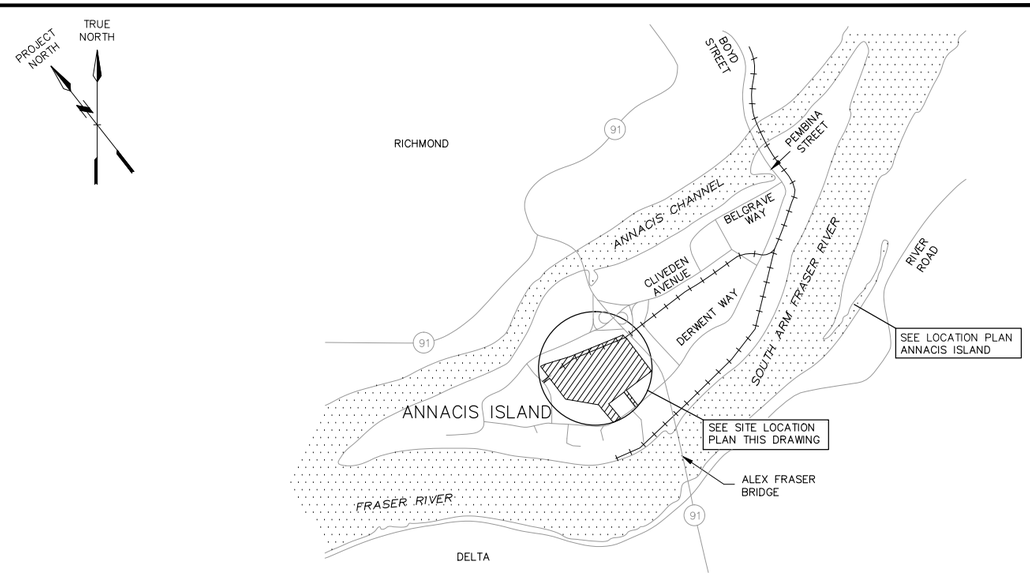

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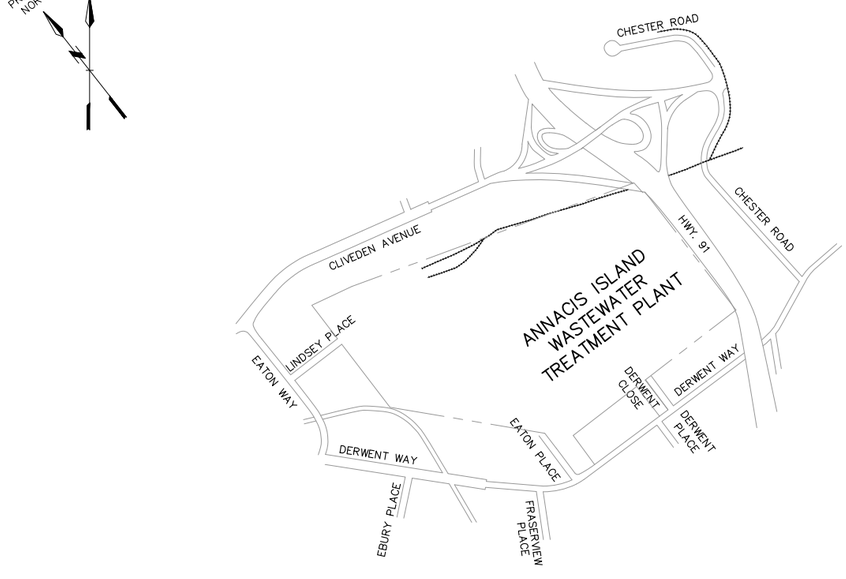
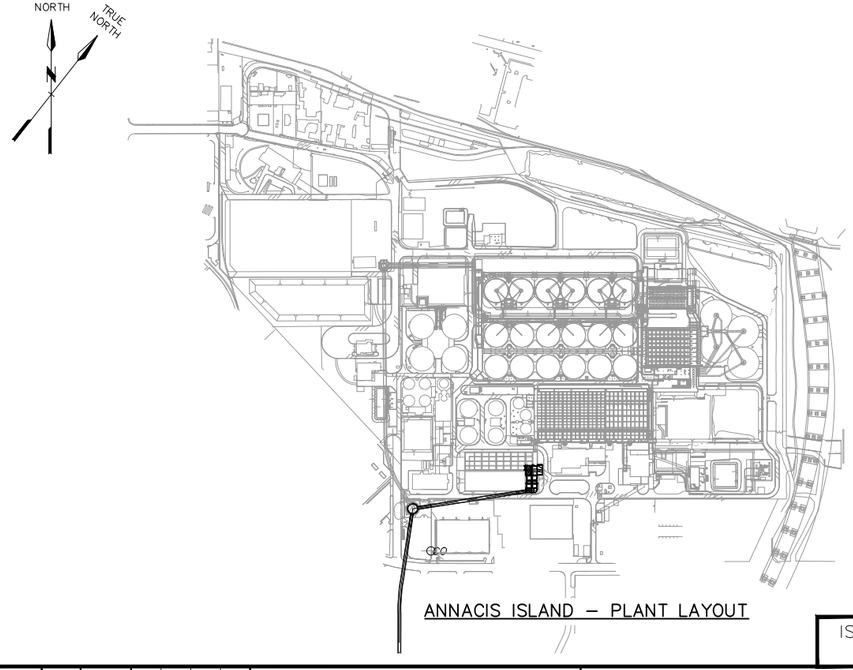


SITE LOCATION PLAN



ANNACIS ISLAND – PLANT LAYOUT

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Burnaby, BC V5H 4M2
Canada
Phone: 604–431–0242

Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P2	NOV. 2017	AK	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW
P1	AUG. 2017	AK	CEB	GLL	JNC	ISSUED FOR 90% DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: AK
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

AREA 10 – GENERAL SITEWORKS
GENERAL LOCATION AND VICINITY MAP

SCALE: NTS
DISTRICT FILE SF-1933
DRAWING NUMBER A10G0031

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P2

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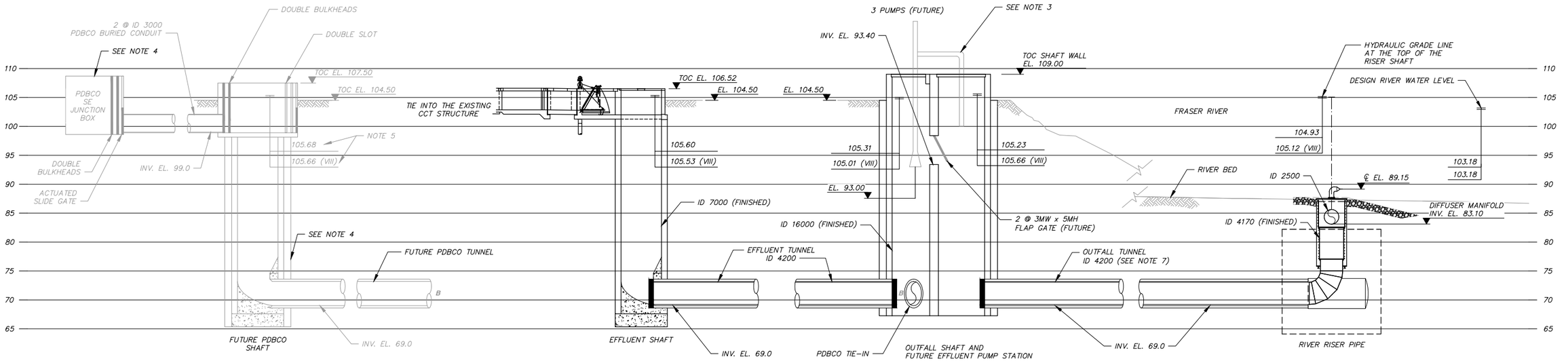

HYDRAULIC PROFILE – NEW OUTFALL SYSTEM
N.T.S.

NOTES:
1. ALL ELEVATIONS ARE IN METERS.
2. PLANT DATUM = CGVD28GVRD2005 + 100m
3. FUTURE EFFLUENT PUMPS AND OUTFALL SHAFT FLAP GATE.
4. PDBCO SHAFT, TUNNEL, BURIED CONDUIT AND SE JUNCTION BOX CONSTRUCTION TO FOLLOW AFTER NOS UNDER SEPARATE CONSTRUCTION CONTRACT.
5. ASSUMES FULL STAGE V AND STAGE VIII (WITH PUMPING) FLOWS THROUGH PDBCO.
6. TUNNEL 3820mm STEEL LINER, PE COATED NOT SHOWN.
7. THE TOP OF THE SHAFTS ELEVATIONS INCLUDE 1.00m FOR GLOBAL SEA LEVEL RISE.

LEGEND:
WATER SURFACE ELEVATION IN METERS

XXX.XX ← STAGE V (18.9 CMS)

YYY.YY VIII ← STAGE VIII (25.3 CMS WITH PUMPING) (VIII)

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NOT FOR CONSTRUCTION

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Canada
Phone: 604–431–0242

Professional Seal

Issue	Date	Desn	Dr'n	Chkd	App'd	Description
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P3	AUG. 2017	RM	CEB	MEA	JNC	ISSUED FOR 90% DESIGN REVIEW
P2	MAR. 2017	RM	CEB	MEA	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	RM	CEB	MEA	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: RM
Drawn: CEB
Checked: MEA
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

HYDRAULIC PROFILE
NEW OUTFALL SYSTEM

SCALE: NONE
DISTRICT FILE SF–1933
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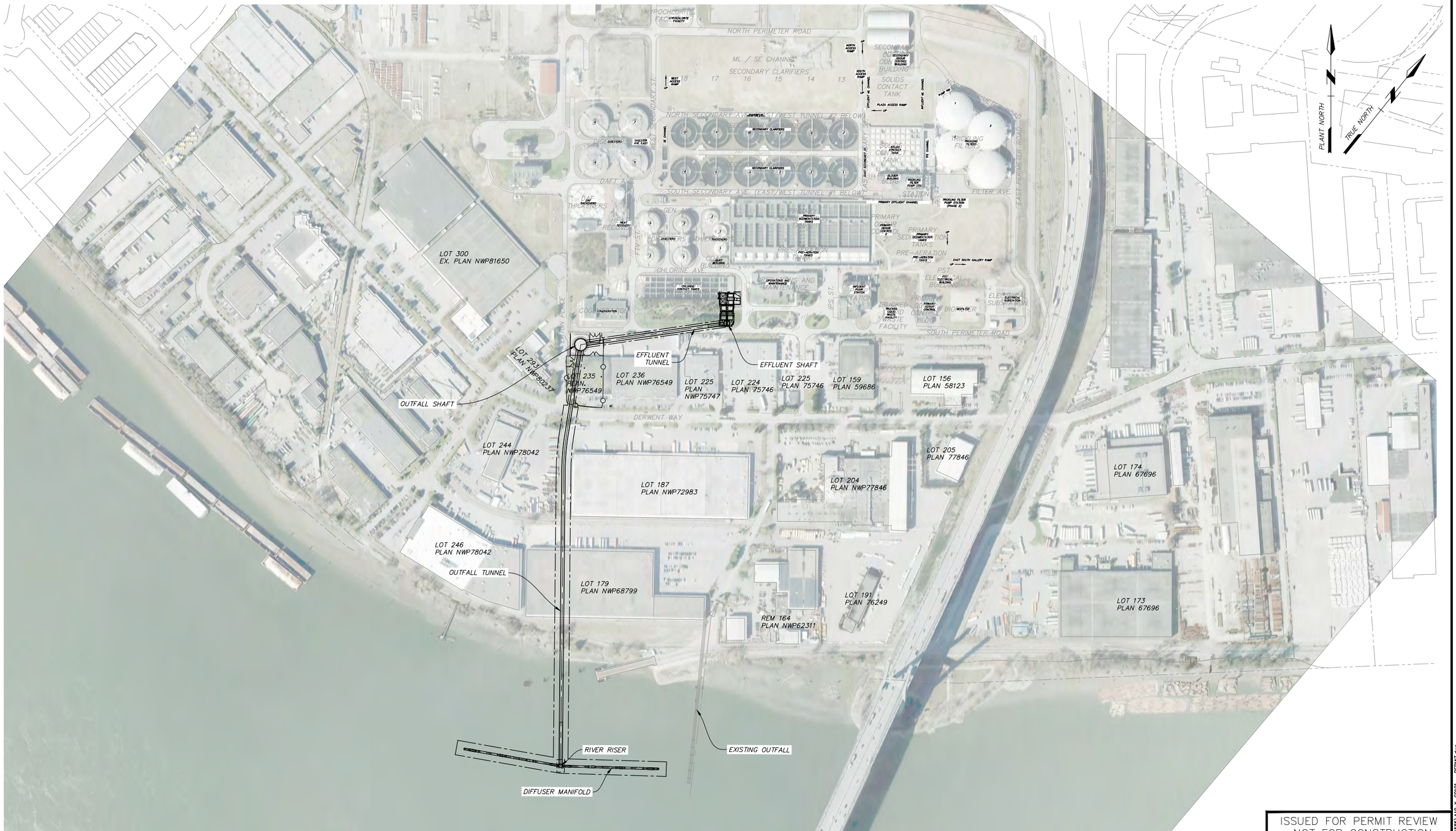

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NOT FOR CONSTRUCTION

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1001–4710 Kingsway
Burnaby, BC V5H 4M2
Canada
Phone: 604–431–0242

Professional Seal

Issue	Date	Desn	Dr'n	Chkd	App'd	Description
P3	NOV. 2017	AK	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW
P2	MAR. 2017	AK	CEB	GLL	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	AK	CEB	GLL	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: AK
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

A10 – GENERAL SITE WORKS
NOS AERIAL MAP

SCALE: 1:2500
DISTRICT FILE SF-1933
DRAWING NUMBER A10 X-G0101

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P3

XREFDWG

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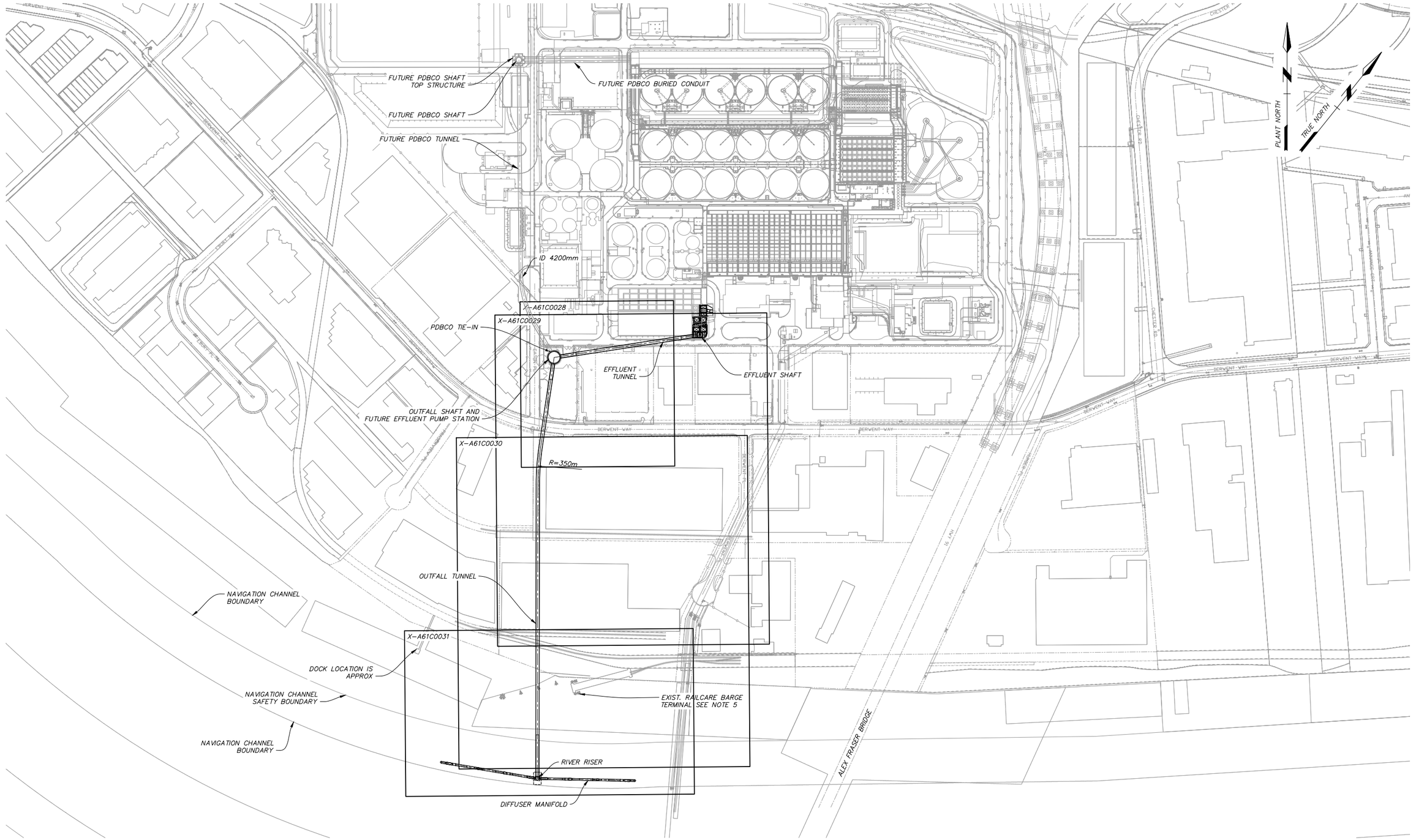

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Burnaby, BC V5H 4M2
Canada
Phone: 604-431-0242

Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P1	DEC. 2017	AK	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: AK
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

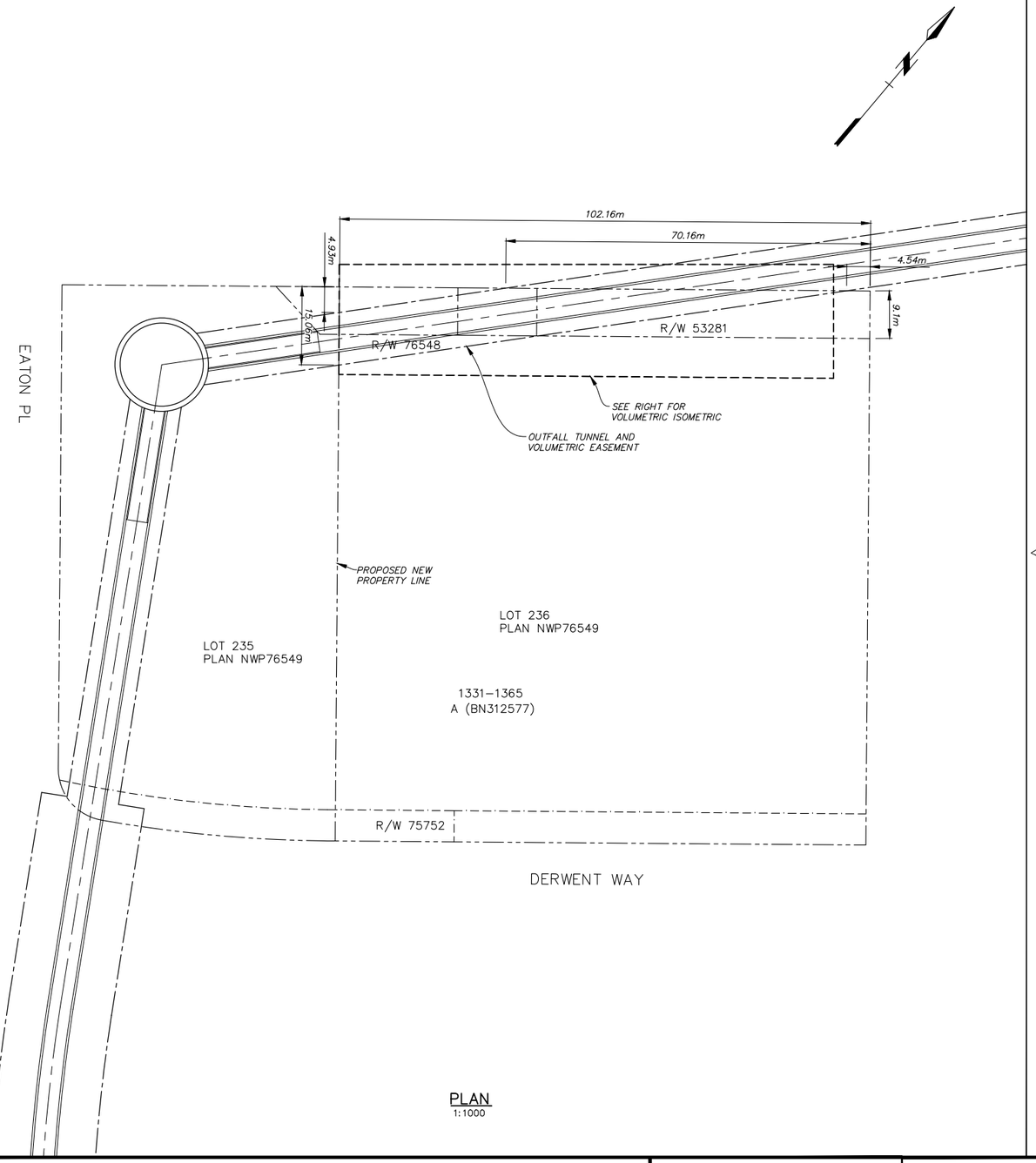
RIGHT OF WAY KEY PLAN

SCALE: 1: 2500
DISTRICT FILE SF-1933
DRAWING NUMBER A10 X-C0101

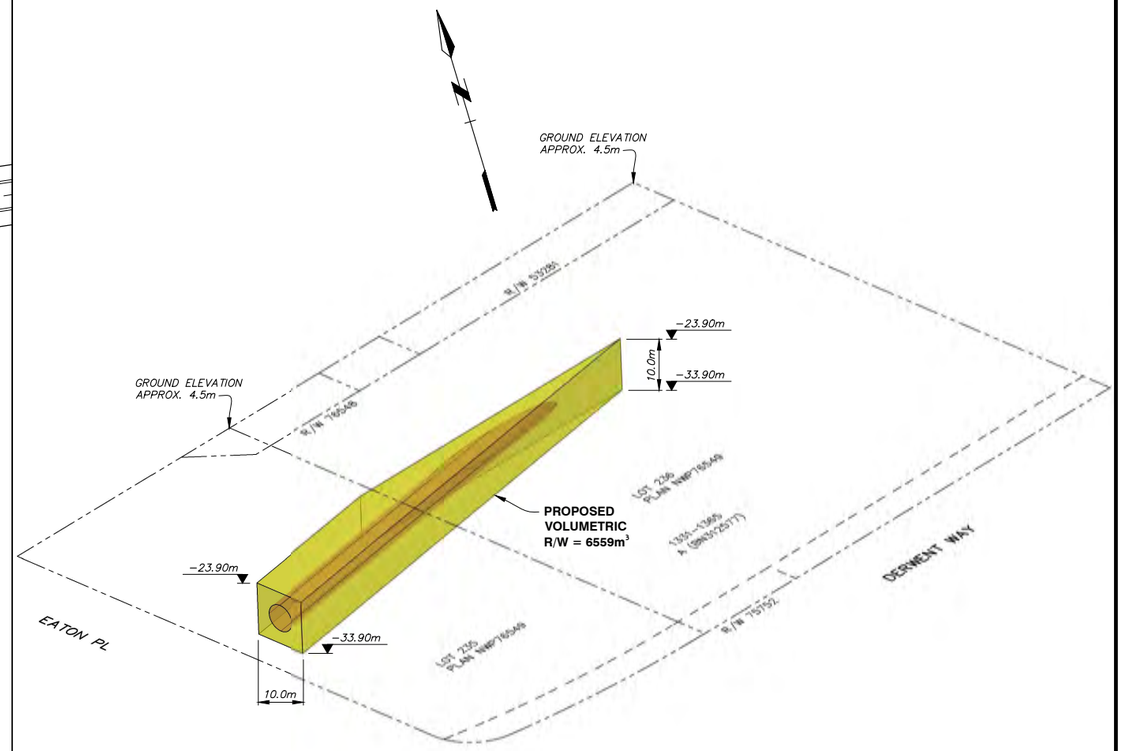
SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P1

2017-10-23 12:44 RV C:\cdmsmith\v1\d282158\A10 X-C0101 - PERMIT.dwg

xref files:



PLAN
1:1000



3D PLAN
N.T.S.

ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

NOTES:
1. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD – GEODETIC DATUM.

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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P5	NOV 2017	JEN	CEB	JNC	JEN	ISSUED FOR PERMIT REVIEW
P4	AUG 2017	JEN	CEB	JNC	JEN	REVISED AS PER NOS ALIGNMENT
P3	AUG 4 16	KM	DT	KM	PW	REVISED AS PER PROPERTIES COMMENTS
P2	JULY 28 16	KM	DT	KM	PW	REVISED AS PER MARKUPS
P1	JULY 27 16	KM	DT	KM	?	PRELIMINARY SKETCH FOR REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: K.M.
Drawn: D.T.
Checked: K.M.
Approved
Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

LOT 236
PLAN AND ISOMETRIC

SCALE: AS NOTED
DISTRICT FILE SF–1933
DRAWING NUMBER X–A61C0028

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P5

xref files:

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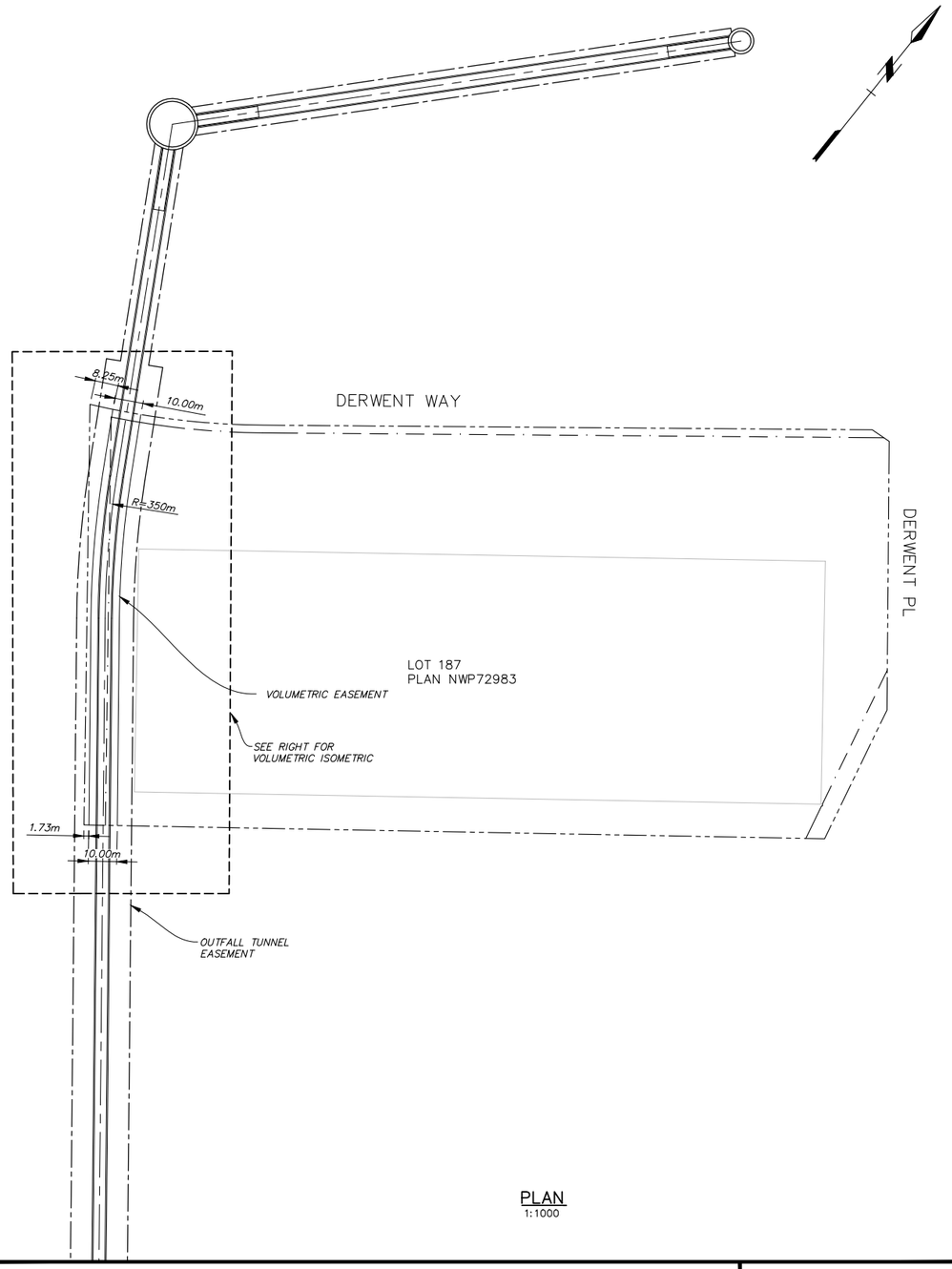
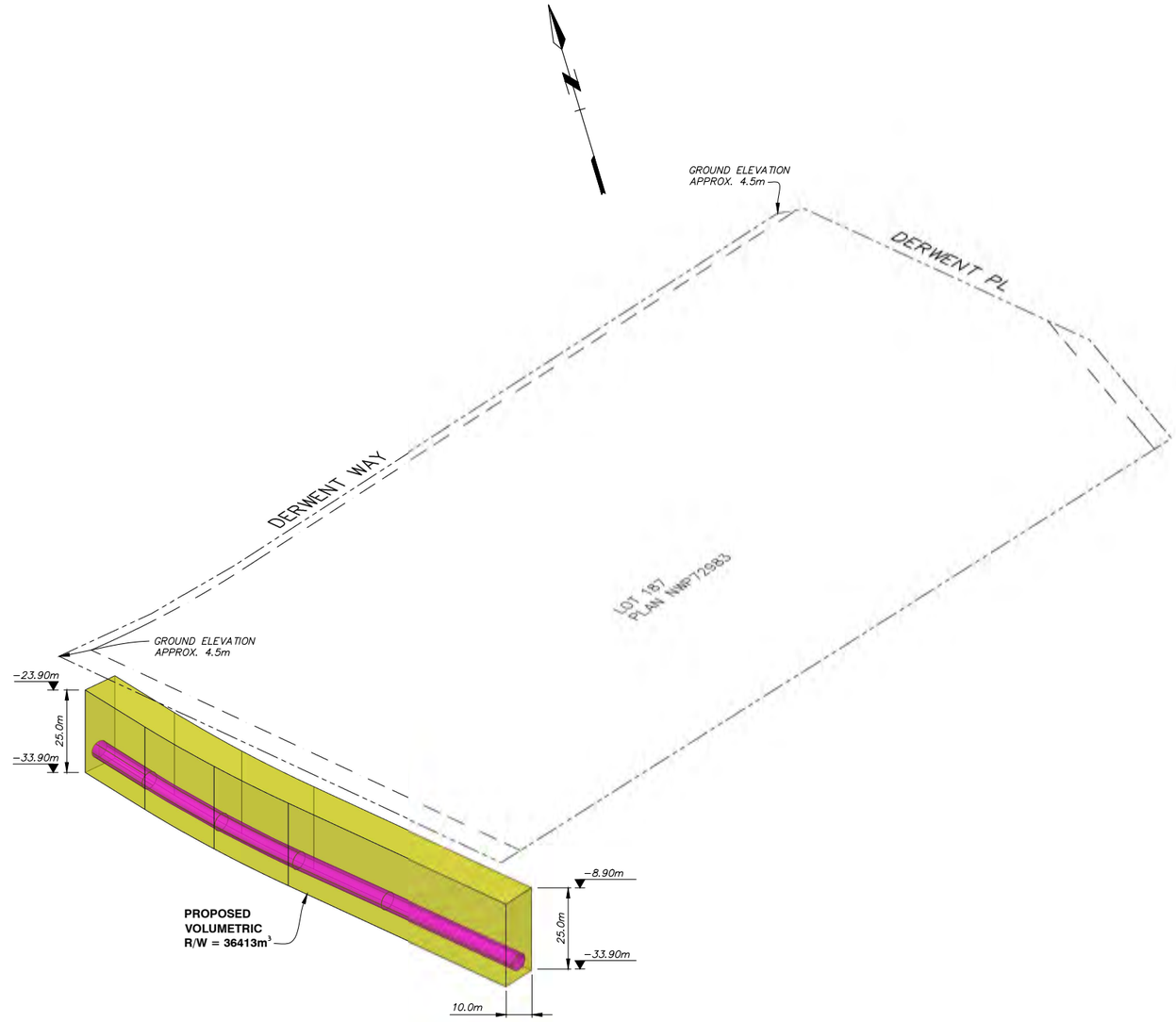


PLAN
1:1000



3D PLAN
N.T.S.

ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

NOTES:
1. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD – GEODETIC DATUM.

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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P.3	NOV 2017	JEN	CEB	JNC	JEN	ISSUED FOR PERMIT REVIEW
P.2	AUG 2017	JEN	CEB	JNC	JEN	REVISED AS PER NOS ALIGNMENT
P.1	SEPT 17 16	KM	DT	KM		PRELIMINARY SKETCH FOR REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: K.M.
Drawn: D.T.
Checked: K.M.
Approved
Manager

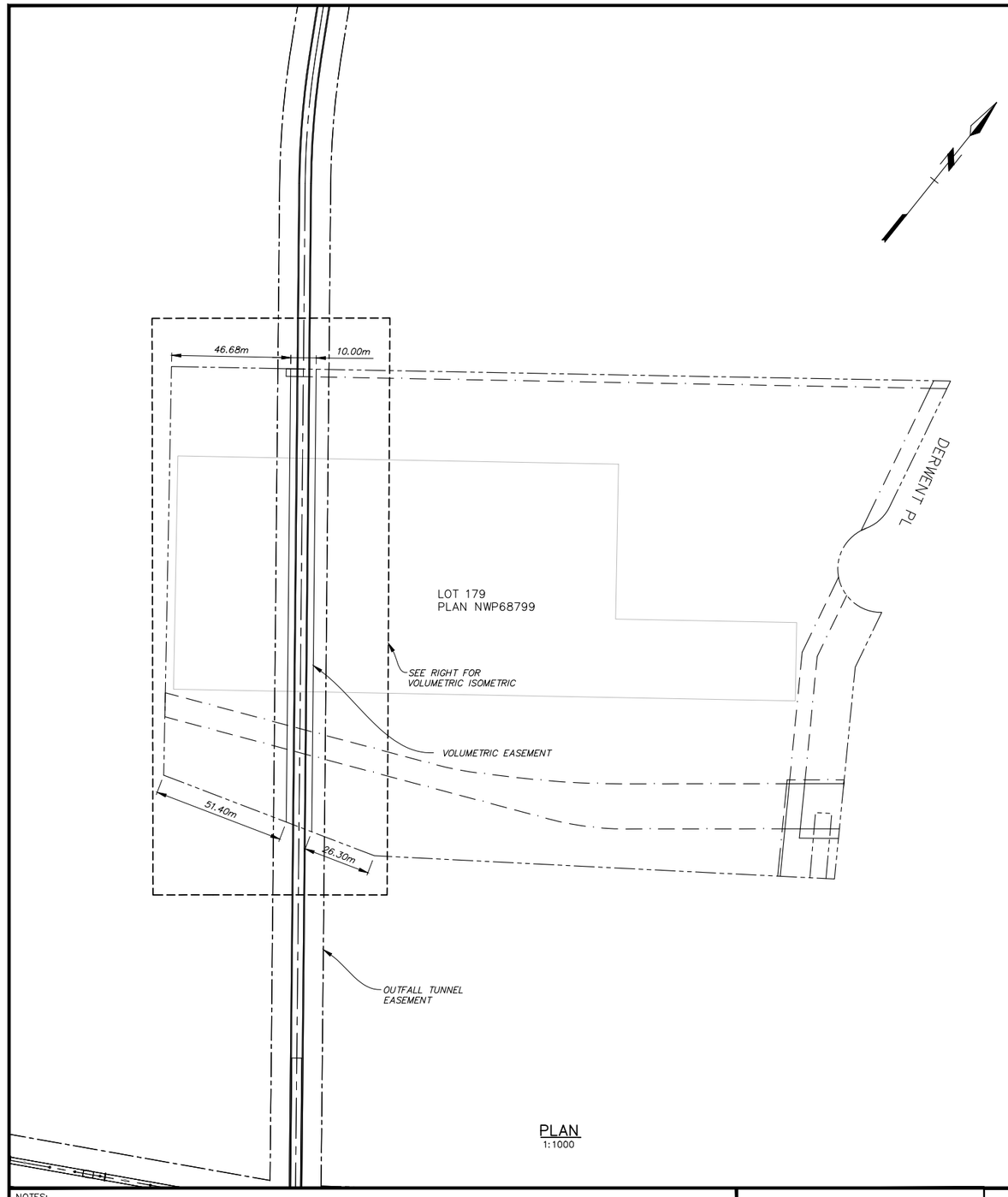
ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

LOT 187
PLAN AND ISOMETRIC

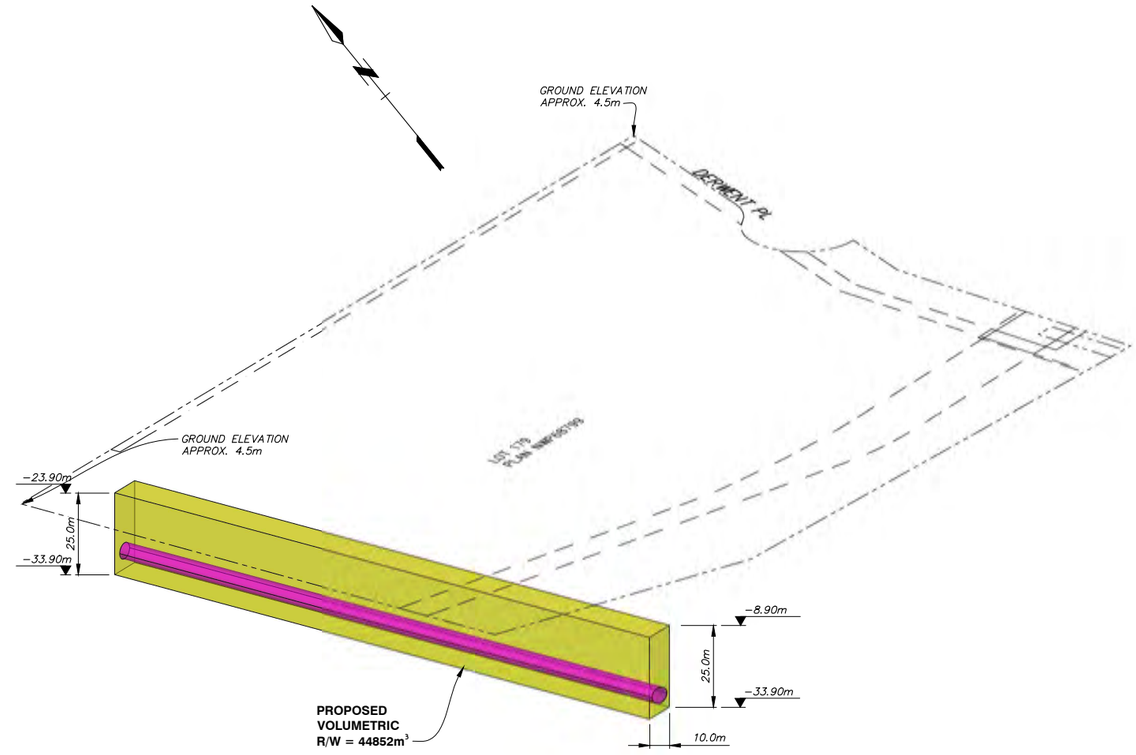
SCALE: AS NOTED
DISTRICT FILE SF–1933
DRAWING NUMBER X–A61C0029

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P.3

2017–11–02 11:34 Bilderbackce C:\cdmwm\Bilderbackce\v2821585\X–A61C0029 – PERMIT.dwg
xref files:



PLAN
1:1000



3D PLAN
N.T.S.

ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

NOTES:
1. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD – GEODETIC DATUM.

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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P3	NOV 2017	JEN	CEB	JNC	JEN	ISSUED FOR PERMIT REVIEW
P2	AUG 2017	JEN	CEB	JNC	JEN	REVISED AS PER NOS ALIGNMENT
P1	SEPT 17 16	KM	DT	KM		PRELIMINARY SKETCH FOR REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: K.M.
Drawn: D.T.
Checked: K.M.
Approved
Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

LOT 179
PLAN AND ISOMETRIC

SCALE: AS NOTED
DISTRICT FILE SF-1933
DRAWING NUMBER X-A61C0030

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P3

2017-11-02 11:40 Bilderbocke C:\cdmsm\bilderbocke\v2821585\X-A61C0030 - PERMIT.dwg
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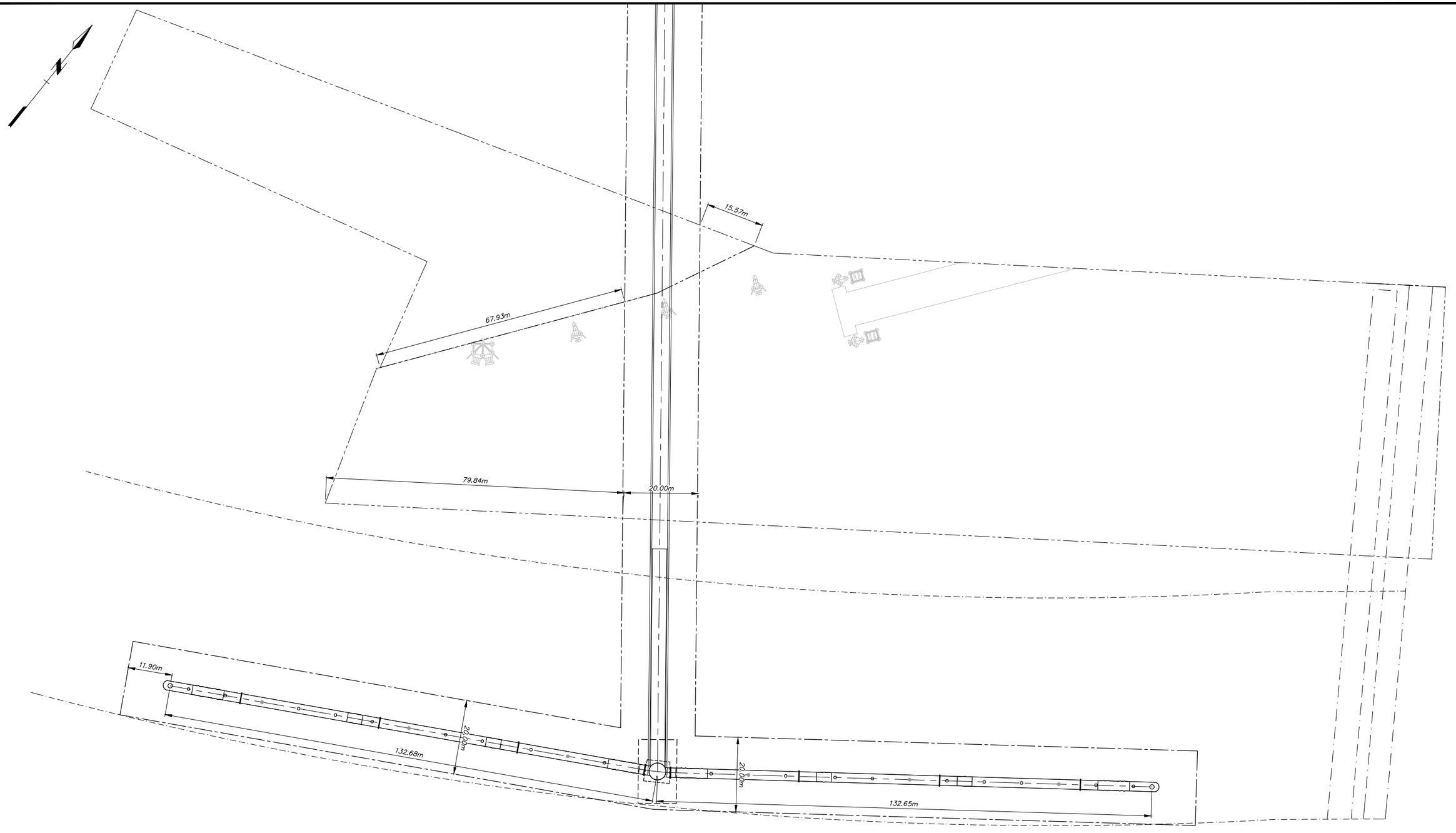

PLAN
1:500

ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

NOTES:
1. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD – GEODETIC DATUM.

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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	App'd	Description
P5	NOV 2017	JEN	CEB	JNC	JEN	ISSUED FOR PERMIT REVIEW
P4	AUG 2017	JEN	CEB	JNC	JEN	REVISED AS PER NOS ALIGNMENT
P3	SEPT 27 16	KM	DT	KM		VOLUMETRIC R/W REMOVED, IN RIVER ADDED
P2	SEPT 19 16	KM	DT	KM		GENERAL REVISIONS
P1	SEPT 16 16	KM	DT	KM		PRELIMINARY SKETCH FOR REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: K.M.
Drawn: D.T.
Checked: K.M.
Approved
Manager

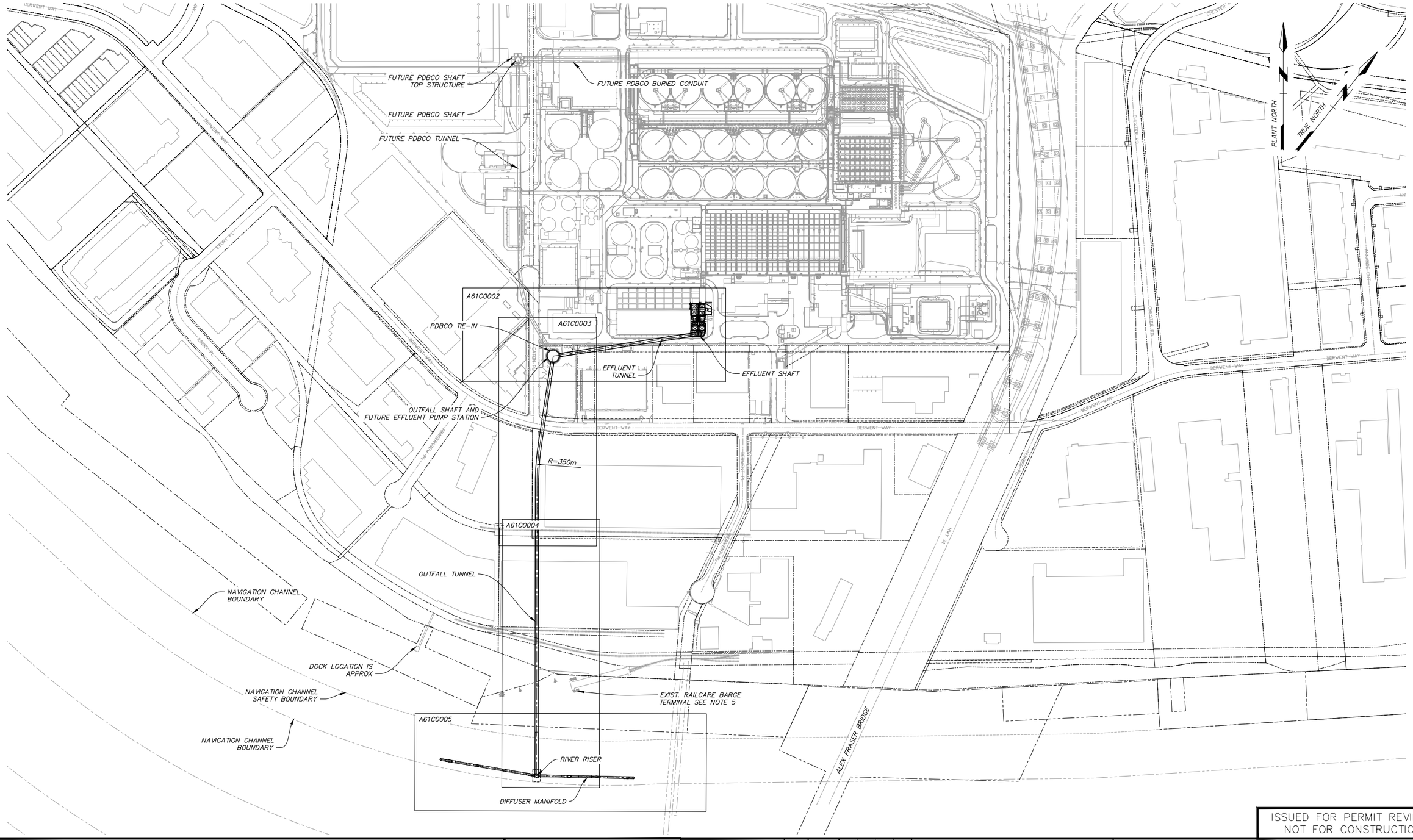
ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

WATERFRONT LOT
PLAN

SCALE: AS NOTED
DISTRICT FILE SF–1933
DRAWING NUMBER X–A61C0031

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P5

2017-10-20 17:18 RV C:\cdmwm\Vx\d282585\Vx-A61C0031 – PERMIT.dwg
xref files:



ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

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1001–4710 Kingsway
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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	App'd	Description
P4	NOV. 2017	AK	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW
P3	AUG. 2017	AK	CEB	GLL	JNC	ISSUED FOR 90% DESIGN REVIEW
P2	MAR. 2017	AK	CEB	GLL	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	AK	CEB	GLL	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: AK
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

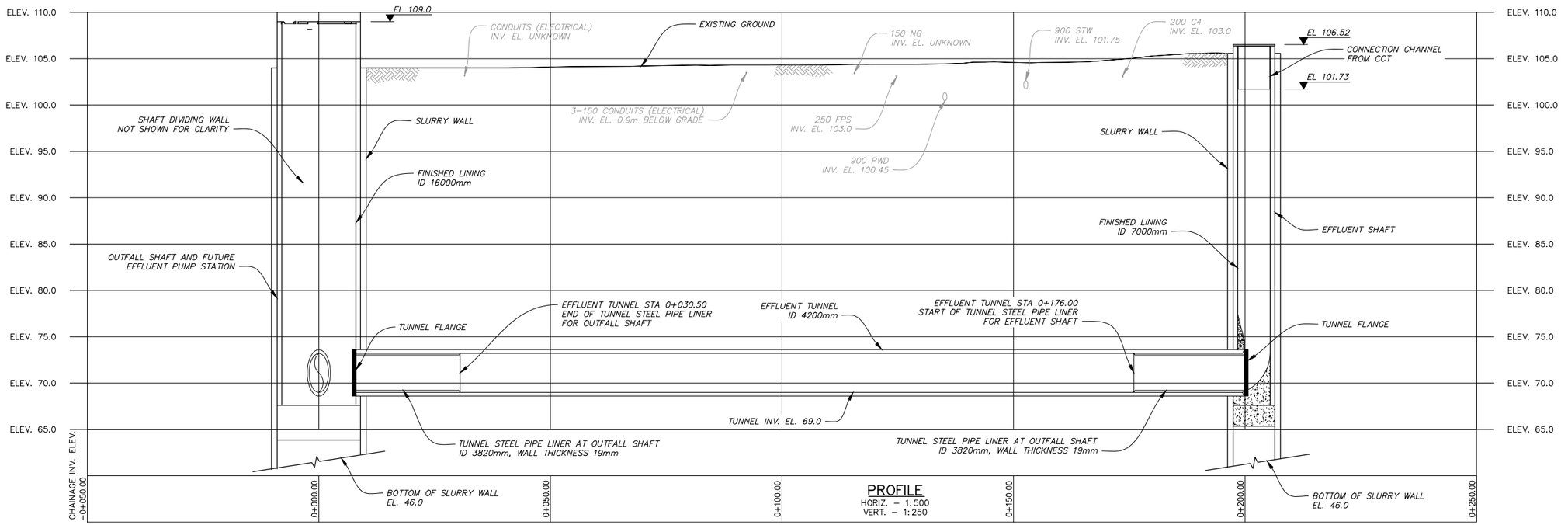
A61 – GENERAL SITE WORKS
SITE PLAN SHEET KEY MAP 2

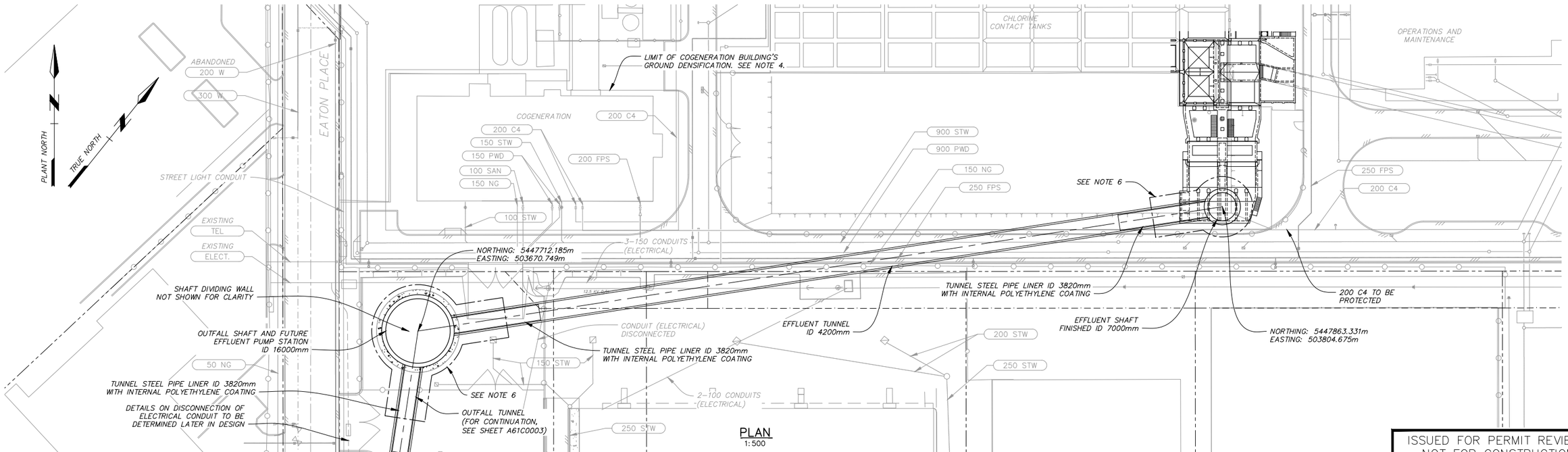
SCALE: 1:2500
DISTRICT FILE SF-1933
DRAWING NUMBER A61C0001

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

2017-11-06 16:24 RV C:\cdmsmith\v*\V2821585\V61C0001SF1933.dwg

xref files:





ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

NOTES:
1. COORDINATES ARE UTM NAD83 ZONE 10 – 4.0.0.BC.1.GVRD GROUND UNITS. COMBINED SCALE FACTOR = 0.9996026.
2. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD2005 GEODETIC DATUM. 100m HAS BEEN ADDED TO ALL ELEVATIONS AND TIED TO BENCHMARK 87H3501 (ELEV: 3.546'). TBM ELEV: 103.546'.
3. TOPOGRAPHICAL SURVEY PROVIDED BY PROTECH ON JANUARY 2013.
4. COGENERATION BUILDING'S GROUND IMPROVEMENT TO EL. 86.5 PER DRAWINGS A81 S1003 AND A81 S1004, DATED JAN 1996 OF THE AIWWTP CONTRACT A11 COGENERATION – STAGE IV.
5. ALL LOCATIONS AND ELEVATIONS OF UTILITIES ARE APPROXIMATE. CONTRACTOR TO LOCATE, PROTECT, AND RELOCATE UTILITIES AS REQUIRED.
6. CONTRACTOR TO PROTECT UTILITIES WITHIN SHAFT AND TUNNEL CONSTRUCTION IMPACT ZONE.
7. FIELD APPLIED POLYETHYLENE COATING ON THE TUNNEL STEEL PIPE LINER AND STEEL SHAFT TO TUNNEL CONNECTIONS AFTER INSTALLATION.

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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	App'd	Description
P4	NOV. 2017	AK	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW
P3	AUG. 2017	AK	CEB	GLL	JNC	ISSUED FOR 90% DESIGN REVIEW
P2	MAR. 2017	AK	CEB	GLL	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	AK	CEB	GLL	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: AK
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

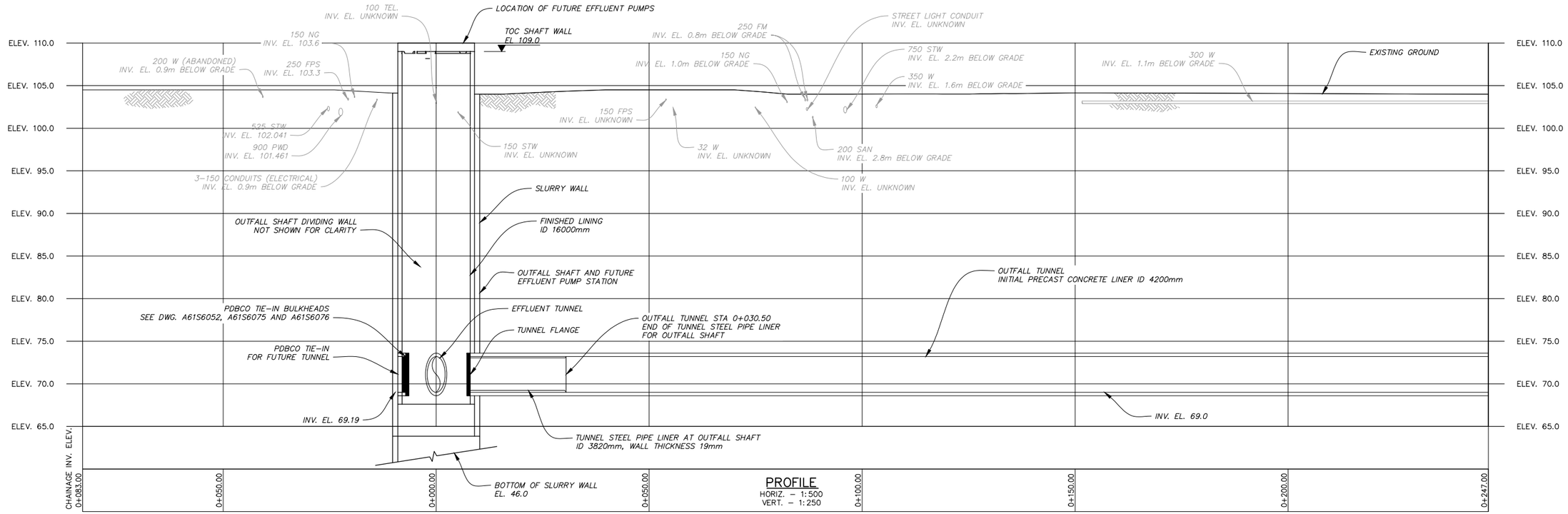
A61 – NOS
TUNNEL PLAN AND PROFILE 1

SCALE: AS NOTED
DISTRICT FILE SF–1933
DRAWING NUMBER A61C0002

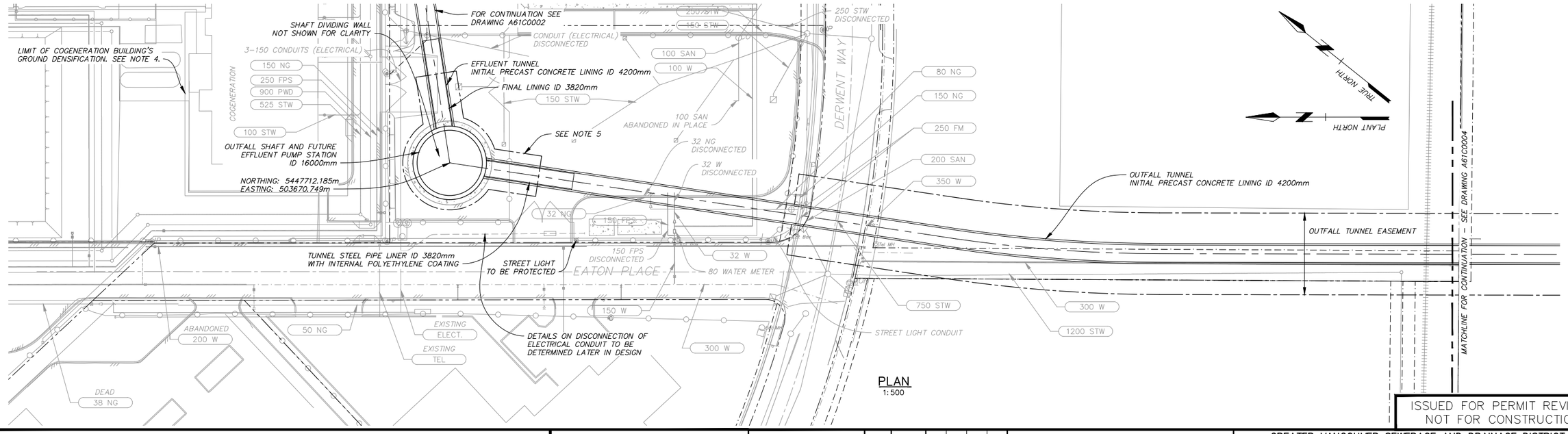
SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

2017–11–06 16:39 RV C:\cdmsmi\rv\d282158\A61C0002SF1933.dwg

xref files:



PROFILE
HORIZ. – 1:500
VERT. – 1:250



PLAN
1:500

ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

NOTES:
1. COORDINATES ARE UTM NAD83 ZONE 10 – 4.0.0.BC.1.GVRD GROUND UNITS. COMBINED SCALE FACTOR = 0.9996026.
2. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD2005 GEODETIC DATUM. 100m HAS BEEN ADDED TO ALL ELEVATIONS AND TIED TO BENCHMARK 87H3501 (ELEV: 3.546'). TBM ELEV: 103.546'.
3. TOPOGRAPHICAL SURVEY PROVIDED BY PROTECH ON JANUARY 2013.
4. ALL LOCATIONS AND ELEVATIONS OF UTILITIES ARE APPROXIMATE. CONTRACTOR TO LOCATE, PROTECT, AND RELOCATE UTILITIES AS REQUIRED.
5. CONTRACTOR TO PROTECT UTILITIES WITHIN SHAFT AND TUNNEL CONSTRUCTION IMPACT ZONE.
6. FIELD APPLIED POLYETHYLENE COATING ON THE TUNNEL STEEL PIPE LINER AND STEEL SHAFT TO TUNNEL CONNECTIONS AFTER INSTALLATION.

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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P4	NOV. 2017	AK	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW
P3	AUG. 2017	AK	CEB	GLL	JNC	ISSUED FOR 90% DESIGN REVIEW
P2	MAR. 2017	AK	CEB	GLL	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	AK	CEB	GLL	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: AK
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

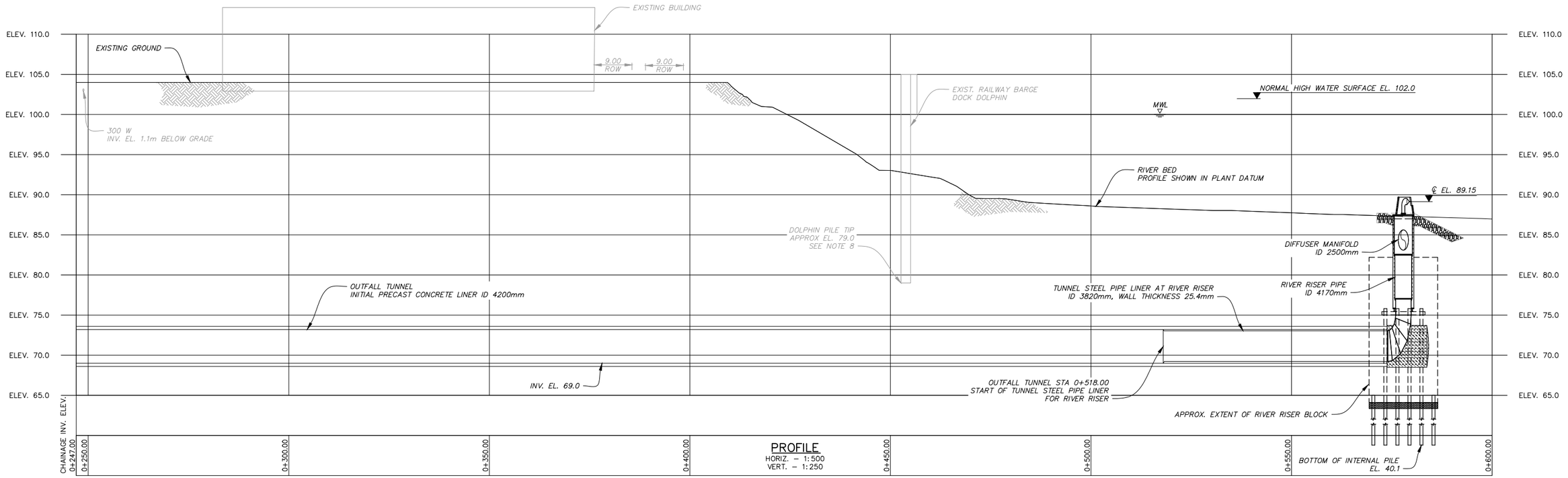
A61 – NOS
TUNNEL PLAN AND PROFILE 2

SCALE: AS NOTED
DISTRICT FILE SF–1933
DRAWING NUMBER A61C0003

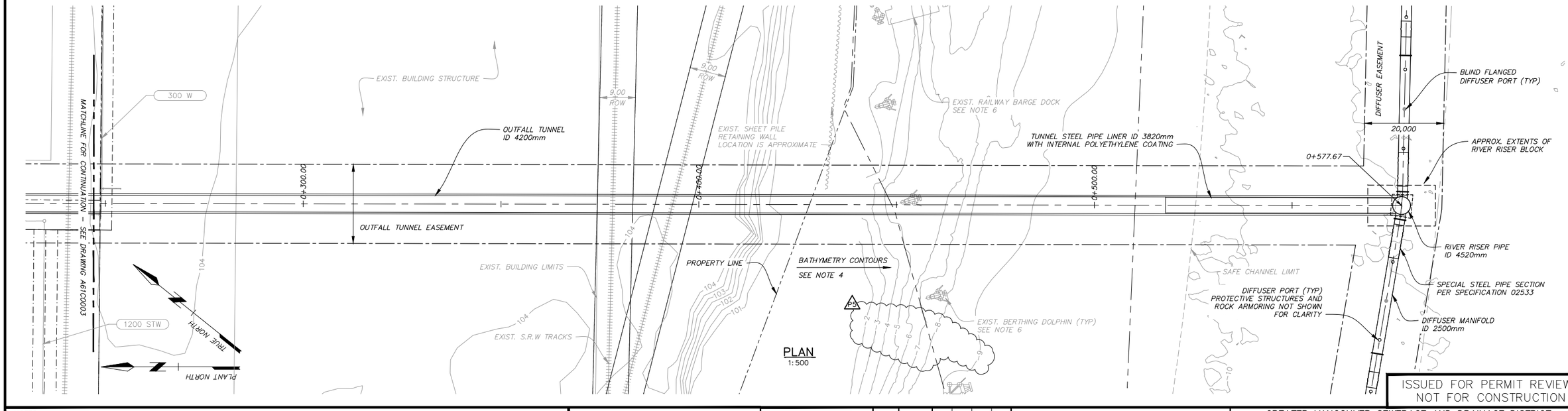
SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

2017–11–06 16:45 RV C:\cdmsm\v*\V282585\V61C0003SF1933.dwg

xref files:



PROFILE
HORIZ. – 1:500
VERT. – 1:250



PLAN
1:500

ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

NOTES:
1. COORDINATES ARE UTM NAD83 ZONE 10 – 4.0.0.BC.1.GVRD GROUND UNITS. COMBINED SCALE FACTOR = 0.9996026.
2. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD2005 GEODETIC DATUM.
   100m HAS BEEN ADDED TO ALL ELEVATIONS AND TIED TO BENCHMARK 87H3501 (ELEV: 3.546'). TBM ELEV: 103.546'.
3. TOPOGRAPHICAL SURVEY PROVIDED BY PROTECH ON JANUARY 2013.
4. RIVER BOTTOM (BATHYMETRY ELEVATION IN TIDE & CHART DATUM (EL 0.00 GEODETIC=EL+1.59 TIDE & CHART).
   RIVER BATHYMETRY IS VARIABLE. CCG BATHYMETRY SURVEY DATA FROM JANUARY 2016.
5. NEW STRUCTURES AND DIFFUSER MANIFOLD PIPELINE ARE IN AIWWTP DATUM PER NOTE 2 ABOVE.
6. ANNACIS ISLAND RAILCAR BARGE TERMINAL LOCATION PER SOUTHERN RAILWAY BRITISH COLUMBIA DRAWING FILE 25141102, MAY 2009.
   LOCATION IS APPROXIMATE.
7. ALL LOCATIONS AND ELEVATIONS OF UTILITIES ARE APPROXIMATE. CONTRACTOR TO LOCATE, PROTECT, AND RELOCATE UTILITIES AS REQUIRED.
8. SOUTHERN RAILWAY OF BC, ANNACIS ISLAND RAILCAR BARGE TERMINAL
   ISSUED FOR CONSTRUCTION DRAWING NO. 25141–102. REV. C, AUG 19, 2009.

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Burnaby, BC V5H 4M2
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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P4	NOV. 2017	AK	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW
P3	AUG. 2017	AK	CEB	GLL	JNC	ISSUED FOR 90% DESIGN REVIEW
P2	MAR. 2017	AK	CEB	GLL	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	AK	CEB	GLL	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: AK
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

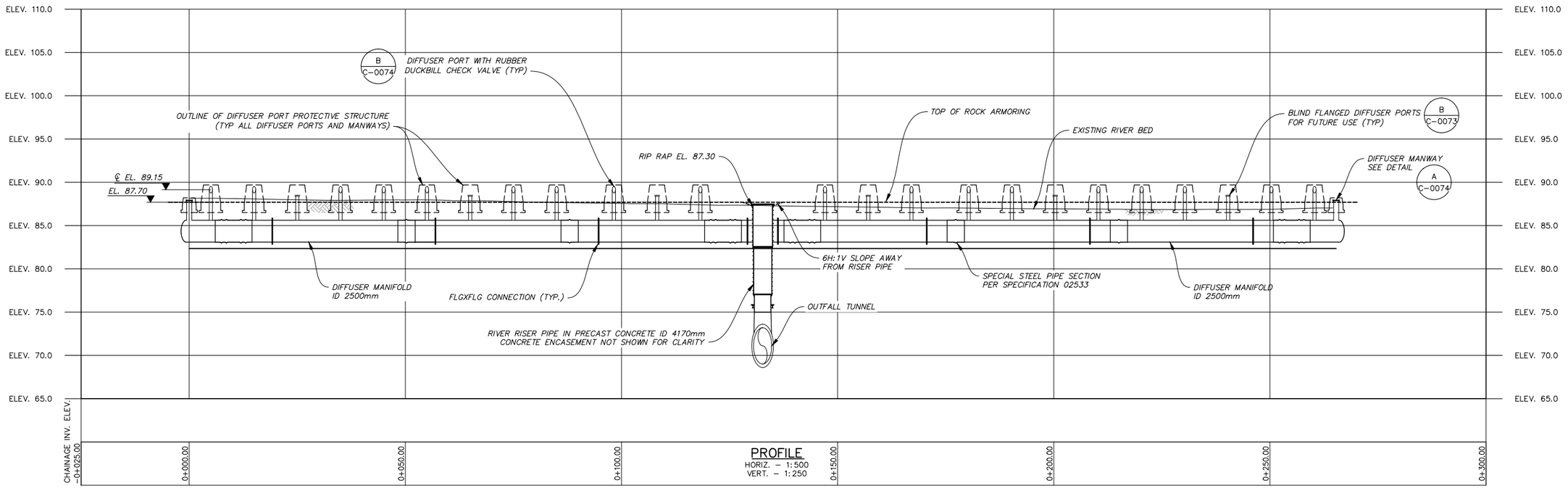
A61 – NOS
TUNNEL PLAN AND PROFILE 3

SCALE: AS NOTED
DISTRICT FILE SF–1933
DRAWING NUMBER A61C0004

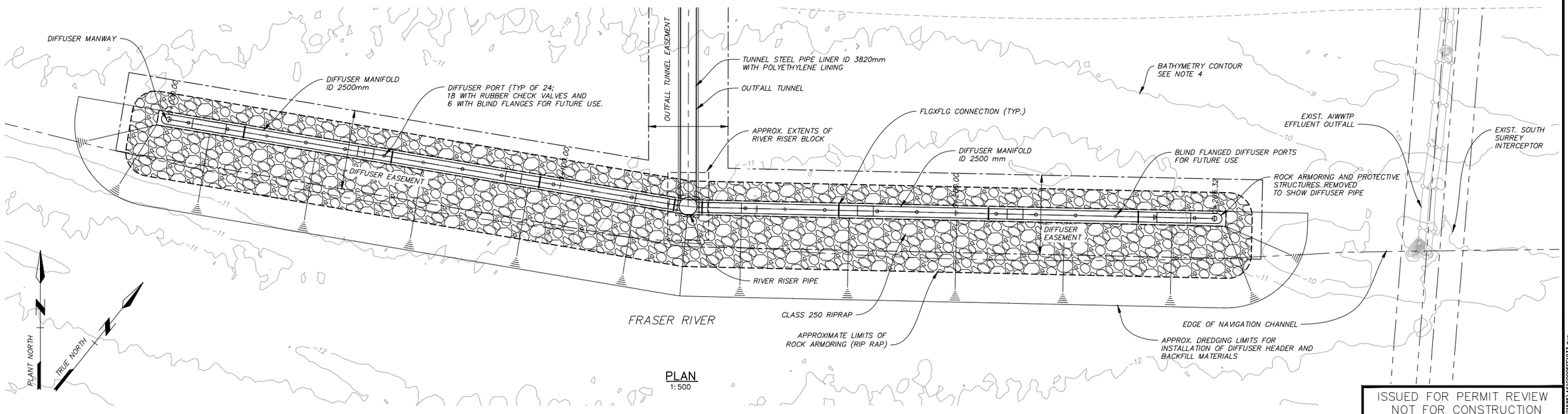
SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

2017–11–06 16:59 RY C:\cdmsmYrv\d2821585\A61C0004SF1933.dwg

xref files:



PROFILE
HORIZ. – 1:500
VERT. – 1:250



PLAN
1:500

ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

NOTES:
1. COORDINATES ARE UTM NAD83 ZONE 10 – 4.0.0.BC.1.GVRD GROUND UNITS. COMBINED SCALE FACTOR = 0.9996026.
2. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD2005 GEODETIC DATUM. 100m HAS BEEN ADDED TO ALL ELEVATIONS AND TIED TO BENCHMARK 87H3501 (ELEV: 3.546'). TBM ELEV: 103.546'.
3. TOPOGRAPHICAL SURVEY PROVIDED BY PROTECH ON JANUARY 2013.
4. RIVER BOTTOM (BATHYMETRY ELEVATION IN TIDE & CHART DATUM (EL 0.00 GEODETIC=EL+1.59 TIDE & CHART). RIVER BATHYMETRY IS VARIABLE. CCG BATHYMETRY SURVEY DATA FROM JANUARY 2016.
5. NEW STRUCTURES AND DIFFUSER MANIFOLD PIPELINE ARE IN AIWWTP DATUM PER NOTE 2 ABOVE.
6. ANNACIS ISLAND RAILCAR BARGE TERMINAL LOCATION PER SOUTHERN RAILWAY BRITISH COLUMBIA DRAWING FILE 25141102, MAY 2009. LOCATION IS APPROXIMATE.

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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P4	NOV. 2017	AK	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW
P3	AUG. 2017	AK	CEB	GLL	JNC	ISSUED FOR 90% DESIGN REVIEW
P2	MAR. 2017	AK	CEB	GLL	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	AK	CEB	GLL	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: AK
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

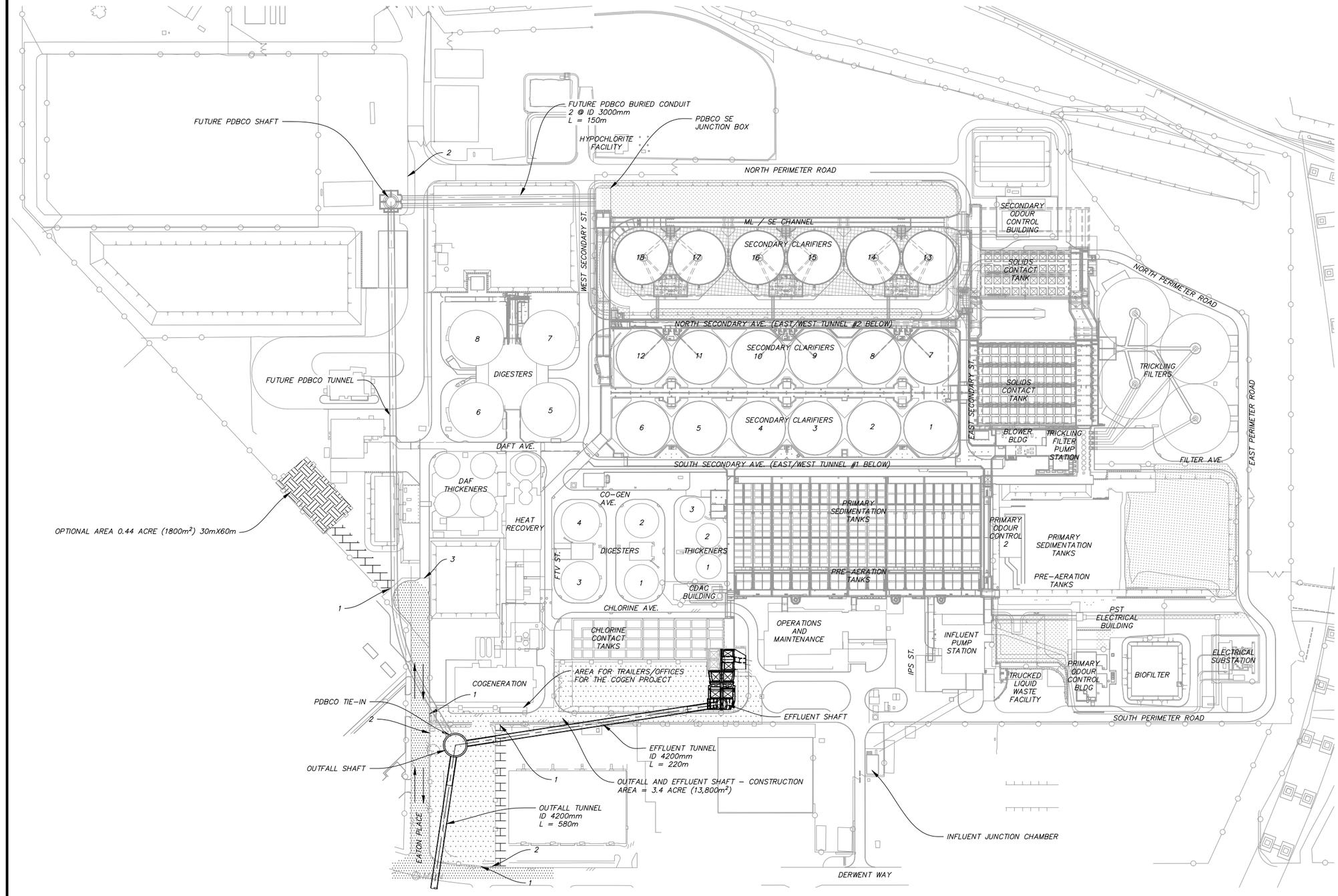
ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

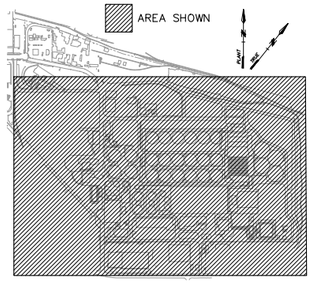
A61 – NOS
TUNNEL PLAN AND PROFILE 4

SCALE: AS NOTED
DISTRICT FILE SF–1933
DRAWING NUMBER A61C0005

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

2017–11–06 17:18 RV C:\cdmsm\V\V2821585\A61C0005SF1933.dwg
xref files:





NOTES:

1. REFER TO DRAWING A10 _____ FOR GENERAL NOTES.
2. REFER TO DRAWING A10 _____ FOR PROJECT SURVEY CONTROLS.
3. REFER TO DRAWING A10 _____ FOR EXISTING SITE CONTOURS.

ISSUED FOR PERMIT REVIEW
NOT FOR CONSTRUCTION

LEGEND

- CONSTRUCTION STAGING AREAS
- TUNNEL CONSTRUCTION STORAGE AREAS (RINGS, STEEL PIPES, ETC). OPTIONAL AREA
- ACCESS ROAD – TRUCK ROUTE
- NEW ROAD ACCESS – OPTIONAL AREA – EFFLUENT SHAFT

1 SITE ACCESS
2 NEW SECURITY KIOSK
3 ENTRANCE SECURITY GATE
EXISTING PLANT FENCE
CONSTRUCTION FENCE
TRAFFIC DIRECTION

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Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P3	NOV. 2017	JFA	CEB	GLL	JNC	ISSUED FOR PERMIT REVIEW
P2	AUG. 2017	JFA	CEB	GLL	JNC	ISSUED FOR 90% DESIGN REVIEW
P1	MAR. 2017	JFA	CEB	GLL	JNC	ISSUED FOR 60% DESIGN REVIEW

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: JFA
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

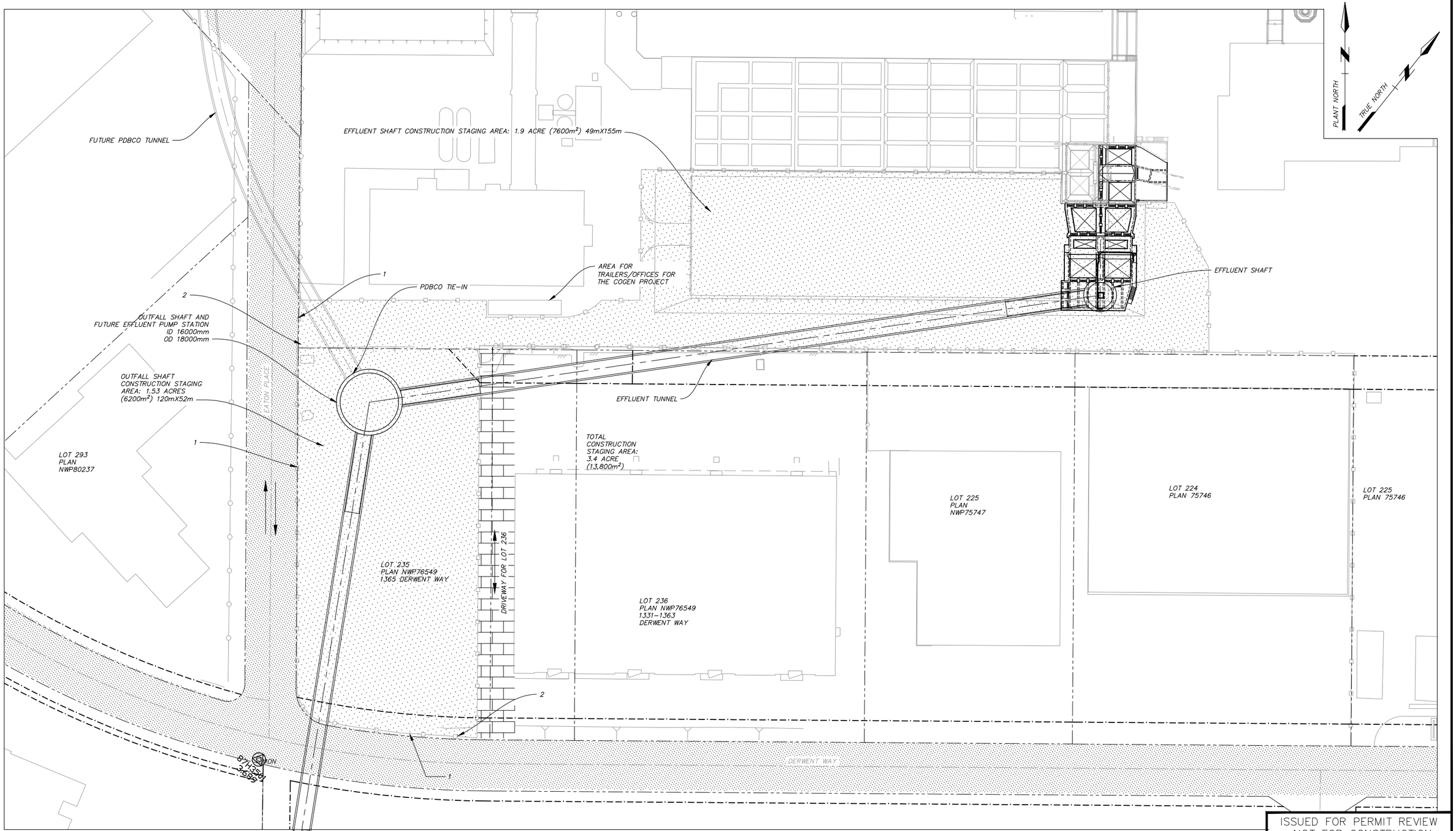
ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

CIVIL WORKS – SITE PLAN
CONSTRUCTION ACCESS AND FENCING

SCALE: NTS
DISTRICT FILE SF-1933
DRAWING NUMBER X-A10C007

2017-10-17 20:17 kaalkumarg C:\cdmsm\Vaalkumarg\G282158$\X-A10C007 - PERMIT.dwg

xref files:



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LEGEND

- CONSTRUCTION STAGING AREAS
- ACCESS ROAD – TRUCK ROUTE
- NEW ROAD ACCESS
- TRAFFIC DIRECTION
- 1 SITE ACCESS
- 2 NEW SECURITY KIOSK
- EXISTING PLANT FENCE
- CONSTRUCTION FENCE

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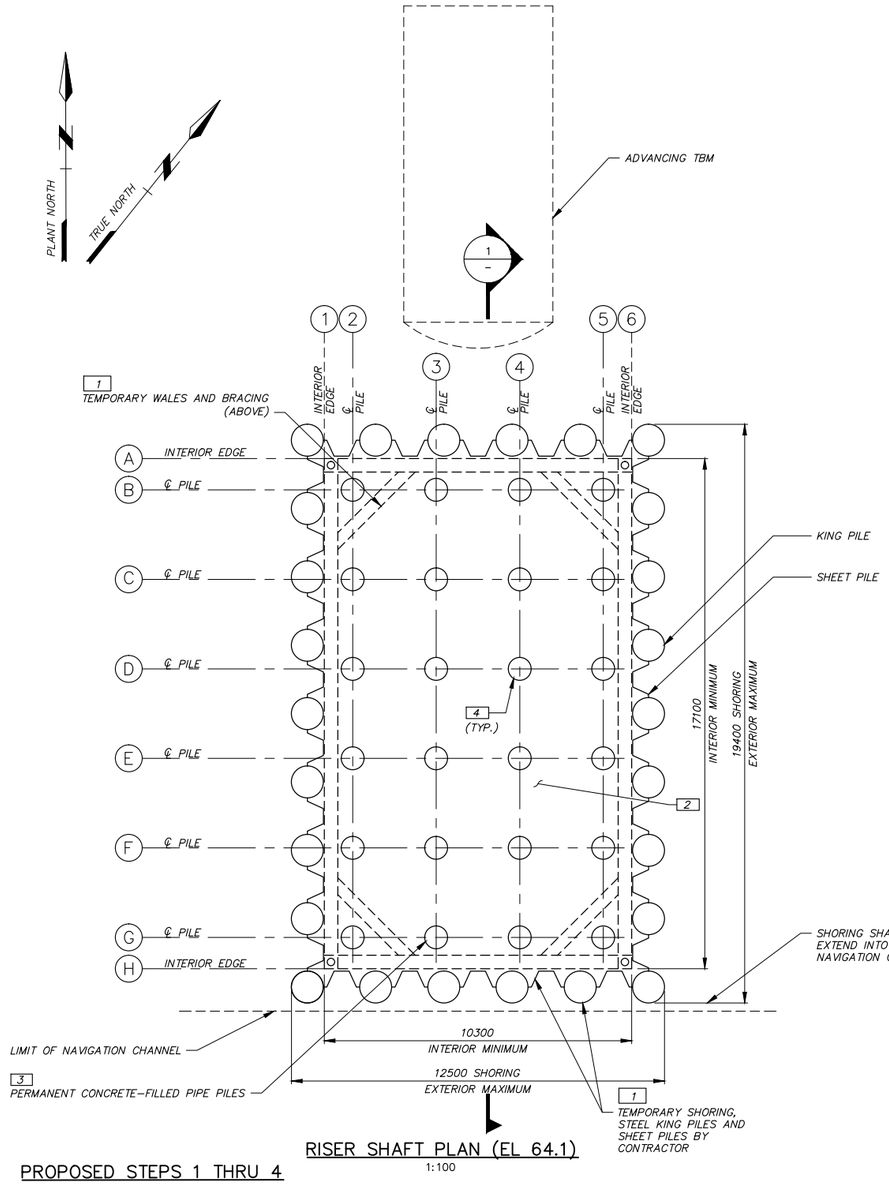
Drawn: CEB
Checked: GLL
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

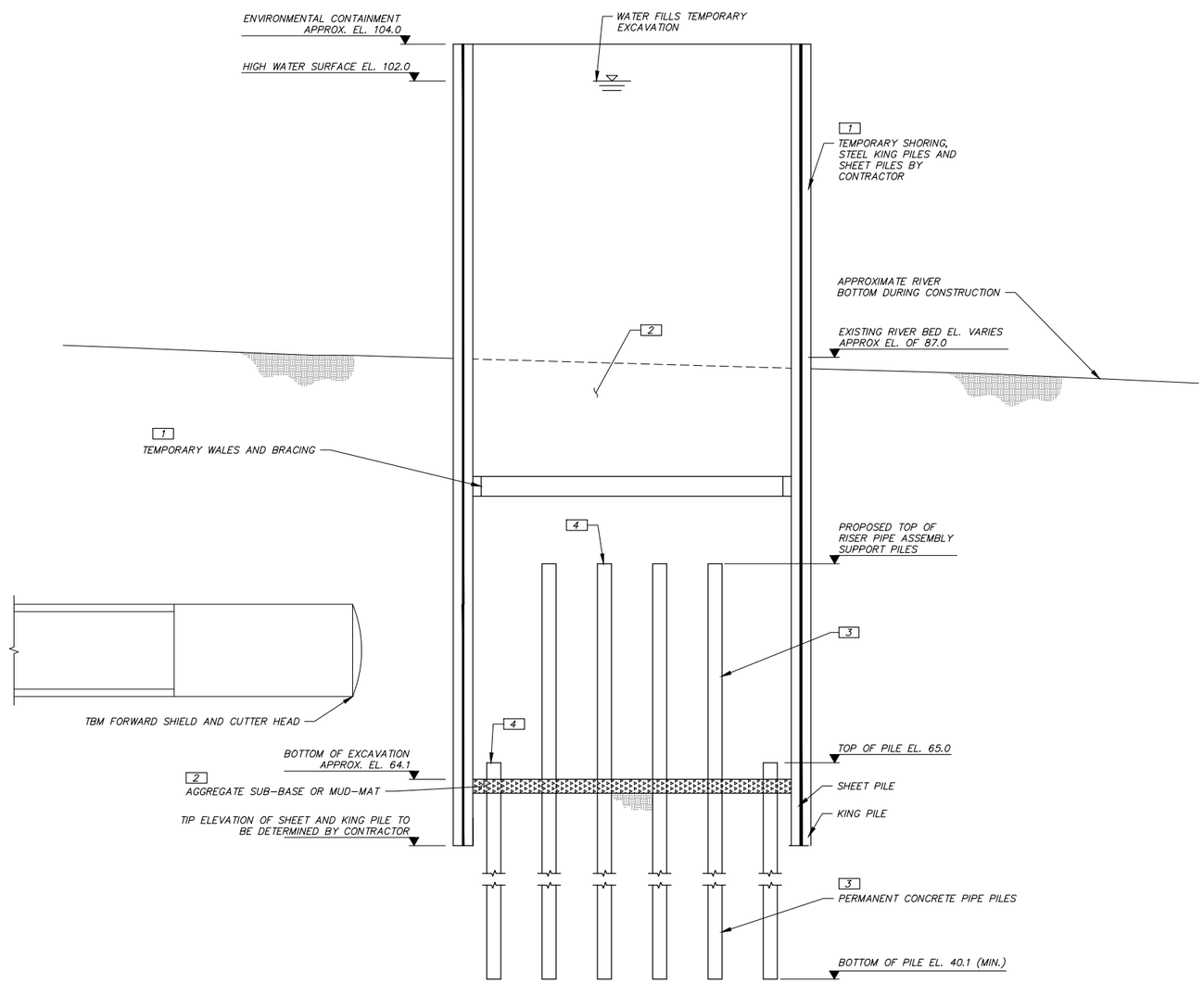
CIVIL WORKS – GENERAL ARRANGEMENT
CONSTRUCTION STAGING AREA – 1

SCALE: NTS
DISTRICT FILE SF–1933
DRAWING NUMBER X–A10C008

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P3



RISER SHAFT PLAN (EL 64.1)
1:100



SECTION 1
1:150

PROPOSED STEPS 1 THRU 4

1 INSTALL TEMPORARY SHORING AS REQUIRED TO MEET MINIMUM EXCAVATION LIMITS. TEMPORARY SHORING TO BE DESIGNED AND CONSTRUCTED BY THE CONTRACTOR.

2 EXCAVATE SOIL TO THE LIMITS SHOWN. CONTRACTOR TO PROVIDE A LAYER OF AGGREGATE OR A CONCRETE MUD-MAT TO PREVENT INTERMIXING OF LOOSE SOILS WITH STRUCTURAL TREMIE CONCRETE.

3 DRIVE PILES. THE REQUIRED PILE CUT-OFF ELEVATION IS 65.0. TOP OF PILES ELEVATIONS MAY BE INCREASED AT CONTRACTORS OPTION TO TEMPORARY SUPPORT THE INSTALLATION OF THE RISER PIPE. PILE 1C, 1D, 1E, 1F, 5C, 5D, 5E & 5F ARE SHOWN EXTENDED TO SUPPORT THE RISER PIPE ASSEMBLY. PILES WITHIN THE PATH OF THE TBM SHALL TERMINATE AT ELEVATION 65.0.

4 FILL PIPE PILES WITH CONCRETE AS REQUIRED PER DESIGN.

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P2	SEP. 2017	CSC	CEB	PFB	JNC	ISSUED FOR 90% DESIGN REVIEW
P1	SEP. 2017	CSC	CEB	PFB	JNC	ISSUED FOR INTERIM LCS DESIGN REVIEW

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: CSC
Drawn: CEB
Checked: PFB
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JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

RISER SHAFT
CONSTRUCTION SEQUENCE 1

SCALE: AS NOTED
DISTRICT FILE SF-1933
DRAWING NUMBER X-A61S0081

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P3

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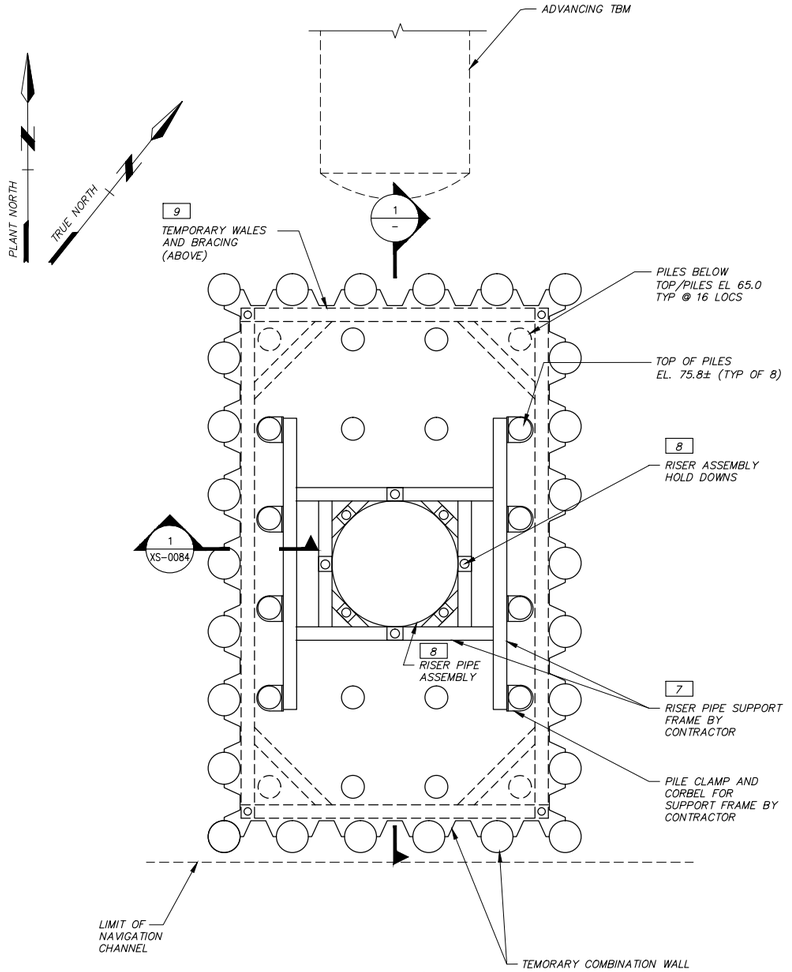
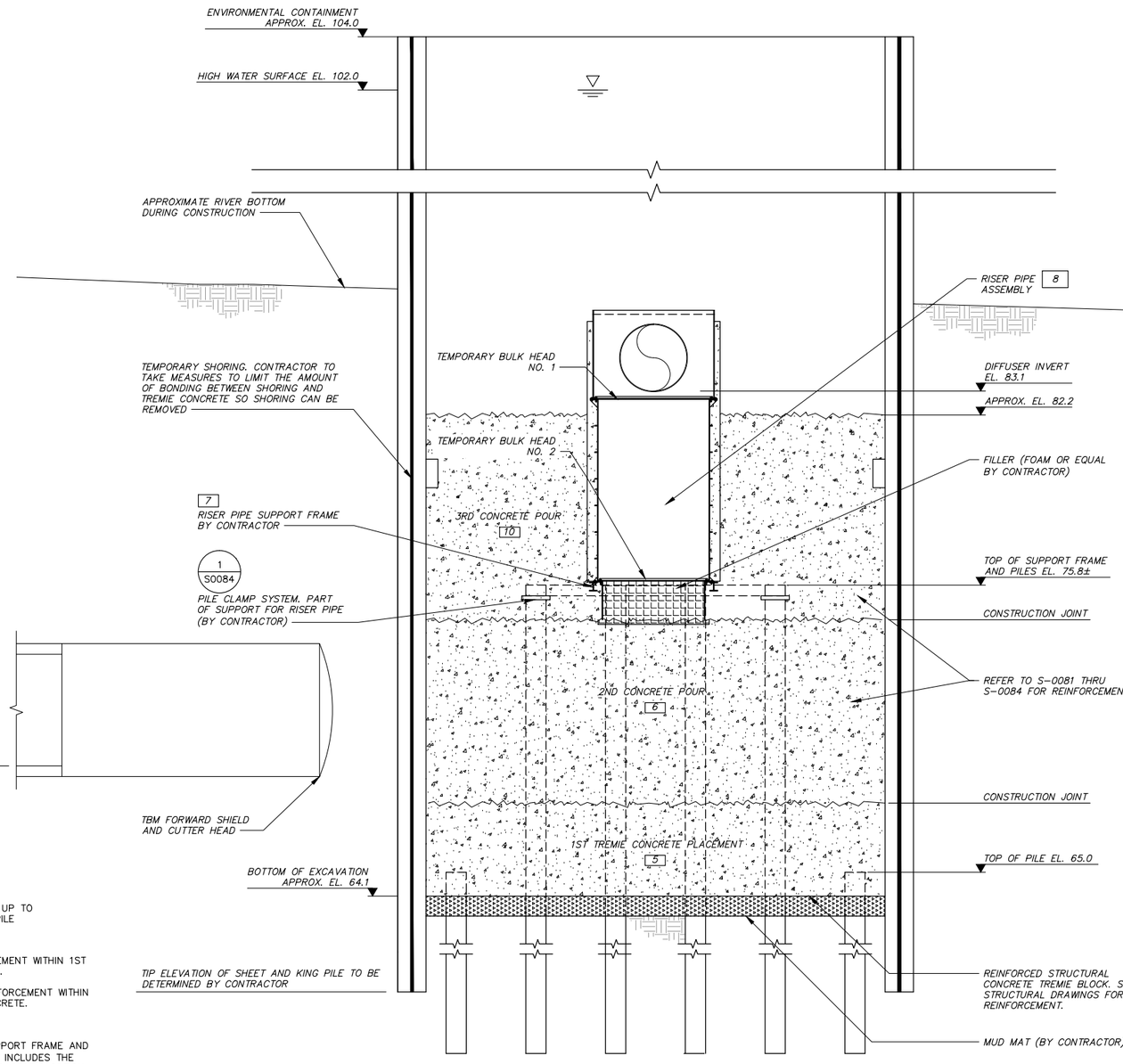
xref files:



RISER SHAFT PLAN (EL 75.8)

1:100



SECTION 1 – 1:100

GENERAL NOTES:

1. CONTRACTOR TO DESIGN, FABRICATE AND INSTALL TEMPORARY FRAMING AND OTHER COMPONENTS FOR SUPPORTING THE RISER PIPE ASSEMBLY DURING THE PLACEMENT OF THE TREMIE CONCRETE. THIS SUPPORT FRAMING WILL BE ABANDONED IN-PLACE AND WILL BE ENCAPSULATED IN TREMIE CONCRETE.
2. THE TEMPORARY FRAMING MAY BE SUPPORTED BY ANY OTHER STRUCTURAL ELEMENT THAT THE CONTRACTOR DETERMINES IS STRUCTURALLY SUFFICIENT TO SUPPORT THE TEMPORARY LOADS OF THE RISER PIPE ASSEMBLY. THE RISER PIPE ASSEMBLY INCLUDES THE PRECAST CONCRETE RISER PIPE/TEE AND FILLER THIS INCLUDES BUT IS NOT LIMITED TO THE STEEL PIPE PILES, TOP OF CONCRETE PLACEMENTS, AND TEMPORARY SHORING.
3. THE CONTRACTOR HAS THE OPTION TO EXTEND ANY PIPE PILE NOT LOCATED WITHIN THE PATH OF THE TBM TO A HIGHER ELEVATION TO ACT A GUIDE POST OF LOWERING THE TEMPORARY SUPPORT FRAMING AND RISER PIPE ASSEMBLY INTO POSITION. ANY PILE EXTENDING ABOVE THE FINAL TOP SURFACE (APPROXIMATELY ELEVATION 82.2) OF THE STRUCTURAL TREMIE CONCRETE SHALL BE CUT BACK TO AT LEAST 1 METER BELOW THE TOP SURFACE AND FULLY FILLED WITH CONCRETE.
4. THE DETAILS AND SEQUENCES OF THE FOLLOWING DETAILS SHALL BE COORDINATED BY THE CONTRACTOR WITH THE METHOD CHOSEN TO TEMPORARILY SUPPORT THE RISER PIPE ASSEMBLY:

A. LOCATIONS OF CONSTRUCTION JOINTS IN THE STRUCTURAL TREMIE CONCRETE.
B. PLACEMENT OF THE CONCRETE REINFORCING STEEL.
C. PLACEMENT OF THE CONCRETE ENCASED RISER PIPE ASSEMBLY.
D. PLACEMENT OF THE CONCRETE AND THE LOCATIONS OF THE TREMIE PIPES.
E. REMOVAL OF THE TEMPORARY SHORING.

PROPOSED STEPS 5-9

PROPOSED SEQUENCED DRAWINGS ASSUME 8 PILES ARE EXTENDED UP TO ELEVATION 75.8 AND A SUPPORT FRAME IS SUPPORTED OFF THE PILE SYSTEM. THE PROPOSED SEQUENCE IS AS FOLLOWS:

5. INSPECT MUD-MATT SURFACE, PLACE CONCRETE REINFORCEMENT WITHIN 1ST CONCRETE PLACEMENT ZONE AND PLACE TREMIE CONCRETE.
6. INSPECT PREVIOUS POUR SURFACE, PLACE CONCRETE REINFORCEMENT WITHIN 2ND CONCRETE PLACEMENT ZONE AND PLACE TREMIE CONCRETE.
7. INSTALL SUPPORT FRAME FOR RISER PIPE ASSEMBLY
8. SET THE RISER PIPE ASSEMBLY ONTO THE TEMPORARY SUPPORT FRAME AND INSTALL/TIGHTEN HOLD-DOWNS. THE RISER PIPE ASSEMBLY INCLUDES THE PRECAST CONCRETE RISER PIPE/TEE AND FILLER. AT CONTRACTOR'S OPTION THEY MAY FLOOD THE SPACE BETWEEN THE BULKHEADS, HOWEVER THEY MUST EVACUATE THE WATER BETWEEN THE BULKHEADS AFTER STEP 9 AND BEFORE STEP 11
9. REMOVE TEMPORARY WALES AND BRACING.
10. INSPECT PREVIOUS POUR SURFACE, PLACE CONCRETE REINFORCEMENT WITHIN 3RD CONCRETE PLACEMENT ZONE AND PLACE TREMIE CONCRETE.

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P3	NOV. 2017	CSC	CEB	PFB	JNC	ISSUED FOR PERMIT REVIEW
P2	SEP. 2017	CSC	CEB	PFB	JNC	ISSUED FOR 90% DESIGN REVIEW
P1	SEP. 2017	CSC	CEB	PFB	JNC	ISSUED FOR INTERIM LCS DESIGN REVIEW

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

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Checked: PFB
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

NOS RISER SHAFT
CONSTRUCTION SEQUENCE 2

SCALE: 1:100
DISTRICT FILE SF-1933
DRAWING NUMBER X-A61S0082

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P3

xref files:

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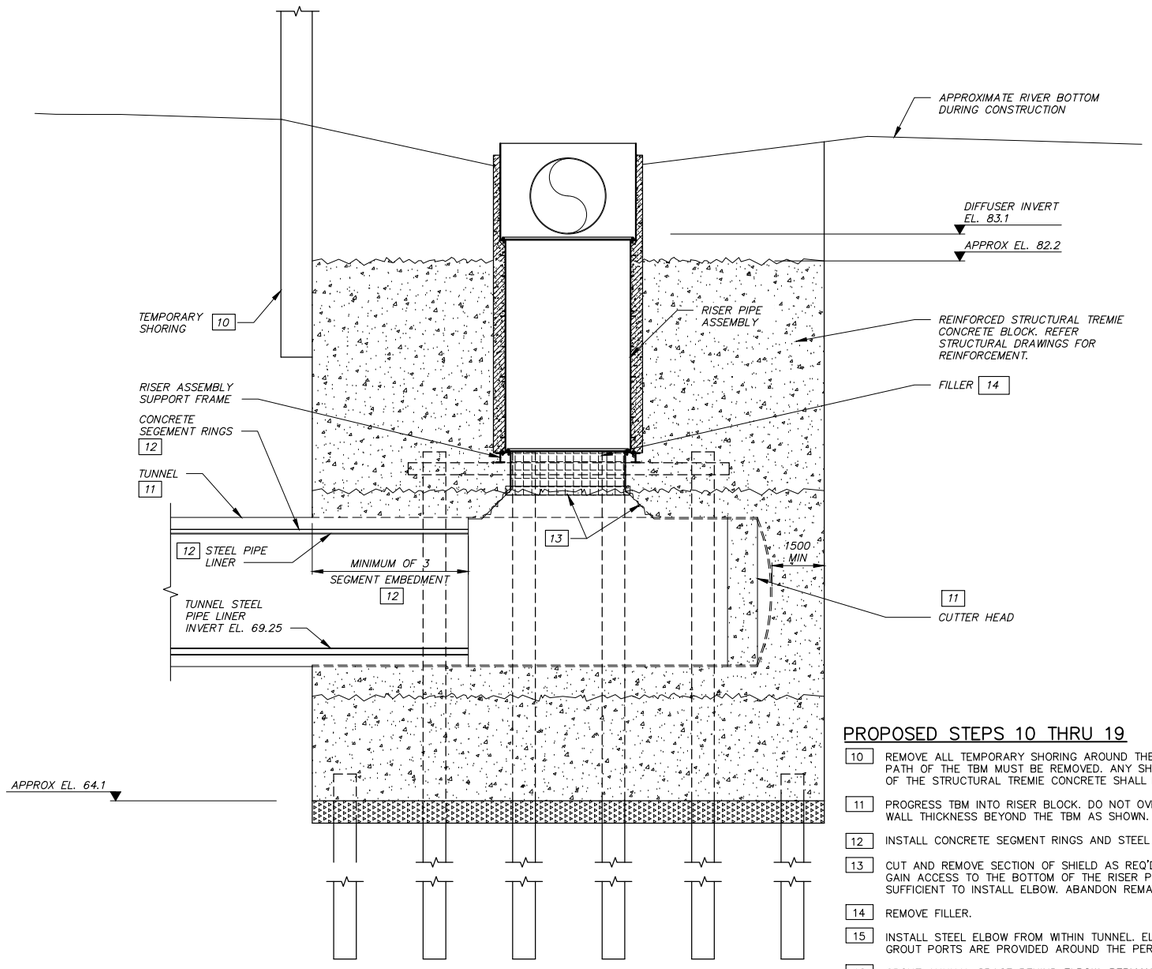
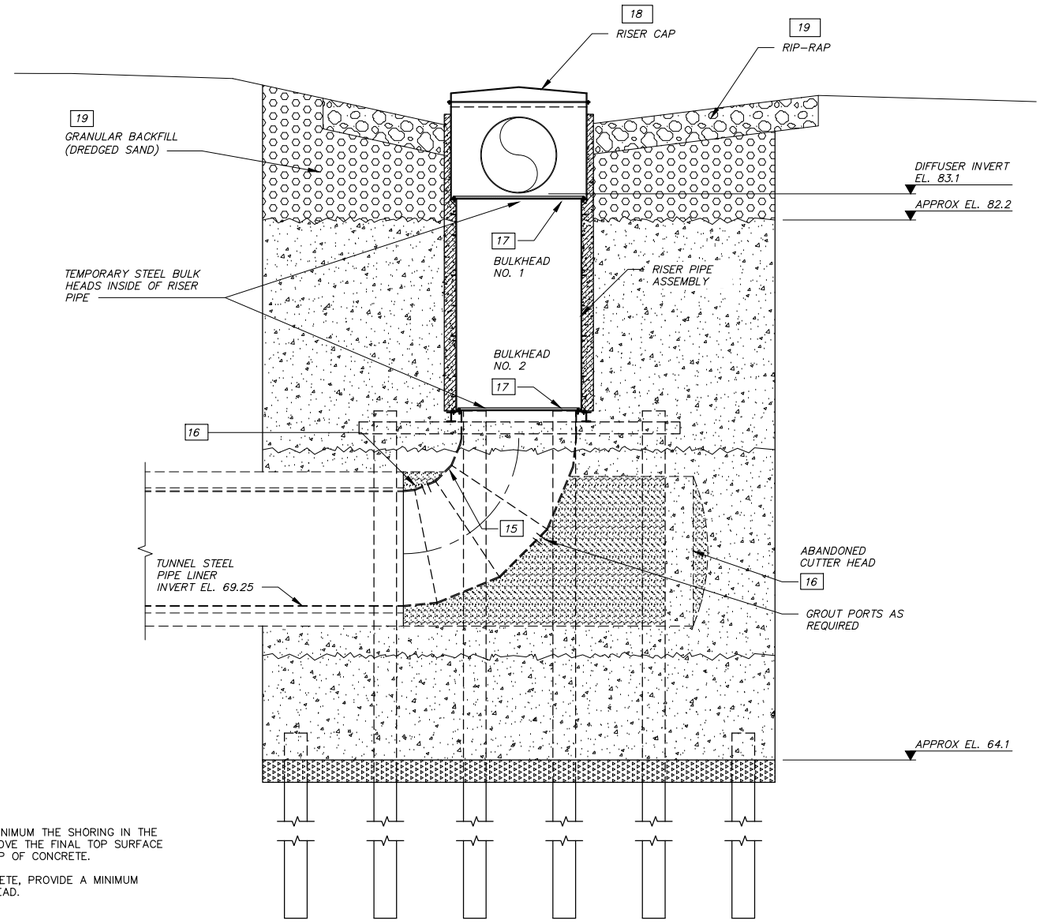


SECTION 1:100 (1 / S-0081)



SECTION 1:100 (2 / S-0081)

PROPOSED STEPS 10 THRU 19

10 REMOVE ALL TEMPORARY SHORING AROUND THE PERIMETER. AT A MINIMUM THE SHORING IN THE PATH OF THE TBM MUST BE REMOVED. ANY SHORING EXTENDING ABOVE THE FINAL TOP SURFACE OF THE STRUCTURAL TREMIE CONCRETE SHALL BE CUT DOWN TO TOP OF CONCRETE.

11 PROGRESS TBM INTO RISER BLOCK. DO NOT OVERCUT TREMIE CONCRETE, PROVIDE A MINIMUM WALL THICKNESS BEYOND THE TBM AS SHOWN. ABANDON CUTTER HEAD.

12 INSTALL CONCRETE SEGMENT RINGS AND STEEL LINING.

13 CUT AND REMOVE SECTION OF SHIELD AS REQ'D AND REMOVE CONCRETE ABOVE TUNNEL TO GAIN ACCESS TO THE BOTTOM OF THE RISER PIPE. EXTENTS OF CUTTING AND REMOVAL TO BE SUFFICIENT TO INSTALL ELBOW. ABANDON REMAINING TBM SHIELD IN PLACE.

14 REMOVE FILLER.

15 INSTALL STEEL ELBOW FROM WITHIN TUNNEL. ELBOW WILL BE INSTALLED IN WELDED SECTION. GROUT PORTS ARE PROVIDED AROUND THE PERIMETER OF THE ELBOW.

16 GROUT ANNUAL SPACE BEHIND ELBOW. PERMANENTLY SEAL GROUT PORTS WITH WELDED STEEL COMPONENTS, COAT AS REQ'D. COMPLETE COATINGS ON INSIDE OF ELBOW.

17 FLOOD THE TUNNEL PRIOR TO ATTEMPTING TO REMOVE BULKHEADS. BLEED BULKHEAD NO. 1 AND REMOVE. BLEED BULKHEAD NO. 2 AND REMOVE. REMOVAL OF BULKHEADS SHALL BE AFTER APPROVAL OF THE CONSTRUCTION MANAGER.

18 INSTALL RISER CAP

19 PLACE BACKFILL AND RIP-RAP ABOVE CONC BLOCK.

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

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ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

RISER SHAFT
CONSTRUCTION SEQUENCE 3

SCALE: 1:100
DISTRICT FILE SF-1933
DRAWING NUMBER X-A61S0083

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P3

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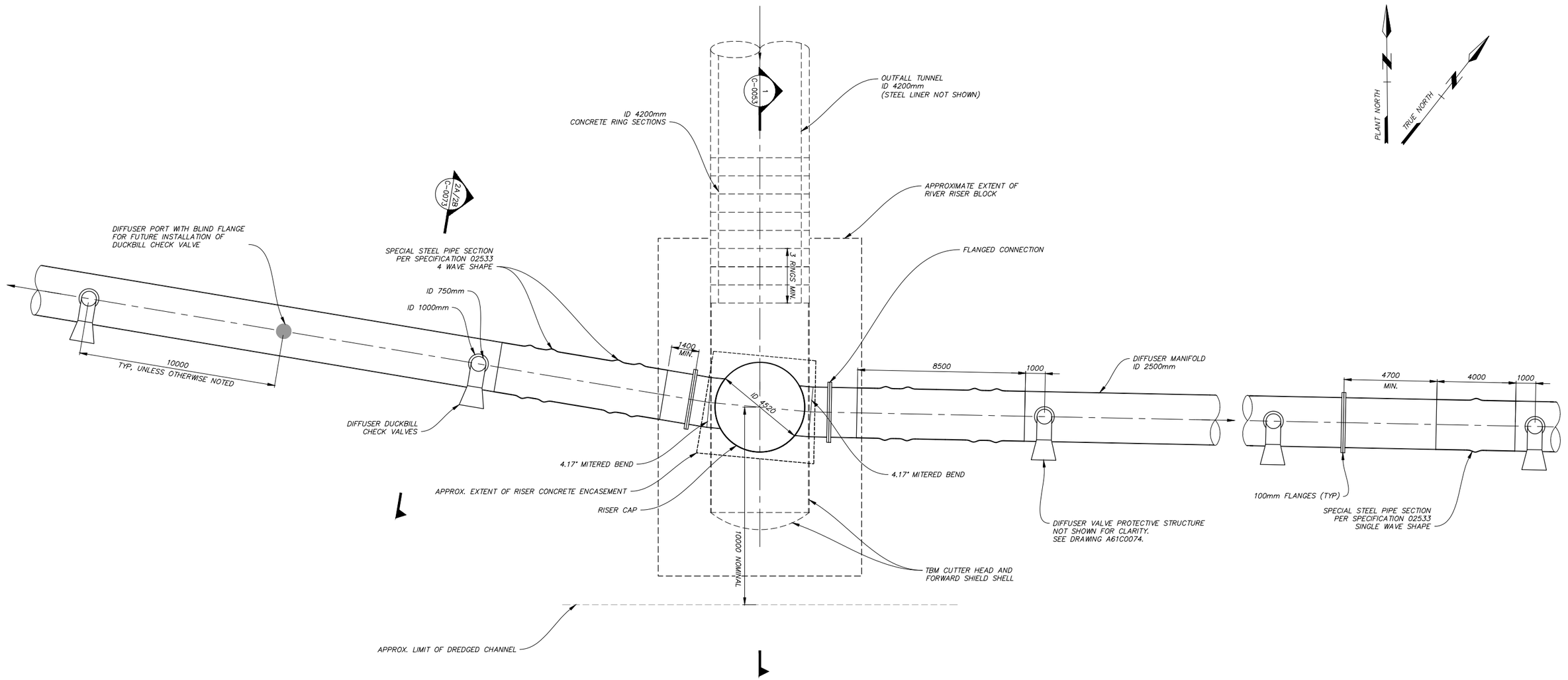

NOTES:

1. CENTER TO CENTER SPACING BETWEEN TWO PORTS IS 10,000 MM, UNLESS OTHERWISE NOTED.
2. SEE STRUCTURAL DRAWINGS FOR ADDITIONAL INFORMATION.

RIVER RISER PLAN

1:100

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P4	NOV. 2017	DAW	CEB	MSS	JNC	ISSUED FOR PERMIT REVIEW
P3	AUG. 2017	DAW	CEB	MSS	JNC	ISSUED FOR 90% DESIGN REVIEW
P2	MAR. 2017	DAW	CEB	MSS	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	DAW	CEB	MSS	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: DAW
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JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

A61 – NOS
RIVER RISER PLAN
TOP LEVEL

SCALE: 1:100
DISTRICT FILE SF-1933
DRAWING NUMBER A61C0052

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

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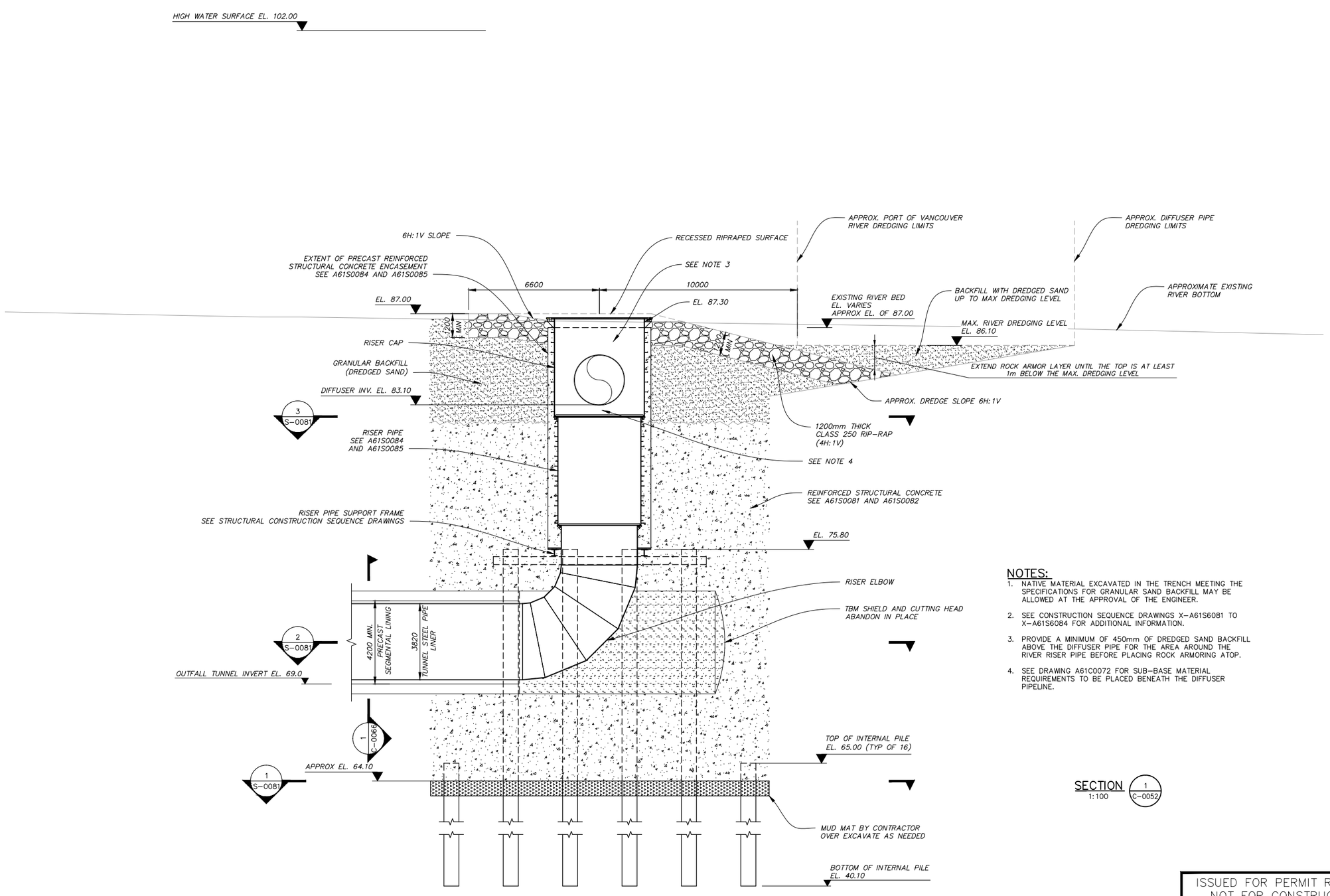

NOTES:

1. NATIVE MATERIAL EXCAVATED IN THE TRENCH MEETING THE SPECIFICATIONS FOR GRANULAR SAND BACKFILL MAY BE ALLOWED AT THE APPROVAL OF THE ENGINEER.
2. SEE CONSTRUCTION SEQUENCE DRAWINGS X-A61S6081 TO X-A61S6084 FOR ADDITIONAL INFORMATION.
3. PROVIDE A MINIMUM OF 450mm OF DREDGED SAND BACKFILL ABOVE THE DIFFUSER PIPE FOR THE AREA AROUND THE RIVER RISER PIPE BEFORE PLACING ROCK ARMORING ATOP.
4. SEE DRAWING A61C0072 FOR SUB-BASE MATERIAL REQUIREMENTS TO BE PLACED BENEATH THE DIFFUSER PIPELINE.

SECTION 1:100 (1 C-0052)

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P1	AUG. 2016	DAW	CEB	MSS	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

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ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

NOS RIVER RISER
SECTION

SCALE: 1:100
DISTRICT FILE SF-1933
DRAWING NUMBER A61C0053

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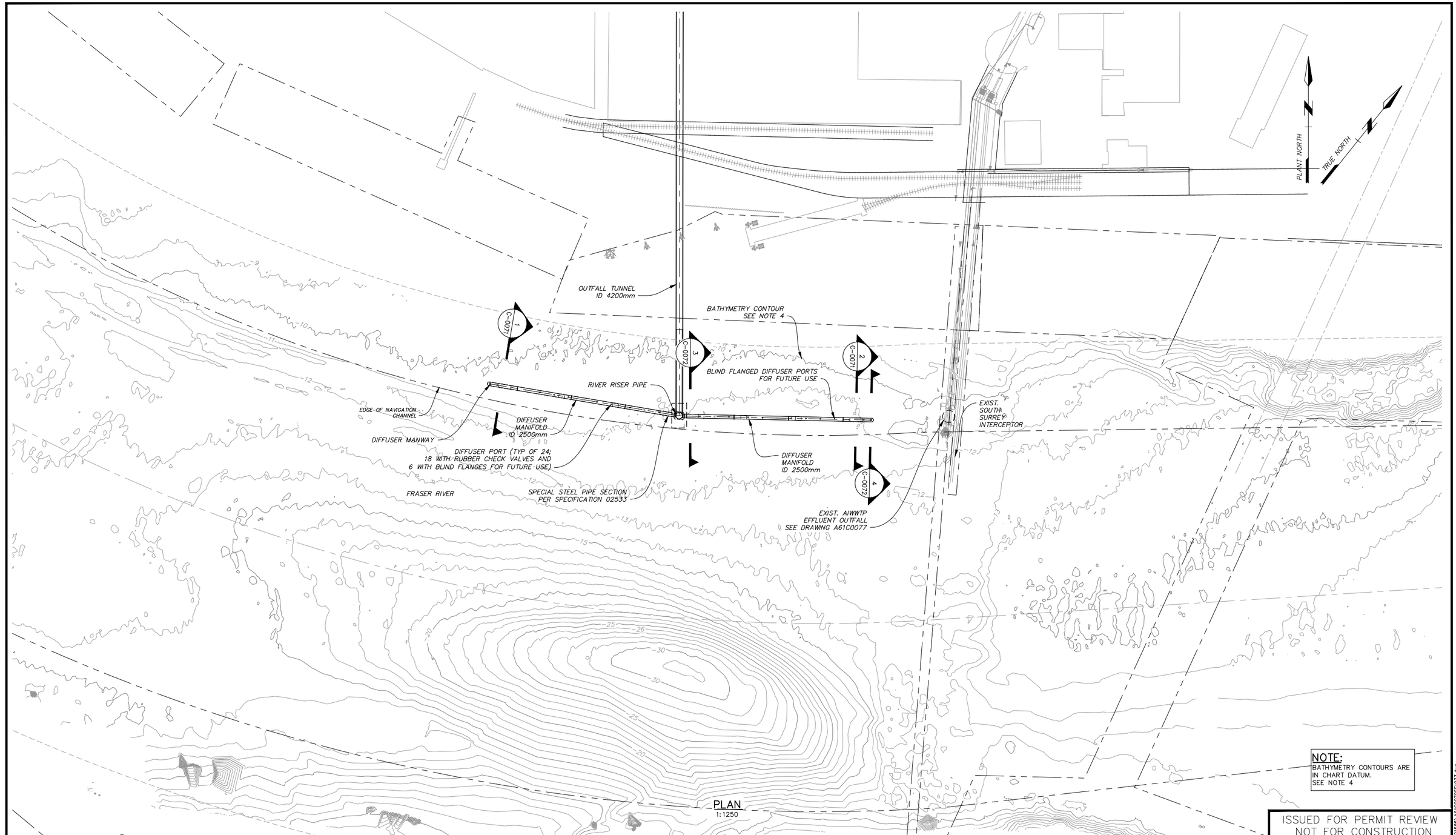

NOTES:
1. COORDINATES ARE UTM NAD83 ZONE 10 – 4.0.0.BC.1.GVRD GROUND UNITS.
   COMBINED SCALE FACTOR = 0.9996026.
2. ELEVATIONS ARE IN METERS AND REFER TO CVD28GVRD2005 GEODETIC DATUM.
   100m HAS BEEN ADDED TO ALL ELEVATIONS AND TIED TO BENCHMARK 87H3501 (ELEV: 3.546'). TBM ELEV: 103.546'.
3. TOPOGRAPHICAL SURVEY PROVIDED BY PROTECH ON JANUARY 2013.
4. RIVER BOTTOM (BATHYMETRY ELEVATION IN TIDE & CHART DATUM (EL 0.00 GEODETIC=EL+1.59 TIDE & CHART).
   RIVER BATHYMETRY IS VARIABLE. CCG BATHYMETRY SURVEY DATA FROM JANUARY 2016.
5. NEW STRUCTURES AND DIFFUSER MANIFOLD PIPELINE ARE IN AIWWTP DATUM PER NOTE 2 ABOVE.
6. ANNACIS ISLAND RAILCAR BARGE TERMINAL LOCATION PER SOUTHERN RAILWAY BRITISH COLUMBIA DRAWING FILE 25141102, MAY 2009. LOCATION IS APPROXIMATE.
7. DIFFUSER'S ROCK ARMORING AND DIFFUSER PROTECTIVE STRUCTURES NOT SHOWN FOR CLARITY.

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: SR
Drawn: CEB
Checked: MSS
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JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

A61 – NOS
DIFFUSER MANIFOLD RIVER PLAN

SCALE: 1:1250
DISTRICT FILE SF–1933
DRAWING NUMBER A61C0070

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

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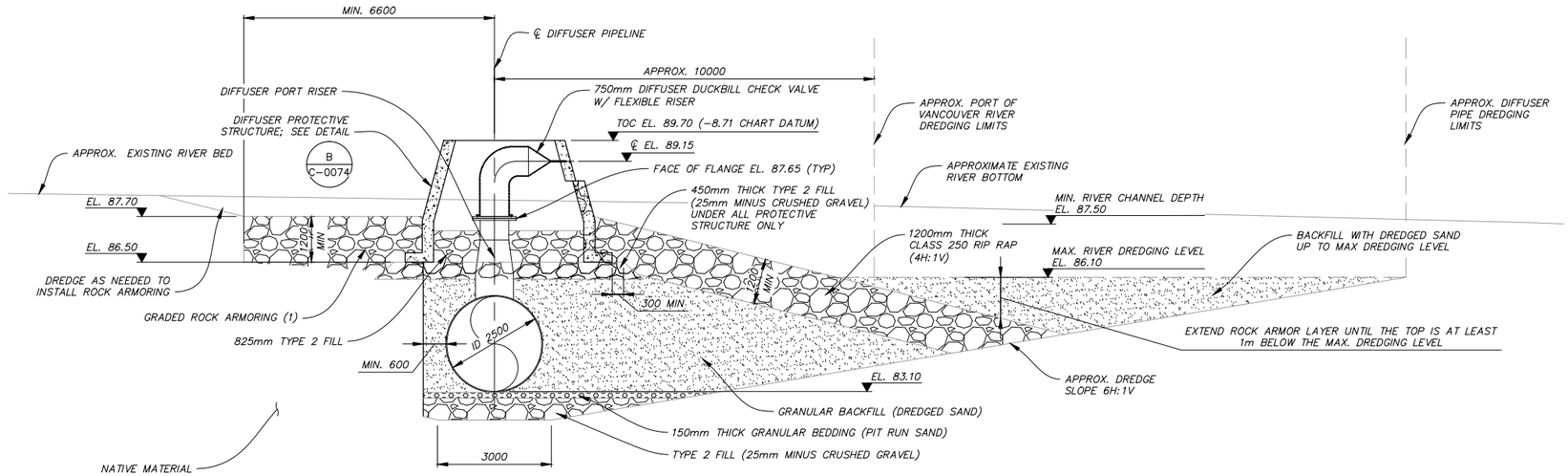
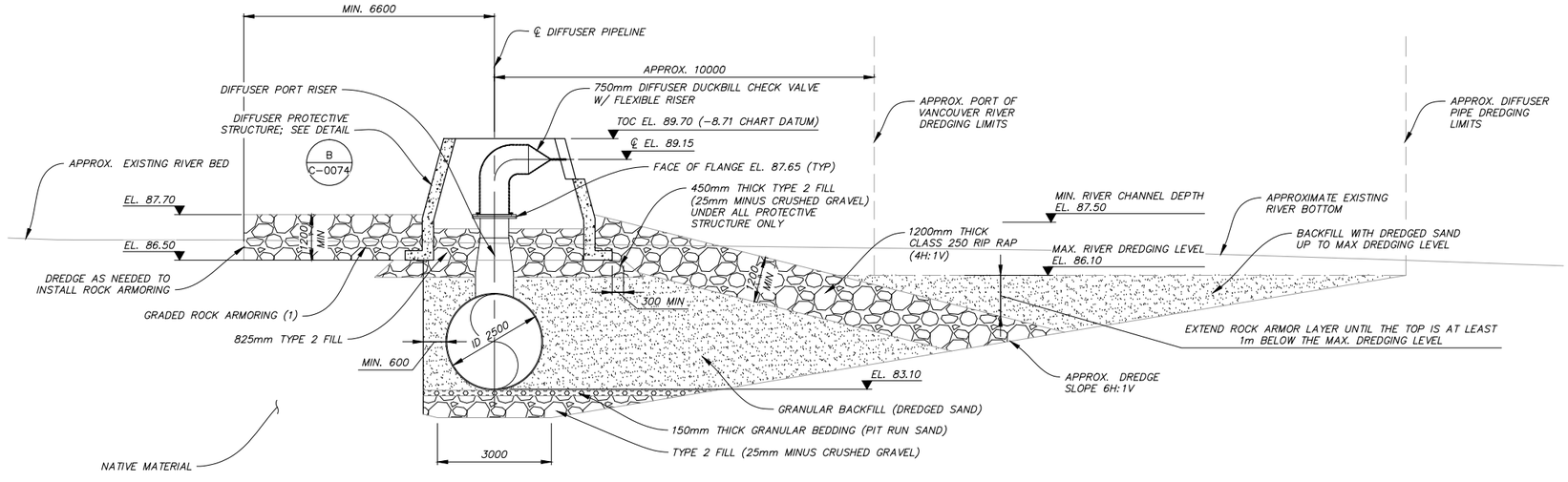
xref files:



RIVER BED PROFILE

SECTION 1:75 (1 / C-0070)



RIVER BED PROFILE

SECTION 1:75 (2 / C-0070)

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: SR
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JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

A61 – NOS
DIFFUSER MANIFOLD
SECTIONS 1 OF 3

SCALE: 1:75
DISTRICT FILE SF-1933
DRAWING NUMBER A61C0071

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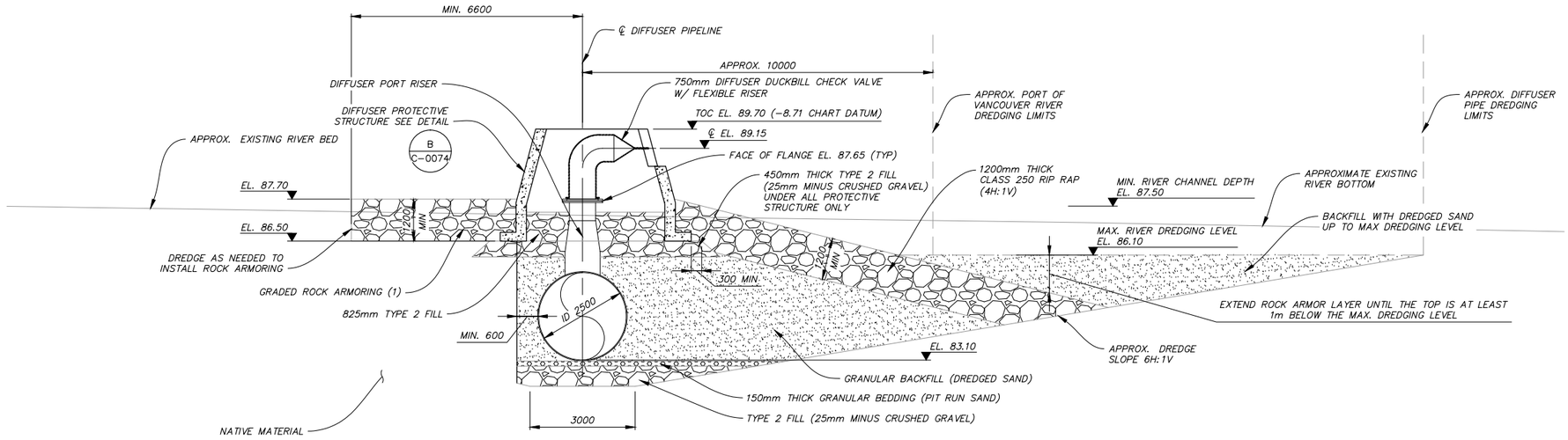
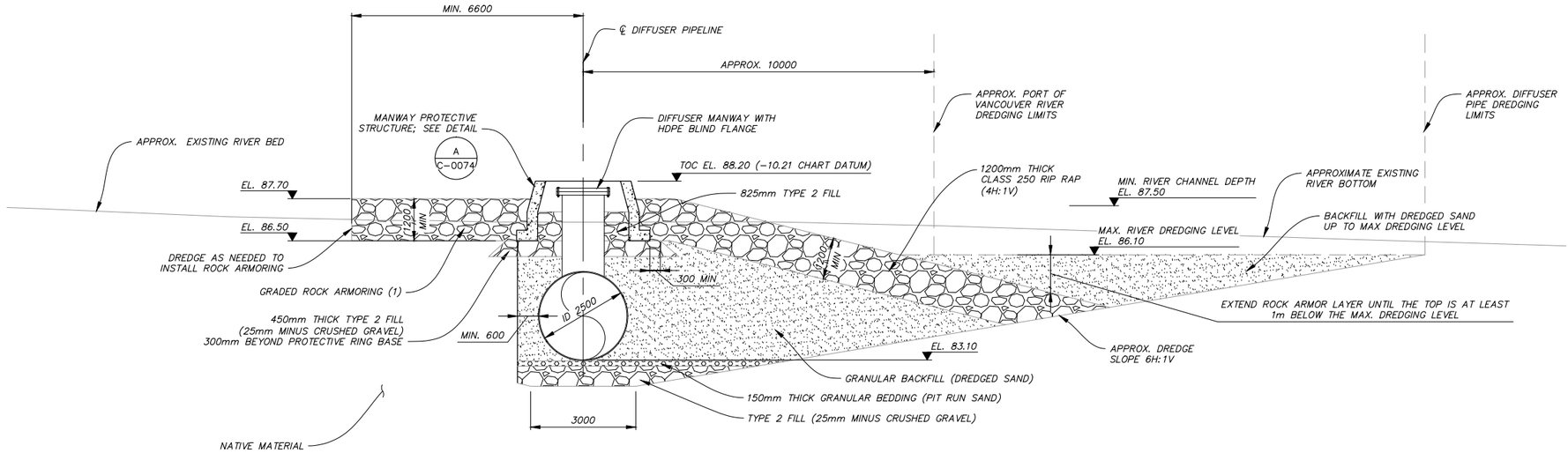


RIVER BED PROFILE

SECTION 3 C-0070
1:75



DIFFUSER PIPE END MANWAY SECTION

SECTION 4 C-0070
1:75

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NOT FOR CONSTRUCTION

CDM Smith
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Professional Seal

Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P4	NOV. 2017	SR	CEB	MSS	JNC	ISSUED FOR PERMIT REVIEW
P3	AUG. 2017	SR	CEB	MSS	JNC	ISSUED FOR 90% DESIGN REVIEW
P2	MAR. 2017	SR	CEB	MSS	JNC	ISSUED FOR 60% DESIGN REVIEW
P1	AUG. 2016	SR	CEB	MSS	JNC	ISSUED FOR PRELIMINARY DESIGN REVIEW

0 20 Bar is 20mm On Original Drawing. If Not On This Sheet, Adjust Scales Accordingly.

GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: SR
Drawn: CEB
Checked: MSS
JNC Approved
JEN Manager

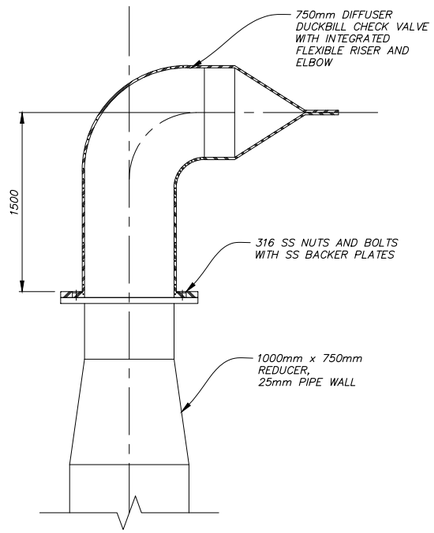
ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

A61 – NOS
DIFFUSER MANIFOLD
SECTIONS 2 OF 3

SCALE: 1:75
DISTRICT FILE SF-1933
DRAWING NUMBER A61C0072

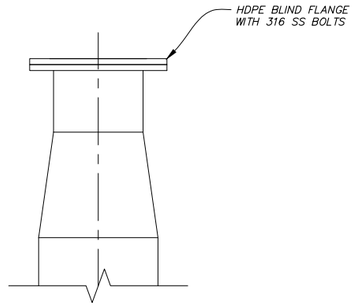
SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

2017-11-06 18:30 RV C:\cdmsmYrV\28221585\A61C0072SF1933.dwg
xref files:



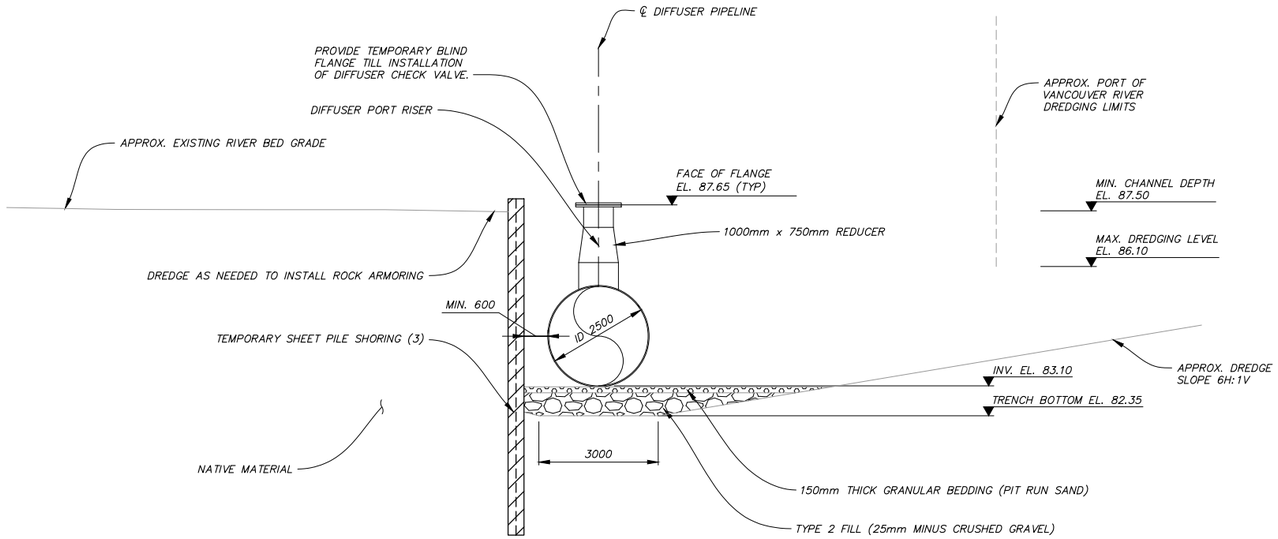
DIFFUSER PORT WITH CHECK VALVE

DETAIL A / N.T.S.



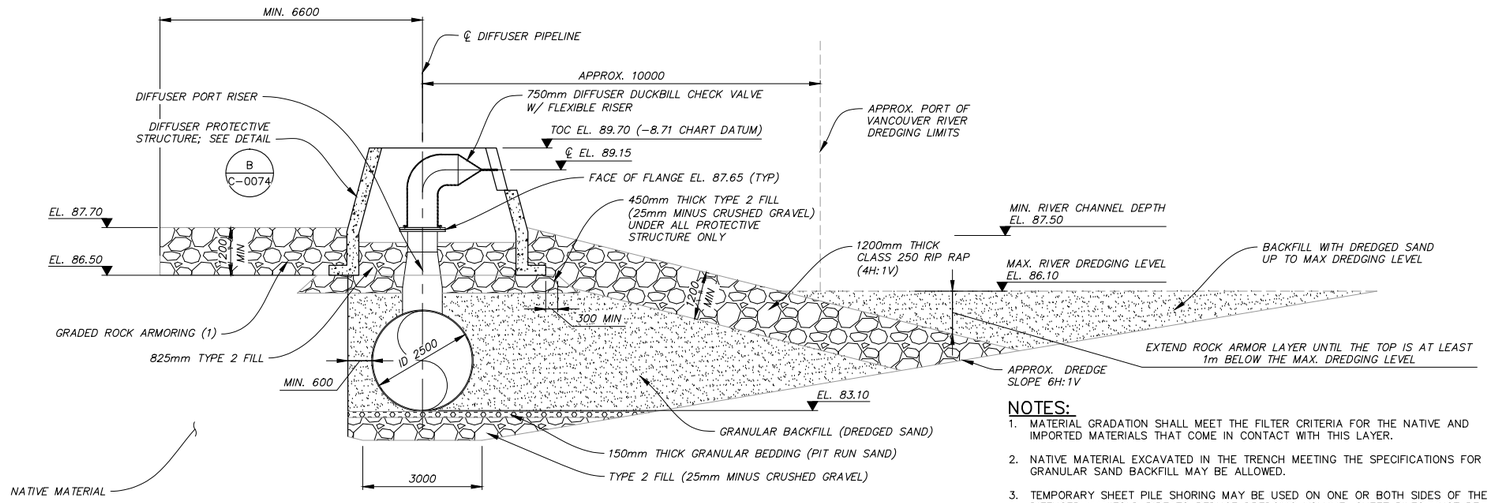
DIFFUSER PORT WITHOUT CHECK VALVE

DETAIL B / N.T.S.



DIFFUSER MANIFOLD SECTION – GENERAL TEMPORARY SHORING CONDITIONS

SECTION 2A / C-0052 / 1:75



DIFFUSER MANIFOLD SECTION – GENERAL INSTALLED CONDITIONS

SECTION 2B / C-0052 / 1:75

NOTES:

1. MATERIAL GRADATION SHALL MEET THE FILTER CRITERIA FOR THE NATIVE AND IMPORTED MATERIALS THAT COME IN CONTACT WITH THIS LAYER.
2. NATIVE MATERIAL EXCAVATED IN THE TRENCH MEETING THE SPECIFICATIONS FOR GRANULAR SAND BACKFILL MAY BE ALLOWED.
3. TEMPORARY SHEET PILE SHORING MAY BE USED ON ONE OR BOTH SIDES OF THE DIFFUSER MANIFOLD PIPE TO REDUCE DREDGING VOLUME. SHEET PILES MUST BE REMOVED FOLLOWING INSTALLATION AND BACKFILL OF THE DIFFUSER MANIFOLD AND BEFORE PLACEMENT OF THE ARMOR ROCK AND PRE-CAST CONCRETE RINGS.
4. ALL DIFFUSER DUCKBILL CHECK VALVES SHALL BE INSTALLED TO THE SAME ELEVATION.
5. INSTALL A CONCRETE PROTECTIVE COVER ON EACH PORT, BOTH VALVED AND BLIND FLANGED, TOTAL OF 24.

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Issue	Date	Desn	Dr'n	Chkd	Appd	Description
P4	NOV. 2017	SR	CEB	MSS	JNC	ISSUED FOR PERMIT REVIEW
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P2	MAR. 2017	SR	CEB	MSS	JNC	ISSUED FOR 60% DESIGN REVIEW
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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: SR
Drawn: CEB
Checked: MSS
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

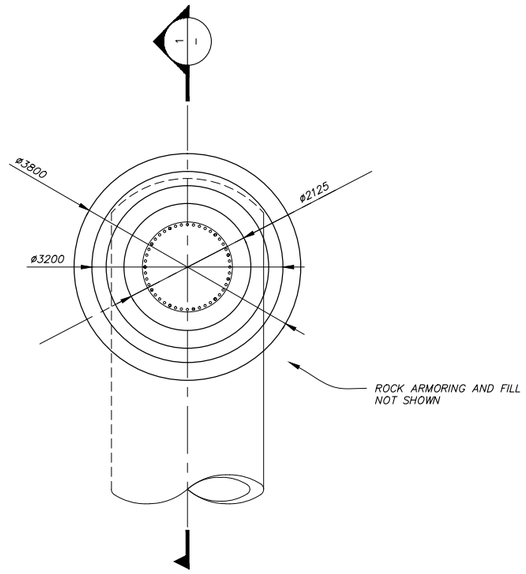
A61 – NOS
DIFFUSER MANIFOLD
SECTION 3 OF 3

SCALE: AS NOTED
DISTRICT FILE SF-1933
DRAWING NUMBER A61C0073

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

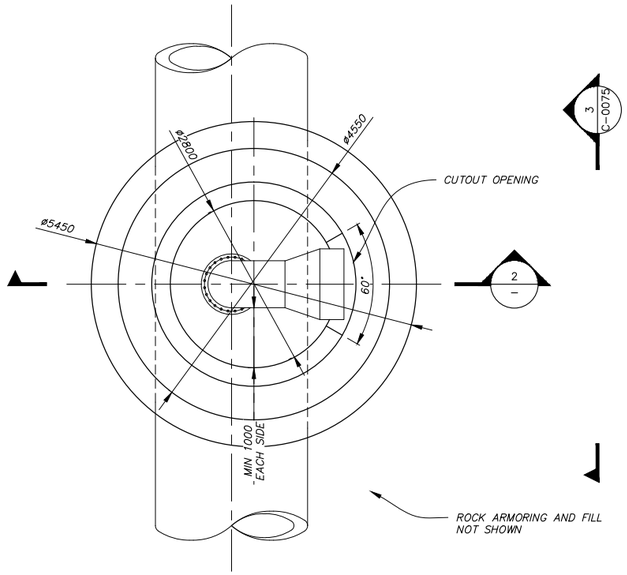
2017-11-06 18:36 R:\ c:\cdmsmith\r\v2821585\A61C0073SF1933.dwg

xref files:



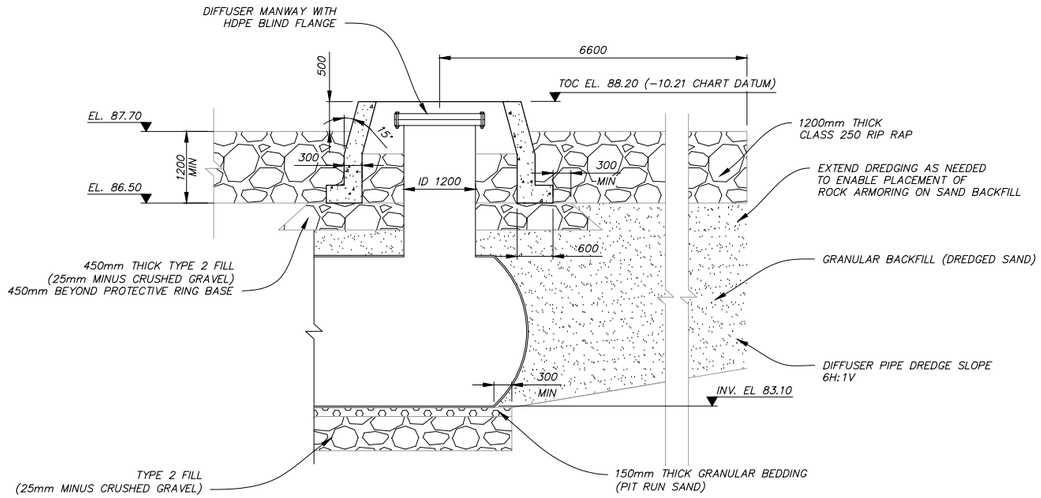
DIFFUSER PIPE END MANWAY PLAN

DETAIL 1:50 — A / C-0005



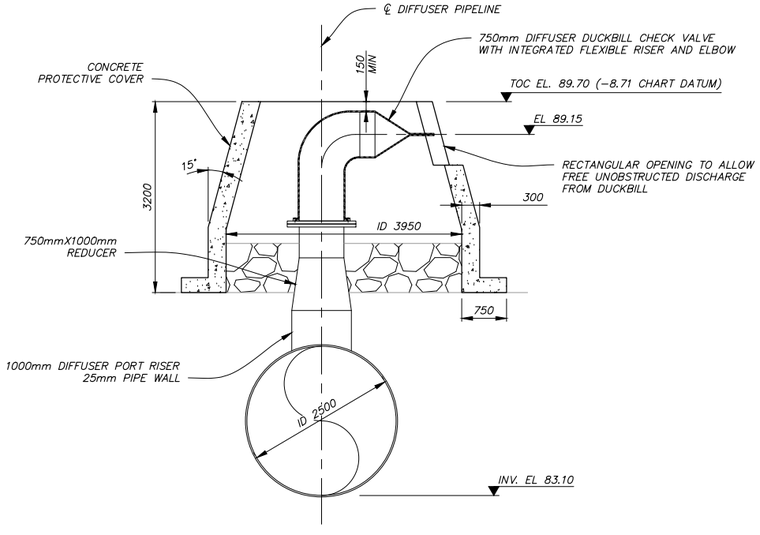
DIFFUSER MANIFOLD PLAN

DETAIL 1:50 — B / C-0073 — B / C-0005



DIFFUSER PIPE END MANWAY SECTION

SECTION 1:50 — 1 / –



DIFFUSER MANIFOLD SECTION

SECTION 1:50 — 2 / –

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Professional Seal

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GREATER VANCOUVER SEWERAGE AND DRAINAGE DISTRICT

Design: SR
Drawn: CEB
Checked: MSS
JNC Approved
JEN Manager

ANNACIS ISLAND WWTP
NEW OUTFALL SYSTEM
CONSTRUCTION SERVICES FOR THE OUTFALL

DIFFUSER MANIFOLD DETAILS 1

SCALE: 1:50
DISTRICT FILE SF–1933
DRAWING NUMBER A61C0074

SUPERSEDES PRINTS OF THIS DRAWING NUMBER WITH LETTERS PREVIOUS TO → P4

xref files:

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