BC Hydro
Power smart

Acid Rock Drainage and Metal Leachate Management Plan – Water Quality Annual Report: January 1 to December 31, 2021

Site C Clean Energy Project

March 31, 2022

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Acronyms

ABA	acid base accounting
AFDE	Aecon, Flatiron, Dragados, and EBC
ARD/ML	acid rock drainage/metal leaching (or leachate)
BCWQG	British Columbia Water Quality Guidelines for Protection of Aquatic Life
CEMP	construction environmental management plan
CVC	conventional vibrated concrete
DOC	diversion outlet cofferdam
DTIP	diversion tunnel inlet portal
DTOP	diversion tunnel outlet portal
EAC	Environmental Assessment Certificate
EOP	end of pipe (in relation to discharge limits)
EPP	environmental protection plan
IDZ	initial dilution zone
IEM	Independent Environmental Monitor
LB	left bank (of the Peace River, when facing downstream)
LBCD	left bank cofferdam
LBDA	left bank draiange adit
LBDT	left bank drainage tunnel
LBEX	left bank excavation
MCW	main civil works
MWTF	mobile water treatment facility
Non-PAG/NPAG	non-potentially acid generating
PAG	potentially acid generating
PRHP	Peace River Hydro Partners
RB	right bank (of the Peace River, when facing downstream)
RBDT	right bank drainage tunnel
RCC	roller compacted concrete
RSEM	relocated surplus excavated materials (area)
SBIAR	south bank initial access road
TSS	total suspended solids
QP	Qualified Professional

1. ACID ROCK DRAINAGE AND METAL LEACHATE MANAGEMENT PLAN

1.1 Background and Reporting Requirements

The Acid Rock Drainage and Metal Leachate Monitoring Plan has been developed in accordance with the following regulatory conditions:

- Condition 7 of the Site C Project's Federal Decision Statement, issued to BC Hydro on October 14, 2014 and re-issued November 25, 2014, which requires BC Hydro to:
  - "…develop, in consultation with Environment Canada and Natural Resources Canada, a water quality management plan to address environmental effects to the aquatic environment from the Designated Project, including acid rock drainage and metal leaching."
- Condition 3 of the Site C Project's Environmental Assessment Certificate, (EAC #E14-02), issued to BC Hydro on October 14, 2014, which requires BC Hydro to:
  - "…. develop a water quality monitoring program, [which] must be detailed in the Acid Rock Drainage and Metal Leachate Management Plan."

The Site C Project's Construction Environmental Management Plan (CEMP; Revision 10 dated March 9, 2022), Appendix E – Acid Rock Drainage and Metal Leachate Management Plan (Version 6.0, January 17, 2022) fulfills the requirements of the water quality management plan referenced in the above conditions.

This update satisfies the annual reporting requirements specified by these conditions, covering the reporting period from January 1 to December 31, 2021.

We acknowledge this work is being conducted on the traditional territory of Treaty 8 First Nations of Dunne Zaa, Cree and Tse'khene cultural descent.

2. OVERVIEW OF SITE ACTIVITIES IN 2021

2.1 General Description of Site Activities

Site C construction activities continued through 2021, the sixth full year of construction that was initiated in July 2015 and is scheduled to be completed in 2024. In 2021, the dam core was being placed and compacted in the isolated section of the former Peace River channel following river diversion in Q3 2020. Once the dam core is in place, the dam, generating station, and spillways will be completed.

Major construction activities conducted as part of the Site C Clean Energy Project in 2021 involving ground disturbance included the placement and compaction of the dam core. In 2021, minor excavations on the Left Bank (Cofferdam and Drainage Adit) were placed in RSEM Area L5 and RSEM Area R5A. PAG excavation from the Earthfill Dam Core Trench, Ramp and Foundation Prep was placed in RSEM Area 5A and Zone 8. The majority of material excavated from the Right Bank was from the Approach Channel and Spillway, with minor quantities from

the Dam Core Buttress, Right Bank Drainage Tunnel, Laydown Area 32A and 32B, and RCC Buttress. Right Bank material was placed in RSEM Area R5A and Zone 8. Off-site construction activities continued in 2021, including reservoir clearing, Highway 29 re-alignment work and transmission line excavations. Details of construction areas are presented in Section 2.6.

2.2 Environmental Protection Plans (EPPs)

Each construction area is required to have a BC Hydro approved environmental protection plan (EPP) which describes ARD/ML mitigation and management plans relevant to the site work as per Appendix E of the CEMP. A chance find procedure is included in the EPP document where exposure or disturbance of bedrock is not anticipated as part of the construction activities. As of December 31, 2021 (cumulatively since the start of project construction), 1,625 EPPs (including revisions) have been reviewed by BC Hydro covering all contractors and scopes of work. In the calendar year 2021, 235 of these EPPs (including revisions) were submitted to and reviewed by BC Hydro). Implementation of these plans is the responsibility of site contractors, and is overseen by BC Hydro, the Independent Environmental Monitor (IEM) and ARD/ML Qualified Professionals (QPs).

The location of construction areas and water management structures relevant to ARD/ML material management are described below and are shown on Figure 1 (dam site) and Figure 2 (off dam site). On the dam site, the areas are categorized per their location on the Right (south) Bank or Left (north) bank of the Peace River, and are listed by excavation site, followed by permanent storage facility. Complete details of the site activities related to ARD/ML, including material excavation, placement, mitigation and monitoring programs should be referenced in the attached appendices.

2.3 ARD/ML Mitigation Hierarchy

Mitigation measures implemented to minimize exceedances of discharge limits due to ARD/ML include material management (e.g. excavating or covering bedrock exposure), water management to contain water that may be influenced by ARD/ML, and water treatment to neutralize pH and remove total and dissolved metals.

The primary mitigation strategy for ARD/ML is material management to limit exposure of AG material and the generation of PAG contact water that may trigger the implementation of additional water management. Weathered material that has been exposed for several months and is becoming acidic is monitored to determine when mitigation is required. PAG bedrock monitoring is discussed in Section 2.4. In addition, material that is placed in RSEM disposal areas is monitored, and weathered material is covered with recently excavated bedrock or overburden.

The secondary mitigation strategy is water management, including diversion of non-contact runoff from above the project to bypass the construction site, such as Garbage Creek, and retaining as much contact water as possible within the site. Water that must be released is directed to RSEM sediment control ponds or monitored and discharged from the associated rock cut location, from where it is discharged to the Peace River.

The tertiary mitigation strategy is water treatment, wherein contact water not anticipated to meet end of pipe (EOP) discharge limits is conveyed to the MWTF which is positioned at RSEM Area R6 and discharges treated effluent through a series of sludge settling cells and ultimately to the RSEM R6W sediment pond. In 2021, PAG-contact water from LBEX, Approach Channel and Dam Core was managed by trucking to the MWTF or retaining it within the site and avoiding discharge.

2.4 PAG Bedrock Monitoring

On the dam site, ARD/ML monitoring is undertaken in areas where bedrock is excavated or where these materials are deposited. Appropriate sampling locations are determined as construction activities proceed rather than routinely sampling at fixed monitoring stations.

Contractors are each responsible for their respective work areas on the MCW site, and have their own QP (ARD/ML) for monitoring, management and mitigation of PAG excavation areas. The primary contractor on the MCW site is Peace River Hydro Partners (PRHP) and their QP (ARD ML) is Lorax Environmental (Lorax). AFDE is responsible for limited areas on the MCW including L2 and the Powerhouse. Any PAG excavated by AFDE is managed within the PRHP RSEMs and AFDE does manage PAG or PAG contact water within their scope on the MCW site.

Geochemical analysis of samples collected during the monitoring program include rinse pH measurements to determine surface pH, as well as acid-base accounting (ABA) and solid phase metals analysis. Rinse pH monitoring is generally focused where samples were previously identified to produce circumneutral to alkaline drainage (rinse pH > 5.5). Where acidic drainage is prevalent, ARD mitigation strategies are identified and recommended.

The geochemical testing program was effective at identifying the onset of ARD/ML, and at identifying areas where mitigation is needed, or is likely to be required.

Details of the PAG bedrock monitoring program is presented in Section 2.3 of the Lorax report (Appendix A). A brief summary of the program is presented below, with sample locations and sample numbers analyzed presented in Table 1.

- In 2021, a total of 270 samples were collected for rinse pH analysis from the Earthfill Dam and the Left and Right Banks.
- Approximately 10% of the samples underwent geochemical testing including ABA and metals analysis.
- Left Bank samples collected from exposed surfaces in acid generating (AG) material were identified in RSEM Area L5 and the Left Bank Excavation (LBEX). RSEM Area L5 is mostly covered with NPAG material, which restricts widespread ARD development from facility.
- Monitoring in the Earthfill Dam indicated that the Core Trench Excavation remained non-AG for the duration of the exposure until it was filled by the Dam Core construction.
- PAG material placed in Zone 8 showed early signs of ARD progression in 2021 Q3 and subsequently covered with fresh PAG rock with neutral pH. Monitoring conducted ensured that PAG rock placed as a temporary thermal barrier over the Earthfill Dam Core was pH neutral when placed in 2021 Q4.

- On the Right Bank, AG material was identified in the Approach Channel, RSEM Area R5A, and exposures within the RSEM Area R5B catchment. The AG bedrock exposed in the Approach Channel was excavated and placed in RSEM Area R5A. AG samples from RSEM Area R5A were generally clustered at the northwest end of the RSEM area. Continued placement of fresh PAG in Q4 2021 limited AG exposures in RSEM Area R5A.
- The Approach Channel has extensive AG exposures, however, excavation in the Approach Channel was reinitiated in Q4 2021 which exposed fresh bedrock with neutral rinse pH.
- AG bedrock exposed in the RSEM Area R5B catchment are associated with natural bedrock exposures and inactive roads. The runoff from this area is collected in the Phase 2 R5B Sump, and monitored and treated, if necessary.

Table 1: Overview of Sample Distribution and Analyses Conduced

Location	Rinse pH	ABA and Metals
Left Bank		
RSEM Area L5 and RSEM L5 Extension	35	4
Left Bank Excavation	11	1
Right Bank		
RSEM Area R5A	66	5
RSEM Area R5B West exposure	13	0
Approach Channel and Auxiliary Spillway	54	6
Approach Channel Drainage Channel	10	1
777 Haul Road	13	3
Core Trench Excavation		
Left Bank Dam Core (LBDC)	6	1
Core Trench Excavation	43	8
Right Bank Dam Core (RBDC)	5	0
Zone 8	14	1
Total	**270**	**30**

2.5 Dam Site Activities Related to PAG Material Management

In 2021, a total of 1,690,486 m^3 of bedrock was excavated. Right Bank excavation (1,314,746 m^3) was primarily from the Approach Channel and Spillway, and Earthfill Dam area (373,977 m^3) from the main excavation of the Core Trench. Left Bank excavation (1,763 m^3) was mostly from the Left Bank Drainage Adit.

Material excavated in 2021 was placed primarily in RSEM Area R5A and Zone 8 within the Earthfill Dam footprint.

2.5.1 Right Bank PAG Material Management & Excavation

Excavations on the Right Bank in 2021 amounted to a total of 1,314,746 m^3 of PAG bedrock. Much of this material was produced from excavations in the Approach Channel and Spillway (1,276,527 m^3), primarily in Q4 2021.The remaining volume was excavated from the Dam and Core Buttress (18,161 m^3), the RCC Buttress and Powerhouse (16,587 m^3), Laydown Areas 32A and 32B (1,888 m^3), the Right Bank Drainage Tunnel (RBDT; 1,319 m^3), RSEM Area R5B (198 m^3), and Area A (66 m^3). See Appendix A for full breakdown of excavation volumes from different locations.

Most of the material excavated on the Right Bank was deposited in RSEM Area R5A. No additional PAG material was placed at the RSEM Area R5B and the RSEM Area R5A Starter Dyke.

The cumulative volumes of material placed in RSEM areas at the end of 2021 were:

- 6,092,786 m^3 of PAG bedrock in RSEM Area R5A and Starter Dyke; and
- 363,618 m^3 remaining in RSEM Area R5B, which is covered by non-PAG material.

In 2021, roughly 374 m^3 of PAG material related to a hydrocarbon spill was placed in the Area A temporary stockpile in April and later moved off site in Q2 2021.

2.5.2 Right Bank RSEMs and Catchment Areas

There are three catchment RSEM areas within the construction site on the Right Bank:

- RSEM Area R6 (which includes Area 20/21, the RBDT and associated facilities to the south, and Earthfill Dam, as well as the Approach Channel above it), from which contact water is conveyed to the RSEM Area R6 sediment ponds.
- RSEM Area R5A (which includes the area where the majority of excavated PAG material will be deposited on the west side of the Moberly River), from which contact water is conveyed to the RSEM Area R5A sediment ponds. Water is periodically pumped between the ponds to minimize discharge.
- The RSEM Area R5B sediment pond was decommissioned and backfilled. The majority of water that previously reported to the RSEM R5B sediment pond is now conveyed to the RSEM R6 ponds. Contact water immediately south of RSEM Area R5B and the western extents of the Approach Channel accumulate in the RSEM Area R5B Phase 2 Sump.

Two additional catchment areas are located within the construction site on the Right Bank:

- Area A – contact water from the western portion of the area is directed to North ditch and transferred to the RSEM R6 sediment control ponds or crusher, as needed and groundwater intercepted in the eastern portion is dewatered to vegetation

- Area 30 sediment pond - runoff from the stockpiled aggregates in Area 30 accumulate in the Area 30 sediment control pond. The pond discharges to the adjacent wetlands through a rip-rap lined channel.

Water quality monitoring within the Right Bank RSEM catchment is described by Lorax (Appendix A). Monitoring of water quality associated with the RSEM pond discharges is referenced in Sections 3.1.2 (pond water quality), 3.1.3 (toxicity), and 3.1.5 (Peace River water quality downstream of discharges).

2.5.3 Left Bank PAG Material Management

Excavations on the Left Bank in 2021 occurred as a result of construction activities around the Left Bank Drainage Adit and the Dam Core/Central Cofferdam. In 2021, a total of 1,488 m^3 was excavated from the Left Bank Drainage Adit. Excavation in the Left Bank Drainage Adit occurred in Q1 2021, with the largest volumes excavated in January. A total of 275 m^3 was excavated from the Dam Core/Central Cofferdam in January 2021. Additional details of theses excavation volumes and areas are provided in Appendix A.

In total, 3,929 m^3 of PAG material was stockpiled on the Left Bank in 2021. All of the PAG material was placed in RSEM Area L5. At the end of the year, RSEM Area L5 contained 1,013,037 m^3, the RSEM Area L5 Extension contained 495,240 m^3, L5 Garbage Creek contained 24,240 m^3, the RSEM Area L5 Starter Dyke contained 4,869 m^3, the Left Bank Dam Core contained 12,345 m^3, and the RSEM Area L6 contained 64,345 m^3.

2.5.4 Left Bank RSEMs and Catchments

There are two large and one smaller catchment areas on the Left Bank. Contact water catchments on the Left Bank are:

- The RSEM Area L5 catchment area contact water is conveyed to the RSEM Area L5 Phase 2 sediment control ponds;
- The Left Bank Excavation (LBEX) catchment area contact water is directed to the RSEM Area L5 East sediment control pond. Contact water from exposed AG bedrock exposed on Bench 0 is directed to the MWTF;
- The small RSEM Area L6, from which contact water is generally conveyed to the RSEM Area L6 sediment pond.

The Diversion Inlet and Diversion Outlet Tunnels are complete, and the Peace River is diverted through the tunnels. Garbage Creek water is diverted through the construction site via lined ditches and pipes. RSEM Area L3 that contains non-PAG material is managed by BC Hydro.

Water quality monitoring within the Left Bank RSEM catchment is described by Lorax (Appendix A). Monitoring of water quality associated with the RSEM pond discharges is referenced in Sections 3.1.2 (pond water quality), 3.1.3 (toxicity), and 3.1.5 (Peace River water quality downstream of discharges).

2.5.5 Earthfill Dam

Excavation of PAG bedrock from the Earthfill Dam area began in March 2021. In 2021, a total of 373,977 m^3 of PAG material was excavated. The majority of the PAG material originated from the main excavation (345,764 m^3) while the remaining volumes were excavated from the ramp

(16,899 m3) and foundation preparation (11,314 m^3). Throughout 2021, this material was placed in RSEM Area R5A and Zone 8, while some of the material was transported to RSEM Area L5.

Zone 8 is an area within the upstream side of the Earthfill Dam approved for the placement of PAG material. The majority of PAG material placement in this area occurred in Q4 2021. At the end of 2021, Zone 8 contained 1,017,497 m^3 of PAG bedrock. In Q4 2021, PAG material was also placed in the Dam Core Temporary Blanket (77,678 m^3) as a thermal barrier over the core trench and in temporary ramps (24,222 m^3).

2.6 Off Dam Site Activities Related to PAG Material Management

2.6.1 Reservoir Clearing

OLTC16/17 Middle Reservoir Clearing Project – Halfway Frost

A planned PAG exposure produced approximately 232 m^3 from the high-chain approach fill associated with the MWS36 Crossing located near the end of the 17.5a Rd on the southbank of the Peace River. All of the PAG material has been moved to a permanent storage location on the low-chain side of the MQS36 Crossing. No PAG water quality monitoring was conducted in 2021 and no contact water was known to be near or around the permanent disposal location. There were no flagged discharges from OLTC16/17 Middle Reservoir Clearing Project in 2021.

OLTC20a – 4Evergreen Resources

- Phase 1: A planned exposure of PAG produced approximately 42m^3 from the ditch line along the 13.5 km on Eagle Road and is temporarily being stored at the bottom of the 13.5 km hill.
- Phase 2: A planned exposure in the keyed-in-fill produced 70 m^3 during the keyed in fill construction during construction of the high-chain approach fill and the material has been temporarily stored on the high-chain side of Crossing WR6a on Eagle Road.

Total PAG encountered is 406 m^3. Suspected PAG material has been placed on tarps, covered and is awaiting more permanent disposal. No PAG water quality morning was conducted in 2021 and no contact water was known to be near or around the stockpiles. There were no flagged discharges from OLT20a (Phase 1 or 2) in 2021.

2.6.2 Transmission Line Right of Way

No planned nor incidental PAG excavation or exposures associated with the 5L5 or 5L6 Transmission Line Right of Way occurred in 2021.

2.6.3 Highway 29 Realignment

Planned and incidental PAG excavation and exposures associated with the Highway 29 Realignment works occurred in 2021. Areas of construction which encountered PAG materials include the following segments and activities:

- *Cache Creek*; PAG was excavated during pier pile installations in the Cache Creek floodplain and during development of the East and West bridge abutments.
- *Halfway River*; PAG was excavated during final development of the West abutment at the Halfway River Bridge.

- *Farrell Creek*; PAG was excavated during pier pile installations, and during development of the East and West abutments.
- *Dry Creek;* PAG was excavated during work on the West abutment.
- *Lynx Creek*; PAG was excavated during work on East and West Abutments, and construction of the ROW.

PAG Disposal Areas were constructed for permanent disposal of PAG excavation associated with Highway 29 Realignment construction within several of the segments. PAG Areas with associated volumes of PAG disposed in 2021 include:

- *Cache Creek*: 11,653 m^3 PAG disposed in Disposal Area in 2021
- *Halfway River*: 500 m^3 PAG disposed in Area B in 2021.
- *Farrell Creek*: 1,410 m^3 PAG disposed in Area 12A in 2021.
- *Dry Creek*: 500 m^3 PAG disposed in Area 10 PAG Disposal in 2021.
- *Lynx Creek*: 23,500 m^3 PAG disposed in Area B15 in 2021.

Exposed PAG from excavations were mitigated by engineered covers, or by temporary covers in accordance with design and the individual segments PAG Management Plans, and in accordance with the CEMP Appendix E, S.5.2.2.

All PAG disposal areas were constructed and monitored in accordance with the CEMP, Appendix E, S.5.2.2.

3. OVERVIEW OF WATER QUALITY MONITORING PROGRAMS RELATED TO ACID ROCK DRAINAGE AND METAL LEACHING

The CEMP Appendix E identifies responsibilities specific to BC Hydro and the contractor. In 2021, BC Hydro, as owner, and Peace River Hydro Partners, as MCW contractor, engaged QPs in ARD/ML to assist with implementation of the various water quality monitoring programs identified in Table 2. Additional qualified professionals were engaged by off dam site contractors as warranted. These roles were filled in accordance with CEMP Appendix E, S.6.1.2.

Lorax Environmental, PRHP's QP for ARD/ML, monitors surface water quality within the construction site, groundwater quality and levels at RSEM Area R5A and R5B (prior to 2020 decommissioning), and observes and tests to assess the geochemical characteristics of bedrock that has been disturbed in the course of construction, such as exposed, excavated and relocated bedrock and RSEM sediment pond dredgate and sludge removal from mobile water treatment facility reactor and settling ponds. In addition to overseeing these water quality monitoring programs, Lorax provided general materials management and professional advice on the topic of ARD/ML

ASKI Environmental Reclamation and Ecofish Research Ltd., BC Hydro's QP, complete Peace River mixing dynamics and water quality monitoring work undertaken in relation to discharge from PAG-contact RSEM sediment ponds.

BC Hydro's QP, Tetra Tech Canada Inc., acted in the capacity of auditor of contractor compliance with CEMP Appendix E, while also providing professional advice on the topic of ARD/ML to BC Hydro.

The results of the 2021 ARD/ML water quality program are summarized below. The network of monitoring stations for the Site C project has been adapted as site conditions change, with some stations that were established early in the construction phase no longer in use, and other new stations added. Water quality monitoring is conducted at end of pipe and upgradient station locations. In addition to the surface water quality stations within the construciton area, surface water quality samples at established upstream, far-field downstream and IDZ locations in the Peace River are sampled.

The water quality monitoring program on the Left Bank included areas of the Left Bank Excavation (LBEX), RSEM Area L5, and RSEM Area L6. Rock cut water quality monitoring was conducted at River Road rock cut and Left Bank Debris Boom areas.

The water quality monitoring network that was utilized on the Right Bank in 2021 included several stations in Area 30, Area A, Approach Channel, Right Bank Core Trench, RSEM Area R6 and R5B catchments, and at the RSEM R6 and R5A sediment ponds. Rock cut water quality monitoring was conducted at the South Bank Initial Access Road (SBIAR) area and L2 Powerhouse rock cut.

The water quality monitoring program at the Earthfill Dam included a variety of stations including sumps on both sides of the Earthfill Dam Core Trench, sumps receiving water from the Left and Right Bank Dam Core trench excavations, end of pipe discharges of the Earthfill Dam Core trench waters, as well as Peace River locations upstream and downstream of the earthfill dam.

Table 2 Water Quality Monitoring Programs related to the ARD/ML Management Plan (CEMP Appendix E)

	Program Description	CEMP Appendix E Reference	Frequency	Duration	Geographic Extent	Program Responsibility	Monitoring Program Qualified Professional (QP), 2021
Monitoring associated with PAG-contact RSEM Sediment Ponds	**Collected/Contained Water**						
	PAG-contact RSEM Sediment Pond Water Quality Water quality sampling, and installation and operation of data loggers for measurement of pH, turbidity and electrical conductivity from PAG containing RSEM sediment ponds.	7.3.2	Hourly (*in situ* measurements) Daily (water quality sampling)	Ongoing from December 2016	RSEM sediment ponds conveying PAG-contact water	Contractor (Peace River Hydro Partners)	Lorax Environmental
	RSEM Sediment Pond Toxicity Collection of acute toxicity tests (96hr LC50) from water in PAG-contact RSEM sediment ponds	7.2.1, 7.3.1	Bi-monthly In event of failure, additional sample 96 hours after first failed sample, additional samples every 96 hours until sample passes. Targeted acute toxicity if pH drops below 6.5 for more than one hour.	Ongoing from November 2016	RSEM sediment ponds conveying PAG-contact water	BC Hydro	ASKI Environmental Reclamation and Ecofish Research Ltd.
	Groundwater						
	Groundwater Monitoring *Install groundwater monitoring wells upgradient and downgradient of RSEM R5A and R5B, and water quality monitoring of groundwater.*	*7.2.5, 7.3.3*	*Quarterly (No longer required as of September 2020 due to river diversion/headpond creation)*	*September 2016 to July 2020 (wells decommissioned September 2020)*	*RSEM R5A and RSEM R5B*	*Contractor (Peace River Hydro Partners)*	*Lorax Environmental*
	Peace River Surface Water						
	Peace River Mixing Dynamics and Water Quality Monitoring Field verification of modelled river mixing dynamics for the RSEM discharge sites, assessment of appropriateness of Initial Dilution Zone (IDZ) sample sites through discharge plume characterization, and collection of surface water quality samples at established upstream, far-field downstream and IDZ locations in the Peace River.	6.1.1, 7.2.3, 7.3.4	Monthly during RSEM discharge events	Ongoing from December 2016	Peace River at locations upstream and downstream of PAG containing RSEM areas	BC Hydro	ASKI Environmental Reclamation and Ecofish Research Ltd.
Other Monitoring	**Surface Water**						
	Dam Site Road Cut Water Quality Monitoring Water quality monitoring at construction-related road cuts into PAG material.	5.2.1.7	Monthly (except while dry/frozen) for first year of observation, then quarterly thereafter unless otherwise directed by the QP(ARD)	Ongoing from fall 2016	Throughout the dam site (left and right Peace River banks)	BC Hydro & Contractor (Peace River Hydro Partners), in their respective work areas	Tetra Tech Canada Inc. (on behalf of BC Hydro) Lorax Environmental (on behalf of Peace River Hydro Partners)
	Off Dam Site Project Components Water quality monitoring at excavations into PAG material during construction of these project components.	5.2.2	Once prior to initial discharge, then monthly (except while dry/frozen) for first year of observation, then quarterly thereafter	Ongoing from time of exposure until decommissioning	Throughout exposure area, as appropriate	Contractor (various)	Various

3.1 Summary of Implementation Status: Monitoring Programs Associated with PAG-contact RSEM Sediment Ponds

A summary of RSEMs that are designated to contain PAG material and/or PAG-contact water, and an indication of those that were operational with sediment ponds in 2021, is provided in Table 3.

Table 3 Summary of PAG-contact RSEM Sediment Pond Operational Status in 2021

RSEM	Status in 2021
Right Bank	
RSEM R5A (Phase 1)	Decommissioned in Q3 2020
RSEM R5A (Phase 2)	Operational
RSEM R5B	Sediment Pond decommissioned in Q3 2020. Phase 2 Sump now receives water which is conveyed to RSEM R6.
RSEM R6 (PRHP)[1]	Operational, East and West Ponds
Left Bank	
RSEM L5 (Phase 1)	Decommissioned in Q3 2020
RSEM L5 (Phase 2)	Operational, East and West Ponds
RSEM L6	Operational, no discharge to Peace River in 2021

NOTES:
[1] The RSEM R6 ponds operated by the Main Civil Works Contractor, PRHP, are differentiated from the RSEM R6 pond operated by the Generating Station and Spillways contractor, AFDE (which is a non-PAG contact pond). RSEM R6 does not receive PAG material, but the sediment ponds operated by PRHP receive PAG-contact water.

In 2021, surface water quality sampling was undertaken at a total of 74 stations, including 11 stations on the Left Bank, 12 stations on the Earthfill Dam and river and 51 stations on the Right Bank. Laboratory results for a total of 1,364 surface water quality samples and 216 quality control samples obtained in 2021 from these stations are summarized by Lorax (Appendix A)

Additionally, continuous *in situ* measurements of pH, conductivity and turbidity were collected by installed instruments and dataloggers in the RSEM Area L5, L6, R6 and R5A sediment ponds during periods when the ponds were managed to discharge. Field measurements of the same parameters were obtained at other locations to monitor conditions across the site.

In 2021, as a result of snow melt and larger precipitation events, exceedances were measured in water discharged from PAG-containing RSEM sediment ponds to the Peace River. Discharge monitoring identified three events where EOP discharge limits (or WQGs, as applicable in the case of the Earthfill Dam) were exceeded:

- a single-day concentration spike of total zinc from the RSEM Area R6E pond on January 6th attributed to sample contamination;
- multi-day discharge with elevated total zinc from the RSEM Area R6W sediment pond during cold winter freeze in November and December attributed to corrosion of a metal culvert; and

- discharge from the Earthfill Dam West Sump in early July attributed to analytical error (dissolved aluminum) and isolated inclusion of iron-rich sediment into the water sample (total iron).

None of these non-compliant events are attributed to the influence of ARD/ML. Details of the exceedances are provided by Lorax (Appendix A) and summarized in the proceeding sections.

3.1.1 RSEM Sediment Pond Water Management

Water management focuses on segregating possible ARD influenced water (i.e., PAG contact water) from non-PAG contact waters within PAG containing construction areas. Transfers within and between Project area catchments are conducted to improve water management efficiency and to ensure contact waters are routed through an appropriate treatment facility prior to discharge.

The general water management objectives are to:

- Segregate ARD influenced water that must be treated by the MWTF;
- Maximize storage capacity for surges of PAG contact water associated with heavy runoff from rainfall or snowmelt; and,
- Minimize the number of treatment facilities (i.e., sediment control ponds) that require daily management.

The water management system is continuously adapted as earthworks are undertaken, and generally utilizes a series of one or more conveyance and holding structures, including ditches, sumps, and settling ponds. Ultimately, the majority of PAG contact water is diverted to one of five RSEM sediment pond facilities for discharge to the Peace River. Higher risk water is directed through the Mobile Water Treatment Facility (MWTF) for treatment prior to discharge to an RSEM sediment pond.

A quarterly summary of water transfers in 2021 to PAG containing RSEM sediment control ponds and to the MWTF Pre-Treatment Pond, from Left Bank and Right Bank catchment areas, is provided in Table 4.

Table 4 Quarterly Summary of PAG and Non-PAG Contact Water Transfer to PAG Containing RSEM Sediment Control Ponds and the MWTF Pre-Treatment Pond in 2021 (from Lorax, 2022)

Receiving Facility	Type of Water and Source Area			
	Q1	Q2	Q3	Q4
RSEM L5 East Phase 2 Sediment Control Pond	Non-PAG contact from LBEX	Non-PAG contact from LBEX	Non-PAG / PAG contact from LBEX	Non-PAG / PAG contact from LBEX
RSEM R6 East Sediment Control Pond	Non-PAG contact from LBEX, Area A, CVC, AC	Non-PAG contact from Area A, CVC, AC, R5B	Non-PAG contact from LBCT, Area A, CVC, AC, R5B	Non-PAG contact from Area A, CVC, AC, R5B

RSEM R6 West Sediment Control Pond	PAG contact from Earthfill Dam Core Trench	PAG contact from Earthfill Dam Core Trench	PAG contact from EDES, EDWS	PAG contact from EDES
MWTF Pre-Treatment Pond	PAG contact from LBEX, LBCT, RBCT, AC	PAG and cement contact from Earthfill Dam, RBCT, LBCT and AC	PAG and cement contact from LBEX, LBCT, Earthfill Dam, RBCT, AC and RBDT	PAG contact from LBEX, LBCT, RBCT, AC and RBDT

Notes:
LBEX = Left Bank Excavation; CVC = CVC Batch Plant; AC = Approach Channel; RBCT = Right Bank Core Trench, LBCT = Left Bank Core Trench, EDES=Earthfill Dam East Sump; EDWS=Earthfill Dam West Sump, RBDT=Right Bank Drainage Tunnel, R5B=R5B Sump.
PAG-contact is defined as contact water with a possible ARD influence.
Non-contact is defined as runoff, construction water and groundwater that are not ARD influenced.

The active PAG-contact sediment ponds on the dam site are presented below with approximate volumes of water discharged during the year. Details of water discharge by month is provided in Appendix A.

Right Bank: total volume of just over 800,000 m^3 water discharged in 2021

- RSEM R6 East – 202,000 m^3 total discharge (reduced by ~40% in 2021 compared to 2020)
- RSEM R6 West – 625,000 m^3 total discharge
- RSEM R5A – water levels remained low to moderate, no discharge in 2021
- RSEM R5B – decommissioned and backfilled

Left Bank: total volume of just over 16,000 m^3 water discharged in 2021

- RSEM L5E – 13,793 m^3, from June - September
- RSEM L5W – 563 m^3, August and September
- RSEM L6 – 1,926 m^3, April and November

3.1.2 RSEM Sediment Pond Water Quality

A brief summary of monitoring undertaken at PAG-contact RSEM sediment ponds is provided below; a detailed description is included in Appendix A.

In general, operational PAG-contact RSEM sediment ponds are subject to the following monitoring regime:

- Continuous (minimum hourly) measurements of pH, turbidity, and electrical conductivity via *in situ* sonde.
- Continuous measurements of discharge volume to the Peace River.
- Daily collection of water quality samples for laboratory analysis of total and dissolved metals, pH, total suspended solids (TSS), turbidity, sulphate, nitrates, conductivity,

temperatures, conductivity, and hardness (plus hydrocarbons, if applicable due to a spill event).

These monitoring measures are undertaken except when the pond is dry or frozen.

PAG-contact RSEM sediment pond water quality is subject to EOP discharge limits, as described in the CEMP Appendix E (Table 2), for the following parameters: total metals (cadmium, cobalt, copper, zinc), TSS, and pH. Water quality and flow data are used to calculate metals loading of each PAG-contact RSEM sediment pond to the Peace River on a weekly basis.

Water quality at stations within the construction site upgradient of RSEM sediment ponds are compared to RSEM EOP limits to inform water management. Water that accumulates at these stations is not discharged directly to the Peace River. Consequently, water quality at these stations that exceeds RSEM EOP limits does not indicate non-compliance with CEMP requirements. It indicates only that water management may be required.

Any exceedance of EOP discharge limits in laboratory analysis of water discharged from PAG-containing RSEM sediment ponds to the Peace River is reported within 24 hours of receiving the analytical water quality results. Exceedances are also noted in weekly reports.

RSEM R5A

Site reports indicate that RSEM R5A Phase 2 ponds water levels remained low to moderate and did not discharge in 2021. The RSEM R5A Phase 2 sediment control ponds were managed to not passively discharge, and active pumping from between the different R5A ponds was used as needed to maintain low water levels in the ponds.

PAG material placed in RSEM Area R5A is compacted and covered with NAG soon after placement. This is reflected in the pond water quality which generally meets RSEM EOP limits and BC WQGs.

Field measurements were collected every few days to every few weeks at each pond when there was sufficient water for monitoring, primarily during Q2 and Q3 of 2021. Analytical samples were collected from all ponds in May and from Pond D on August 26.

The water quality in the RSEM R5A ponds was alkaline with moderate conductivity, though at times elevated up to 8,640 µS/cm in Pond D. The maximum concentration for sulphate was 690 mg/L in pond D and TSS was low (< 15mg/L) in all analytical samples.

Field pH, TSS and metals concentrations were below RSEM EOP discharge limits.

RSEM R5B

The RSEM R5B Phase 2 water quality monitoring consists of two sample stations. The R5B-P2-SUMP location which collects runoff from RSEM Area R5B and the western extent of the Approach channel and the R5B-P2-W-SUMP location which collects runoff from west of R5B-P2-SUMP location

The RSEM R5B sump did not discharge in 2021. It was dewatered to RSEM R6 sediment control ponds, as needed throughout 2021. Field measurements were collected daily to weekly at the two water quality monitoring locations. Twenty-four laboratory samples were also collected from the R5B-P2-SUMP location

The water quality measured at the two stations was neutral to slightly alkaline with conductivity in the range of 358 to 1,740 µS/cm. Laboratory results from the R5B-PS-SUMP location show moderate sulphate concentrations (up to 392 mg/L) generally low TSS values (median 7.9 mg/L), and metal concentrations below RSEM EOP discharge limits.

RSEM R6

The RSEM Area R6 East and West sediment control ponds are divided by a berm which isolates the two ponds from each other. The berm was designed to allow the cells to merge in a lager (greater than 1-in-10 year 24 hour) storm event.

The monitoring records for the RSEM R6 East sediment control pond indicate that the pond discharged most days in 2020, and daily from August into December. The RSEM R6 West sediment control pond generally discharged at flows < 40 L/s with flows dropping to 2 L/s or lower in November and December.

Analytical water quality monitoring of RSEM R6 East and West sediment control ponds was conducted throughout 2021, including daily at end-of-pipe sample locations when discharging or occasional in-pond sampling as water levels allowed. The continuous measurement in situ sonde was deployed in-pond throughout 2021 at both ponds, excluding brief periods when the pond was not discharging due to low water levels, or the sonde required maintenance.

Field measurements were collected on a daily to weekly basis upstream of the RSEM R6 East pond, when flowing, and three analytical samples were collected in March, May and July. Field measurements and two analytical samples were also collected at upstream of the RSEM R6 East pond flocculation shack, from March to August, with the analytical samples collected May 27 and August 22.

RSEM R6 East Catchment

The 2021 monitoring data indicate the RSEM R6 East sediment control pond water and EOP discharges were circum-neutral to slightly alkaline, with sulphate concentrations up to 371 mg/L.

The RSEM EOP limits were met for all analytical samples and in situ field pH measurements for RSEM R6 East sediment control pond discharges, except for a single total zinc exceedance (0.0373 mg/L) on January 6. The concentration of zinc was <0.010 mg/L on the days before and after this date. The source of elevated zinc is attributed to TSS because although the TSS level was low (1.5 mg/L), the dissolved zinc concentration was 0.0072 mg/L, well below the value reported for total zinc.

RSEM R6 West Catchment

The 2021 monitoring data indicate that the RSEM R6 West sediment control pond water and EOP discharges were circum-neutral to slightly alkaline, with sulphate concentrations up to 437 mg/L.

All analytical samples and in situ field measurements met RSEM EOP limits except for zinc for several days in late November and again from mid-December through to the end of the year. The exceedances observed for zinc are attributed to soluble zinc released from the zinc plated corrugated steel culvert that is in contact with MWTF treated effluent that flows to RSEM R6 pond. Although total zinc is typically below the detection limit (<0.005 mg/L) from March through October, elevated zinc concentrations relative to the ice-free period were observed in February and mid-November through December.

A single TSS result (0.0291 mg/L) report for the March 5 sample was slightly above the RSEM EOP limit. However, the TSS concentrations on March 4 and 6 were below the limit, therefore the March 5 result is considered to have met the RSEM EOP TSS limit for clear flow conditions on the Peace River based on the screening approach where TSS remains elevated for more than 24 hours.

RSEM L5

The RSEM Area L5 Phase 2 East sediment control pond began discharging in late June 2021, as the site thawed and water levels in the pond rose. Discharge continued intermittently until late September 2021. Discharge from the RSEM Area L5 Phase 2 West sediment control pond was limited to August 25th through September 6th, 2021. Water levels in RSEM Area L5 Phase 2 East and West ponds were low and/or frozen for the rest of the year and did not discharge.

Analytical water samples were collected from the RSEM Area L5 Phase 2 East and West sediment control ponds at EOP on a daily basis when discharging; otherwise in-pond samples were periodically collected. In situ field measurements were collected in parallel with analytical samples, with few exceptions.

The 2021 analytical data and field pH measurements for RSEM Area L5 Phase 2 East monitoring data indicate pond waters were typically circum-neutral to alkaline. Carbon dioxide sparging was occasionally applied near the East and West pond discharge pipe intake to reduce pH at EOP. Sulphate occurred at moderate levels in both the RSEM L5 Phase 2 East pond (up to 1,240 mg/L) and the RSEM L5 Phase 2 West pond (up to 1,360 mg/L). Maximum sulphate concentrations at respective EOP stations were comparable, at 1,340 mg/L at the East pond EOP and 1,400 mg/L at the West pond EOP. Concentrations of TSS and metals in analytical samples from the RSEM Area Phase 2 L5 East and West sediment control ponds were generally low.

Field and analytical measurements of the RSEM Area L5 Phase 2 East and West pond discharges met the RSEM EOP limits.

RSEM L6

The RSEM L6 sediment control pond did not discharge in 2021 except on April 29th to 30th and November 9th to 10th, when water was pumped from the pond to the Peace River. Analytical water samples and field measurements were periodically collected from the pond in late March through November 2021. One analytical sample and corresponding field measurement were collected from the EOP station on April 30th and the pond station on November 9th, when the pond was discharging.

The pH in all analytical samples and field measurements was circumneutral to slightly alkaline, with low TSS (up to 78.5 mg/L) and moderate sulphate levels (up to 485 mg/L). On April 30, 2021, TSS at the EOP station was above the derived RSEM EOP limit, however, the pond discharged for less than 24 hours. Therefore, the measured TSS is not considered an exceedance of the EOP limit, as outlined in the screening approach described in Section 3.2.1 above. The observed low concentrations of Cd, Co, Cu and Zn are mostly attributed to the dissolved components of these metals.

The water quality sample collected from the RSEM L6 sediment control pond EOP station met the RSEM EOP limits when the pond discharged.

3.1.3 RSEM Sediment Pond Toxicity

The acute toxicity (Rainbow Trout 96 hour LC50) monitoring program is designed to confirm that water discharged from the PAG contact RSEM ponds is not acutely toxic to aquatic life at the point of discharge into the Peace River. Therefore, prior to discharge into the Peace River, and for the duration of discharge into the Peace River, acute toxicity testing is required for each RSEM pond.

A brief summary of toxicity testing undertaken at PAG-contact RSEM sediment ponds in 2021 is provided below; a detailed description is included in Appendix B.

In general, acute toxicity of RSEM pond water was conducted on a bi-monthly basis throughout 2021, provided sufficient water was available for sampling. Toxicity samples were not collected if the water level was too low or the pond was frozen to the bottom, in this case, sampling was postponed until sufficient water was available.

Acute toxicity was evaluated using a standard laboratory assay (rainbow trout 96-h LC50 test) performed on water samples collected directly from the outflow of each RSEM pond (or the pond itself when not discharging). In addition, a targeted monitoring program is initiated if a trigger is exceeded that suggests there might be elevated risk to aquatic biota due to poor water quality in the pond, as indicated by in situ pH measurements. In 2021, only routine toxicity monitoring was necessary.

The acute toxicity testing is performed by Nautilus Environmental (Nautilus) in Burnaby or Calgary (under subcontract to ALS Environmental). Sample carboys are delivered to ALS in Fort St. John shortly after sampling (on the same day) and the samples are shipped to Nautilus Environmental following standard chain of custody and within acceptable hold times.

In the event that a toxicity sample is determined to be acutely toxic, the LC_{50} (i.e., the concentration at which there is mortality in 50% (v/v) of the fish) is estimated and reported by Nautilus based on the toxicity results at serial dilutions of the pond water sample. Data are provided in tabular format as % Survival of Rainbow Trout for serial dilutions (% v/v) of the RSEM Pond Water.

Considering all RSEM ponds, a total of 38 toxicity samples were collected in 2021 and all the tests passed (>100% v/v). There were no acute toxicity test failures.

RSEM R5A

Acute toxicity sampling of the RSEM R5a-P2 ponds (R5a-P2A, R5a-P2B, R5a-P2C, R5a-P2D) commenced on April 22, 2021. Prior to this the ponds were frozen or contained an insufficient depth of water for sample collection. In 2021, toxicity samples were collected from each pond on a bi-monthly basis from April until October. During October sampling, RSEMR5aP2A and C ponds were dry and could not be sampled; RSEMR5aP2B pond had just enough water to collect an in-situ sample but no toxicity sample could be collected. Sampling of RSEMR5aP2A, B and C ponds was attempted on November 24, 2021 and sampling of all ponds was attempted on December 13, 2021; however, due to frozen conditions the ponds could not be sampled.

In 2021, all 13 samples collected from the four RSEM R5a-P2 ponds (four from pond D, three from ponds A, B, and C) passed the acute toxicity test.

RSEM R5B

The Phase 1 RSEM R5B ponds were decommissioned in 2020. No toxicity testing was completed for the R5B sumps as there is no longer a direct discharge from this RSEM to the receiving environment (Peace River).

RSEM R6

RSEM R6 toxicity samples were collected on a bi-monthly sampling schedule as site conditions allowed starting in January for RSEM R6E and in March for RSEM R6W.

All 11 samples collected from the two RSEM R6 ponds (five samples from RSEM R6W and six from RSEM R6E) passed the acute toxicity test.

RSEM L5

The Phase 2 RSEM L5-P2 pond is divided by a berm, resulting in two ponds: an east pond (RSEM-L5E-P2) and a west pond (RSEM-L5W-P2).

Toxicity samples were collected from the two RSEM L5-P2 ponds on a bi-monthly basis from March (the ponds were frozen/empty in January and February) through November.

In 2021, all ten samples collected from the two Phase 2 RSEM L5 ponds (five samples from RSEM L5W-P2 and five from RSEM L5E-P2) passed the acute toxicity test.

RSEM L6

Toxicity sampling of the RSEM L6 pond was done on a bi-monthly basis beginning in April; sampling was not done prior to this due to frozen conditions/insufficient water for sample collection.

All four samples collected from the RSEM L6 pond passed the acute toxicity test.

3.1.4 Peace River Mixing Dynamics and Water Quality Monitoring

A brief summary of Peace River mixing dynamics and water quality monitoring work undertaken in relation to discharge from PAG-contact RSEM sediment ponds is provided below; a detailed description is included in Appendix B (EcoFish, 2022).

Initial Dilution Zone Mixing Study and Discharge Plume Characterization

Monitoring of RSEM pond discharge plumes within the Initial Dilution Zone (IDZ) is conducted to characterize dilution under a variety of pond discharge and Peace River flows to meet the CEMP requirement to confirm discharge plume dynamics, and modeling predictions. Characterization of discharge relies on measurements of in-situ specific conductivity, as conductivity in the RSEM ponds is reliably higher than the Peace River. In-situ specific conductivity measurements are recorded in the Peace River at different depths (typically 15 and 30 cm below the surface), distances from shore, and distances upstream and downstream from pond discharge points.

Prior to the construction of RSEM sediment ponds and any associated discharges, water quality modelling was undertaken by the project to examine the predicted mixing capacity of the Peace River through a 100 m IDZ. Modelling in previous years has demonstrated that the RSEM discharge plume is generally fully mixed with the Peace River 20 m to 40 m downstream of the pond discharge location, but when present at the 100 m IDZ, is detectable at the proposed 10-15 cm depth 1 m from shore.

In 2021, IDZ characterization was completed for RSEM R6 (October 25) and RSEM L6 (November 9) to confirm that the pond upstream and IDZ monitoring sites are adequate under Phase 2 hydraulic conditions. Characterization for the new Phase 2 ponds (RSEM R5a-P2 and RSEM L5-P2) is not currently possible due to safety constraints around working in or next to the Site C headpond in close (~1 km) proximity to the entrance to twin tunnels that divert the entire flow of the Peace River around the Site C dam. Results of the IDZ characterization for the R6 and L6 ponds is not reported in the Appendix B annual report, and will be reported on separately in a stand-alone report.

RSEM Discharge/Peace River Surface Water Quality Monitoring

The ARD/ML Management Plan (BC Hydro 2020) stipulates water quality criteria (i.e., BC WQG for the protection of aquatic life) at the IDZ location 100 m downstream of each PAG-contact RSEM sediment pond discharge location. To evaluate compliance, a full suite of water quality parameters (including physical parameters, nutrients, anions, total metals and dissolved metals) was measured in-situ and/or sampled for laboratory analysis. Sampling was conducted on monthly and 5 in 30-day sampling schedules (5 sets of samples over a 30 day period during both turbid and clear flow conditions). Sampling was conducted at IDZ sites 100 m downstream of discharging RSEM ponds, as well as at upstream (upstream of all Site C construction influences), immediate background (just upstream of RSEM discharge points), and far-field downstream locations.

TSS discharge limits at EOP, which are prescribed as the BC water quality guidelines for freshwater aquatic life (CEMP Appendix E, Table 2) and thus, are dependent upon background Peace River water clarity conditions, were determined through measurements collected by automated turbidity gauges located on either bank of the Peace River, upstream of the confluence with the Moberly River. Site-specific TSS:turbidity relationships were continually re-evaluated through frequent sampling through a range of Peace River and tributary flow conditions. In total 142 TSS samples collected over 33 dates between March 14, 2018 to December 31, 2021 were used to develop the TSS:turbidity relationship used in 2021. These data encompassed a wide range of turbidity and TSS observations.

BC WQG were occasionally exceeded in 2021 due to naturally occurring Peace River conditions. Natural exceedances occurred predominantly during the freshet period (April to the end of June) and were observed at all sample sites. Exceedances were most often associated with elevated concentrations of suspended solids in the Peace River.

There were no exceedances of BC WQG measured at IDZ sites that were attributable to discharge of water from RSEM sediment ponds.

The range in water quality parameter concentrations measured in 2021 were similar to those measured in 2017, 2018, 2019, and 2020 and were within historical water quality data ranges observed in the Peace River.

3.1.5 Groundwater Monitoring

The groundwater monitoring program at RSEM R5A and R5B was initiated in 2016 and completed in 2020 to fulfill the requirements of CEMP Appendix E, S.7.25 and S.7.3.3. The program included quarterly monitoring of water quality and continuous monitoring of water levels. Groundwater quality in the downgradient wells was evaluated with respect to compliance targets specified in the CEMP and the Groundwater Quality Mitigation Plan.

The Peace River flood plain in both areas where the wells were located was completed flooded during diversion of the Peace River and establishment of the headpond. All monitoring wells were decommissioned on September 23-25, 2020, in advance of the October 2020 river diversion and flooding, and sealed with bentonite.

3.2 Summary of Implementation Status: Other Monitoring Programs

3.2.1 Dam Site Road Cut Water Quality Monitoring

Two large double lane dam site road cuts referred to as River Road (exposed in 2015) on the Left Bank between Howe Pit and the Peace River, and the South bank Initial Access Road (SBIAR), exposed in early 2017, on the Right Bank between Area A and RSEM R6 have been constructed to allow site vehicle access from the upper terrace to the lower flood plain. Continued exposure of bedrock materials from both of these road cuts requires that routine water quality monitoring be conducted by BC Hydro as required by CEMP Appendix E S.5.2.1.7.

Additional monitoring locations were added in October 2020 at the L2 Powerhouse Area and the BC Hydro LBDB to monitor water quality from exposed PAG slopes. The monitoring program includes locations at the discharge points and at midstream locations as well as locations upstream from the discharge to characterize variation to water chemistry within the catchment due to mixing and inflow of water from multiple sources.

A brief summary of the 2021 monitoring results for the dam site road cut water quality program is included below, see Appendix C for details.

River Road

A total of eleven (11) monitoring locations have been established in the River Road catchment near Blind Corner to monitor the effectiveness of the limestone riprap in the ditch line and on the rock slope, and to observe longer term influences from the PAG outcrop at Blind Corner and run-off/seepage from Howe Pit on the water collected in the River Road ditch. Surface runoff along River Road, which contacts bedrock at Blind Corner, is conveyed via a pipe to the River Road ditch line for infiltration. The placed limestone riprap is effective at mitigating the pH of the drainage when there are fresh surfaces of limestone available for chemical reactions. Potentially acidic leachate generated from the rock cut-slopes reacts with the alkaline limestone to help neutralize water as it passes through the riprap lined ditch.

In July/August 2021, the limestone rip rap was replaced along River Road following observation of orange coating and mineral precipitate on the limestone and increased sediment loads in the water in the ditch. Chemical efficiency of the limestone to buffer acidic water is decreased when coated in precipitate. The new limestone has fresh surfaces to provide acid-buffering capacity when contacted by slope leachate. Sampling at River Road after the limestone replacement was limited due to dry or frozen conditions and therefore it is difficult to interpret specific changes pre- and post- limestone replacement. The effectiveness and impact of the limestone refresh will continue to be monitored in future sampling events and analyzed for trend analysis over time.

Water quality laboratory data was collected from six locations (LBRR-DD, LBR-EDP, LBRR-LC, LBRR-UC, LBRR-12+500 and RR9) and in situ measurements were collected at eleven of a total twelve water sample locations along the River Road catchment in 2021.

Water quality monitoring continues to show that active ARD-ML processes are progressing on PAG shale slopes shown in observed trends, such as elevated concentrations above the BCAWQG-FST for total iron (six occurrences) and total arsenic (two occurrences) at LBRR-

12+500, LBRR-EDP and RR9. No BCAWQG-FST exceedances were measured at LBRR-DD, LBRR-UC or LBRR-LC. In 2021, a total of thirty-three (33) in situ field measurements of pH within the River Road ditch indicated a neutral to alkaline pH of between 7.17 to 8.89.

The source of TSS is primarily from River Road run-off, scouring of sediment deposited within the River Road ditch and washing from the cut-slopes. Seasonally, elevated TSS levels have been noted to occur during spring melt and freshet season, typically April, when water flow can wash elevated precipitates from rock. The March 17, 2021, sampling event represents early spring freshet conditions and appear to be slightly earlier than in 2020.

South Bank Initial Access Road

Surface runoff which contacts the bedrock at SBIAR is channelled via a lined ditch to PRHP RSEM R6 pond for management prior to being discharged to the Peace River and does not have a direct downstream receptor. There is an intensive water quality monitoring program in the pond (continuous in situ measurements of pH, conductivity; daily lab analysis for all parameters) conducted prior to discharge by Lorax Ecofish Research Ltd. and others, as well as Peace River receiving environment monitoring conducted by Ecofish and others.

Water quality data was collected from five established sampling locations in 2021, four of which measure water directly from within the SBIAR ditch locations (sampled February to November 2021) and a fifth location in the side channel down-gradient of the SBIAR construction (RBSC-DS) that was sampled up to and including May 2021.

The SBIAR sampling locations were monitored on a monthly basis and water quality samples were collected between January to November 2021 outside of frozen or dry conditions. Water quality data was collected from five established sampling locations in 2021, four of which measure water directly from within the SBIAR ditch locations (sampled February to November 2021) and a fifth location in the side channel down-gradient of the SBIAR construction (RBSC-DS) that was sampled up to and including May 2021.

Evidence of active ARD-ML process are observed on the shale slopes in SBIAR through rinse pH analysis and observation of secondary iron hydroxide mineral formation. Alkalinity and pH indicate that the waters in SBIAR have consistently remained alkaline in 2021. Screening of analytical data during 2021 for the downstream ditch locations resulted in occurrences of BCAWQG-FST guideline exceedances at RBSBIAR-DS (total iron (4), dissolved aluminum (3), total arsenic (1), total zinc (1), total cobalt (1), dissolved cadmium (1), dissolved copper (1), pH < 6.50 (1)) and RBSBIAR-EDS (total iron (4), dissolved aluminum (2), total arsenic (1) and total zinc (2).

BC Hydro Left Bank Debris Boom

Shale was exposed during construction of the BC Hydro Left Bank Debris Boom (LBDB) anchor area in approximately March 2020. In September 2020, the river was currently at Phase 1 elevation (~410 m) followed by a partial block and diversion of the Peace River to allow

construction of the main Site C dam in October 2020, causing the river/reservoir to flood up to stage 2 levels (~417-420 m). The final river/reservoir elevation is ~ 460 m.

The ditches above the 420 m elevation are lined with 3-10 inch size fraction limestone as a management measure to provide additional buffering capacity to leachate entering the ditches. The area below 420 m elevation was flooded by the head pond after construction in early Fall 2020, and therefore that area did not require riprap. The area above 420 m elevation will be exposed for 3-4 years, prior to flooding to the final river/reservoir elevation of around 460 m elevation.

Sampling at BC Hydro's LBDB area commenced in 2020 and initially included sampling at LBP Pond and a Peace River side channel location, which is now back flooded. Additional sample locations were added in July 2021 following a review of the area during the Tetra Tech site audits to monitor construction contact water. The added monitoring locations are located in the armor ditches at the toe of the exposed construction PAG faces and downstream of the LBP Pond.

In May 2021, there was evidence of erosion and scouring beneath the LBP Pond, issues with water management structures, and evidence of ARD/ML processes on the slopes. In addition to the new sample locations added to address these issues, water management structures and ditch linings were also amended following the July site audit review. The water management structures were improved to manage flow and prevent erosion and ditches were lined with limestone to provide acid buffering capacity. These were proactive measures to manage signs of erosion and initial signs of ARD/ML generation on the exposed shale slopes.

At LBP Pond, between April to October 2021 during seven sampling events there were BCAWQG-FST exceedances measured for total iron (5), dissolved iron (2), dissolved aluminum (1), total manganese (3), and total zinc (2). Water is not commonly observed to discharge from the LBP-Pond, but if it does it passes through a limestone lined water management ditch system.

Two downstream Armor Ditch locations were sampled for the first time in 2021. Sampling was possible due to the heavy rainfall event occurring around the sampling event, and these ditches are otherwise generally dry. No samples were collected from the remaining laydown drainage and armor ditch sample locations due to dry conditions. On July 20-21, 2021, the downstream east Armor Ditch, LBDB-EDS, measured four BCAWQG-FST exceedances for total iron, total arsenic, total zinc and dissolved aluminum, and the downstream west Armor Ditch, LBDB-WDS, measured one BCAWQG-FST exceedance for total iron. Field samplers confirmed that there was no direct discharge to the Peace River, and that both sampled watercourses drain to sufficiently sized sumps to retain water that is noted in the ditches.

LBP Pond is the only location within the area that has been consistently available for sampling. Limited surface flow is observed in this area, and the only time that the sample stations in the LBDB area can be sampled, except for the LBP Pond location, is immediately following a significant rainfall event. Sample staff are instructed to sample these locations outside of regular monitoring events, if possible, when high rainfall is observed.

L2 Powerhouse Area

The L2 Powerhouse Area PAG slope is mitigated by covering of the slope that effectively makes it a non-PAG contact surface. The water quality monitoring program has been put in place to verify that the mitigation applied is working and that non-PAG contact water is observed in this area. Water conveyed to AFDE RSEM R6 pond from this area is non-PAG contact and is monitored at the pond prior to discharge.

In 2021, the L2 DS location next to the L2 Powerhouse had eleven sampling events and BCAWQG-FST exceedances measured for total iron (4), dissolved aluminum (10), total silver (4), total zinc (3), ammonia (2), total arsenic (5) and pH > 9.0 (4). In 2021, the L2 US location had seven sampling events and three BCAWQG-FST exceedances measured for total iron.

At L2 DS, the pH is consistently alkaline and in four of eleven sampling events the pH value exceeded the upper limit of the BCAWQG-FST guideline (pH 6.5-9.0). Some events are coincident with elevated metals of total iron, total silver and total zinc, whereas other events are not, and rather shows an inconsistent up and down see-saw trend that not confirmatory of a PAG signature, e.g., decreased pH value. Trend charts for the L2 Powerhouse sampling stations present consistent neutral to alkaline pH values and slightly higher pH values at L2-DS relative to L2-US. Total alkalinity values are highly variable whereas acidity values are commonly at or below detection limit.

The ammonia BCAWQG-FST guideline value is dependent on pH value, and, since pH is above the upper limit of the guideline it is a capped value that calculates two exceedances in ammonia due to the high pH. The source of ammonia is thought to be from the construction activities at the L2 Powerhouse and is inferred to be structure material and admixtures in concrete cement at the sample location.

Given the above observations and data, Tetra Tech infers that the elevated dissolved aluminum, elevated pH, and ammonia are connected, and the concentrations are not representative of a PAG leachate issue and are possibly related to the construction activities/concrete in the Powerhouse area. Total concentrations are significantly higher than dissolved concentrations for aluminum and iron, and other metals, e.g., arsenic, cadmium, copper, manganese and zinc which is a trend at L2-DS and will continue to be monitored in 2022.

It is noted that water quality in the L2 area as well as the adjacent area for the AFDE foundation enhancement trial drilling program, both contained an excess of dissolved aluminum. This was investigated and determined that the most likely source of the dissolved aluminum to be originating from the RCC concrete which contains fly-ash (21.2% aluminum oxide) and GU cement (5% aluminum oxide). The elevated metal may indicate that ARD-ML processes are occurring however the processes are being buffered and an alkaline pH is being maintained.

3.2.2 Earthfill Dam

Water management within the Earthfill Dam evolved over the course of 2021. Initially, during the first half of 2021 Q1 water was removed from the isolated area (Isolation Zone) by excavating

ice, and by pumping residual river water to the Peace River. The excavated ice was placed in RSEM Areas R5A and L5. After the area was dewatered and excavation of the Earthfill Dam Core Trench proceeded, river water seepage into the core trench excavation that may have contacted PAG material was pumped to the RSEM R6 West sediment control pond for sediment removal, and non-PAG contact seepage water from the isolation zone and other areas of the Earthfill Dam continued to be pumped to Peace River, as needed. PAG and shotcrete contact water from the core trench is directed to the MWTF pre-treatment pond. Later in the year during Q4 2021, all water from the Earthfill Dam was directed to the Peace River through the Earthfill Dam-DS-Out location.

Twelve surface water monitoring stations have been established to monitor water quality associated with the Earthfill Dam. Sample locations and details of the water quality monitoring program are presented in Appendix A.

The Earthfill Dam West and East Sumps collect river water that seeps through the cofferdams on the west and east sides of the core trench. As these sumps may on occasion also receive PAG contact water, the water was typically discharged through the RSEM Area R6 West Pond. The west sump discharge directly to the Peace River upstream of the cofferdam was initiated July 1 and continued until October 25, except July 21st to August 3rd and September 13th to 15th, when the sump was temporarily redirected back to RSEM R6 West sediment control pond.

Field measurements and analytical samples were collected daily from the west sump when water was discharged to the river. At the east sump, field measurements were collected daily for most of July and weekly thereafter while four analytical samples were collected in early July and six samples were collected in late September. Field measurements indicate the sump samples were alkaline and had moderate field conductivity (up to 814 µS/cm) and low concentrations of sulphate (< 51 mg/L) except for one anonymously high sample on August 12.

There were exceedances of BCAWQG-FST reported for total iron on July 3rd and dissolved aluminum on July 4th and again from July 8-10 in the discharge from the Earthfill Dam West sump. An internal investigation conducted by BV laboratories determined laboratory contamination during sample filtration was likely responsible for the elevated dissolved aluminum reported by the laboratory and the actual water quality discharged on those dates is expected to have dissolved aluminum concentrations within the BCAWQG-FST.

The end of pipe location of the Earthfill Dam Sump waters that were pumped to the RSEM R6 West sediment control pond were measured to be slightly alkaline with only one slightly acidic field pH measurement in March. Conductivity was typically less than 800 µS/cm although readings elevated up to 18,600 µS/cm were recorded. The five analytical samples collected from this station indicate there were only limited signs of PAG influence as demonstrated by the maximum sulphate concentration of 105 mg/L. Elevated metals were measured on occasion but the combination of high turbidity and low sulphate indicate that metals are not related to ARD

3.2.3 Off Dam Site Water Quality Monitoring

Water quality monitoring at off-dam site exposures was completed in accordance with the CEMP, Appendix E S.5.2.2. Water quality monitoring for all construction area PAG contact

surface water was be confirmed to meet BC WQG prior to the first discharge into the receiving environment, and then subsequently monitored during construction. Monitoring and associated site inspections by the Contractor's QP(ARD) is increased in frequency if ARD and ML is observed and if there is a risk of downstream effects such as negative impacts to receiving environment chemistry.

Water quality monitoring took place at the following Highway 29 Realignment Segments as follows:

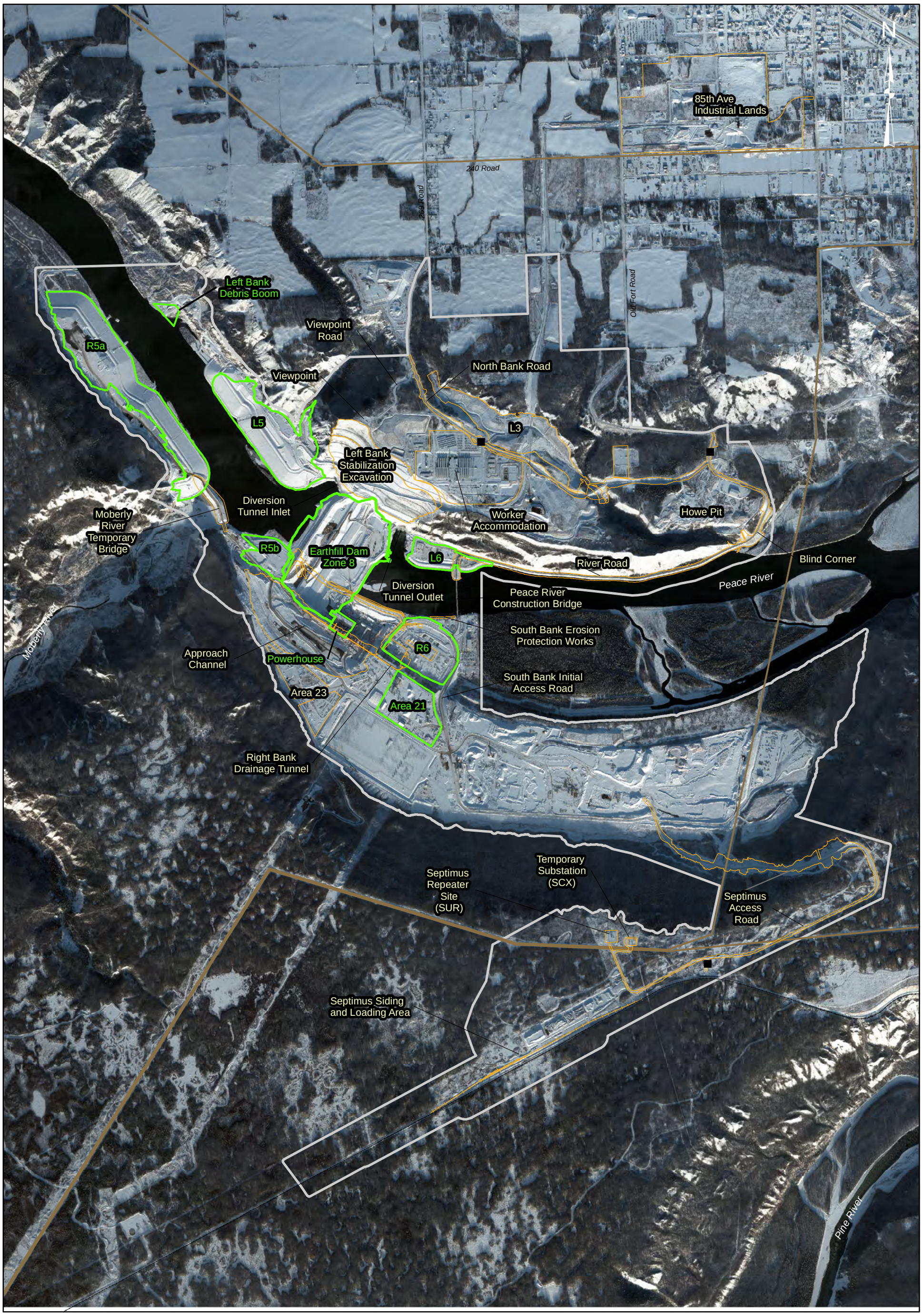
- Bear Flat Cache Creek
    - The PAG disposal site underwent sampling and assessment of the quality of runoff water contained in a containment ditch around the PAG disposal site on March 16th, 2021. Two samples were collected, one from the north ditch and one from the south ditch. Although the samples indicated elevated levels of some metals, these were attributed to be from natural background values as well as concrete slurry disposal and not related to ARD ML related processes. It is also confirmed that all runoff water from the PAG pile is contained in the ditch and not discharged to the environment.
- Halfway River
    - PAG disposal Area perimeter Ditch water sampling in PAG disposal Area B and C, Pier 12 Pad, Pier 12 groundwater discharge, and western abutment on March 27, 2021. Results indicated that PAG disposal Site contact water was not appropriate for release into the environment, and that it was contained to the ditches and did not overflow the ditches.
- Farrell Creek
    - pH monitoring adjacent to and downgradient of the east abutment as well as around Pier 5 was monitored through June, July, August and September when standing water was present for testing. pH results were circa-neutral ranging from 6.82 to 8.28.
- Farrell Creek East
    - Limited activity occurred during 2021 and there was no reported water quality results or exceedances.
- Lynx Creek
    - In situ water quality analysis was completed in 2021 by the contractor's environmental monitor. There were no reports of exceedances or issues related to ARD ML reported to BC Hydro.
- Dry Creek
    - Water quality analysis was completed throughout 2021 in accordance with the project EPP by the contractor's environmental monitor. There were no reports of exceedances or issues related to ARD ML reported to BC Hydro.

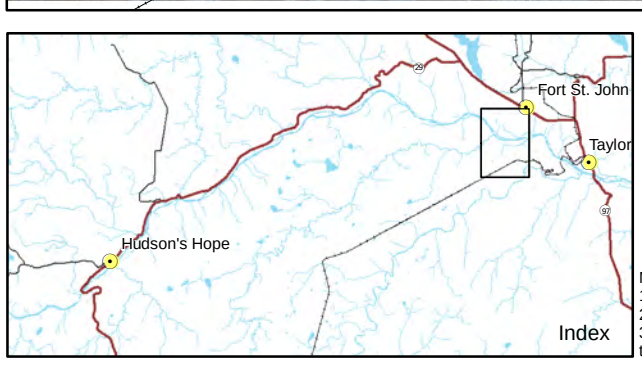
4. SITE AUDITS

BC Hydro has engaged Tetra Tech as QP (ARD), in accordance with the CEMP Appendix E S. 6.1.2, to inspect and monitor various construction areas with potential for ARD/ML since June

2016. Site audits completed during 2021 for the project were limited due to travel restrictions associated with the COVID-19 pandemic, but were conducted as follows:

- July 20 to 23, 2021. Lara Reggin and Scott Kingston completed a site audit at the main civil works (MCW) dam site, and Highway 29 Realignment. Areas visited during the audit include MCW Left Bank Debris Boom, River Road, RSEM R5A, RSEM R5B, SBIAR, Powerhouse, Moberly River slopes, and offsite areas of Highway 29 Realignments Farrell Creek, Lynx Creek and Halfway River Bridge Segments and PAG disposal Areas. Confirmatory geochemistry samples were collected during the site audit at the LBDB on the MCW site and confirmatory geochemistry samples were collected offsite for Farrell Creek alignments. In situ water quality sampling was undertaken at the Farrell Creek alignment. Samples at both sites were confirmed to be PAG and was used to confirm appropriate management and mitigation.
- September 29 to 30, 2021. Lara Reggin completed a site audit at offsite locations at the reservoir clearings and along the Highway 29 Realignment. Locations visited during the September site audit included the South Bank Reservoir Clearing (OLTC20a Phase 1 and Phase 2), and Highway 29 Realignment, Farrell Creek Segment, East Abutment. . Confirmatory geochemistry samples were collected during the site audit at the South Bank Reservoir Clearing and identified that planned excavation areas were PAG. This information will be used in future management and mitigation plans for this area.





Legend

- PAG-contact RSEMs
- Components
- Dam Site Area

1:30,000

0 0.5 1 km

Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Dam Site Imagery from PhotoSat taken Nov 20, 2021

BC Hydro

Figure 1
Overview - Dam Site

Date	Mar. 23, 2022	DWG NO	1016-N11-01392	R 0

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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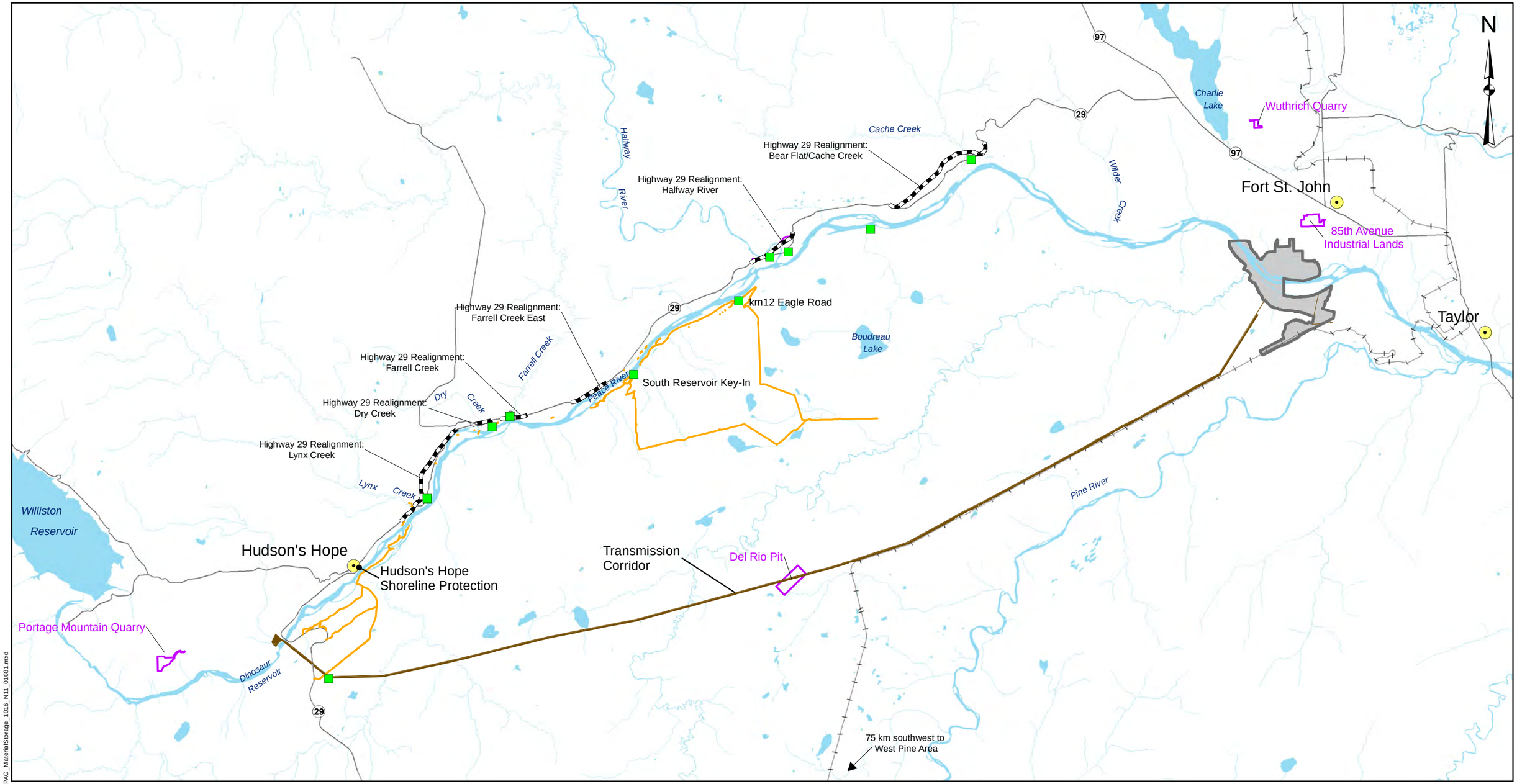

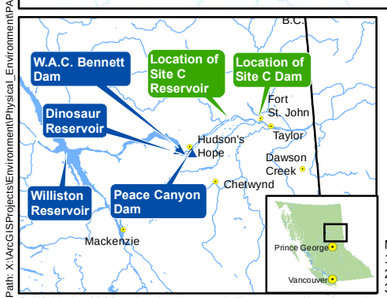

Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.

Legend

- PAG Material Disposal Sites
- OLTC 20 Proposed Access
- Dam Site Area
- Transmission Corridor
- Highway 29 Realignment
- Existing Railway
- Existing Road
- City/District Municipality
- Off-site Construction Material Sources

1:250,000 0 10 km

BC Hydro

Figure 2
Overview – Off Damsite

Date	Mar 24, 2022	1016-N11-01081	R 1

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals

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Appendix A