



Rebar, Concrete, Dam

Site C Clean Energy Project - BC Hydro

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UBC Applied Science Co-op Program

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1

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- This file and presentation are defined as NON-NERC CIP
- I would like to acknowledge that the Site C project is situated on the traditional territory of the Saulteau First Nations. Myself, as a UBCV student; UBC Point Grey campus is located on the traditional, ancestral, unceded territory of the Musqueam people. I would also like to acknowledge that you are joining us from many places, near and far, and acknowledge the traditional owners and caretakers of those lands.

2

Outline

Introduction

- Site location and facts
- MCW & GSS
- Main components

Technical

- IFC drawings
- CO/CR drawings
- Connections and relationships

Analytical

- Rebars
- Concrete
- Geological

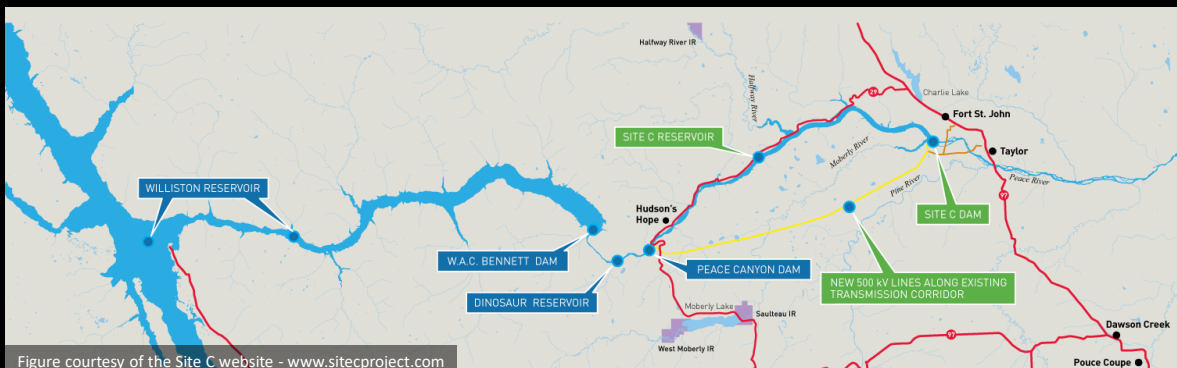
Conclusion

- Current site status
- My contribution
- Recommendations

3

Location

- Peace river
- Two existing dams
- Third dam



4

Introduction

Why BC Hydro named “hydro” but transmits electricity?

- BC Hydro and Power Authority
- Third largest electric utility in Canada
- Serves more than 94% of BC’s population
- 30 hydroelectric generating plants

5

Introduction

Why BC Hydro is building another clean energy station?



5,147,712
2020



6,550,640
2041



2.8
AVERAGE
FAMILY SIZE



~500,000
NEW FAMILIES
IN BC

Data source and prediction: BC Stats

6

Site Facts



9330

HECTARES
SITE C
RESERVOIR



Typical family
using ~
10,715 kWh
per year*



450,000

HOMES PER
YEAR IN BC



100

YEARS OF
RENEWABLE
ELECTRICITY
(AT LEAST)

* <https://shrinkthatfootprint.com/average-household-electricity-consumption/>

7

What is GSS?

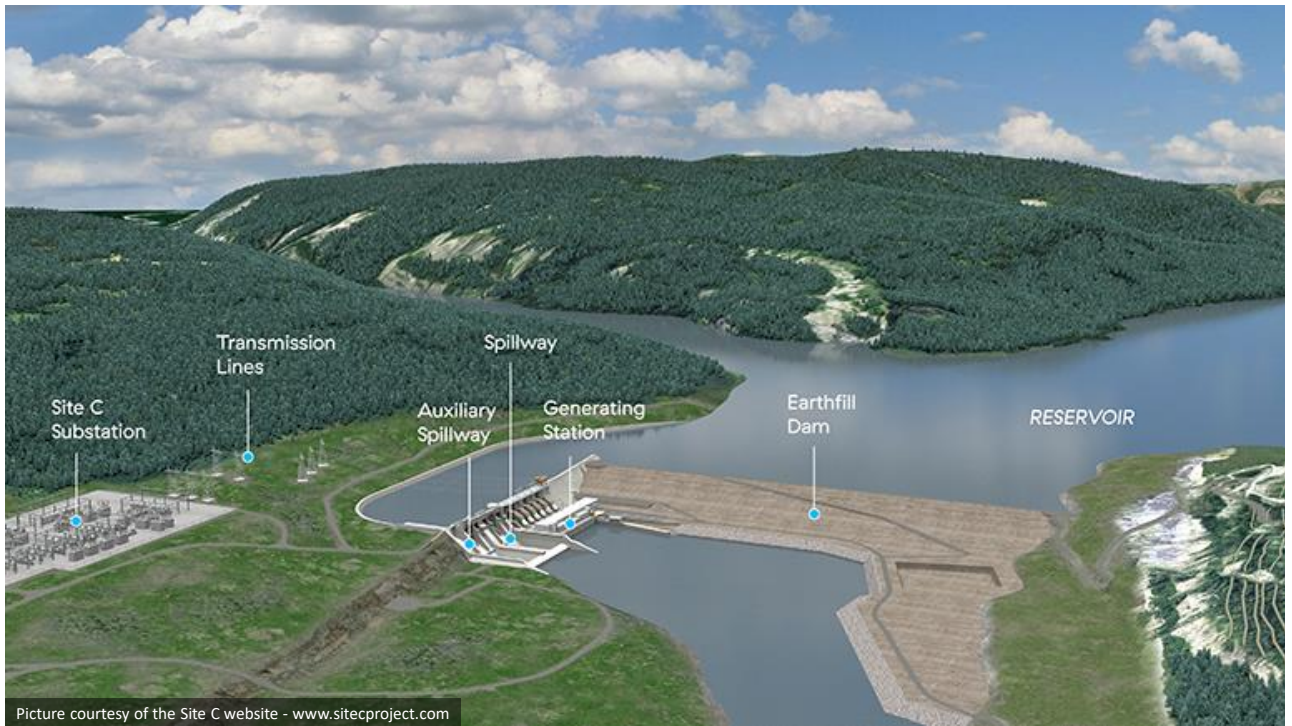
GSS – Generating Station and Spillway

MCW – Main Civil Work

...



8



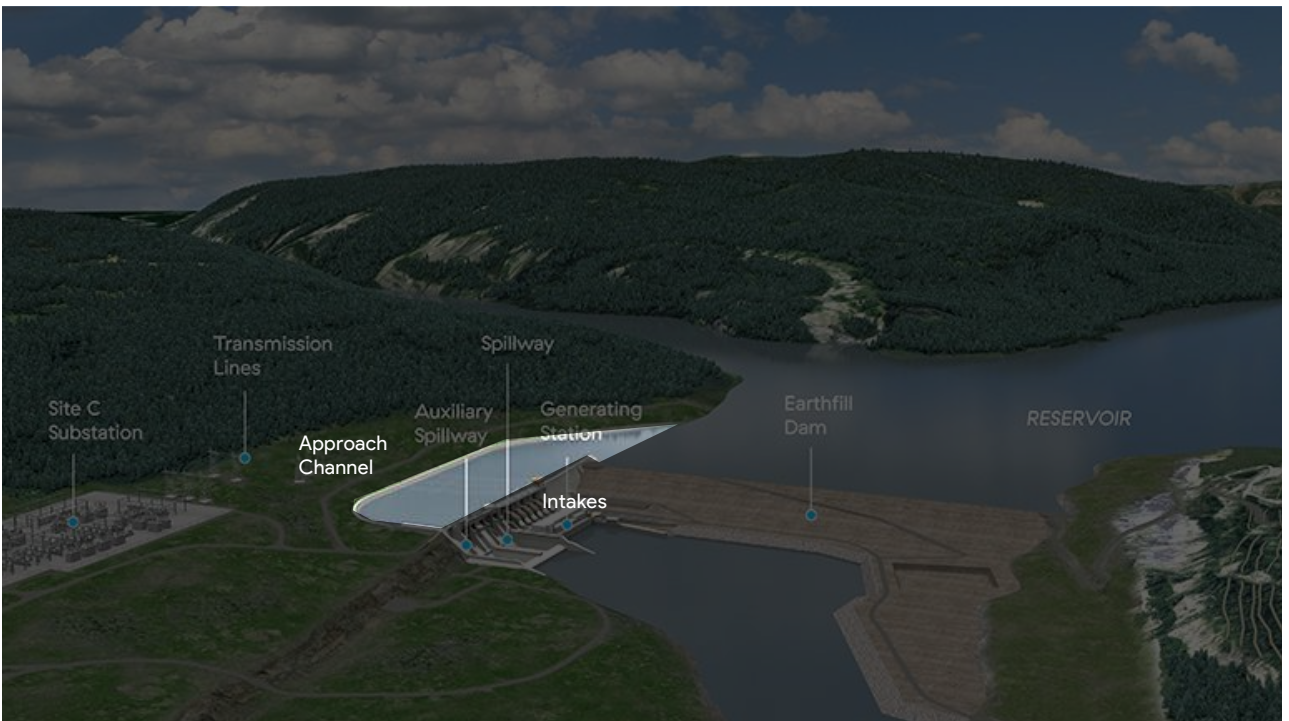
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11



12

Approach Channel



13

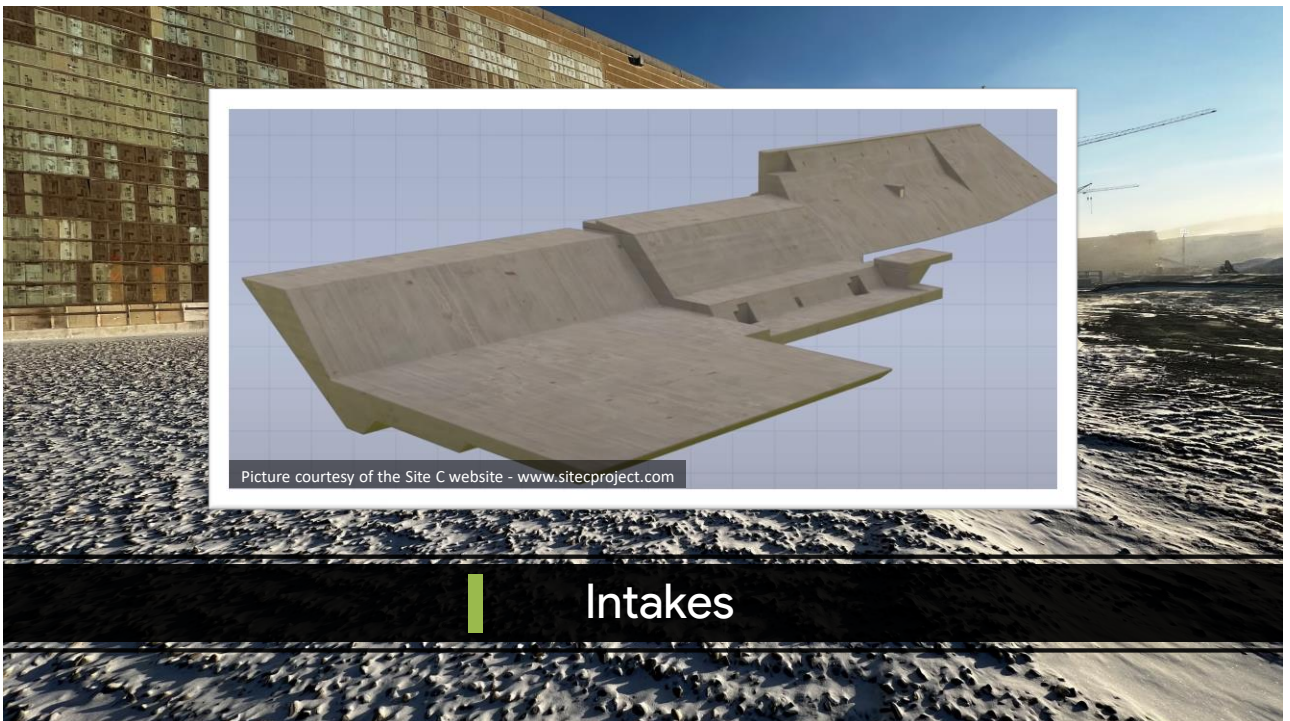
Approach Channel



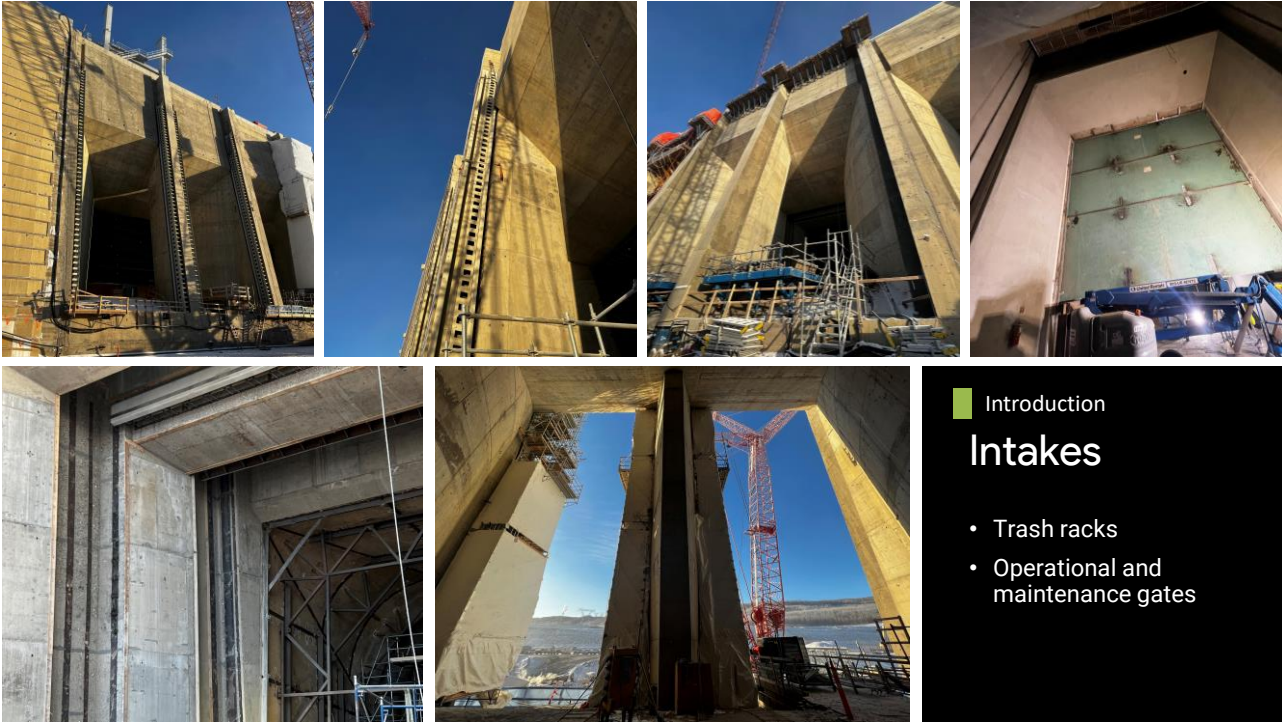
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16



Introduction

Intakes

- Trash racks
- Operational and maintenance gates

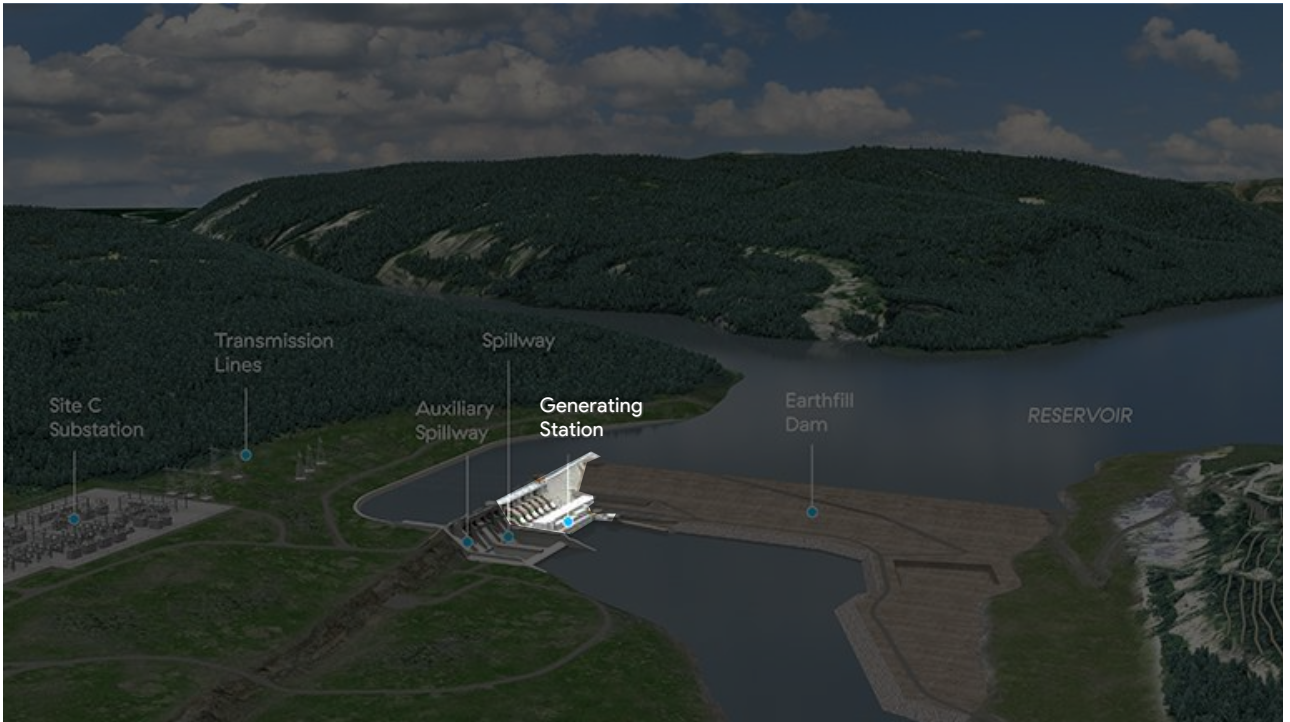
17



Headworks

- Hydraulic Mechanical Equipment
 - Radial gates
- Hoist house
- Gantry crane

18

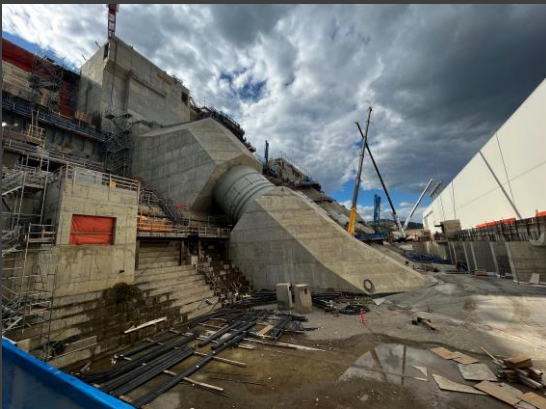


19

Introduction

Generating Station

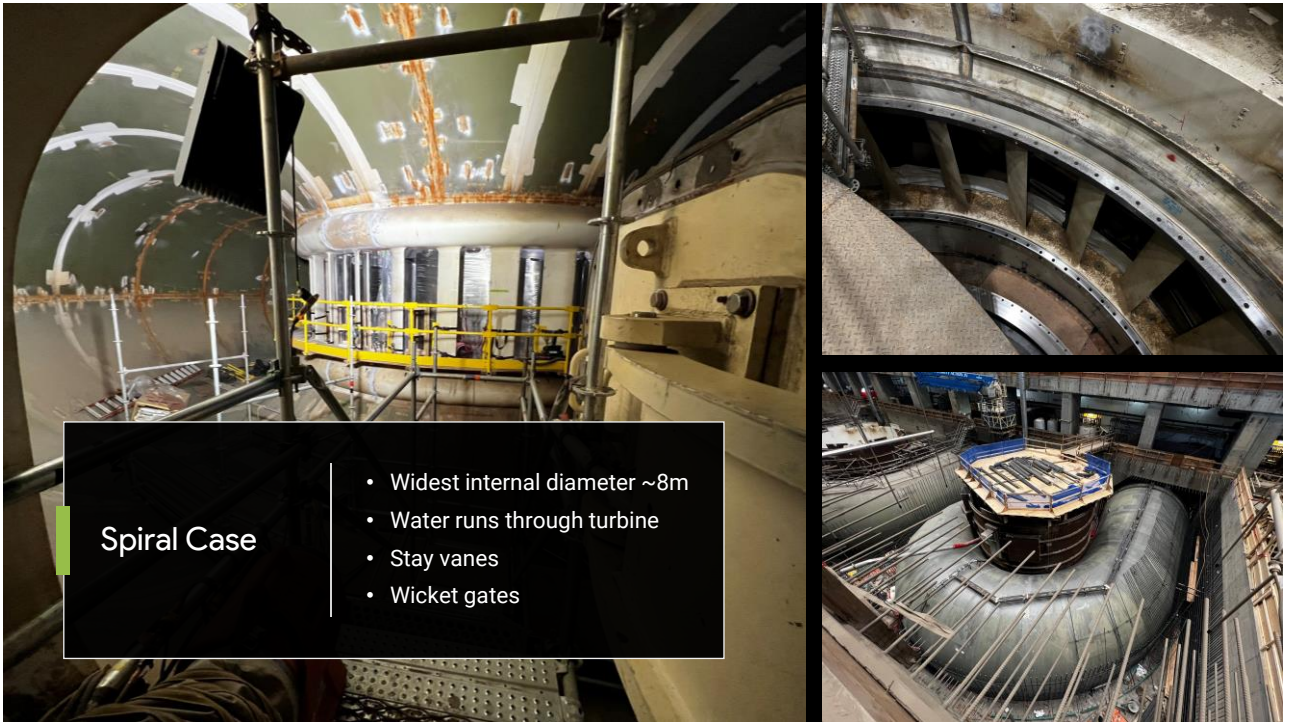
Penstocks



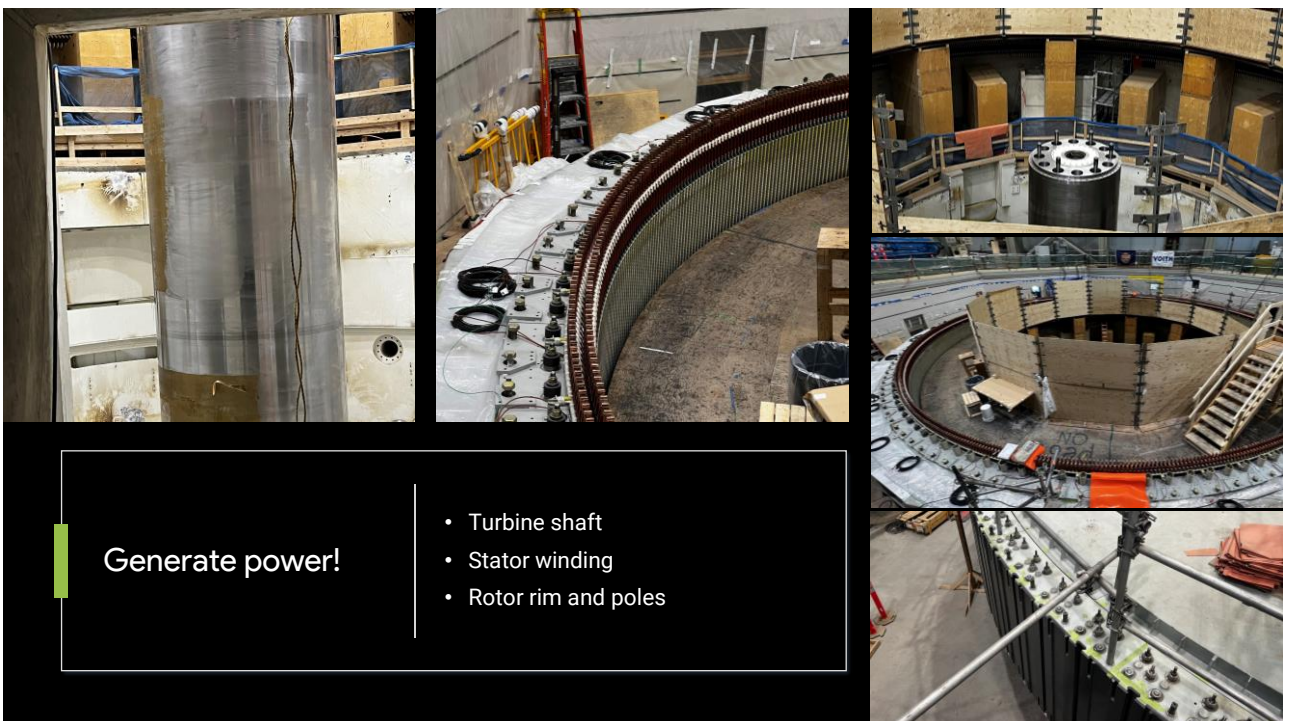
Generators and Turbines



20



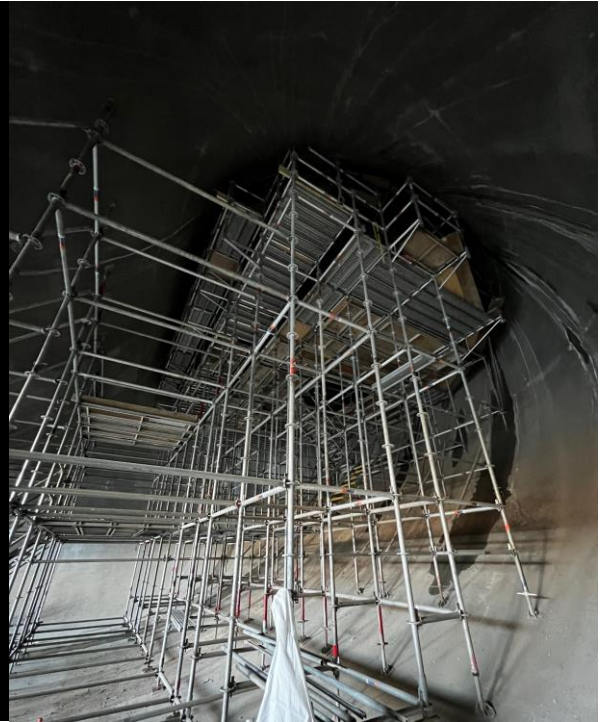
23



24

Draft tube & Pier

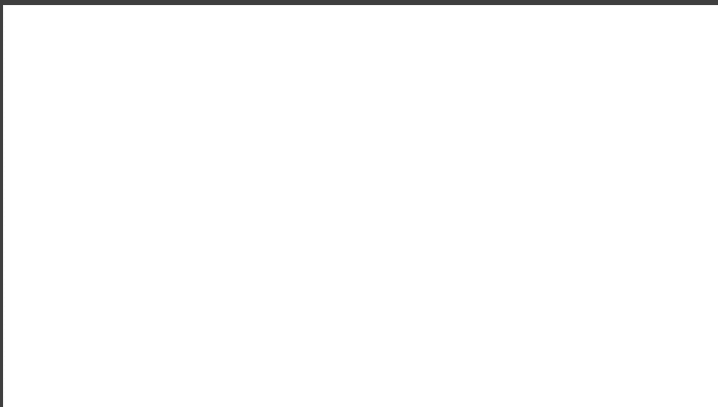
- Water outlet



25

Technical

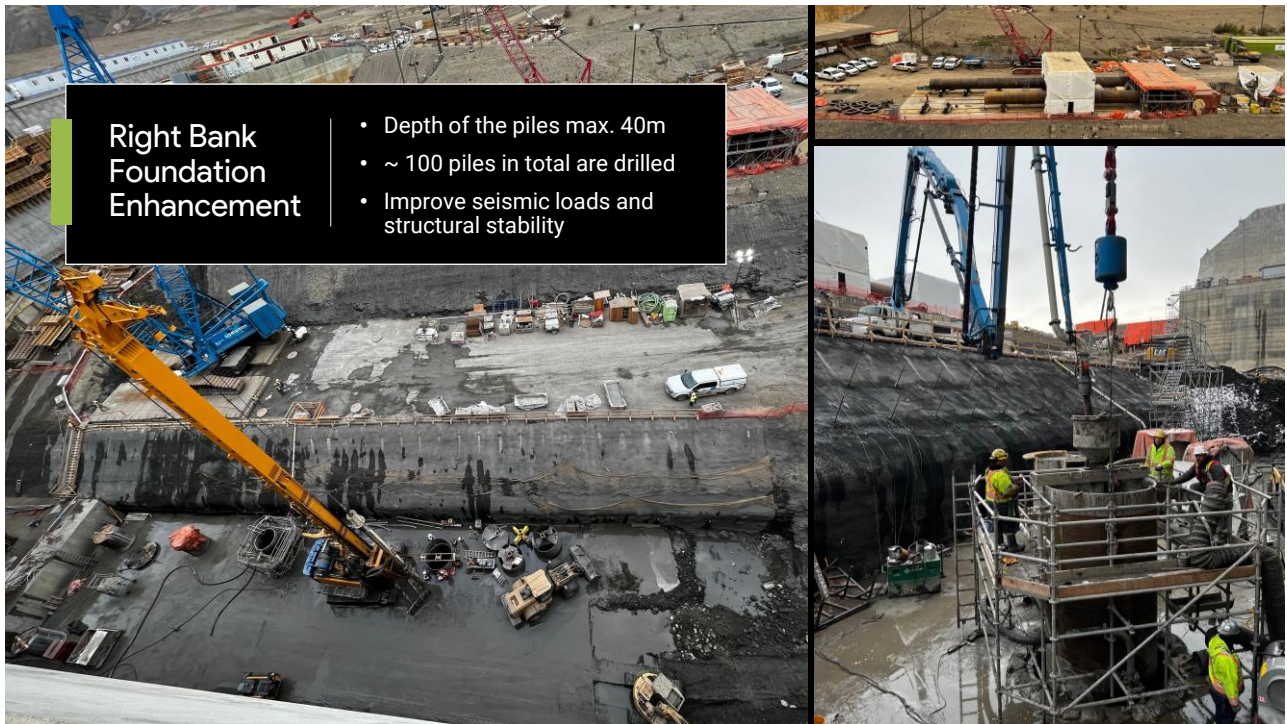
Generators and Turbines



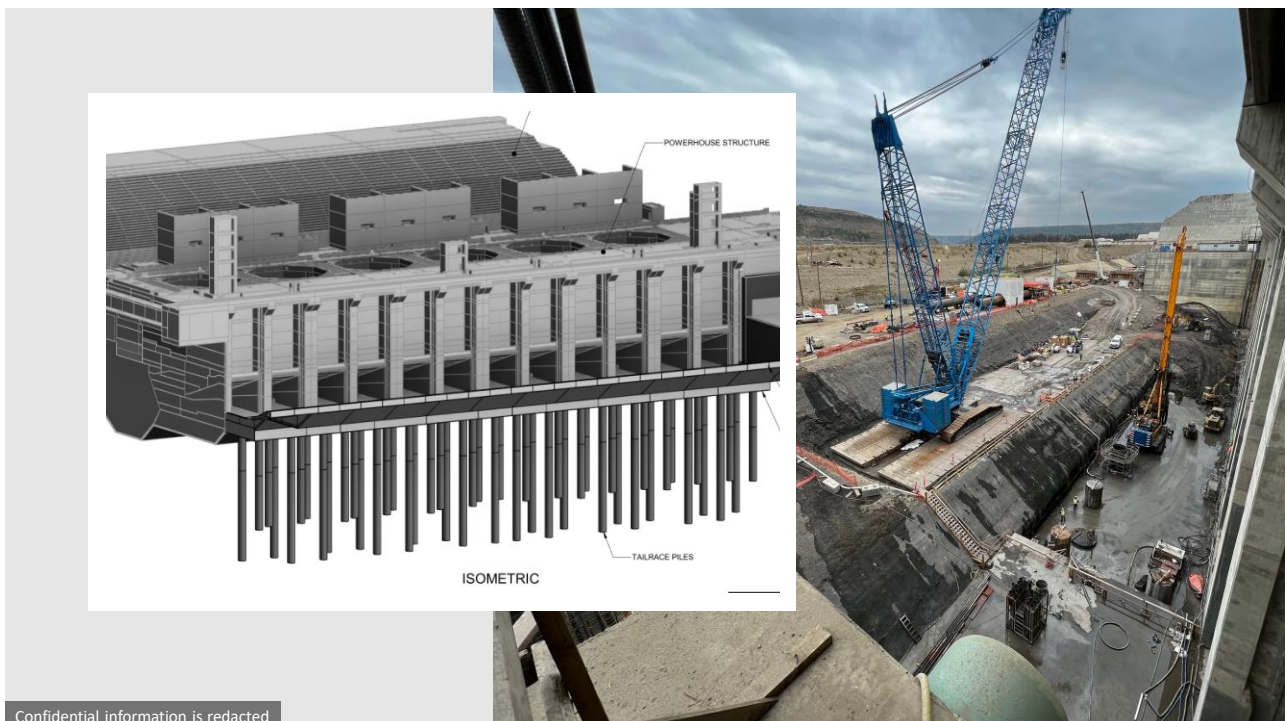
- Hydraulic Machinery
- Bracket
- Stator
 - Frame
 - Winding
- (Turbine guide) Bearing
- Rotor
- Rotor Poles
- Magnetic Flux
- Stress and Ventilation

Video courtesy of VOITH on YouTube

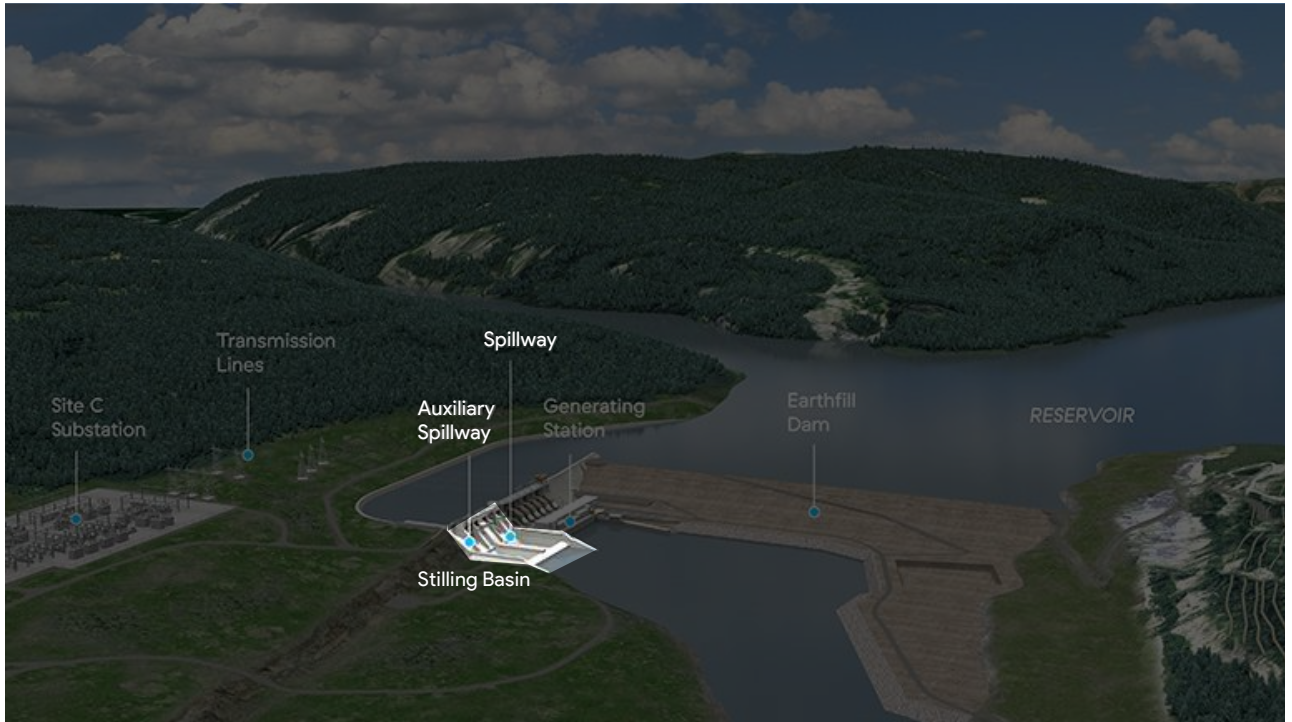
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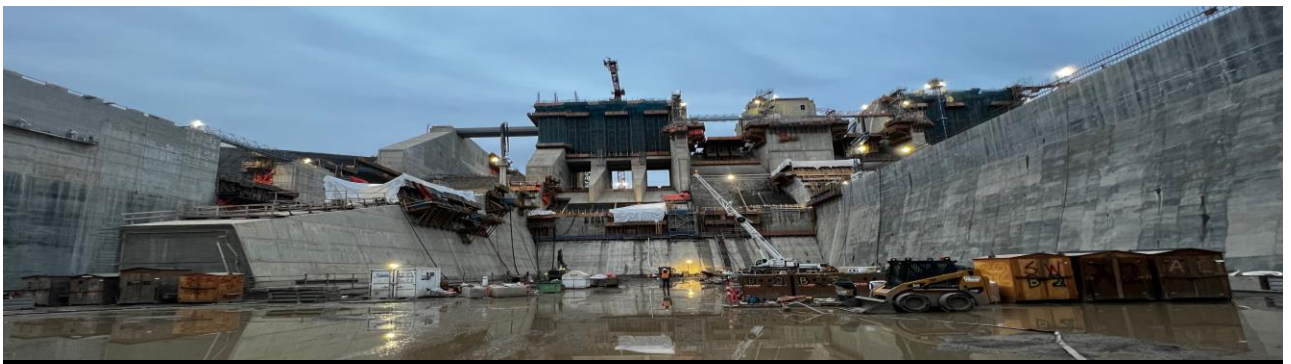
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28

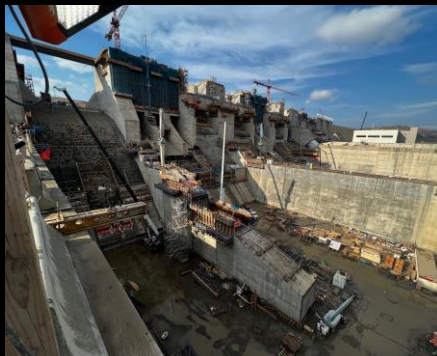


29



Spillway and Auxiliary Spillway

- Safety purposes
- 3 bays
- 6 overflow channels
- 1 auxiliary spillway



30



Outlets, Jet Deflectors

- Elevation drop max ~50m



Photo courtesy of <https://protonsforbreakfast.wordpress.com>



31



Stilling Basin

- Discharge of high velocity water into lower velocity area
- Outlet erosion control structures



32

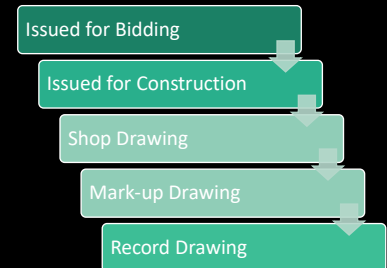
Technical Drawings



33

Technical Drawings

- General
- Concrete Outline
- Concrete Reinforcement
- Lift
- Electrical / Grounding
- Formwork
- ...



34

Technical Drawings

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE	
Klohn Crippen Berger	SNC-LAVALIN
CLEAN ENERGY PROJECT	BC Hydro
CLEAN ENERGY PROJECT - SITE C SPILLWAY - CHUTE LOW LEVEL OUTLETS 01, 02, AND 03	
REINFORCEMENT ELEVATION AND SECTIONS - SH 2	
MECH GEO ELEC	
DATE	DIST DWG NO 1020 - C 21 - 02126
SIZE A0	R 2
NOT TO BE REPRODUCED WITHOUT THE PERMISSION OF BC HYDRO	

ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE	
Klohn Crippen Berger	SNC-LAVALIN
CLEAN ENERGY PROJECT	BC Hydro
CLEAN ENERGY PROJECT - SITE C SPILLWAY - CHUTE LOW LEVEL OUTLETS 01, 02, AND 03	
CONCRETE OUTLINE ELEVATIONS AND SECTIONS - SH 1	
DATE	DIST DWG NO 1020 - C 21 - 01166
SIZE A0	R 1
NOT TO BE REPRODUCED WITHOUT THE PERMISSION OF BC HYDRO	

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Issued for Bidding

Issued for Construction

Shop Drawing

Mark-up Drawing

Record Drawing

- Concrete reinforcement
- Concrete outline

35

Technical Outline Drawings



Some information is blurred

Issued for Bidding

Issued for Construction

Shop Drawing

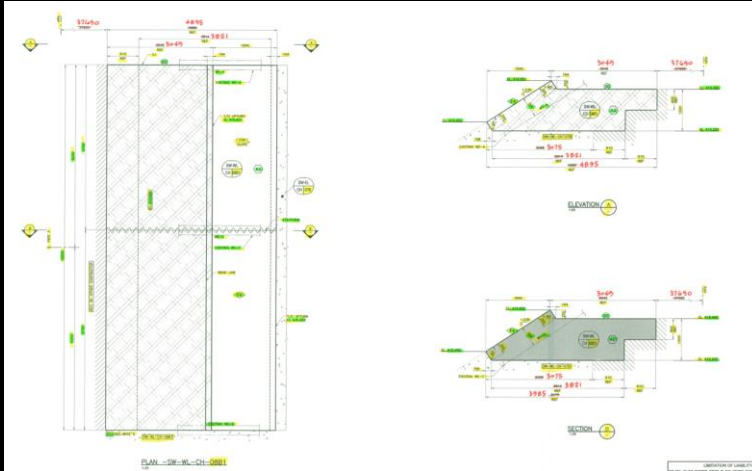
Mark-up Drawing

Record Drawing

- Where is the lift?
- Concrete shape
- Concrete strength (A2)
- Finishes (F4)
- Embedded parts
- ...

36

Technical Lift Drawings



Issued for Bidding

Issued for Construction

Shop Drawing

Mark-up Drawing

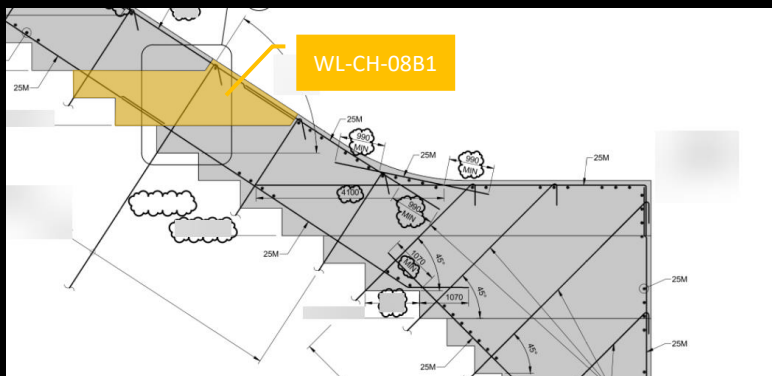
Record Drawing

- Lift shape
- Stay-form
- Water-stop
- Check if it is consistent with IFC

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37

Technical Reinforcement Drawings



Issued for Bidding

Issued for Construction

Shop Drawing

Mark-up Drawing

Record Drawing

- Where is the lift?
- Rebar spliced location and requirement
- Rebar size
- Hook, angles
- ...

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38

Technical Rebar Drawings

25M $\emptyset$ 300 V N1 (REFER LIST-A)

LIST-A
25M $\emptyset$ 300 V N1
8-BK25020 $\emptyset$ 300 V N1 (a)
6-BK25019 $\emptyset$ 300 V N1
9-BK25018 $\emptyset$ 300 V N1
3-BK25017 $\emptyset$ 300 V N1

LIST-B
25M $\emptyset$ 300 H N2
1-25M $\times$ 4600 $\emptyset$ 300 H N2 (a)
1-25M $\times$ 5260 $\emptyset$ 300 H N2
1-25M $\times$ 5910 $\emptyset$ 300 H N2
1-25M $\times$ 6560 $\emptyset$ 300 H N2

TABLE 4 : $f_y = 400$ MPa $f'_c = 35$ MPa

BAR SIZE	TOP BARS		OTHER BARS	
	DEVELOPMENT LENGTH (mm)	LAP SPLICE LENGTH (CLASS B) (mm)	DEVELOPMENT LENGTH (mm)	LAP SPLICE LENGTH (CLASS B) (mm)
10M	320	420	300	320
15M	480	620	370	480
20M	620	810	480	620
25M	990	1290	770	990
30M	1190	1540	910	1190
35M	1390	1800	1070	1390

Some information is blurred

Issued for Bidding

Issued for Construction

Shop Drawing

Mark-up Drawing

Record Drawing

- Rebar size, quantity, type
- Spacing and splicing
- Rebar cover
- Concrete strength
- ...

39

Technical Drawings

BC Hydro

Site C Clean Energy Project

This review was for observing general conformity to contract only. BC Hydro accepts no legal responsibility for the content, accuracy or completeness of this document even if it has been accepted with or without revision based on BC Hydro's observation.

☒	C1 - Accepted
☐	C2 - Proceed Subject to Conditions
☐	C3 - Do Not Proceed – Re-Submit as Noted

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Issued for Construction

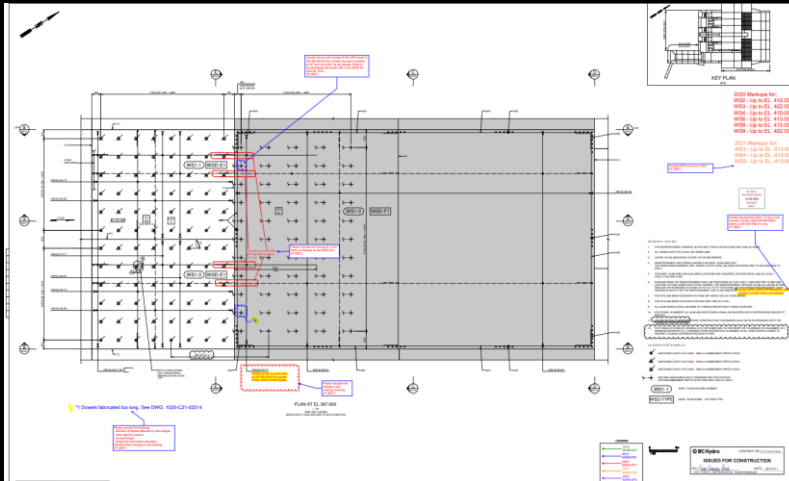
Shop Drawing

Mark-up Drawing

Record Drawing

40

Technical Redline Drawings



Issued for Bidding

Issued for Construction

Shop Drawing

Mark-up Drawing

Record Drawing

- Changes made through official documents
- Addition, subtraction, changes, modifications, etc.

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41

Technical Drawings

- Engineering Design Team
 - Review, approve, stamp, seal

Issued for Bidding

Issued for Construction

Shop Drawing

Mark-up Drawing

Record Drawing

42

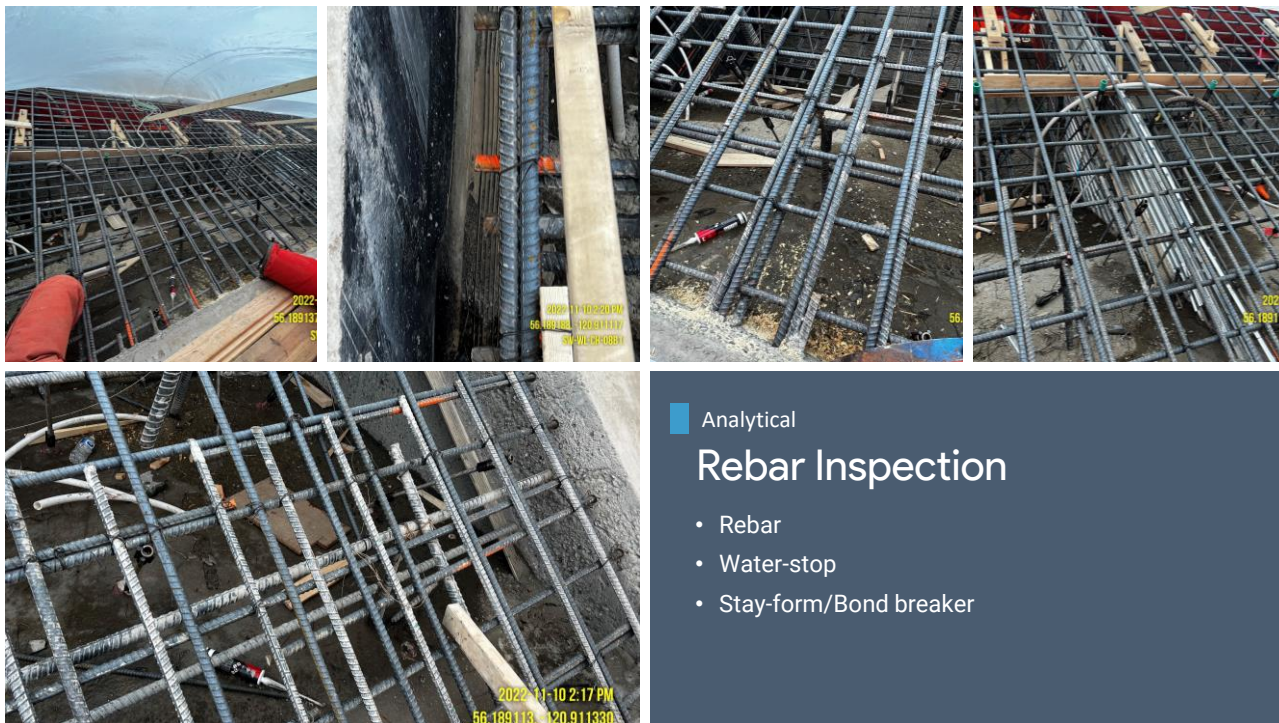
Analytical

Field Review Plan

- Pre-inspection tasks
- Before sign-off
 - Final Observation
- After sign-off
- After pour completion

Site C Clean Energy Project				Field Review Plan	
Engineering Design Team					
Contract (and Sub-Items)	Component(s)	Discipline(s)	Document No.	Revision	Revision Date
GSS		CIVIL	S007	0	SEP 11 1019
Project: SITE C CLEAN ENERGY PROJECT – GENERATING STATION AND SPILLWAY					
Subject: CIPC INSPECTION CHECKLIST					
Pour No.			Pour Date:		
ITEM DESCRIPTION	DATE	YES	NO	N/A	COMMENTS
Pre-Inspection Tasks:					
a) Latest revision of IFC Drawings have been followed					
b) Shop Drawings are approved					
c) Any RFI, SRQ, FCF, NCR, DCN, FAM related to the pour					
d) TCP is approved					
e) Pour folder updated at SharePoint					
Inspection Tasks – before pour sign-off:					
Surface Preparation - RCC:					
a) Horizontal surface survey of RCC is within ± 25 mm from the design elevation					
b) Horizontal and Vertical surfaces of RCC are rough enough with exposed aggregate of 5 mm and NPTT is signed off					
c) Any loose aggregate at the placement area					
d) Placement area is clean					
e) Any standing or running water at placement area					
Surface Preparation - CIPC:					
a) Horizontal and Vertical surfaces of CIPC are rough enough with exposed aggregate of 5 mm					
b) Any loose aggregate at the placement area					
c) Placement area is clean					
d) Any standing or running water at placement area					
Construction Joint Preparation (CJ):					
a) Construction joint (CJ) indicated in IFC Drawing					
b) Vertical surface of existing CIPC are rough enough with exposed aggregate of 4 mm					

43

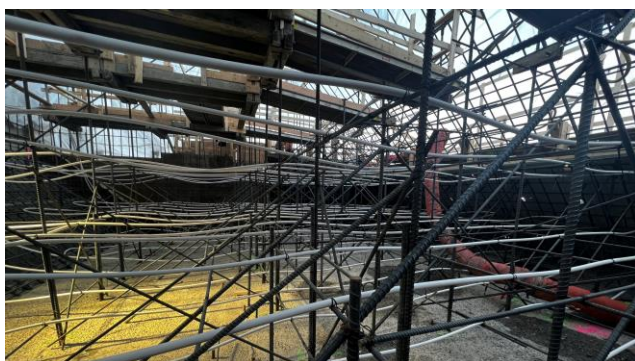


Analytical

Rebar Inspection

- Rebar
- Water-stop
- Stay-form/Bond breaker

44



Analytical

Rebar / Pre-panel Inspection

- Rebar
- Water-stop
- Stay-form/Bond breaker
- Surface cleanliness
- Thermal Control Plan (TCP)

45

Analytical

Thermal Control Plan (TCP)

- Minimize temperature difference
- Protect concrete during the curing process
- Prevent concrete from cracking
- Both winter and summer

5. THERMAL CONTROL MEASURES

Criteria:

- $T_{max} \leq 60^\circ\text{C}$ and
- ΔT (interior) $\leq 20^\circ\text{C}$.
- Alternatively, ΔT can be exceeded if proper engineering analysis shows that the stress-strength ratio will be maintained below 0.75 at all times.

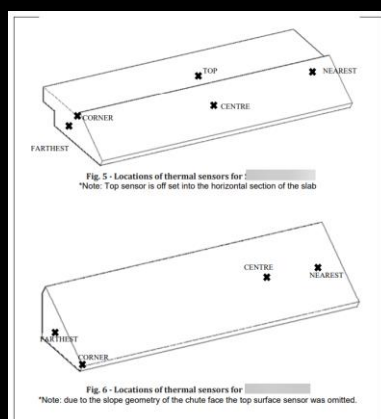
Scenarios evaluated:

- Placing Temperature: $5 \pm 10^\circ\text{C}$ (modelled at 10°C). Placing temp should be kept as close to 5°C as possible.
- Surface Insulation:
 - Top surface: insulated with 1 layer of thermal blankets for a minimum of 96 hours
 - Corner: insulated with 2 layers of thermal blankets for a minimum of 96 hours
 - Heating and hoarding will be installed when forecasted ambient temperatures are expected to drop below 10°C ; the temperature under hoarding shall be kept at or above 10°C .
- Formwork Removal: If the formwork is removed during the curing period, thermal control protection will be installed; If formwork is removed prior to stated time in this TCP then thermal blankets will be installed.
- Cooling pipes: 2, 3 and 4 layers at 1.0m.
 - Cooling water temperature and flow rate: 13°C at $2.4\text{m}^3/\text{h}$
 - Ambient Temperature: 10°C

Concrete Mixture:

Results meeting Specification:

Pour	Concrete Placement Temperature	Insulation (Surface thermal blankets)	Cooling Pipes	Ambient Temperature
	5-10 C	Surface Thermal blankets for 96 hours	4 layers at 1.0m	10 C
	5-10 C	Surface Thermal blankets for 96 hours	2 layers at 1.0m	10 C
	5-10 C	Surface Thermal blankets for 96 hours	3 layers at 1.0m	10 C



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46

Analytical

Cooling lines

- Mass concrete: typically having a minimum dimension equal or greater than 1m (CSA A23.7.6.3.1)
- Exothermic reaction
- Not using low heat cement? Cost effective?



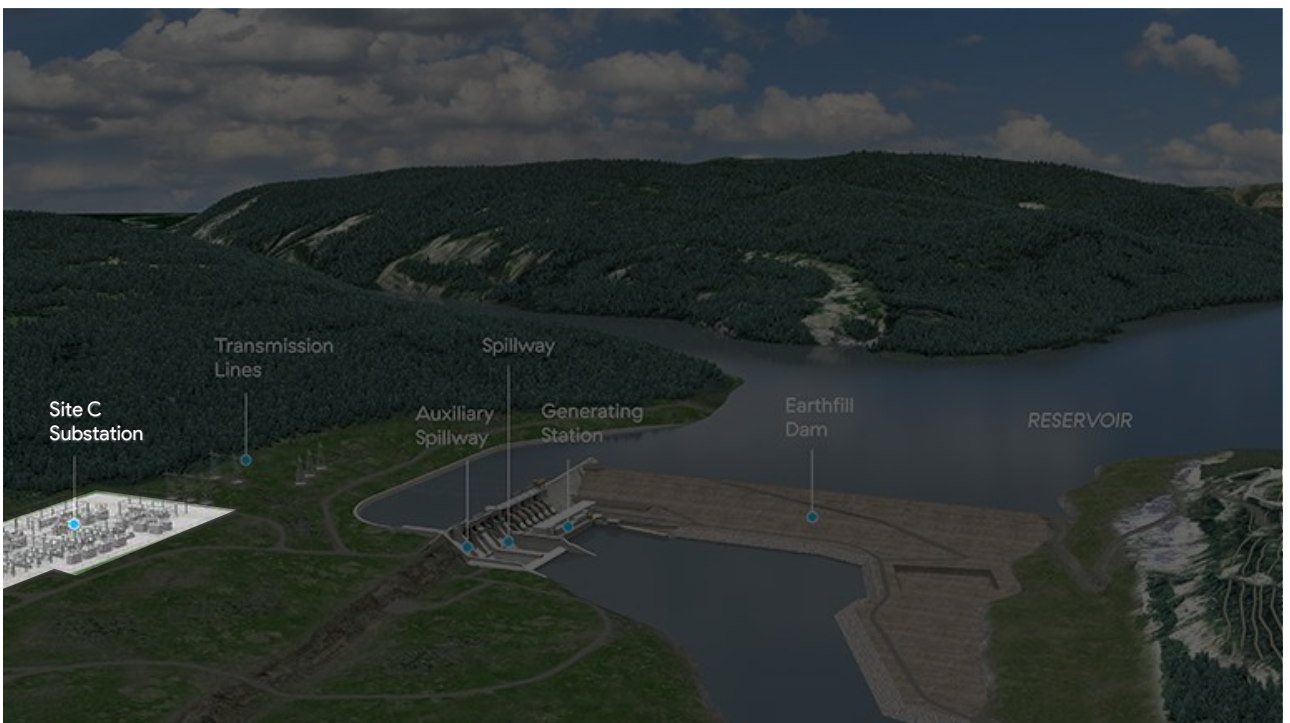
47



48



49



50



51

Analytical

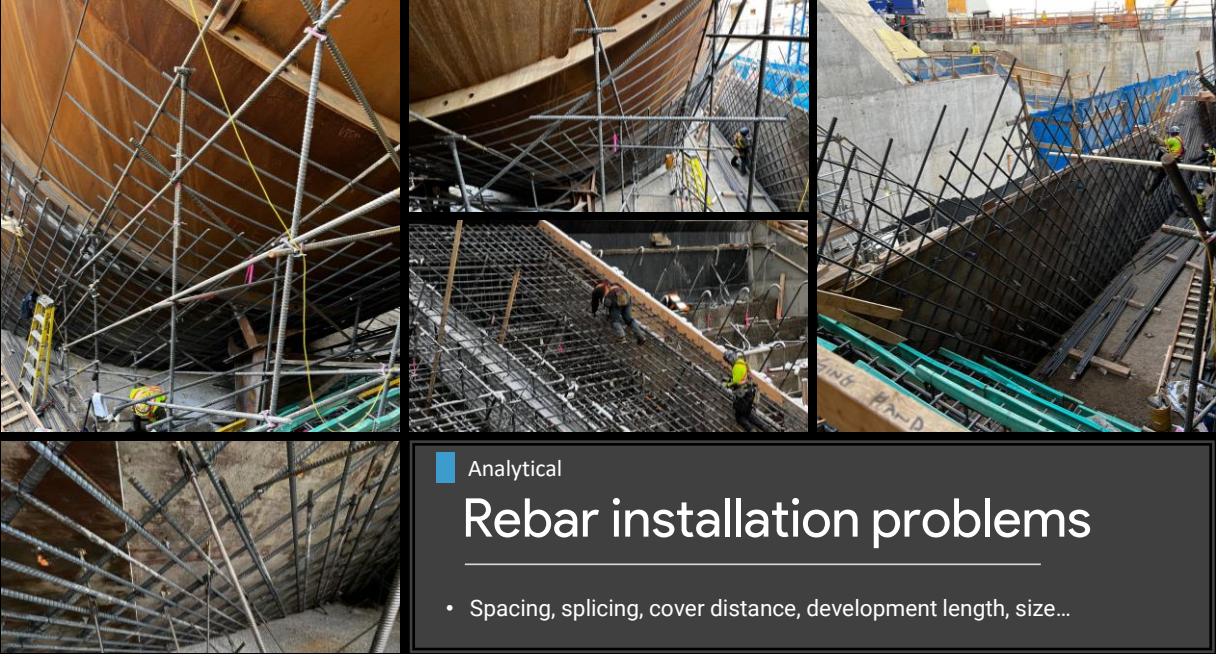
Why called engineers if we are just measuring, comparing, and finding errors, and tell contractors to fix them?

I heard the geological conditions at Site C is pretty bad, how to mitigate the impacts and make this feasible?

How to install rebar, and then pour mass concrete? How much concrete does Site C need per day?

Do we need some special tests during the construction to make sure this giant hydro facility works properly and safely?

52



Analytical

Rebar installation problems

- Spacing, splicing, cover distance, development length, size...

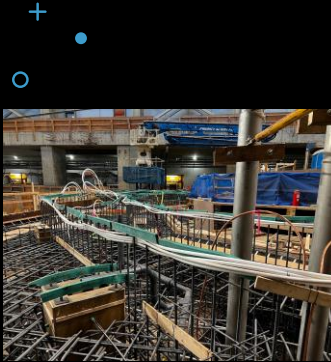
53

Analytical

Spiral Case Pressure Test

- Testing pressure ~ 920 kPa
- Minimum 5 hours
- No leakages allowed
- Lower to 60% of designed pressure during 2nd stage concrete placement

54

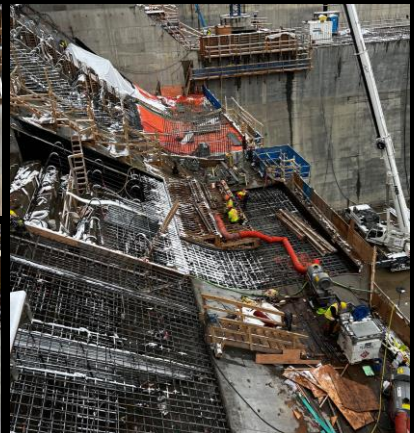
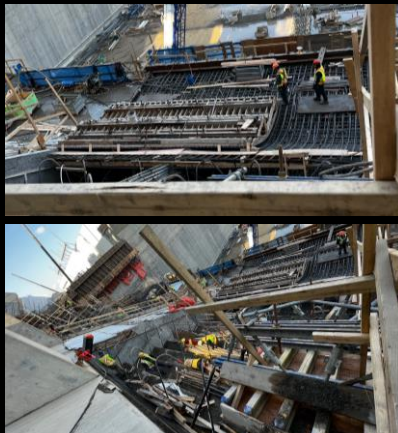


Analytical

1000+ m³ concrete
pour in one lift

- Check everyday
- Communicate with journeyman
- Locate potential problems
- Solve before it's getting complicated

55

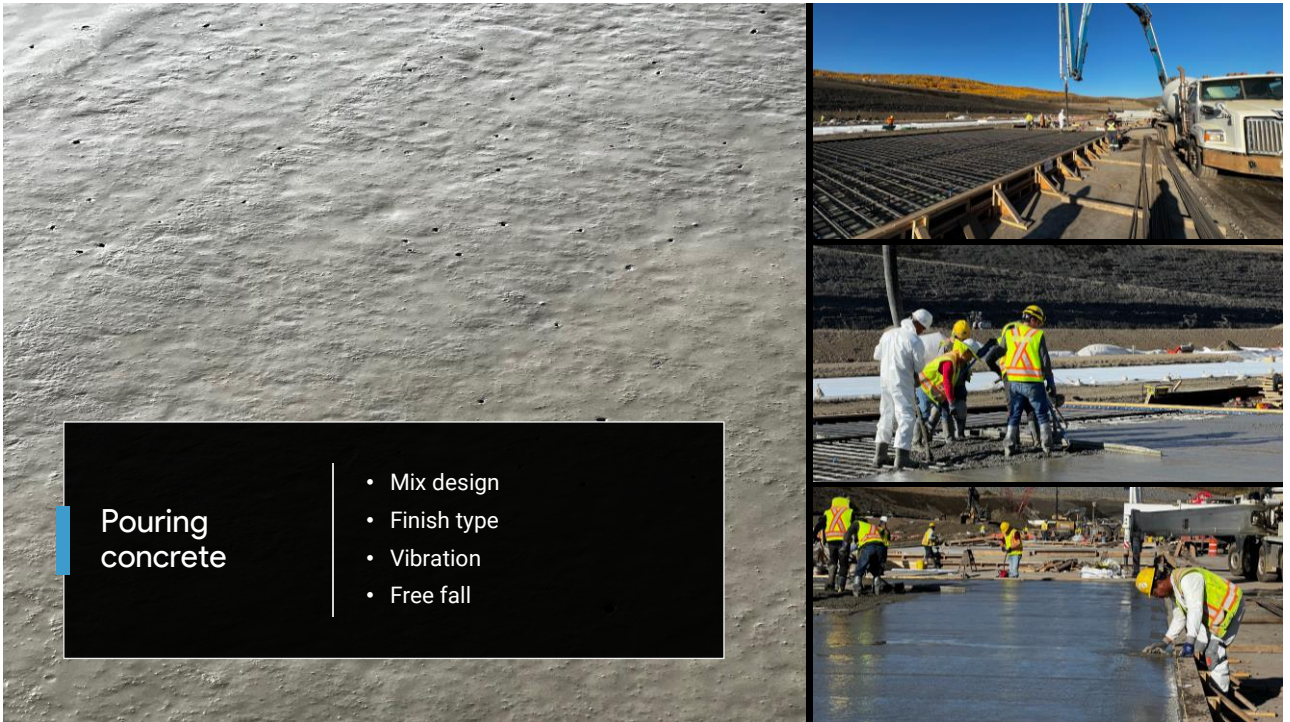


Analytical

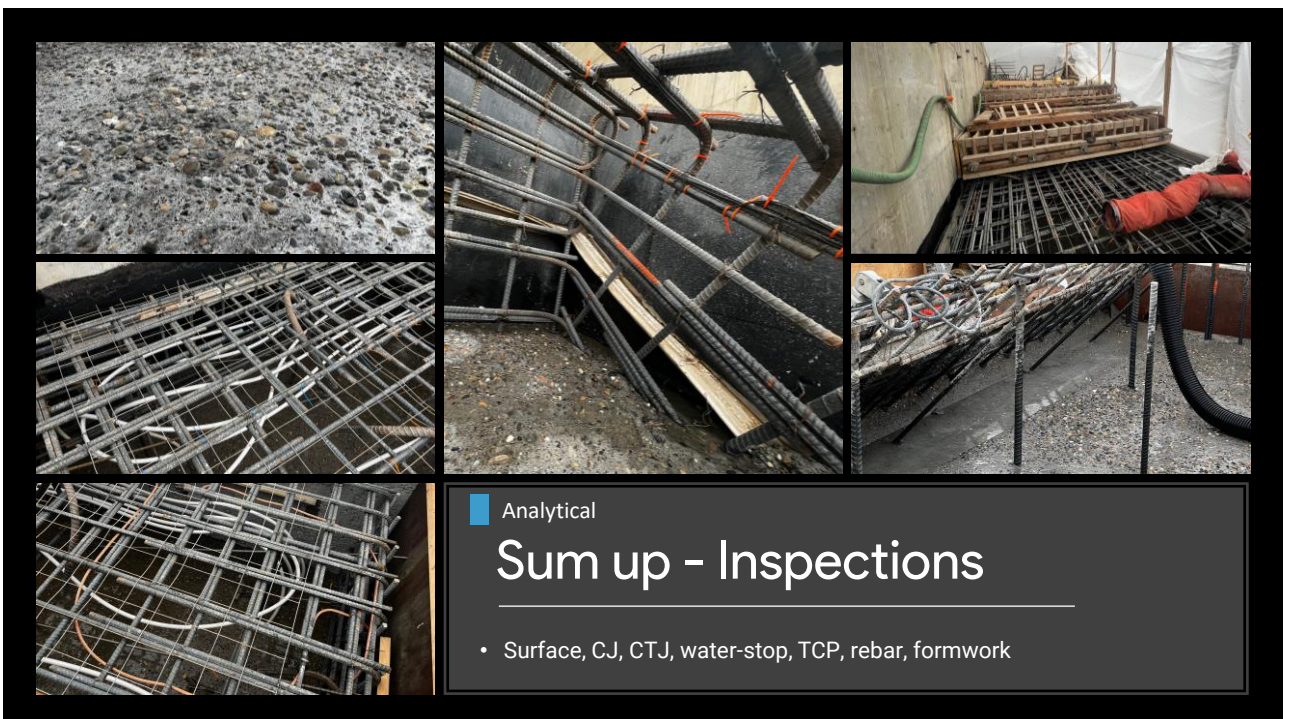
Formwork installation

- Cover distance

56



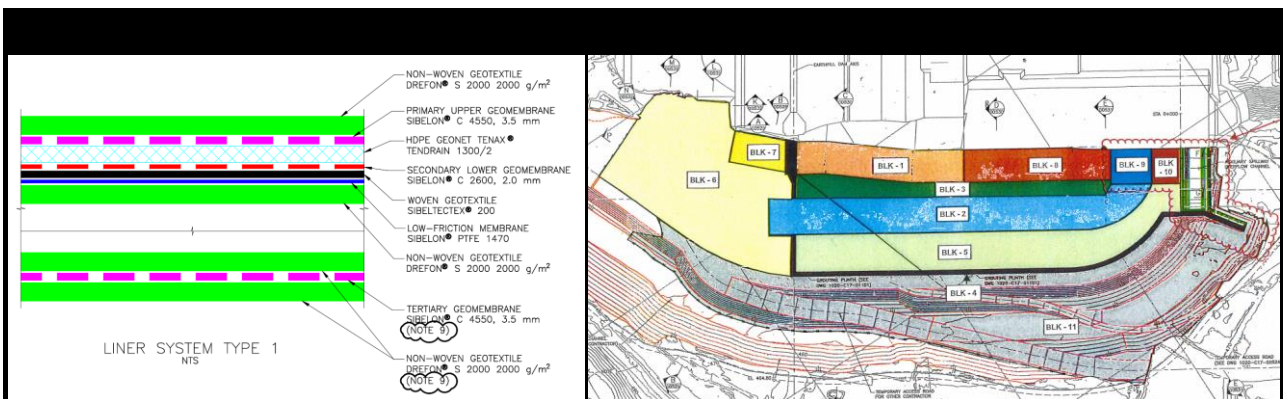
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58



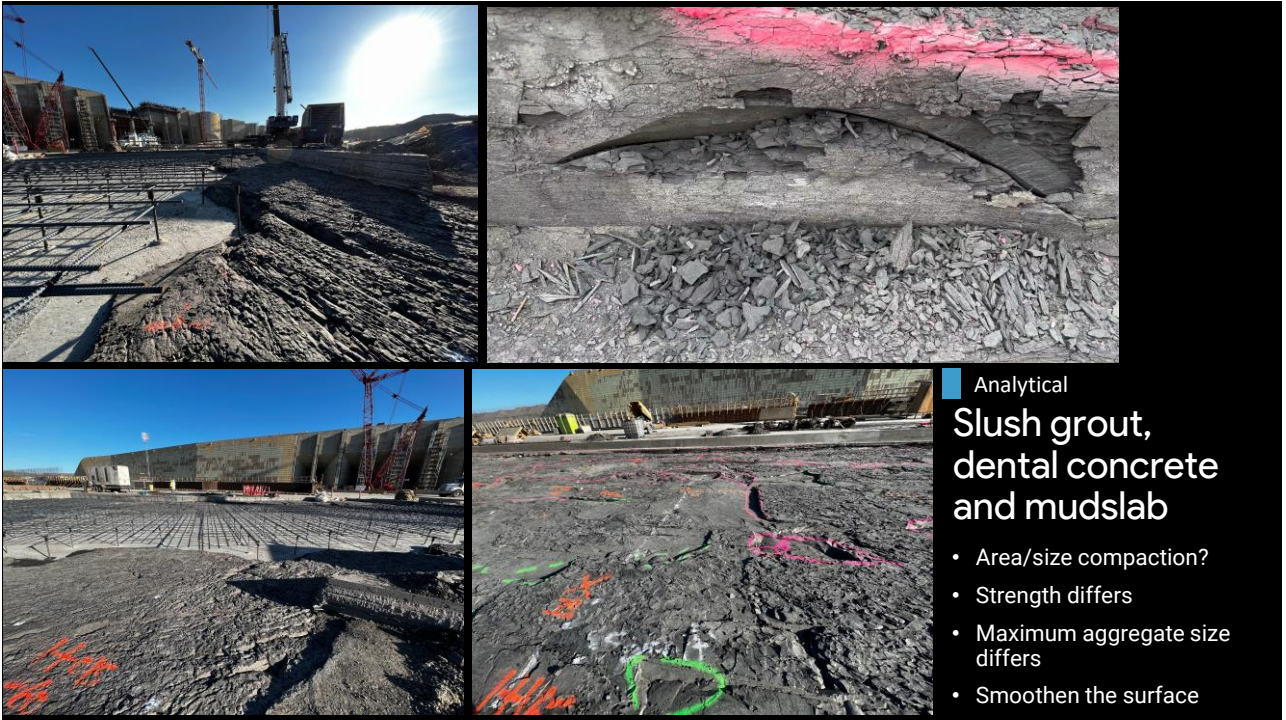
59



Foundation preparation and Liner system

- 3 foundation preparation for rock surfaces types
- 4 liner system types

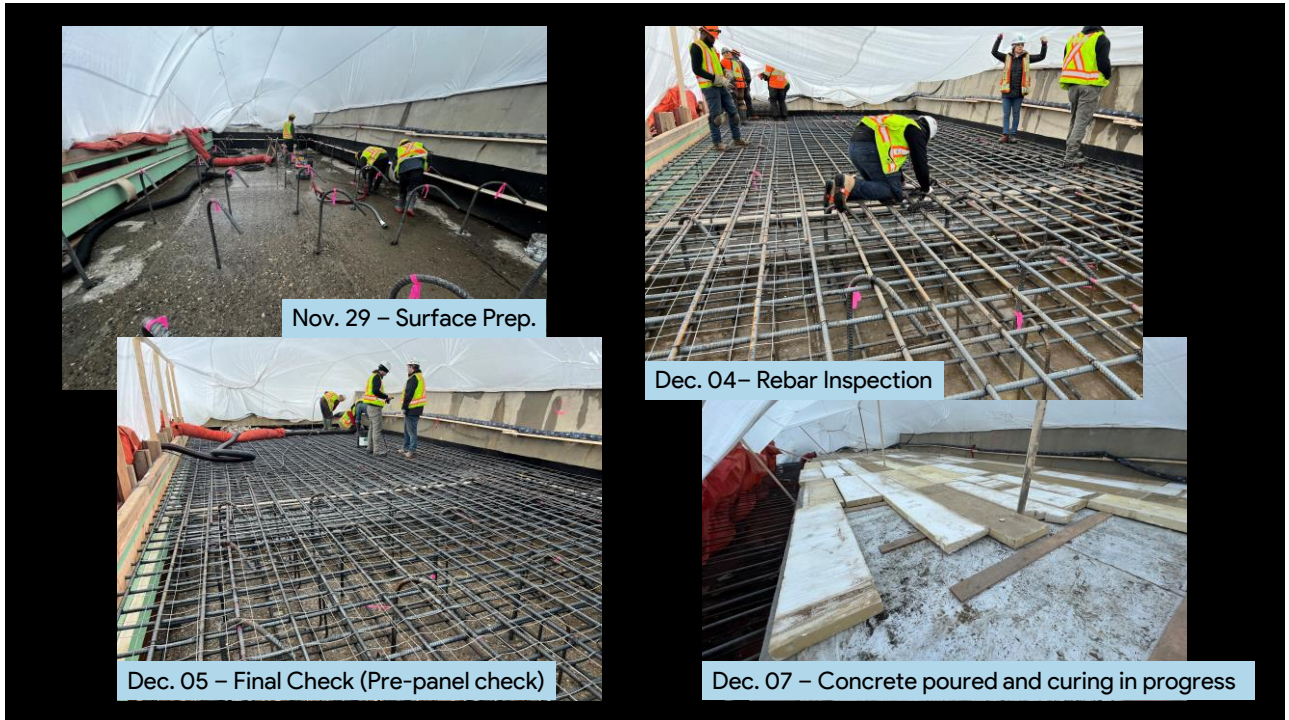
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61



62

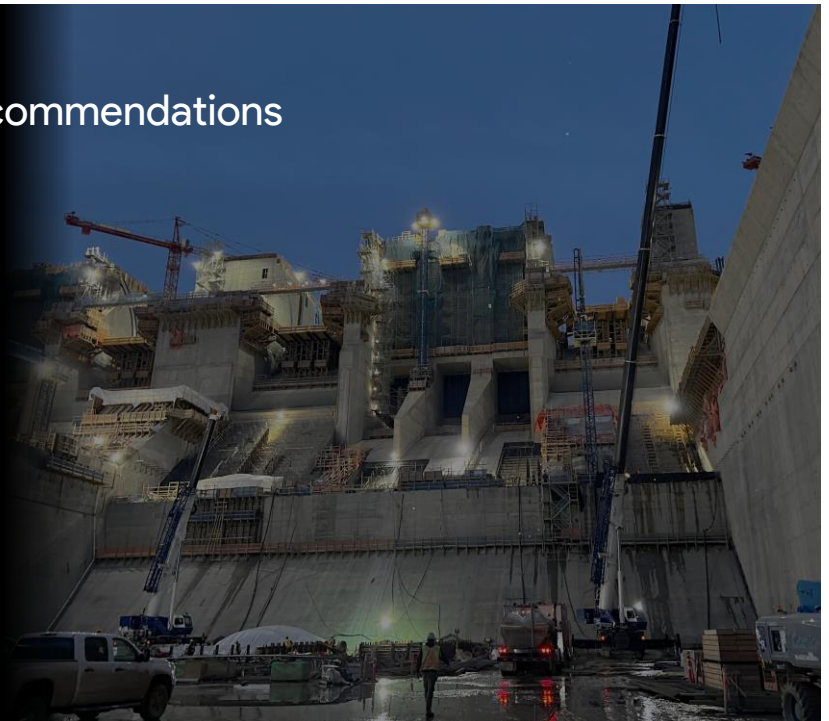


63

Conclusion

Conclusion and Recommendations

- GSS scope of work
- Very fast-paced project
- SAFELY achieving Ready for reservoir filling by **July 1st, 2023**
- Recommendations
 - For GSS
 - For General Contractors

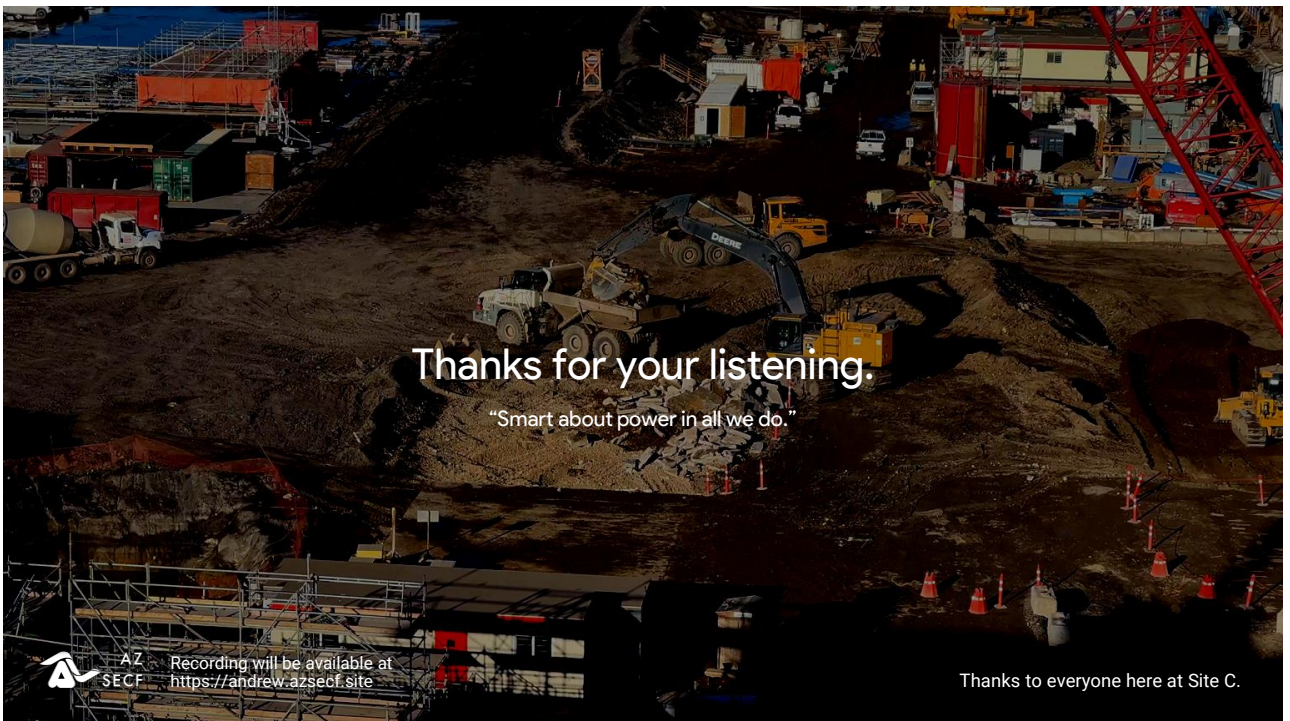


64



Learn everyday, think everything, big or small.

65



Thanks for your listening.

"Smart about power in all we do."



AZ
SECF

Recording will be available at
<https://andrew.azsecf.site>

Thanks to everyone here at Site C.

66