Trans Mountain Pipeline ULC (Trans Mountain)
Trans Mountain Expansion Project – Condition Compliance

Condition 27 – Burnaby Tunnel
File: OF-Fac-Oil-T260-2013-03 61

Information Request 15
Due Date: June 6, 2023

Engineering Matters

15.1 Updates to Stress Analysis

CER Reference:

i. Trans Mountain filing dated 26 April 2023, CER-TMX Condition 27 Technical Conference Responses to Action Item (C24190)
ii. Trans Mountain Filing dates 12 May 2023, CER-TMX Condition 27 Technical Conference Responses to Action Items (C24474)

CER Preamble

For Action Items 10,11, and 12, Reference ii), PDF p.13 of 25 states “For the seismic ground movement concern, the more severe case is typically stiffer interaction parameters (springs) connecting with the pipe. Thus, previously, the Cellular Concrete properties at the upper end of the expected range were incorporated, including compressive strength of 15 MPa, elastic modulus of 9600 MPa, and Cellular Concrete to-pipe bond strength of 1.3 MPa. Recently, the tunnel engineering company, Hatch, requested analysis with reduced strength properties of the Cellular Concrete as follows: minimum compressive strength of 1.5 MPa, minimum elastic modulus of 500 MPa, and Cellular Concrete to-pipe bond strength of 0 to 300 kPa.”

CER Request

Clarify the reasons for reassessing the seismic ground movement scenario by applying lower stiffness interaction parameters over the more severe case approach previously taken in Rev. 0 of the report.

Trans Mountain Response

The basic reason for performing a second set of analyses for seismic Permanent Ground Displacement was to perform a consistent analysis, since the lower stiffness interaction parameters are associated with the lower compressive strength of the Cellular Concrete.

For the stiffer values of interaction parameters used in June, 2018 Pipeline stress report, the computed values of the pipe strain and load on the cellular concrete were very similar to the computed values in Reference ii).

15.2 Heat of hydration temperature

CER Reference:

i. Trans Mountain filing dated 26 April 2023, CER-TMX Condition 27 Technical Conference Responses to Action Item (C24190)

ii. Trans Mountain Filing dates 12 May 2023, CER-TMX Condition 27 Technical Conference Responses to Action Items (C24474)

CER Preamble

For Action 13, additional clarification is needed,

CER Request

Confirm whether the new heat of hydration temperature of 90°C will not impact the high strain capacity pipe shop applied coating (i.e., Trans Mountain's response in Reference i) appears to only provide information on field applied coating).

Trans Mountain Response

Confirmed. The high strain capacity pipe coating utilizes 3M Fusion-Bonded Epoxy Coating 726 with a protective top coating of 3M Fusion-Bonded Epoxy Dual Coating System 6352 (Abrasion Resistant Overcoat). The data sheet indicates that the 3M 726 coating should perform satisfactorily at a temperature of up to 110 °C and meets CSA Z245.20 qualification test results. The data sheet is provided in Attachment 1. The data sheet indicates that the 3M 6352 product should perform satisfactorily at a temperature up to 110 °C. The data sheet for this product is provided as Attachment 2.

15.3 Buoyancy and Thermal loads on the Pipelines

CER Reference:

i. Trans Mountain Filing dates 12 May 2023, CER-TMX Condition 27 Technical Conference Responses to Action Items (C24474)

CER Preamble

For Action Item 15, Reference i) provides calculations indicating the pipe carriers are sufficient to resist the buoyancy loads as they are currently designed. Although conclusions regarding the sustainability of the pipe carriers under the modified backfilling scenario are provided in the response, and evaluation of the effects of the altered buoyancy load on the Westridge Delivery Lines (WDL) is not apparent. (Note: In previous submissions, McNally provided a construction and installation pipeline stress analysis confirming that the construction phase analysis considered, among other things, buoyancy and thermal loads, C11635-1, PDF p. 5-19 of 19).

CER Request

a. Clarify whether the buoyancy and thermal loads on the pipeline have been reassessed considering Trans Mountain does not intend to fill the WDL with water during backfilling and remains acceptable.
b. Confirm whether Trans Mountain has accepted the recommendations provided by Kelly Engineering? If not, provide the rationale for not accepting the recommendations.

Trans Mountain Response

a) Confirmed. The author of the buoyancy report was consulted and confirmed that the analysis was based upon the understanding that the Westridge Delivery Lines would *not* be filled with water during backfilling operations and the report indicated that the loads are acceptable.
b) Confirmed. Trans Mountain accepts the recommendations provided by Kelley Engineered Equipment, provided as Attachment 2 in C24474-2.

15.4 Bulkhead material

CER Reference:

i. Trans Mountain filing dated 26 April 2023, CER-TMX Condition 27 Technical Conference Responses to Action Item (C24190)
ii. Trans Mountain Filing dates 12 May 2023, CER-TMX Condition 27 Technical Conference Responses to Action Items (C24474)

CER Preamble

For Action Items 16 additional information is needed.

CER Request

a. What is the benefit of selecting different material types for bulkheads?
b. If the Aluminum bulkhead is to remain in the tunnel after backfill, confirm whether an assessment has been completed that it would not interfere with cathodic protection.

Trans Mountain Response

a. and b.

The benefit of selecting different material types for bulkhead construction is that it will allow for ease of construction without interfering with appropriate cathodic protection. The tunnel contractor currently plans to use plastic materials, and to leave these materials within the tunnel for backfill. An aluminum bulkhead is no longer being considered for installation in the tunnel.

An alternate option would include a wooden bulkhead, which would be stripped prior to completion of backfill (i.e., the pour on the upstream side from Burnaby Portal to 470 m from the end of the tunnel) and strip the bulkhead prior to the pour on the downstream side (470 m section ending at Westridge Portal). A final decision on the choice of bulkhead material has not yet been made.

15.5 Hydraulic Conductivity

CER Reference:

i. Trans Mountain filing dated 26 April 2023, CER-TMX Condition 27 Technical Conference Responses to Action Item (C24190)

ii. Trans Mountain Filing dates 12 May 2023, CER-TMX Condition 27 Technical Conference Responses to Action Items (C24474)

CER Preamble

For Action Items 18, Reference i) states that “Hydraulic conductivity through the tunnel will not be monitored during operations unless required, based on results of the tunnel backfilling activity”.

CER Request

Clarify the statement by providing what “results from backfilling activity” is planned to be collected during backfilling.

Trans Mountain Response

The results from backfilling activities include adherence to the TMEP-TU2500 Revision 1 specification requirements (as provided in C22691-2).

It is expected that backfilling operations will completely fill the tunnel and obviate groundwater discharge from the tunnel during operation. The tunnel portals will be backfilled and restored to their nearly original grade, preventing any access to the tunnel. Therefore, monitoring of hydraulic conductivity through the tunnel during operation cannot be practically performed.

15.6 Pouring sequence

CER Reference:

i. Trans Mountain filing dated 26 April 2023, CER-TMX Condition 27 Technical Conference Responses to Action Item (C24190)

ii. Trans Mountain Filing dates 12 May 2023, CER-TMX Condition 27 Technical Conference Responses to Action Items (C24474)

CER Preamble

For Action Items 19, in Reference i), the pouring sequence set out in Attachment 3-3, the drawing only illustrates the pouring sequence of portion of the tunnel.

CER Request

a. Provide a similar drawing that represents the entire tunnel.
b. In the drawing in Reference i), two tunnel seals are identified at locations 0+550 and 0+650. Both locations are marked as "min 7m". Clarify why two seals are identified when the entire length is filled with Type II concrete?
c. Confirm the tunnel seal length at the location.

Trans Mountain Response

a. Please refer to Attachment 3, which provides a pouring sequence for the entire length of the tunnel. Note that to view the details of pouring sequence, it is necessary to zoom the display to approximately 250% to clearly view the drawing details.
b. The current execution strategy for backfilling the 4.2% sloped section of the tunnel (extending from 0+471 to 2+611 measured from the Westridge portal) is to place a bulkhead at the bottom of the slope and pour horizontal lifts continuing up the slope. It is proposed to simply switch to the Type II cellular concrete mix prior to the leading edge reaching the start of the tunnel seal and switch back to Type I cellular concrete after the trailing edge passes the end of the tunnel seal. This would allow the full planned tunnel seal area (plus a sizable additional volume) to consist of Type II concrete but reduces person hour requirements (and improves schedule performance) by eliminating the bulkheads on either side. Recall that Type II cellular concrete has a lower hydraulic conductivity than Type I cellular concrete and therefore provides an increased resistance to water penetration. Due to the altered geometry, annular sealing around the 762 mm (NPS 30) pipes will be offset accordingly to maintain a minimum 500 mm setback from the edge of the Type II cellular concrete.
c. Please refer to the Attachment 3, where the dimensions are provided. The specification of "minimum 7 metres" refers to the length for which the entire diameter of the tunnel is filled with Type II cellular concrete. As discussed in (b), the length over which there will be Type II cellular concrete deployed will be substantially greater than 7 metres.

Attachment 1

Condition 27 Phase 39

3M FBE 726 Product Data Sheet

3M™ Scotchkote™ Fusion-Bonded Epoxy Coating 726

Data Sheet

Product Description

3M™ Scotchkote™ Fusion-Bonded Epoxy Coating 726 is a one-part, heat curable, thermosetting epoxy powder designed as a stand-alone or the corrosion coating for a dual-layer FBE system for the corrosion protection of pipe.

Temperature Operating Range

Scotchkote 726 coating, when properly applied as a standalone FBE pipe coating, should perform in a satisfactory manner on pipelines operating between -100°F/-73°C to 230°F/110°C. However, it is difficult to accurately predict field performance from the laboratory data due to the wide variation in actual field conditions. Soil types, moisture content, temperatures, coating thickness and other factors specific to the area all influence the coating performance and the upper temperature operating limit.

Application Temperature

Scotchkote™ 726 is specifically designed for low temperature application processes. Scotchkote 726 applies at temperatures as low as 338°F / 170°C without degrading product performance. Scotchkote 726 will meet or exceed many industry test standards including CAN/CSA-Z245.20.

Patching and Repair

Scotchkote™ 226P (Polymeric Hot Melt Patch Compound)

Scotchkote™ 323 Two-part Liquid Epoxy Coating

Property	Test Description	Typical Value	
Density		1.43 (powder)	
Coverage		134 ft^2/lb/mil (0.699 m^2/kg/mm)	
Color		Green	
Moisture Content	CAN/CSA-Z245.20-12.4	<0.5%	
Gel Time	CAN/CSA-Z245.20-12.2 205°C 177°C	 4.9 +/- 20% [1,3] 12 +/- 20% [1,3]	
Cure Time	CAN/CSA-Z245.20-12.1	374°F/190°C 329°F/165°C	30 seconds [2] 90 seconds [2]
Thermal Characteristics	CAN/CSA-Z245.20-12.7 T_g [1] T_g [2] delta H % cure	 51.82 °C 104.02°C 71.51 J/g 99%	

Property	Test Description	Typical Value	
Cathodic Disbondment	CAN/CSA-Z245.20-12.8	(Application Temperature)	Disbondment mm r
	24 Hr., 3.5 volt, 3% NaCl 149°F/65°C	(177°C/350°F)	2.03[1,3]
		(190°C 374°F)	2.04[1,3]
	28 Day., 1.5 volt, 3% NaCl 68°F/20°C	(177°C/350°F)	5.39[1,3]
		(190°C 374°F)	4.66[1,3]
	28 Day., 1.5 volt, 3% NaCl 149°F/65°C	(177°C/350°F)	5.20[1,3]
		(190°C 374°F)	4.70[1,3]
Cross Section Porosity	CAN/CSA-Z245.20-12.10	3 [1]	
Interface Porosity	CAN/CSA-Z245.20-12.10	4 [1]	
Flexibility	CAN/CSA-Z245.20-12.11 3°/PD @ -30 DegC/-22°F	No Cracking	
Impact	Mod. G14 1.5j	Pass	
Strained Coating Cathodic Disbondment	CAN/CSA-Z245.20-12.13 2.5 degrees strain / 28 Day., 1.5 volt, 3% NaCl 149°F/65°C	No Cracking	
Adhesion	CAN/CSA-Z245.20-12.14	(Application Temperature)	Rating
	24 hr (75°C/167°F)	(177°C/350°F)	2[1,3]
		(190°C 374°F)	2[1,3]
	28 day (75°C/167°F)	(177°C/350°F)	2[1,3]
		(190°C 374°F)	2[1,3]
Volume Resistivity	ASTM D-257	1.2×10^{15}	

[1] Average of three tests

[2] Due to fast curing characteristics of this product, there is some overlap of the T_g and the residual exotherm of the cured material. Negative Delta T_g Values may be obtained.

[3] The typical values in this data sheet are based on lab prepared samples. Values shown are not to be interpreted as product specifications.

Handling and Safety Precautions

Read all Health Hazard, Precautionary and First Aid, Material Safety Data Sheet, and/or product label prior to handling or use.

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Attachment 2

Condition 27 Phase 39

3M ARO 6352 Product Data Sheet

3M™ Scotchkote™
Fusion-Bonded Epoxy Dual Coating System 6352

Product Description

3M™ Scotchkote™ Fusion-Bonded Epoxy Dual Coating System 6352 is a hard, mechanically strong top coating for all Scotchkote fusion-bonded epoxy pipeline corrosion protection coatings. When applied at greater thickness, Scotchkote 6352 also enhances the hot, wet performance of the first layer of corrosion coating. It is applied to the base coating to form a tough outer layer that is resistant to gouge, impact, abrasion and penetration. Scotchkote 6352 coating is specifically designed to protect the primary corrosion coating from damage during pipeline directional drilling applications, bores, river crossing and installation in rough terrain.

It is thermosetting, integrally bonded to the base coating and does not shield from cathodic protection. Excellent flexibility provides an added service advantage over other top coating systems.

Properties	
Color	Brown
Specific Gravity - Powder	1.64
Coverage based on film	122 ft.^{2}/lb/mil (0.636 m^2/kg/mm)
Gel Time at 400°F/204°C	
6352-4G	9.5 seconds ± 20%
6352-8G	16 seconds ± 20%
6352-11G	25 seconds ± 20%

Temperature Operating Range

The Scotchkote 6352 coating, when properly applied, should perform in a satisfactory manner on pipelines operating between -100°F/-73°C and 230°F/110°C. For temperatures between 170°F/77°C and 230°F/110°C, laboratory tests indicate that the thicker coatings may improve the service capability. However, it is difficult to accurately predict field performance from the laboratory data due to the wide variation in actual field conditions. Soil types, moisture content, temperatures, coating thickness and other factors peculiar to the area all influence the coating performance and the upper temperature operating limit.

Suggested Thickness

Thickness requirements depend on service conditions. Normally, the following thickness is used: 8 mils/200 µm to 16 mils/400 µm of Scotchkote 6233 and 226 FBE coatings, and 15 mils/380 µm to 35 mils/900 µm of Scotchkote 6352 FBE coating.

Scotchkote 6352 meets the requirements of AWWA C213.

Scotchkote 6352 Fusion Bonded Epoxy Coating Test Data					
Property	**Test Description**			**Typical Value**	
Impact	CSA Z245.20			3.0 J	
Bendability (Mandrel Bend)	Thickness - mils (microns)	First Layer/ Second Layer	Source	Temperature	°/PD*
	30 (762)	15 (381)/15 (381)	Lab	-22°/-30°	2.0
	* Plant application could vary test results				
Hot Water Resistance	24 hours, CAN/CSA-Z245.20-12.14, 203°F/95°C 48 hours, CAN/CSA-Z245.20-12.14, 167°F/75°C			1 rating 1 rating	
Hardness	ASTM D 2240-97 Shore D, run on pucks ASTM D 2583-95 Barcol, run on pucks			86 50	
Gouge Resistance	TISI with R33 bit 30 kg load 40 kg load 50 kg load			 203 µm/8 mils gouge depth 279 µm/11 mils gouge depth 330 µm/13 mils gouge depth	
Abrasion Resistance	ASTM D 4060 CS17 1000 g wt 5000 cycles			0.091 g loss	
Cathodic Disbondment	28 day, 1.5V, 3% NaCl, 176°F/80°C			4.8 mmr 226N/6233	

Note: The typical values in this data sheet are based on lab prepared samples. Run on steel bars coated with 381 µm/15 mils of Scotchkote 226N/6233 overcoated with 508 µm/20 mils of Scotchkote 6352 coating. Values shown are not to be interpreted as product specifications.

Curing Specifications

After application, 3M™ Scotchkote™ Fusion-Bonded Epoxy Dual Coating System 6352 shall be allowed to cure in accordance with Figure 1 or 2. The indicated temperature is that of the outer surface of the corrosion coating primer layer. A properly calibrated IR measuring device shall measure the temperature. Alternatively, an estimate of the surface temperature shall be calculated by multiplying the primer coating thickness in mils by 2 and subtracting that value from the pipe temperature in ˚F (thickness in microns by 0.04 and subtracting that value from the pipe temperature: 475˚F (246˚C). Estimated temperature of coating surface = 475 - (16 x 2) = 443˚F.

(In ˚C, 246 - (400 x 0.04) = 230˚C)

Coating Repair

Areas of pipe requiring small spot repairs shall be cleaned to remove dirt and damaged coating using surface grinders or other suitable means. All dust shall be wiped off.

3M™ Scotchkote™ Liquid Epoxy Coating 323 or 3M™ Scotchkote™ Liquid Epoxy Coating 352 shall be applied in small areas to the thickness as specified. The freshly coated area shall be allowed to properly cure prior to handling and storage. Liquid epoxy shall not be applied if the pipe temperature is 41°F/5°C or less, except when manufacturer's recommended heat curing procedures are followed. Alternatively, for pinhole areas, the heat bondable polymeric 3M™ Scotchkote™ Hot Melt Patch Compound 226P shall be applied in small areas to a minimum thickness of 16mils/400 µm in addition to the parent coating. Abrade the area with sandpaper. A non-contaminating heat source shall be used to heat the area to be repaired to approximately 350°F/177°C. When the Patch Compound sticks to the hot surface, it is hot enough. While continuing to heat the cleaned and prepared area, the patch compound shall be applied by rubbing the stick on the area to be repaired in circular motion to achieve a smooth, neat appearing patch. The patch shall be allowed to cool before handling.

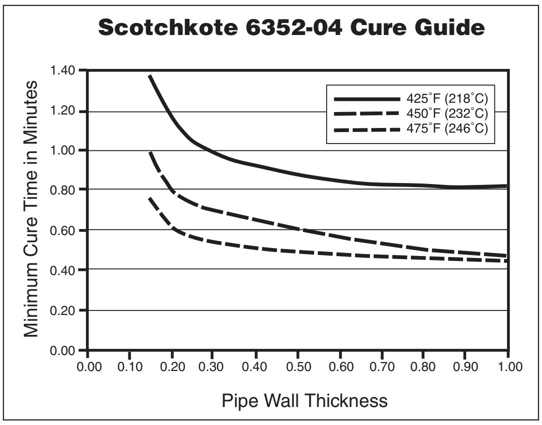

Figure 1

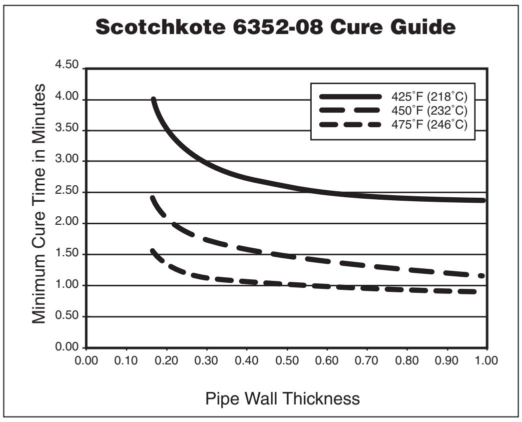

Figure 2

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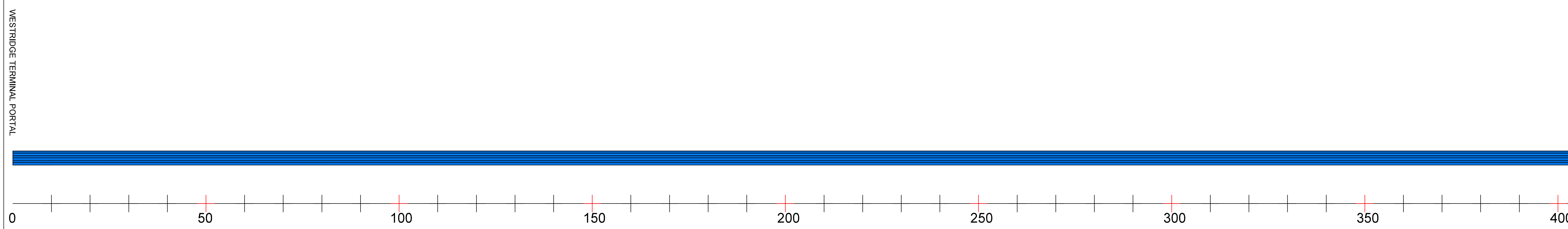
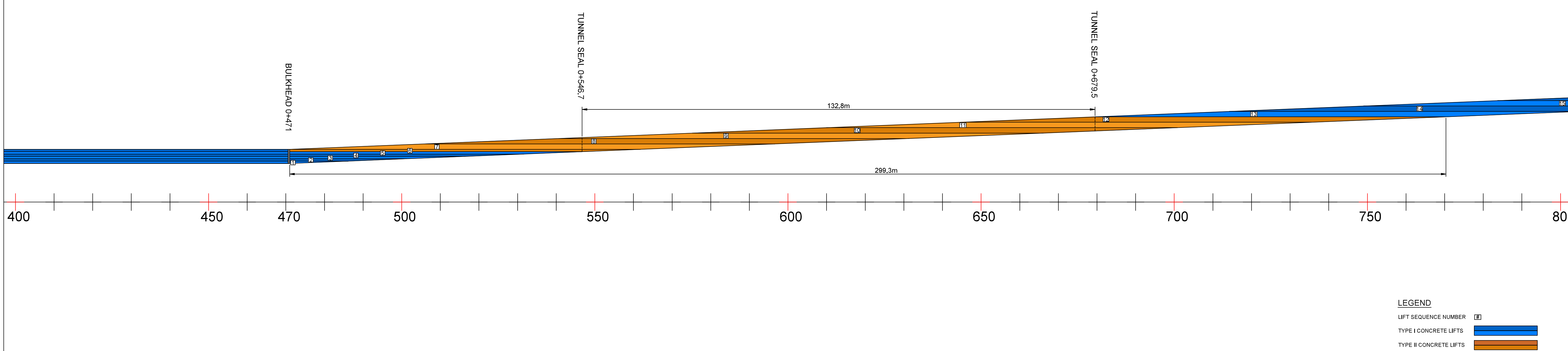
Attachment 3

Condition 27 Phase 39

Burnaby Tunnel Backfill Pour Sequence





REV.	REVISION DESCRIPTION	DRN. BY	CHK'D BY	ENG. APP	CLIENT
A	FOR INFORMATION ONLY	–	–	–	–

0 10 1:1000 50m

KLTP

TRANSMOUNTAIN

SHEET NUMBER: 1

STATION RANGE: 0+000 TO 0+800

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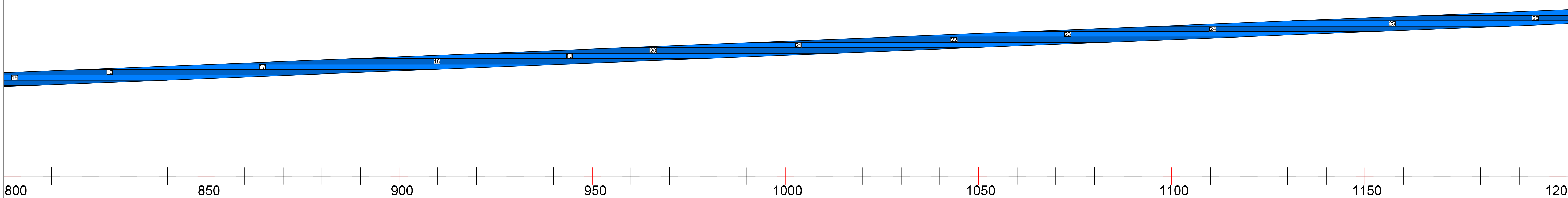
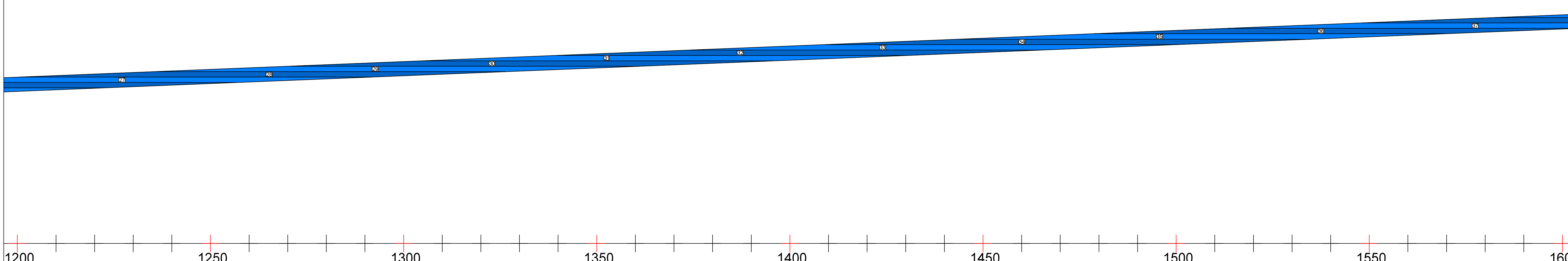
DATE	DRAWING NAME	REV.
2023–06–05	BURNABY TUNNEL BACKFILL POUR SEQUENCE – 230605	A





LEGEND

- LIFT SEQUENCE NUMBER
- TYPE I CONCRETE LIFTS
- TYPE II CONCRETE LIFTS

REV.	REVISION DESCRIPTION	DRN. BY	CHK'D BY	ENG. APP	CLIENT
A	FOR INFORMATION ONLY	–	–	–	–

0 10 1:1000 50m

SHEET NUMBER: 2

STATION RANGE: 0+800 TO 1+600

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DATE	DRAWING NAME	REV.
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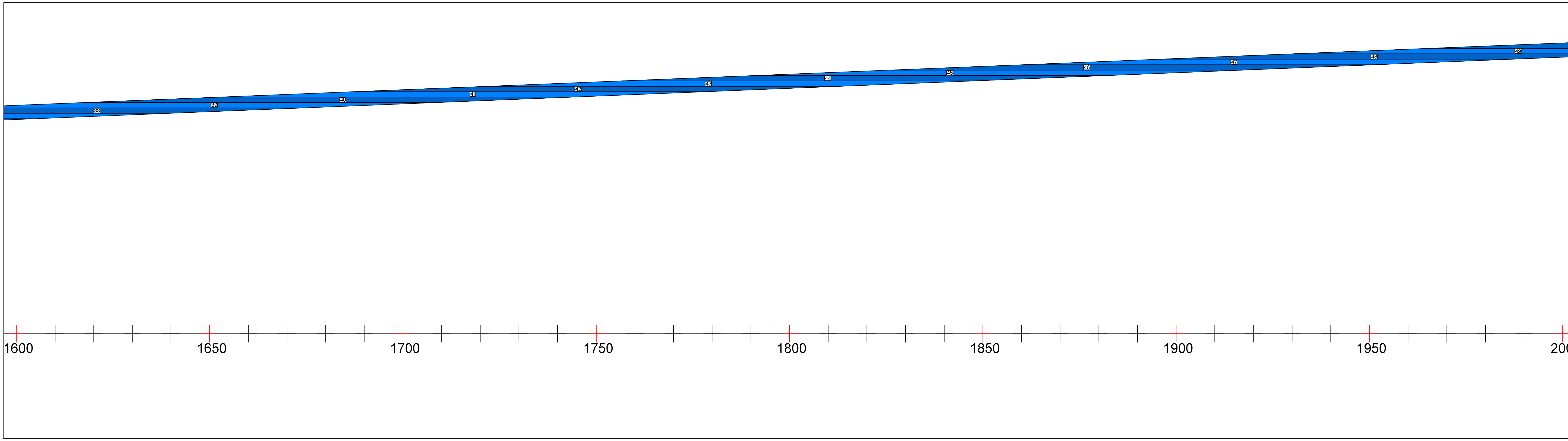

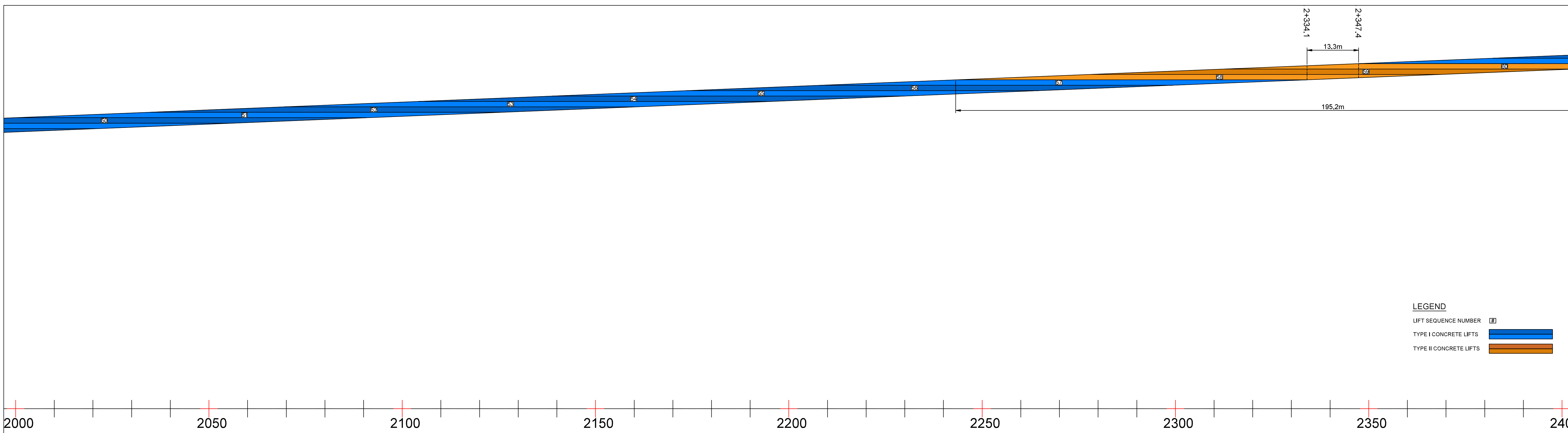

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0 10 1:1000 50m

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TRANSMOUNTAIN

SHEET NUMBER: 3

STATION RANGE: 1+600 TO 2+400

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DATE	DRAWING NAME	REV.
2023–06–05	BURNABY TUNNEL BACKFILL POUR SEQUENCE – 230605	A

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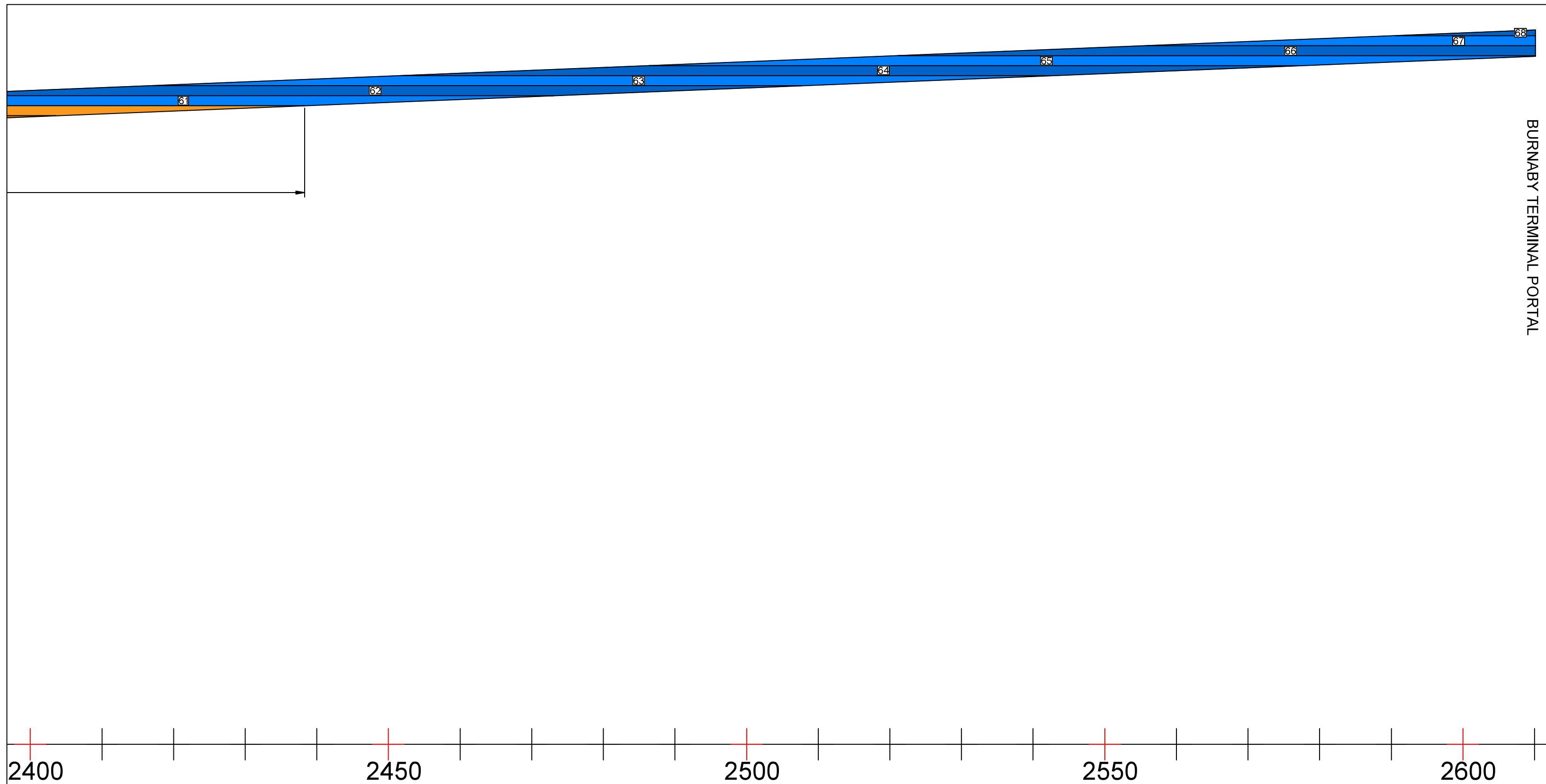

LEGEND

- LIFT SEQUENCE NUMBER
- TYPE I CONCRETE LIFTS
- TYPE II CONCRETE LIFTS

0 10 1:1000 50m

REV.	REVISION DESCRIPTION	DRN. BY	CHK'D BY	ENG. APP	CLIENT
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SHEET NUMBER: 4

STATION RANGE: 2+400 TO 2+610

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BACKFILL POUR SEQUENCE
PROFILE VIEWS

DATE	DRAWING NAME	REV.
2023–06–05	BURNABY TUNNEL BACKFILL POUR SEQUENCE – 230605	A

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