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31 March 2017
NX14001K

Nicole Pesonen
Environmental Manager
Nyrstar Myra Falls Ltd.
PO Box 8000
Campbell River, BC V9W 5E2

Dear Ms. Pesonen:

Re: Lynx TDF Spillways

The Lynx Tailings Disposal Facility (TDF) requires an interim spillway for the current configuration of the facility and a closure spillway for the final configuration of the facility. Nyrstar Myra Falls Ltd. (NMF) has requested that Amec Foster Wheeler Environment & Infrastructure, a division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler), provide a permit-level design for the interim spillway and a conceptual design for the closure spillway.

1.0 Coordinate System

For operations, NMF uses a local grid coordinate system. However, for closure related work NMF would like to use a modern global coordinate system (UTM) and geodetic elevations. The design of the two spillways that is discussed in this report is presented using the UTM coordinate system.

2.0 Background

Myra Falls Mine is an underground polymetallic base metal mine, located within Strathcona Provincial Park, approximately 60 km southwest of Campbell River, British Columbia. There are two TDFs on site. The Old TDF was commissioned in the early 1980s and used until 2009. The Lynx TDF was constructed in 2008 and is the only currently active facility. Only Lynx TDF is discussed herein. Lynx TDF is a paste tailings deposition area within the former Lynx open pit mine, and is retained by a centreline-raised rockfill embankment dam built across the low side of the open pit.

Lynx TDF is the sole active tailings disposal facility at the site. Milling operations stopped in June 2015 to upgrade various infrastructure at the site. Since that time the facility has been used to dispose of tailings waste generated by water management upgrade construction activities on the Old TDF site and to dispose of dredging materials from the site water treatment ponds.

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Lynx Dam has been raised four times by centreline methods, most recently in 2014, and the current crest is at El. 356.78 m (El. 3404.3 m mine grid). The slopes of the south and west sides of the embankment are at 2H:1V and the east side is at 4H:1V.

Recommendations for updating the Inflow Design Flood (IDF) and Environmental Design Flood (EDF) were provided in the Lynx TDF Stability Analysis and Design Update Report (Amec Foster Wheeler, 2015a). As noted in the report, the Lynx TDF does not currently have the capacity to retain the recommended updated EDF or IDF without overtopping the dam. The facility requires a conceptual closure spillway design that will meet the Canadian Dam Association (CDA) guidelines and the mine's environmental permit conditions as part of Nyrstar's closure plan update to the BC Ministry of Energy and Mines (MEM) to be submitted when the conceptual spillway design is complete. An interim spillway is required to prevent overtopping of the facility during the EDF or IDF. The interim spillway will need to be removed and reconstructed during each dam raise as a result of the centreline-raise method employed for that structure. During the design events, storage capacity in the Lynx TDF will be maximized with active pumping. Currently the facility is operating in care and maintenance and the risk of an event triggering flows through the spillway is small prior to moving into operations or closure phases.

3.0 Design Criteria and Assumptions

The Canadian Dam Association (CDA) mining dam supplement provides guidance on the selection of the IDF. The IDF varies based on the consequence classification of the structure and the design phase of the facility. The Lynx TDF has been assessed as being a "High" consequence dam. **Table 3.1** outlines the IDFs for the various phases of life of a mining dam.

Table 3.1: Inflow Design Floods by Phase of Life

Phase	IDF	Spillway
Construction, Operations, Transition and Closure Active Care	1/3 between the 1/1000 Annual Exceedance Probability (AEP) and the Probable Maximum Flood (PMF)	Interim
Closure Passive Care	2/3 between the 1/1000 AEP and the PMF	Closure

The mine's environmental permit prescribes the EDF as the 1/200 AEP Flood.

The Lynx TDF relies on several upslope diversion ditches (Upper Lynx Diversion Ditch and Arnica Diversion Ditch) to assist with water management. The upslope diversions are not considered reliable due to geological hazards on the hillside, and are potentially not large enough to convey runoff flows arising from EDF and IDF events; therefore, the upslope diversion ditches have been assumed to fail during the EDF and IDF. For comparison purposes, in Sections 4.0 and 5.0, the EDF runoff volume below the upslope diversion ditches is presented and compared to the available storage in the Lynx TDF.

There is a regulatory requirement to maintain 1 m of freeboard in the facility at all times. This has been assumed appropriate for both designs. However, the closure design for the top of the Lynx TDF is still being developed so the freeboard elevation for the closure design could be revised in the future. Due to geotechnical stability concerns, the maximum normal operating water level is established as not more than 1 m depth of water directly against the exposed

upstream face of the dam, above the tailings level. The space between the maximum normal operating water level and the freeboard limit is available for use as live storage during storm events. **Table 3.2** presents relevant elevations of the Lynx TDF.

Table 3.2: Lynx TDF Elevations

Item	Mine Grid Elevation (m)	Geodetic Elevation (m)
Top of Paste	3401.0	353.5
Current Dam Crest	3404.3	356.8
Ultimate Dam Crest	3430.0	382.5

4.0 Calculations

Amec Foster Wheeler previously calculated the precipitation depths and the resulting inflows into the Lynx TDF (Amec Foster Wheeler 2015b). The previous Amec Foster Wheeler work divided the contributing area to the Lynx TDF into an area above the upslope diversion ditches (Catchment D-1) and an area below the upslope diversion ditches (Catchment D-8). **Table 4.1** summarizes the precipitation and snowmelt values used in the model, and **Table 4.2** summarizes the flows from the contributing drainage areas.

Table 4.1: Design Storm Events

Design Storm Event	Design Storm Value (mm)
1 in 200 24-hour event (Rainfall) + snowmelt	236
1 in 1000 24-hour event (Rainfall) + snowmelt	253
Probable Maximum Precipitation (PMP) (Rainfall)	635

Table 4.2: Lynx TDF Peak Flow Summary

Location	Catchment Area (km ²)	Peak Flow (m ³ /s)				
		1/200 AEP Rainfall + Snowmelt	1/1000 AEP Rainfall + Snowmelt	Operations IDF (1/3 between the 1/1000 AEP and the PMF)	Closure – Passive Care IDF (2/3 between the 1/1000 AEP and the PMF)	PMF
Catchment D-1 (Upper Reach)	1.487	12.4	13.7	23.8	33.8	43.9
Catchment D-8 (Lynx TDF)	0.382	4.1	4.5	7.3	10.2	13.0
Total to Lynx TDF (D-1 and D-8)	1.869	16.2	17.9	30.7	43.4	56.2

Note that the peak flow values in the bottom row do not necessarily equate to the sum of the two rows above due to flow routing considerations.

For the 1/200 AEP Flood, the total volume from catchment D-8 is 67,600 m³ and the total volume to the Lynx TDF from D-1 and D-8 is 303,000 m³. During the 1/1000 AEP Flood, a total of 332,000 m³ is estimated to report to the Lynx TDF. For the PMF, 1,030,000 m³ is estimated to report to the Lynx TDF.

5.0 Interim Spillway Design

The permit-level design drawings for the interim spillway are presented in **Appendix A**. The proposed location of the interim spillway is near the west abutment of the existing structure, as shown on drawing C-1001 in **Appendix A**. The spillway is designed to convey the attenuated IDF from the Lynx TDF to downstream of the toe of the facility. Until the closure spillway outlet channel is constructed, impacted water released through the interim spillway would be released near the west end of the existing power house and flow overland towards Myra Creek. As indicated in the scoping document, Nyrstar accepts the potential risk to the infrastructure downstream of the interim spillway outlet.

Figure 5.1 presents the stage/storage curve for the Lynx TDF. This stage/storage curve was used to route the Operations IDF through the Lynx TDF for several spillway configurations. Based on input from NMF, a 30 m wide spillway with a crest at El. 355.18 m (El. 3402.7 m mine grid) was selected. **Figure 5.2** presents the results of routing the Operations IDF through the Lynx TDF. The peak discharge is reduced to 27.2 m³/s with a 0.6 m (rounded) flow depth over the spillway, which maintains 1 m (rounded) of freeboard required. **Figure 5.2** does show the maximum water level at about 0.04 m above the minimum freeboard level. This difference is considered acceptable give the uncertainties with calculation of the IDF. If there is a concern with the calculated water level, the spillway crest elevation can be reduced or spillway width can be increased during detailed design. The volume of storage between the spillway crest and top of paste is 87,000 m³, which is sufficient to store the 1/200 AEP flood from below the upslope diversion ditches. There is a potential that parts of the upslope diversion ditches will overtop and even fail during the 1/200 AEP event so more water will reach the Lynx TDF. That additional water from the EDF will flow over the spillway. It is understood that NMF has chosen to accept this option, with the understanding that storage capacity in the Lynx TDF is maximized with active pumping and that the risk of an event triggering flows through the spillway is small prior to moving out of care and maintenance and into operations or closure phases.

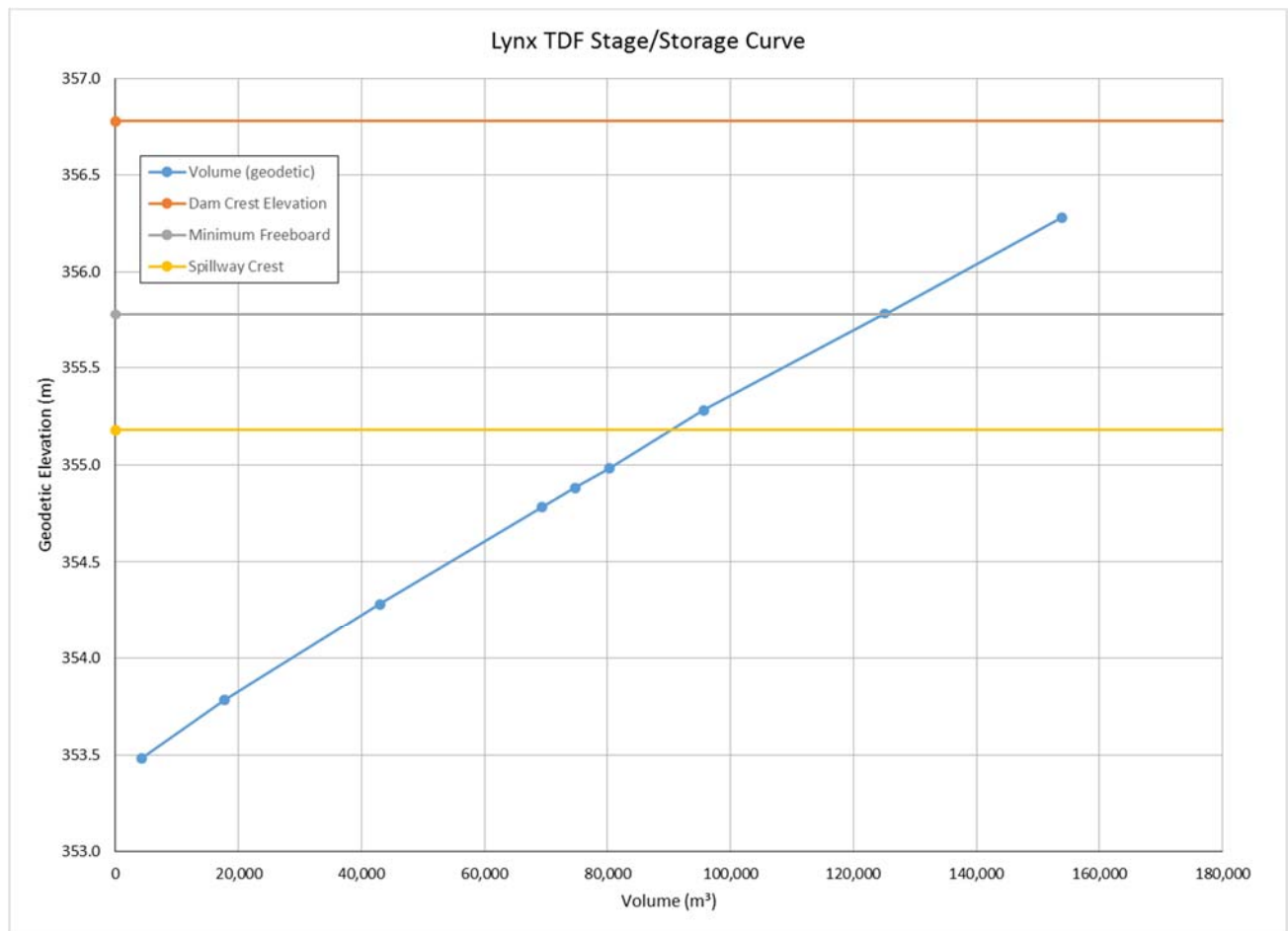


Figure 5.1: Lynx TDF, Stage/Storage Curve

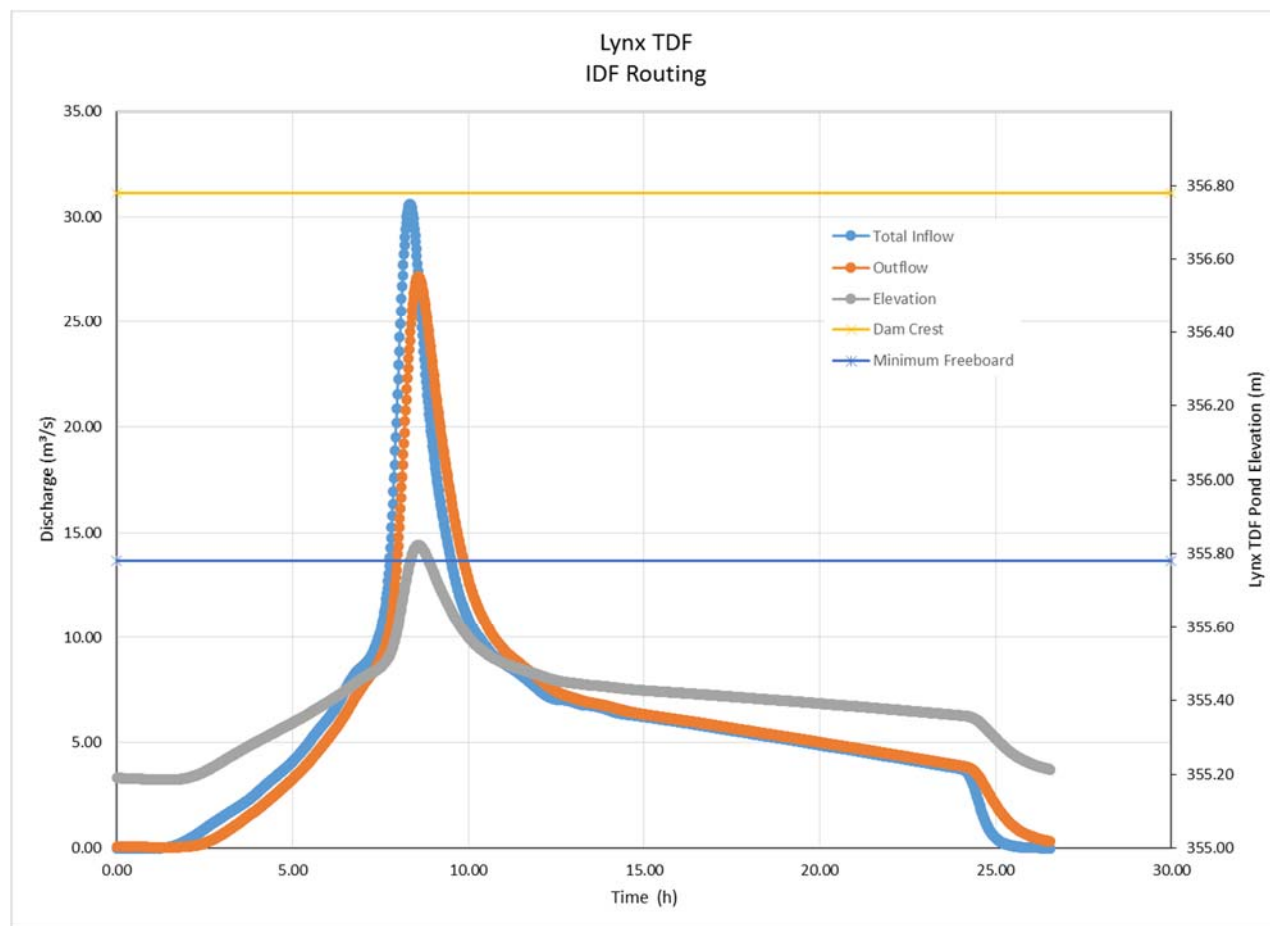


Figure 5.2: Lynx TDF, IDF Routing

The recommended riprap size for most of the channel is Class 250 kg ($D_{50} = 565$ mm). A thicker layer of riprap is recommended where the channel slope is 12% to 13%. For the steeper sections, it is recommended that the bottom of the channel be composed of Class 500 kg riprap ($D_{50} = 715$ mm). This is to help prevent undercutting of the channel in the unlikely event water flows over the spillway. For the interim spillway, the riprap could be composed Possible Acid Generating (PAG) rock since the risk of flow in the spillway is low and any water released through the spillway would be negatively impacted by the mine plant area. For the conceptual closure spillway, the riprap should be composed of Non-Acid Generating (NAG) rock.

6.0 Closure Spillway Design

As mentioned in Section 3.0, the IDF for the design of the closure spillway will be 2/3 between the 1/1000 AEP Flood and the Probable Maximum Flood (PMF). The conceptual design drawings for the closure spillway are presented in **Appendix B**. The proposed location of the closure spillway entrance structure is at the west abutment of the ultimate dam. The spillway is designed to convey the closure (passive care) IDF from the Lynx TDF to Myra Creek. The crest of the spillway will be located in rock. However, the competency of the rock has not been confirmed. For the section of the spillway located in rock (Sta. 2+000.00 to about Sta. 2+045), it has been assumed that no riprap is required and the channel sideslopes can be 1H:1V.

Since the closure configuration of the Lynx TDF is still being developed, there is no theoretical impoundment for the routing of the IDF. To be conservative, the non-attenuated closure IDF was used to size the spillway. To provide the required 1 m of freeboard, the spillway crest needs to be set at El. 380.20 m (El. 3427.70 m mine grid), with 1.3 m of water flowing over the spillway. Class 250 kg riprap ($D_{50} = 565$ mm) has been assumed as the erosion protection for most of the spillway channel; larger rock will be required in local steep sections if bedrock is not encountered. This will be refined as the spillway design is progressed.

7.0 Closure

This letter has been prepared for the exclusive use of Nyrstar Myra Falls Ltd. This letter is based on, and limited by, the interpretation of data, circumstances, and conditions available at the time of completion of the work as referenced throughout the report. It has been prepared in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

Should you require any additional information, please contact the undersigned.

Yours truly,

**Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited**

Reviewed by:

**Original copies signed and sealed by:
Greg Standen**

**Original copies signed by:
Gary Beckstead**

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Principal Engineer – Water Resources

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8.0 References

Amec Foster Wheeler Environment & Infrastructure, 2015a. "Myra Falls Tailings Disposal Facilities Dam Breach Inundation Study". Technical Report, January, 2015.

Amec Foster Wheeler Environment & Infrastructure, 2015b, "Nyrstar Myra Falls Mine, Upper Reach, Cascade Reach and Lower Reach Diversion Ditches, Hydrology update" Letter Report, September, 2015

Canadian Dam Association, 2007. "Dam Safety Guidelines". Revised 2013.

Canadian Dam Association, 2014. "Application of Dam Safety Guidelines to Mining Dams". Technical Bulletin.



Appendix A

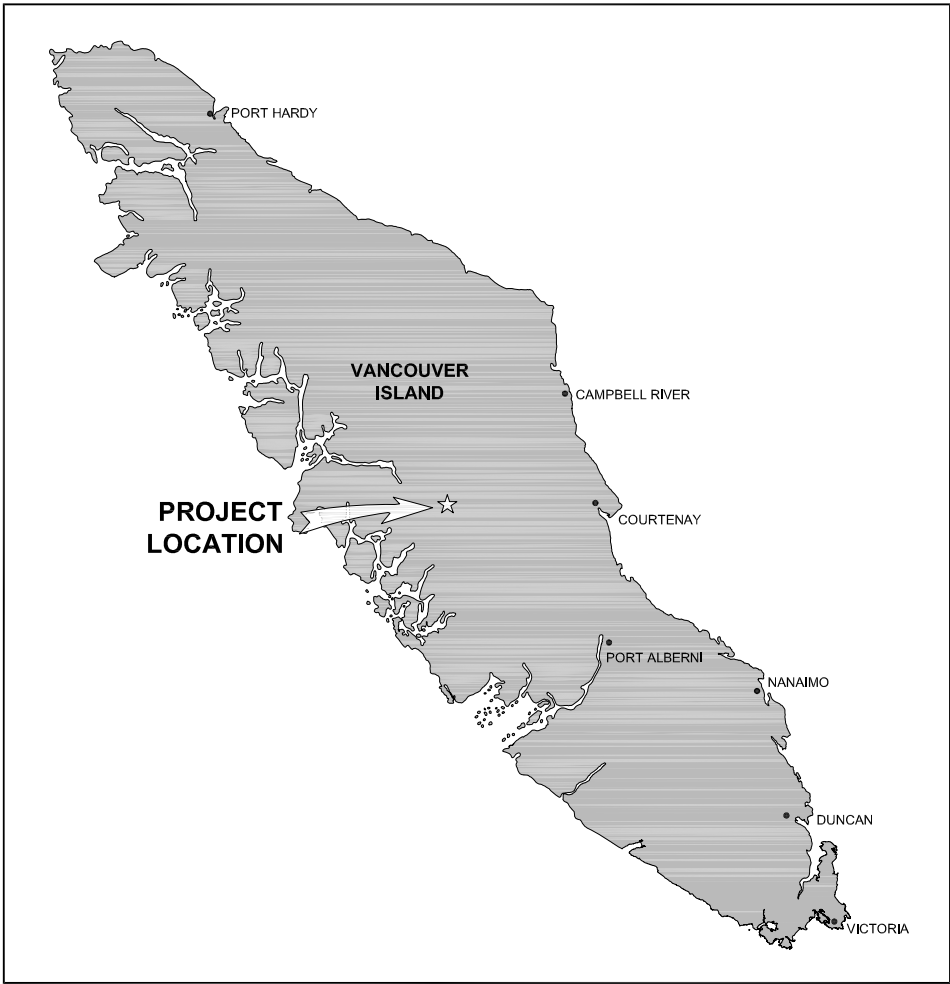
Interim Spillway Permit-Level Design Drawings

NYRSTAR - MYRA FALLS



MYRA FALLS LYNX INTERIM SPILLWAY PERMIT DESIGN

LIST OF PROJECT DRAWINGS		
DWG No.	DRAWING NAME	
DRAWINGS: 0000 - GENERAL		
C-0001	COVER SHEET	
C-0002	LEGEND	
DRAWINGS: 1000 - LYNX INTERIM SPILLWAY		
C-1001	SITE PLAN	
C-1002	INTERIM SPILLWAY	PLAN AND PROFILE
C-1101	TYPICAL SECTIONS AND DETAILS	



PROJECT LOCATION

ISSUED FOR PERMIT

ISSUE DATE: 2017-03-31



Set No.: _____

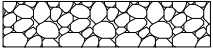
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GENERAL NOTES

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE AMEC FOSTER WHEELER ENVIRONMENT & INFRASTRUCTURE REPORT NO. NX14001K.4, "MYRA FALLS LYNX TDF SPILLWAY", DATED 31 MARCH 2017.
2. SURFACE TOPOGRAPHY FOR "EXISTING GROUND PRE 2015 CONSTRUCTION" BASED ON LIDAR SURVEY FLOWN IN JUNE 2015 (FILES DATED 24 JUNE 2016) SUPPLIED BY CLIENT. SURFACE TOPOGRAPHY FOR "EXISTING GROUND POST 2015 CONSTRUCTION" SUPPLIED BY CLIENT ON 05 DECEMBER 2015. SURFACE TOPOGRAPHY FOR "OLD TDF SURGE POND AND DECANT PIPELINE" BASED ON RE-ISSUED FOR CONSTRUCTION DRAWING SET ISSUED JULY 8, 2016. SURFACE TOPOGRAPHY FOR "LYNX TDF PASTE SURVEY" SUPPLIED BY THE CLIENT 26 OCTOBER 2016.
3. THIS SURVEY IS REFERENCED TO HORIZONTAL DATUM NAD 83 HT 2_0. VERTICAL DATUM IS CGVD2013.
4. COORDINATES PROJECTED IN UTM ZONE 10.
5. ALL DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE NOTED. ELEVATIONS REPRESENT FINISHED GRADE ELEVATIONS UNLESS OTHERWISE NOTED.
6. LYNX SPRINGS DRAIN DESIGN REFERENCES:
AMEC ENVIRONMENT AND INFRASTRUCTURE, 2014. "LYNX SPRINGS DRAIN CONSTRUCTION NOTES". DESIGN DRAWINGS AND SPECIFICATIONS ISSUED TO NYRSTAR MYRA FALLS, MAY 23, 2014
AMEC ENVIRONMENT AND INFRASTRUCTURE, 2013. "LYNX TAILINGS DISPOSAL FACILITY, CONCEPTUAL DESIGN FOR SEEPAGE INTERCEPTOR DRAIN, MYRA FALLS MINE, BC". LETTER REPORT TO NYRSTAR MYRA FALLS, SEPTEMBER 10, 2013.

MATERIAL HATCHING LEGEND

MATERIAL TYPE	SPECIFICATION	HATCH PATTERN
RIPRAP	CLASS 250 kg RIPRAP	

LINETYPE LEGEND

ROAD	
CREEK	
POWERLINE (OVERHEAD/UNDERGROUND)	 E
WATERLINE (UNDERGROUND)	 W
UTILITY PIPELINE	


EXISTING LINETYPES
PROPOSED LINETYPES

GEOTEXTILE	
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ABBREVIATIONS

N	NORTHING	U/S	UPSTREAM
E	EASTING	D/S	DOWNSTREAM
APP	APPROXIMATE	c/w	COMPLETE WITH
STA	STATION	c/c	CENTER TO CENTER
EL	ELEVATION	HWL	HIGH WATER LEVEL
WL	WATER LEVEL	PWL	PERMANENT WATER LEVEL (NO FLOW)
PI	POINT OF INTERSECTION	NWL	NORMAL WATER LEVEL
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CL	CENTERLINE	NON-PAG	NON POTENTIALLY ACID GENERATING (ROCK)
DIA	DIAMETER	HDPE	HIGH DENSITY POLYETHYLENE
MIN	MINIMUM	LLPE	LINEAR LOW DENSITY POLYETHYLENE
TYP	TYPICAL		
THK	THICK		

SYMBOL LEGEND

POWERPOLE	
WATER BODY	
CULVERT	
DITCH INVERT ELEVATION	
FILL ELEVATION	
SURFACE FLOW (RUNOFF)	

EXISTING SYMBOLS
PROPOSED SYMBOLS

SLOPE INDICATOR	
ELEVATION MARKER	
DETAIL / SECTION MARKER (Top # Denotes Detail / Section Number) (Bottom # Denotes Reference Drawing Location)	

SCALE

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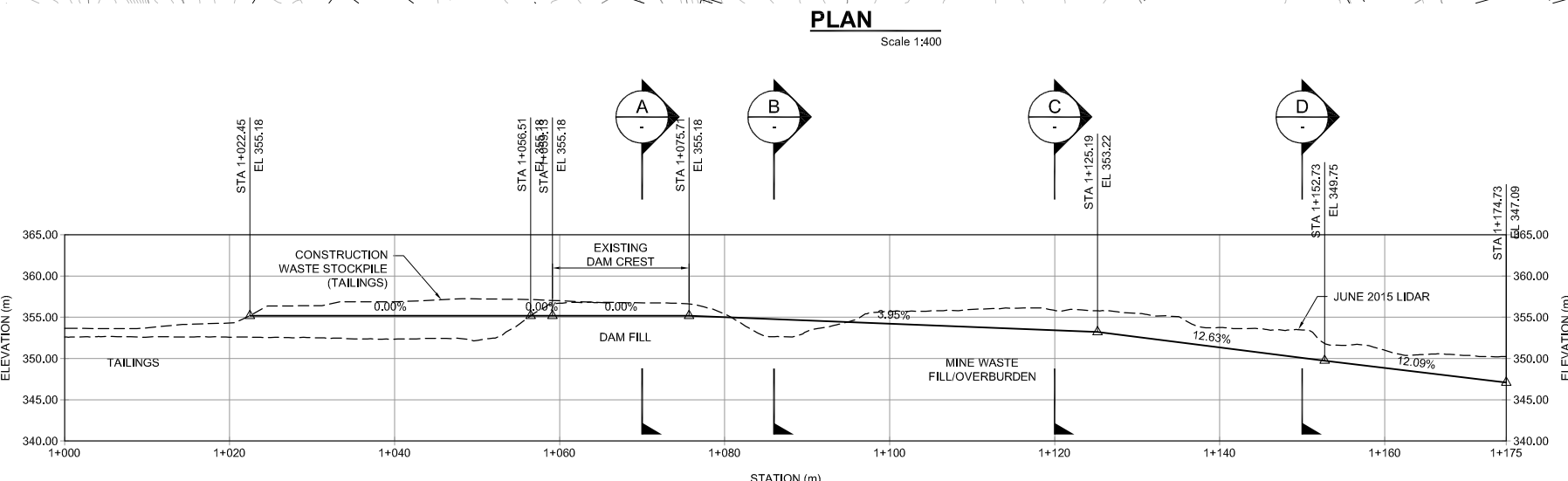
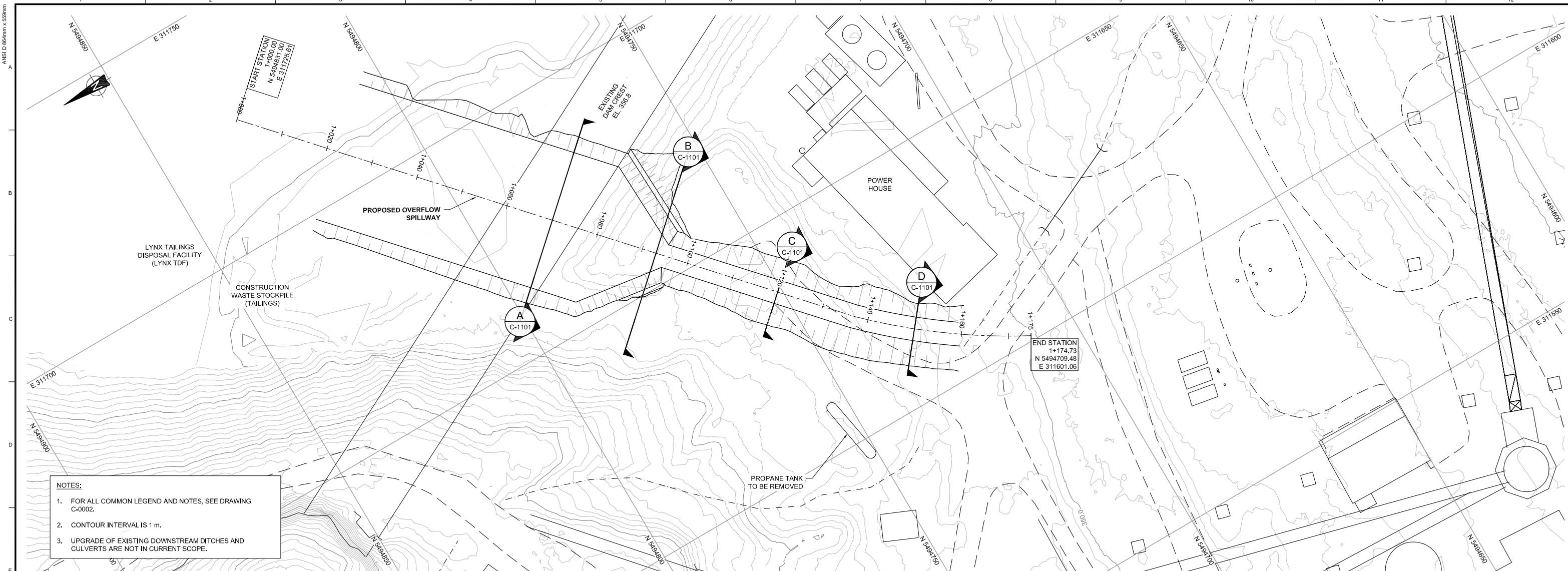


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MYRA FALLS LYNX INTERIM SPILLWAY
PERMIT DESIGN

SHEET TITLE

LEGEND

PROJECT NUMBER
NX14001K.4
DRAWING NUMBER
C-0002
ISSUE/REVISION
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PROJECT NAME
MYRA FALLS LYNX INTERIM SPILLWAY
PERMIT DESIGN

SHEET TITLE
INTERIM SPILLWAY
PLAN AND PROFILE

PROJECT NUMBER
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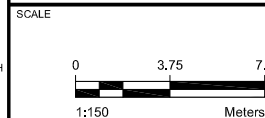
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ISSUE/REVISION
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1. FOR ALL COMMON LEGEND AND NOTES, SEE DRAWING C-0002.
2. UPGRADE OF EXISTING DOWNSTREAM DITCHES AND CULVERTS ARE NOT IN CURRENT SCOPE.



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CLIENT

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PROJECT NAME

MYRA FALLS LYNX INTERIM SPILLWAY
PERMIT DESIGN

SHEET TITLE

TYPICAL SECTIONS AND DETAILS

PROJECT NUMBER

NX14001K.4

DRAWING NUMBER

ISSUE/REVISION

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Appendix B

Closure Spillway Conceptual Design Drawings

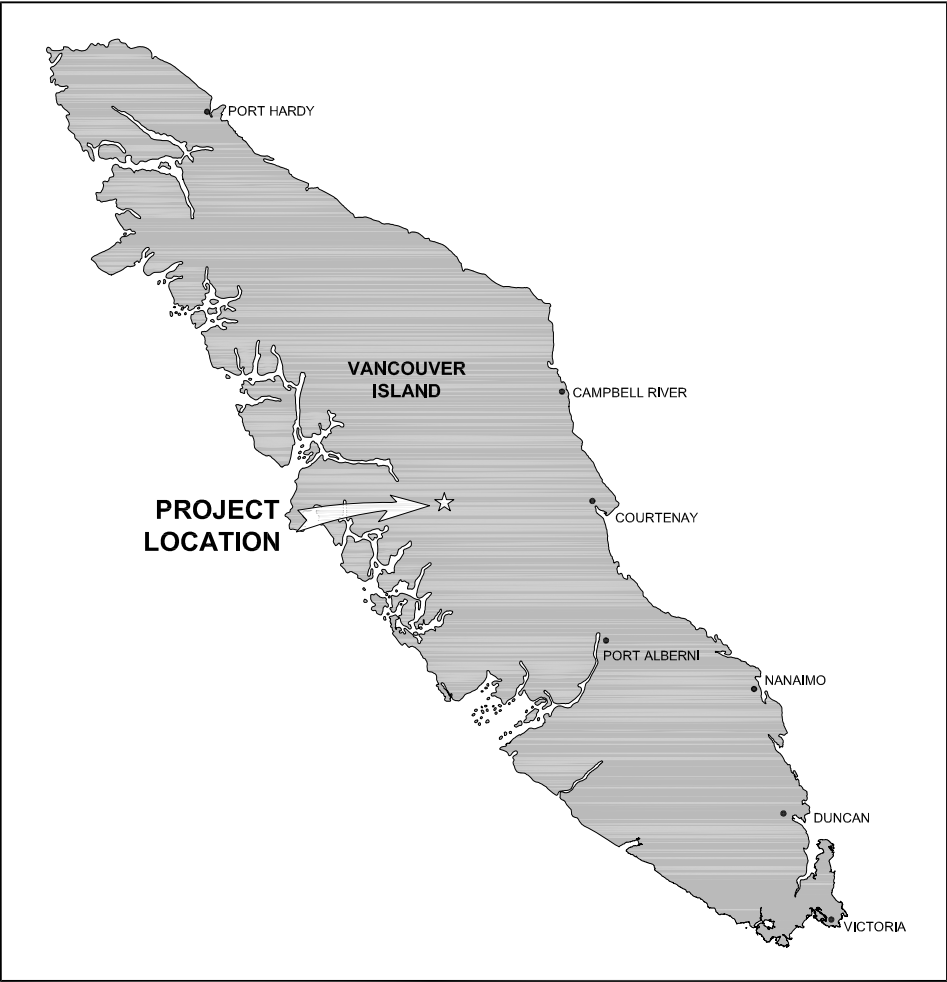
NYRSTAR - MYRA FALLS



MYRA FALLS LYNX CLOSURE SPILLWAY CONCEPTUAL DESIGN

LIST OF PROJECT DRAWINGS

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DRAWINGS: 0000 - GENERAL	
C-0001	COVER SHEET
C-0002	LEGEND
DRAWINGS: 1000 - LYNX XLOSURE SPILLWAY CONCEPTUAL DESIGN	
C-1001	LYNX TDF SITE PLAN
C-1101	TYPICAL SECTIONS AND DETAILS



PROJECT LOCATION

ISSUED FOR INFORMATION

ISSUE DATE: 2017-03-31



Set No.: _____

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
NX14001K.5	C-0001	B

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- GENERAL NOTES
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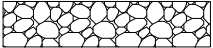
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
ABBREVIATIONS

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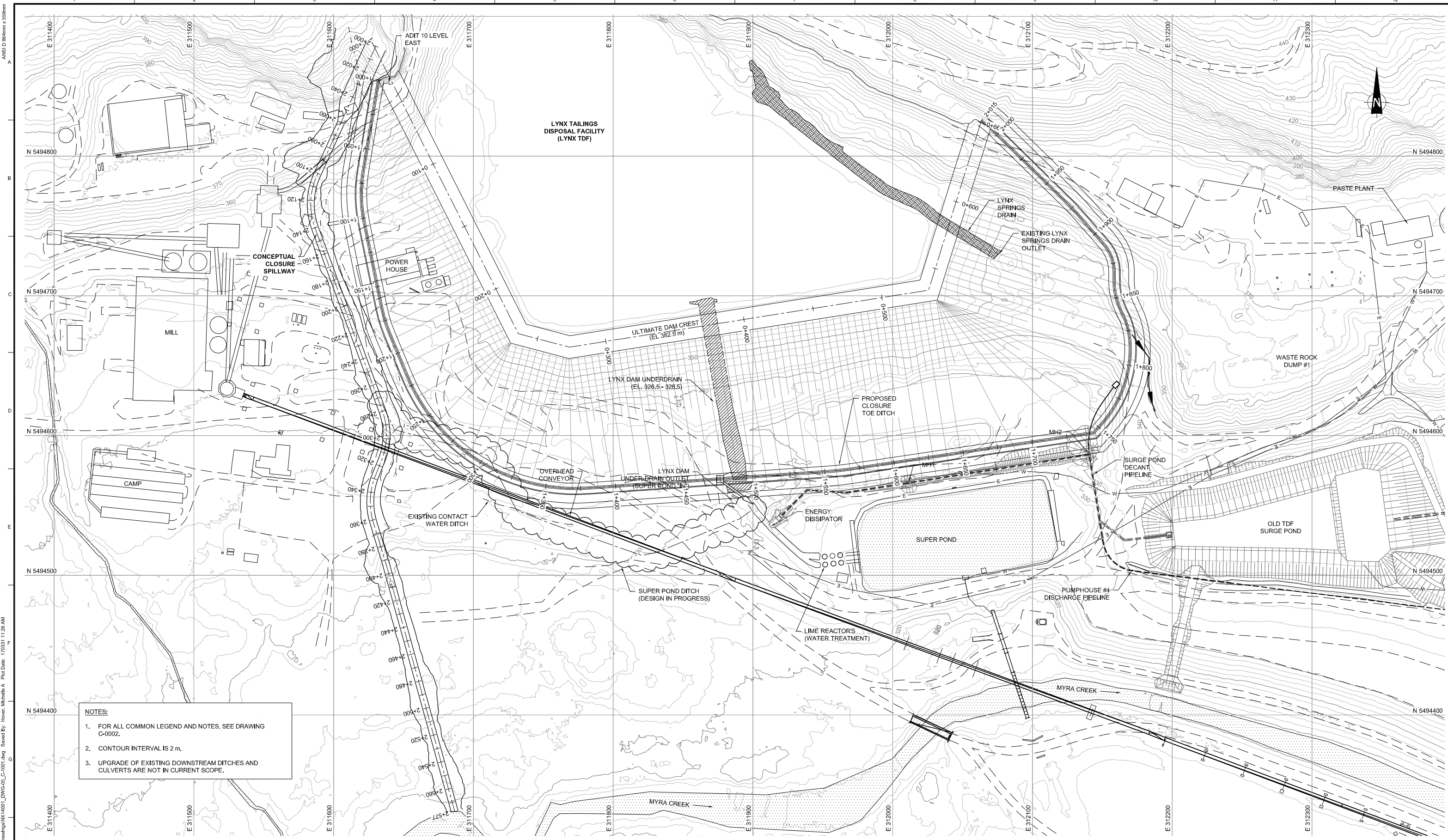
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CLIENT
amec foster wheeler nyrstar

PROJECT NAME MYRA FALLS LYNX CLOSURE SPILLWAY CONCEPTUAL DESIGN	PROJECT NUMBER NX14001K.5
SHEET TITLE LEGEND	DRAWING NUMBER C-0002
	ISSUE/REVISION B



- NOTES:
1. FOR ALL COMMON LEGEND AND NOTES, SEE DRAWING C-0002.
 2. CONTOUR INTERVAL IS 2 m.
 3. UPGRADE OF EXISTING DOWNSTREAM DITCHES AND CULVERTS ARE NOT IN CURRENT SCOPE.

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CLIENT

amec foster wheeler

nystar

PROJECT NAME

MYRA FALLS LYNX CLOSURE SPILLWAY CONCEPTUAL DESIGN

SHEET TITLE

LYNX TDF SITE PLAN

PROJECT NUMBER

NX14001K.5

DRAWING NUMBER

C-1001

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