Rio Tinto

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Ms. Violet Camsell-Blondin
Chair
Wek'èezhìi Land and Water Board
Box 32
Wekweeti, NT X0E 1W0

10 December 2015

Re: Spillway Modification

Diavik Diamond Mines (2012) Inc. (DDMI) is requesting approval for a modification to the Processed Kimberlite Containment spillway design. This request is made under Water License W2015L2-0001 Part G Item 2. DDMI notes for the Board that this request may require an associated Board approval for a revised freeboard limit as permitted under Part H Item 21a.

Attached is the engineering design in support of this request prepared by a Geotechnical Engineer as the Engineer of Record (Golder Associates Ltd.) for the Processed Kimberlite Containment Facility.

DDMI confirms that once this spillway modification is approved, the Processed Kimberlite Containment Facility Operations Plan (Version 2.1) will be revised and submitted for approval. DDMI will also revise internal operations manuals and procedures. DDMI will include in the revisions the conditions referenced in the attached Technical Memorandum in relation to:

a. Pumping out collection ponds during a 1:100 year rainfall event;
b. FPK beach development above elevation 462m; and
c. Pond 3 spillway.

Please let me know if you have any questions.

Regards,

Grant Stewart

David Wells
Superintendent Environment

Grant Stewart
Manager Fixed Plant Operations

cc Sarah Elsasser (WLWB)
Ryan Fequet (WLWB)

Attachment – Golder Technical Memorandum: Processed Kimberlite Containment Facility Operations Spillway Review

TECHNICAL MEMORANDUM

DATE	October 2, 2015	**GOLDER REFERENCE No.**	1521339-1419-TM-Rev0-4000
		DIAVIK PO & WORK PLAN No.	PO#D03154 WP 452
TO	Gord Stephenson, Michael Bembeneck, and Andrew Oliver Diavik Diamond Mines (2012) Inc.		
CC	Adam Campbell, Troy Bortolotto, and Dan Guigon		
FROM	James Ogilvie, Germán Pizarro, and John Cunning	**EMAIL**	jogilvie@golder.com; gpizarro@golder.com; jcunning@golder.com
TASK DESCRIPTION	**PROCESSED KIMBERLITE CONTAINMENT FACILITY OPERATIONS SPILLWAY REVIEW**		

1.0 INTRODUCTION

Diavik Diamond Mines (2012) Inc. (DDMI) is planning to complete the Phase 6 construction works to raise the Processed Kimberlite Containment (PKC) Facility dam crest from elevation 460 m to 465 m by the end of 2015.

Golder Associates Ltd. (Golder) prepared the Phase 6 dam raise design and construction drawings (Golder 2013), which include the design for a spillway located near the south end of the West Dam. A spillway is required to discharge water from the PKC Facility during extreme flood events. As part of the 2015 works, DDMI requested Golder to review the Phase 6 PKC Facility spillway freeboard calculations, spillway location and to consider the use of available volume in Pond 3, located to the northwest of the PKC Facility, for flood storage.

This technical memorandum presents the PKC Facility spillway design criteria, freeboard calculations, recommended spillway invert elevation and an updated spillway location.

2.0 PKC FACILITY DESIGN CRITERIA

2.1 Water Storage Requirements

Excess process water and contributing runoff from the PKC Facility itself and some of the PKC surrounding area (runoff collection ponds) is managed through the PKC Pond. The PKC Pond is maintained in a centralized location within the PKC Facility for water reclaim to the process plant. Management of the water within the PKC Facility currently includes:

- process water and temporary storage of seasonal flows;
- temporary storage of the Environmental Design Flood (EDF); and
- safe conveyance of the Inflow Design Flood (IDF), to ensure the integrity of the PKC Facility.

The EDF is defined as the most severe flood that is required to be managed without the release of water from the facility to the environment. Retaining the EDF within the PKC Facility requires storage capacity between the Normal Operating Water Level (NOWL) and the spillway invert elevation. Alternatively, the EDF could be conveyed and retained in a water retaining facility such as Pond 3 which is located downstream of the PKC Facility. There are no specific guidelines for the return period or duration of the EDF; however, Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (CDA 2014) states that typical return periods range from 1:50-year to 1:200-year. The original design of the PKC Facility conservatively considered an EDF return period of 1:500-year (NKSL 2001). A 1:500-year return period for the EDF was maintained in the most recent PKC Facility design (Golder 2013). The rationale for the selection of a 1:500-year return period in the original design of the PKC Facility could not be identified for this assessment.

The site runoff collection ponds (Ponds 4, 5, 7, and 12) are designed to discharge flow above the 1:100-year event over emergency spillways. Golder recommends that a 1:100-year return period should be used to determine the PKC Facility's EDF volume.

The IDF is defined as the most severe inflow flood for which a dam spillway should be designed. The IDF is not required to be stored but must be conveyed through an emergency spillway without impacting the integrity of the facility. The PKC Facility dams are classified as a high consequence dam class following the Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2013). Based on this classification, the IDF for the PKC Facility is a 1:1,000-year flood event plus one-third of the difference between the Probable Maximum Flood (PMF) and a 1:1,000-year flood event (CDA 2014). The PMF is the inflow event resulting from the Probable Maximum Precipitation (PMP), which is given as a 24-hour precipitation depth (provided in Table 1). The original design of the PKC Facility conservatively assumed the IDF to be equal to the PMF (NKSL 2001), and this assumption was maintained in the PKC Facility Phase 6 design (Golder 2013).

Figure 1 shows the typical configuration of the storage requirements for the IDF and EDF.

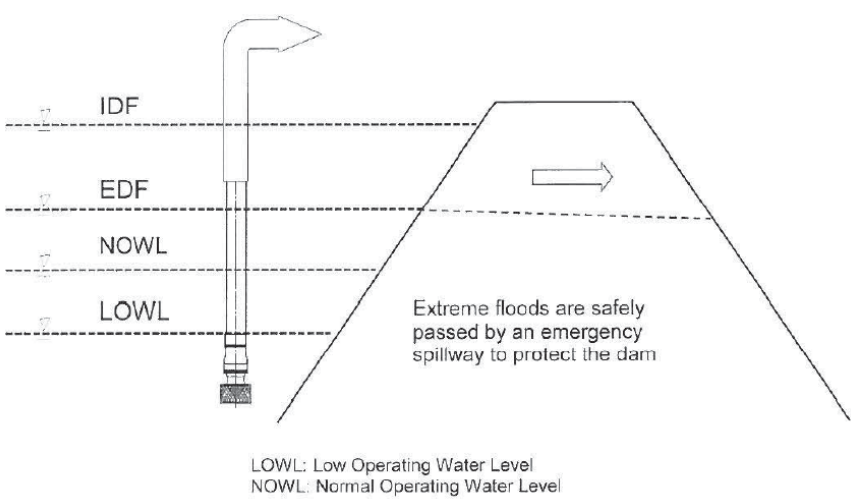

Figure 1: Typical configuration required for EDF storage and IDF conveyance (CDA 2014)

2.2 Precipitation Data

The IDF and EDF events for the PKC Facility were calculated as rain-on-snow events in the assessment by NKSL (2001) and for this assessment. Both events have been assumed to include runoff due to melting of the entire snowpack from an average year over a two-week period, where the rainfall event would occur during the two-week snowmelt period. Details for selected rainfall runoff events for the PKC Facility are summarized in Table 1.

Table 1: Site Precipitation Data

Runoff Event	Precipitation Depth (mm of water)
Probable Maximum Precipitation (PMP), 24-hour rainfall	199
1:500-year, 24-hour rainfall	72.9
1:100-year, 24-hour rainfall	62.1
Average-year snowpack	187

Source: Golder (2008).

2.3 Catchment Area

Previous spillway designs (NKSL 2001 and Golder 2013) considered a total PKC Facility catchment area of 4.16 km^2 to calculate the runoff inflow volumes during extreme flood events. This catchment area included the following areas:

- PKC Facility;
- Plant Site (Ponds 10 and 11);
- North Till and NCRP (Ponds 1, 2, 3, and 13); and
- Runoff collection ponds (Ponds 4, 5, 7, and 12).

The current spillway assessment considers a total PKC Facility catchment area of 1.50 km^2 to calculate the runoff inflow volumes. The reduction in catchment area reporting to the facility from previous designs is based on the last twelve years of operation experience of the PKC Facility and the ponds. The current site water management capabilities allows for controlled pumping from the runoff ponds to the PKC Facility as summarized below:

- Pond 4 is pumped to Pond 3;
- Pond 3 and Pond 2 are pumped to the North Inlet;
- Pond 13 is pumped to Pond 1;
- Pond 1 can be pumped to the North Inlet or the PKC Facility;
- Pond 10 and Pond 11 are pumped to Pond 5;
- Pond 5 can be pumped to the North Inlet or the PKC Facility; and
- Pond 7 and Pond 12 are pumped to the PKC Facility.

Each of the site ponds are designed to discharge flow above the 1:100-year event over emergency spillways. Provided that no pumping from Pond 1, 5, 7 and 12 to the PKC Facility would take place during an extreme flood event (such as the EDF or IDF), the catchment area reporting to the PKC Facility would consist of the direct catchment area only.

The PKC OMS Manual should be updated to include that pumping from the runoff collection ponds to the PKC Facility would not take place during a 1:100-year 24-hour rainfall event.

2.4 PKC Facility Inflows

Inflows to the PKC Facility were estimated using Hydrologic Engineering Center Hydrologic Modelling System (HEC-HMS) software (USACE 2010). The SCS curve number (CN) method (USDA 1986) was used to estimate general catchment losses; losses are taken into account when determining the amount of rainfall during a storm that becomes direct runoff. It was assumed that the ground would be frozen during the design storm event, so a CN of 95 was used for the PKC Facility catchment area.

Table 2 presents the results of the runoff event calculations and inflow volumes to the PKC Facility.

Table 2: Facility Inflow Data

Flow Event	Total Freshet Inflow (mm of water, rain plus snow equivalent)	Inflow Volume (m^3)
IDF (PMP rainfall and average snowpack)	386	560,000
EDF (1:500-year rainfall and average snowpack)	260	370,000
EDF (1:100-year rainfall and average snowpack)	249	350,000

2.5 Freeboard Requirements

The freeboard for a water-containing structure can be defined as the minimum vertical distance between the still pool reservoir level and the crest of the containing structure (CDA 2007). This distance needs to be maintained at all times to prevent overtopping of the containing structure by large waves resulting from the sum of wind, and wave set-up and run-up.

There are two freeboard values that need to be considered as follows:

- *Normal freeboard* is the difference in elevation between the dam crest and the maximum operating water level of the facility.
- *Minimum freeboard* is difference in elevation between the dam crest and the maximum still pool water level that would result from the IDF.

Table 3 provides the freeboard requirements for the PKC Facility.

Table 3: Facility Freeboard Requirements (CDA 2007)

Freeboard	Requirements
Normal freeboard	No overtopping by 95% of waves caused by the most critical wind with a frequency of 1 in 1,000 years, when the reservoir is at its maximum normal elevation.
Minimum freeboard	No overtopping by 95% of the waves caused by the most critical wind, with an annual exceedance probability (AEP) of 1 in 2, when the reservoir is at its maximum extreme level during the passage of the IDF.

Normal and minimum freeboard values were calculated for this assessment as the sum of wind set-up and wave run-up for the wind recurrence values specified above.

3.0 PKC FACILITY FREEBOARD

The PKC Facility normal and minimum freeboard requirements were re-calculated for this assessment. The freeboard calculations follow the procedures and equations discussed in CDA (2013). Wind speeds, pond depth, and dam slope geometry were considered in the eight cardinal directions to determine the greatest wave uprush value for the normal and minimum freeboard scenarios. Wind speeds were taken from the review of baseline climate and surface water hydrology report for Diavik Mine (Golder 2008) and dam geometry information (pond depth, dam slope, etc.) was taken from the PKC Facility Phase 6 design (Golder 2013). The normal and minimum freeboard values presented in Golder (2013) are governed by the assumption that the PKC Pond would be in contact with the 1.5H:1V slope of the PKC Facility dam. For this assessment, the PKC Pond has been assumed to be maintained in a centralized location with FPK beaches between the PKC Pond and the PKC Facility dams. This requirement should be confirmed on site as deposition of FPK takes place.

The corresponding freeboard requirements for the PKC Facility with a 3% beach slope around the PKC Facility's entire perimeter are presented in Table 4.

Table 4: Facility Freeboard Values

Facility Freeboard	Value (m)
Normal freeboard	0.3
Minimum freeboard	0.2

4.0 SPILLWAY DESIGN ELEVATIONS

The minimum crest elevation of the PKC Facility is assumed to be 465.0 masl, which is the design crest elevation presented in Golder (2013), and is expected to be achieved at the end of the Phase 6 construction season. The calculated normal and minimum freeboard values for the PKC Facility from Table 5 which assume a centralized PKC Pond with 3% FPK beach slope were used to determine the NOWL (for normal freeboard) and NOWL (for minimum freeboard) plus IDF depth, respectively. The HEC-HMS software was used to calculate the maximum pond level during the IDF event.

For the PKC Facility, the NOWL calculated using the minimum freeboard results in the lowest NOWL elevation, and therefore is the governing value. The calculation of the NOWL considers that the EDF will be conveyed to Pond 3 and will not be stored in the PKC Facility.

Notable design elevations for the PKC Facility are presented in Table 5.

Table 5: Facility Elevations Assuming FPK Beaches are in Place from the Phase 6 Dam Crest

Elevation	Value (masl)
Dam crest following Phase 6 construction	465.0
Maximum PKC Facility water elevation during IDF	464.8
Normal Operating Water Level (normal freeboard)	464.7
Normal Operating Water Level (minimum freeboard)	464.6
Design invert elevation of the Phase 6 spillway	464.6

Figure 2 presents a visual comparison of the PKC Facility NOWL, as derived from the normal and minimum freeboard requirements. It can be seen that in this case, the minimum freeboard scenario governs.

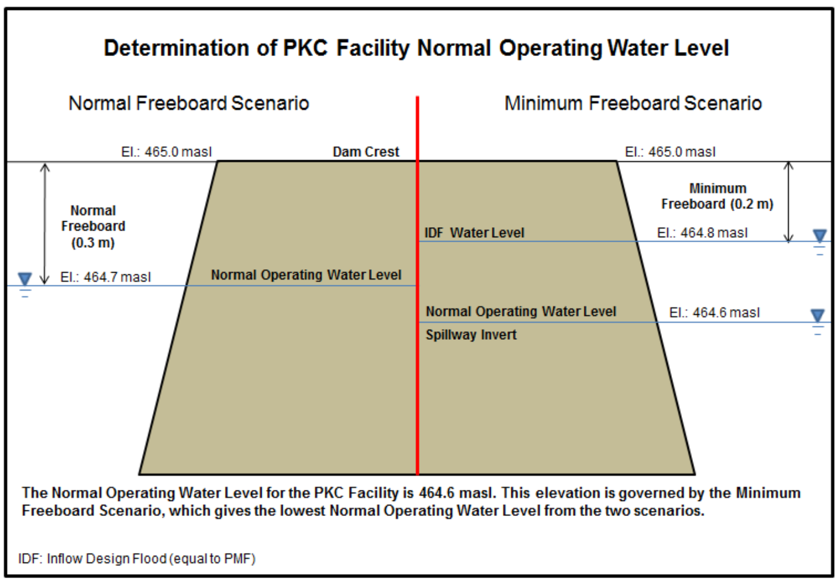

Figure 2: PKC Facility Normal Operating Water Level and Freeboard Requirements

5.0 RECOMMENDATIONS

As discussed in Section 2.1, CDA (2014) Guidelines recommend that mining dams contain EDF events. The EDF considerations for the PKC Facility have been updated to consider current guidelines provided in CDA (2014). Golder recommends that the PKC Facility's EDF volume be based on a rainfall on snow event with a 1:100-year return period as was used in the design of the runoff collection ponds.

Golder has presented an updated assessment which has considered that the equivalent EDF inflow is diverted into Pond 3 to satisfies the EDF containment requirement outside the existing PKC Facility. Based on the Pond 3 storage curve provided by DDMI, Pond 3 has sufficient storage volume to store the PKC Facility EDF inflow of 350,000 m^3 for the 1:100-year rainfall volume. Storage of the EDF in Pond 3 allows the PKC Facility Normal Operating Water Level, based on minimum freeboard, to be equal to the spillway invert elevation of 464.6 m.

The flood inflow volume is directly related to the catchment area reporting to the PKC Facility. The catchment area considered for the original Phase 6 spillway design considered that the Plant Site ponds, runoff collection ponds, and the North Till and NCRP ponds would be pumped to the PKC Facility during an extreme flood event (such as the EDF or IDF). However, operation experience of the ponds shows that these areas are generally not pumped to the PKC Facility and could not be pumped during an extreme flood event, so the contributing catchment area has been reduced for this assessment. Further, the current PKC Facility water management plan allows for transfer of water from the PKC Pond to the North Inlet. The PKC Facility catchment areas and pumping operations assumptions should be reviewed and confirmed by DDMI. The PKC OMS Manual should be updated to include that pumping from the runoff collection ponds to the PKC Facility would not take place during a 1:100-year 24-hour rainfall event.

Golder recommends reducing the normal and minimum freeboard requirements for the PKC Facility by maintaining the PKC Pond in a centralized location with FPK beaches around the PKC Facility's entire perimeter. This would require approximately 10 m to 20 m long FPK beaches between the PKC Pond and the PKC Facility dam slopes at a beach slope of about 3%. The OMS Manual should include a review of FPK beach development as the pond exceeds an elevation of 462 m to confirm beaches are developed and maintained, or can be developed and maintained to meet the assumptions used to calculate freeboard presented in Table 4.

Golder understand DDMI will manage any required water license modifications based on these revised freeboard recommendations.

Golder has updated the Issued for Construction (IFC) spillway drawing 14111-41D1-6123 to show the updated spillway location and routing in the area where the North and West Dams meet, which would direct overflow, including the EDF and IDF, from the PKC Facility to Pond 3. This would require the Pond 3 spillway to be reviewed to confirm it can pass the same IDF as the PKC Facility. Review of the Pond 3 spillway is to be completed before the PKC pond exceeds an elevation of 463 m. The updated IFC spillway drawing 14111-41D1-6123 Rev 1 dated September 17, 2015 showing the spillway location is attached to this technical memorandum.

6.0 CLOSURE

The reader is referred to the Study Limitations, which follows the text and forms an integral part of this memorandum. We trust this technical memorandum meets you present requirements. If you have any questions or concerns, please contact the undersigned.

GOLDER ASSOCIATES LTD.

James Ogilvie, P.Eng. (BC)
Water Resources Engineer

Germán Pizarro, P.Eng. (BC)
Geotechnical Engineer

REGISTERED PROFESSIONAL ENGINEER
Oct 2/15
J.C. CUNNING
LICENSEE
NWT/NU

John Cunning, P.Eng.
Principal, Senior Geotechnical Engineer

PERMIT TO PRACTICE
GOLDER ASSOCIATES LTD.
Signature
Date Oct 2, 2015
PERMIT NUMBER: P 049
NT/NU Association of Professional Engineers and Geoscientists

JO/DRW/GP/JCC/jc/it/jc

Attachment: Study Limitations
Figure 1: Phase 6 Spillway Plan, Profile and Cross-Sections

\\golder.gds\gal\burnaby\final\2015\3 proj\1521339 ddmi surface projects\1521339-1419-tm-rev0-4000\1521339-1419-tm-rev0-4000-pkc spillway review 02oct_15.docx

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USDA-SCS (United States Department of Agriculture- Soil Conservation Service). 1986. *Urban Hydrology for Small Watersheds*. TR-55, 164 p.

STUDY LIMITATIONS

Golder Associates Ltd. (Golder) has prepared this document in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this document. No warranty, express or implied, is made.

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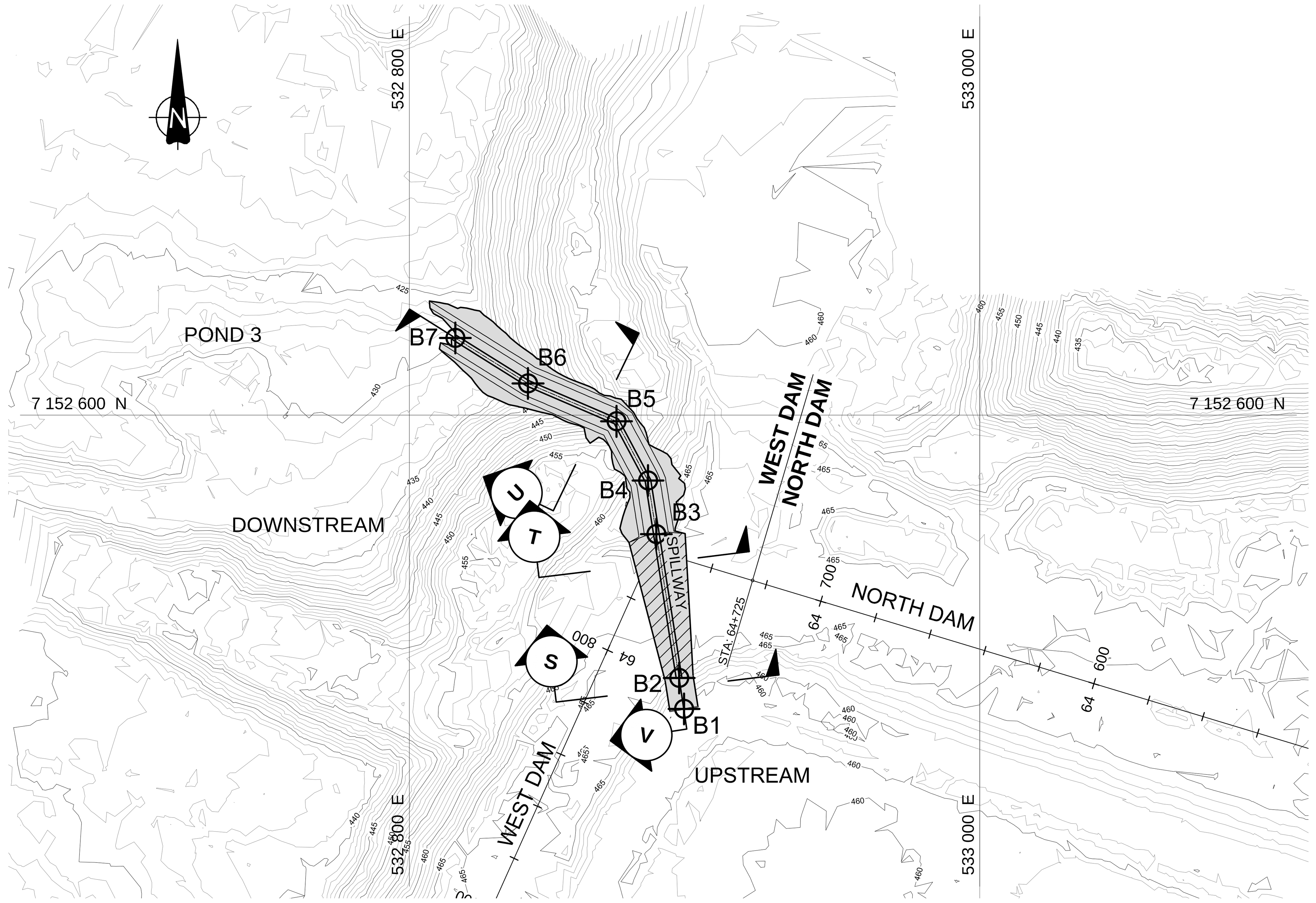
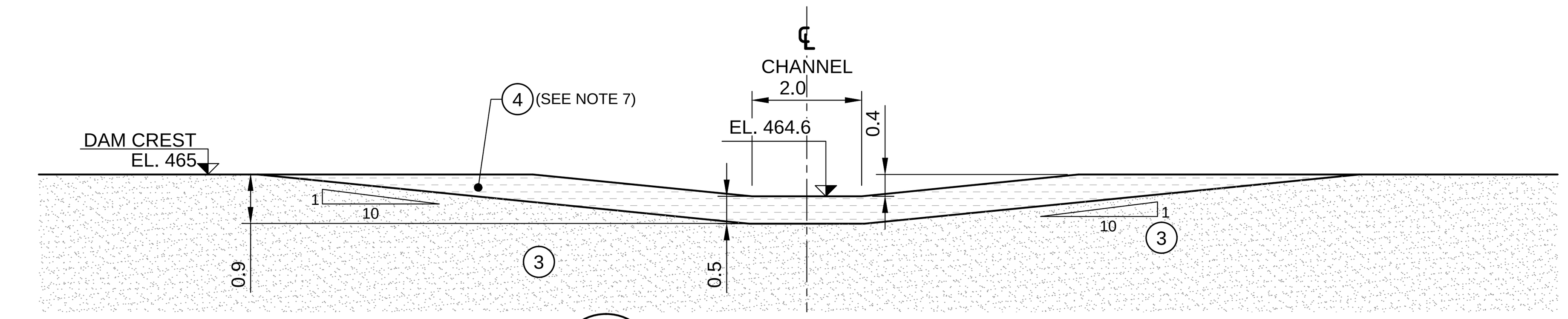
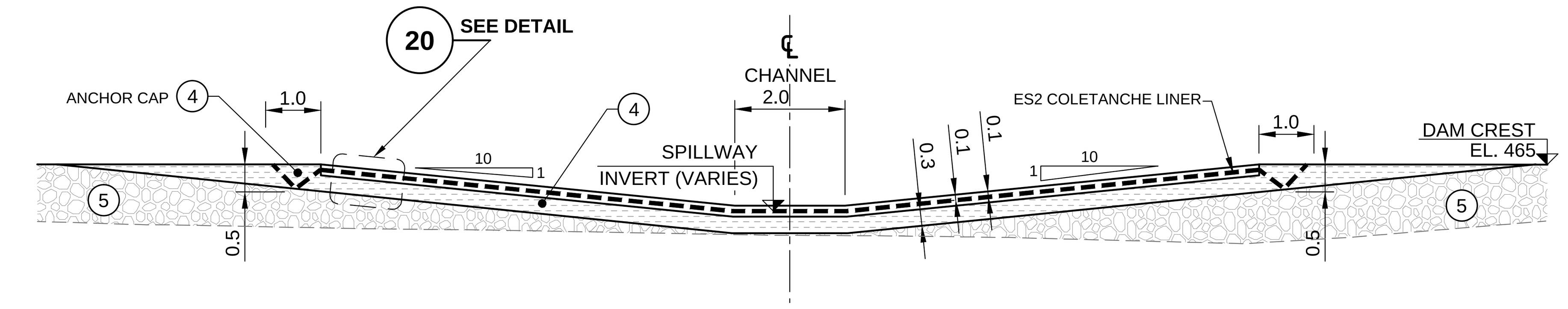


PLAN : PHASE 6 DAM SPILLWAY
SCALE A



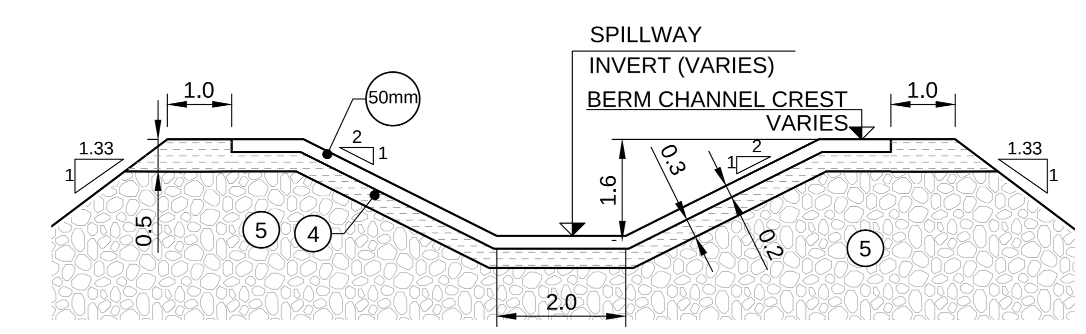
S SECTION : SPILLWAY UPSTREAM SLOPE
SCALE C



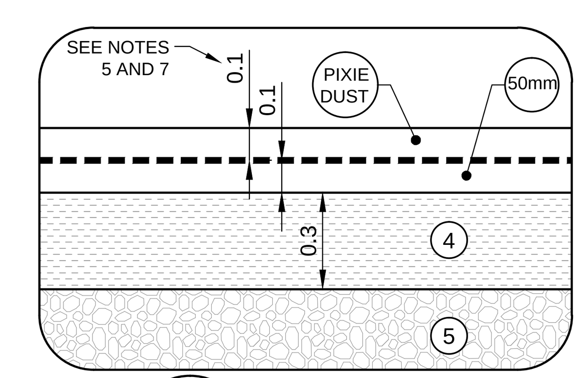
T SECTION : SPILLWAY ALONG DAM REFERENCE LINE
SCALE C

TABLE 1 : SET OUT POINTS				
DESCRIPTION	POINT ID	NORTHING	EASTING	ELEV
INLET CHANNEL	B1	7152497.03	532896.31	464.60
LINER INVERT	B2	7152507.89	532894.59	464.60*
LINER INVERT	B3	7152558.33	532886.64	464.10
OUTLET CHANNEL	B4	7152577.07	532883.68	458.16
OUTLET CHANNEL	B5	7152597.82	532872.64	450.30
OUTLET CHANNEL	B6	7152611.11	532841.64	438.90
OUTLET CHANNEL	B7	7152627.04	532816.15	429.10

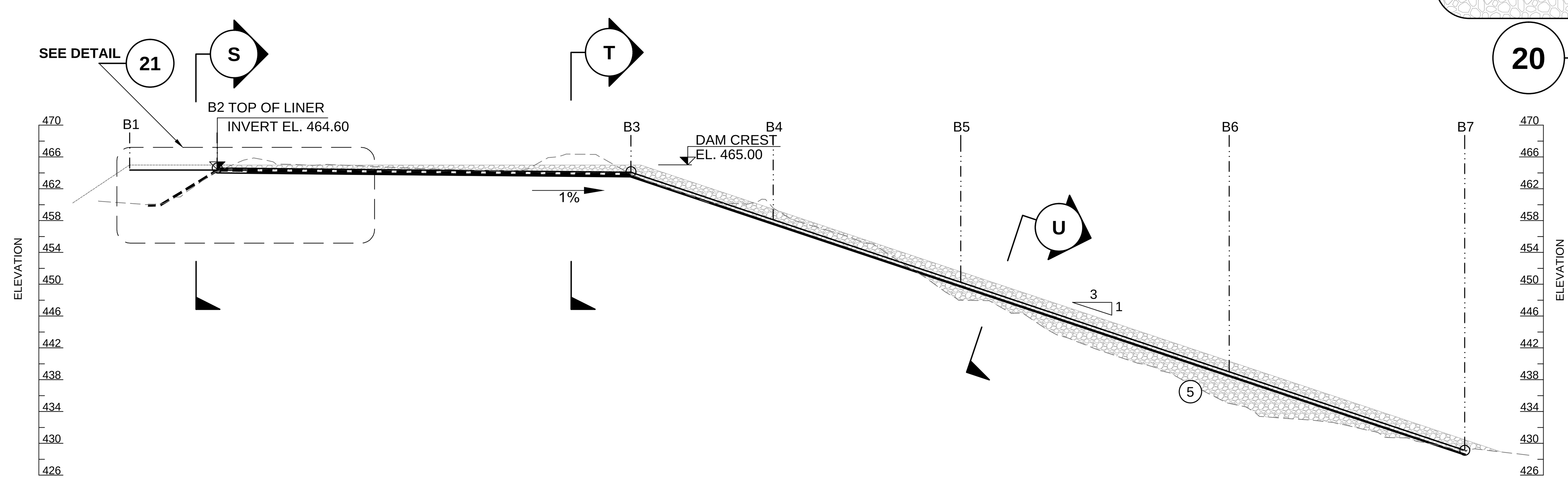
* MINIMUM FREEBOARD IS 0.4m BELOW MINIMUM DAM CREST OF EL 465m.



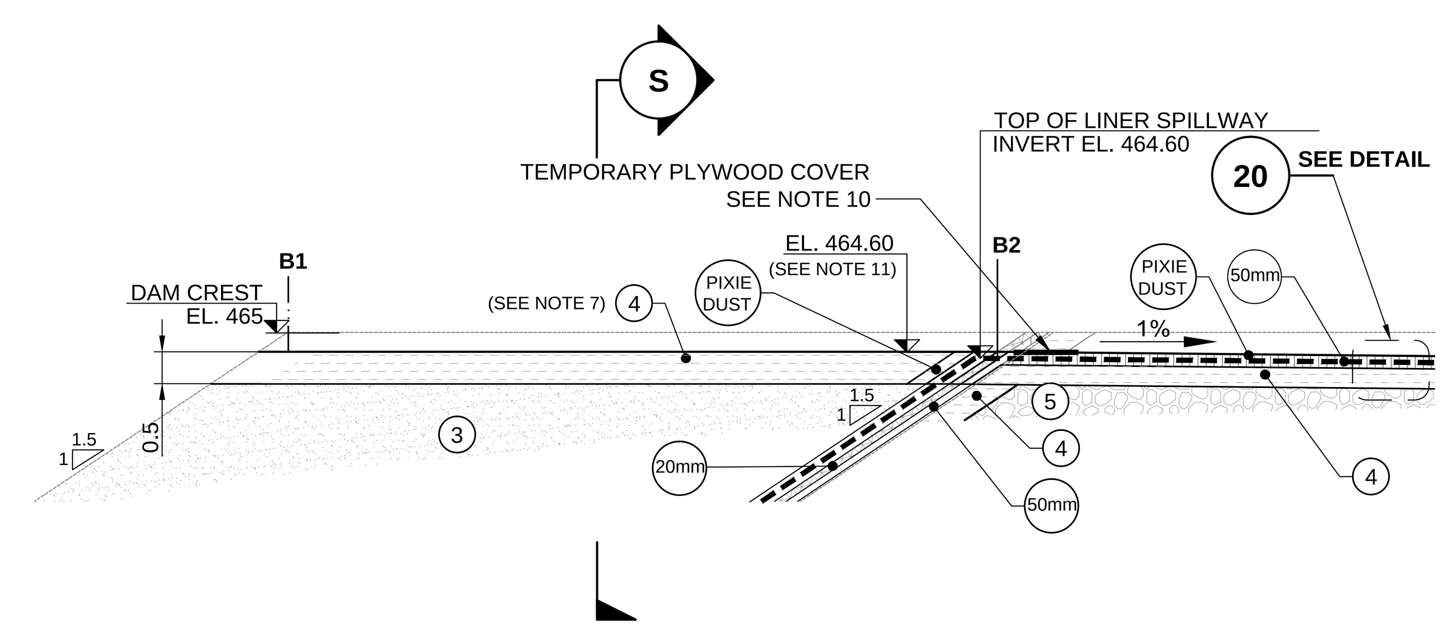
U TYPICAL SECTION : SPILLWAY CHANNEL DOWNSTREAM SLOPE
SCALE C



20 DETAIL
SCALE D



V SPILLWAY PROFILE
SCALE B



21 DETAIL
SCALE C

LEGEND

PHASE 6 PKC DAMS REFERENCE LINE

SET OUT POINT (SEE TABLE 1)

ES2 COLETANCHE BITUMINOUS GEOMEMBRANE LINER

MATERIALS

- (3) CPK
- (4) TRANSITION (300mm MINUS)
- (5) ROCKFILL (900mm MINUS)
- (20mm) LINER BEDDING (20mm MINUS CRUSH)
- (50mm) 50mm MINUS CRUSH
- ES2 COLETANCHE BITUMINOUS GEOMEMBRANE LINER

NOTES

1. COORDINATES ARE IN MINE GRID.
2. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE NOTED.
3. CONTOUR INTERVAL IS 1.0 m WITH EXISTING TOPOGRAPHY PROVIDED BY DDMI REPRESENTING AS-BUILT CONDITIONS AT JULY 2015.
4. DOWNSTREAM ROCKFILL SLOPES SHOWN AT 1.33H:1V AS THE ESTIMATED ANGLE OF REPOSE SLOPE FOR THE ZONE 5 MATERIAL. SIDE SLOPES OF THE SPILLWAY OUTLET ARE ALSO SHOWN AT 1.33H:1V.
5. 0.1 m COVER OF PIXIE DUST MATERIAL TO BE PLACED OVER ES2 LINER IN SPILLWAY.
6. TRAFFIC OVER SPILLWAY SHALL BE MINIMIZED AS IT MAY PUNCTURE LINER INSTALLED IN SPILLWAY. TRAFFIC LIMITED TO PICKUP TRUCKS AND OCCASIONAL HAUL TRUCKS. NO REPEATED HAUL TRUCK TRAFFIC OR TRACK VEHICLES ALLOWED.
7. NO COMPACTION REQUIRED FOR ZONE 4 PLACED OVER CPK BUTTRESS AND PIXIE DUST COVER MATERIAL PLACED WITHIN THE SPILLWAY CHANNEL.
8. ES2 COLETANCHE ROLLS WITH NO IDENTIFICATION TAG OR SPLIT ROLLS MAY BE USED FOR INSTALLATION IN THE SPILLWAY. NO LIMIT ON THE NUMBER OF ALLOWABLE WELDS HAS BEEN SET. WELDS ARE TO BE ORIENTATED SUCH THAT THE OVERLAP FACES DOWNSTREAM.
9. SETTING OUT COORDINATES TO BE CONFIRMED WITH AS-BUILT CONSTRUCTION.
10. TEMPORARY PLYWOOD TO BE PLACED OVER LINER WITHIN 0.1 m OF SURVEYED CREST OF NEW LINER PRIOR TO PLACEMENT OF 50 mm MINUS CRUSH COVER. PLYWOOD TO BE REMOVED FOR LINER TIE-IN DURING NEXT PHASE OF WORK.
11. THE FULL WIDTH OF THE CPK BUTTRESS UPSTREAM OF POINT B2 SHALL FOLLOW THE DETAILS IN SECTION S.

SCALE IN METRES (SCALE A): 0 15 30 45 60 75
SCALE IN METRES (SCALE B): 0 5 10 15 20 25
SCALE IN METRES (SCALE C): 0 1 2 3 4 5
SCALE IN METRES (SCALE D): 0 0.2 0.4 0.6 0.8 1

NOTE:
THE MODIFICATIONS TO THE SPILLWAY DESIGN PRESENTED IN THIS REVISION OF DRAWING 14111-41D1-6123 HAVE NOT BEEN INCLUDED IN DRAWINGS 14111-41D1-6100 TO 14111-41D1-6124. THE REVISION OF THIS DRAWING SUPERSEDES THE SPILLWAY DESIGN PRESENTED IN DRAWINGS 14111-41D1-6100 TO 14111-41D1-6124. THE SPILLWAY DESIGN PRESENTED IN DRAWINGS 14111-41D1-6100 TO 14111-41D1-6124 WILL BE UPDATED AS PART OF THE CONSTRUCTION RECORD PACKAGE.

REV	MM/DD/YY	REVISION	DES	CHK	DRW	CHK	RVW
1	09/17/15	SPILLWAY RELOCATED	G.P.	G.P.	J.K.	J.K.	J.C.C.
0	08/21/12	ISSUED FOR CONSTRUCTION	J.E.K.	G.P.	J.D.	JK	J.C.C.
A	04/24/12	ISSUED FOR CLIENT REVIEW	J.E.K.	J.E.K.	J.D.	J.K.	J.C.C.

REVISIONS

NUMBER	SUBJECT	REVISION

SPECIFICATIONS

REFERENCE TITLE

REFERENCES

THE ASSOCIATION OF PROFESSIONAL ENGINEERS, GEOLOGISTS and GEOPHYSICISTS OF THE NORTHWEST TERRITORIES
PERMIT NUMBER
P 049
GOLDER ASSOCIATES LTD.

STAMP/SEAL

ORIGINAL SIGNED AND SEALED

CLIENT: DIAVIK DIAMOND MINES INC.

CONSULTANT: Golder Associates

PROJECT: DIAVIK DIAMOND MINES INC. PKC FACILITY - PHASE 6 CONSTRUCTION

DRAWING TITLE: **PHASE 6 SPILLWAY PLAN, PROFILE AND CROSS-SECTIONS**

PROJECT No.	PHASE No.	TASK No.
11-1328-0006	4000	3000

ORIGINAL SHEET SIZE	DRAWING No.	REVISION
ANSI D	14111-41D1-6123	1