AREVA

Kiggavik Project

Environmental Impact Statement

Tier 3 Technical Appendix 2E

Conceptual Freshwater Diversions and Wasterock Collections Channels

December 2011

September 2011

KIGGAVIK PROJECT

Conceptual Freshwater Diversions and Wasterock Collection Channels for Kiggavik and Sissons Sites Volume 2E

Submitted to:
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REPORT

Report Number: 09-1362-0610/8000

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1.0 INTRODUCTION

AREVA Resources Canada Inc. (AREVA) is proposing to develop the Kiggavik Uranium Project (the Project) located approximately 80 kilometres (km) west of Baker Lake, Nunavut. Two mine development areas are planned for the project. These are the Kiggavik site and the Sissons site, with ore processing at the Kiggavik site. The Kiggavik site consists of three open pit mines, clean waste rock piles, ore storage, the mill and water treatment facilities, the main camp and other ancillary structures. The Kiggavik site occurs primarily in the Pointer Lake drainage area. The Sissons site consists of one open pit, an underground mine, waste rock and ore storage areas, a small camp and other ancillary buildings. The Sissons site is within the Shack Lake drainage. Both the Pointer Lake drainage and the Shack Lake drainage report to Judge Sissons Lake.

This report provides a conceptual design for water management on the Kiggavik and Sissons mine footprint areas. The focus is to separate clean runoff draining from upstream and clean runoff generated within the site boundaries from potential contaminant source within the mine footprint areas. the site to reduce water treatment requirements and to provide continuity of flow in existing drainage pathways where possible. Drainage around the site is facilitated with freshwater diversion channels which take advantage of local topography to route flow around the site through channels constructed using berms and excavations depending on the channel alignment topography. All channels are designed to convey runoff from a probable maximum precipitation (PMP) event of 184 mm over a 24 hour period. Detailed topography and contributing areas for the design of the fresh water diversion channel were obtained from the available LiDAR data. The watershed boundary and flow pathways were derived using the GIS application ARC-Hydro.

2.0 SCOPE OF WORK

The scope of this work involves preliminary designs and concept drawings for the Kiggavik and Sissons sites including:

- determine runoff volumes and flow pathways during the PMP event;
- design of diversion channel to intercept runoff from natural stream channel and overland flow pathways to convey flow around the core facilities area;
- align the diversion channel to discharge to the natural receiving watercourse down gradient of the core facilities areas; and
- design of collection channels to manage the PMP runoff from clean waste rock piles and pass the drainage through sedimentation pond prior to release in the receiving environment.

3.0 BACKGROUND

The Project is located in the Southern Arctic terrestrial ecozone, which is characterized by continuous permafrost. Summers are short (approximately four months) and cool and winters are long and cold. Low precipitation and extremely low winter temperatures characterize the regional climate. The topography is gently undulating, and is filled with hummocks and patterned ground resulting from permafrost. Vertical drainage is impeded by the permafrost layer, and wetlands, small ponds, and lakes are common over the landscape. Rock outcrops along a ridge trending northeast near the Kiggavik site provides strong local relief.

Climate and permafrost play an important role in the hydrological regime of this area. Peak stream discharges in the region are a result of spring melt, which can account for most of the total annual runoff. Throughout the summer and fall, the active layer of permafrost increases, thereby increasing the amount of storage available. . Secondary peaks are common in the late summer or early fall periods, due to precipitation later in the season. Most streams freeze-off as winter progresses and there is very little flow from even larger streams that drain areas of hundred square kilometres.

The closest meteorological station with long climate records is at Baker Lake. According with this station, the mean annual precipitation is about 270 mm and about 156 mm falls as a rain. Adjusted precipitation data for Baker Lake is also available and are often used for hydrological investigations. These values are primarily adjusted for snow gauge undercatch. The adjusted annual precipitation is 344 mm, with 169 mm occurring as rain. The extreme daily rainfall recorded was 52.1 mm in July 30 of 1975 while the extreme daily snow fall (30.3 cm) was recorded in November 1 of 1977. Snow cover is expected for about eight months of the year and the average maximum snow depth at month-end (54 cm) occurs in March or April. The extreme snow depth recorded (119 cm) was in May 1 of 1978.

The mean annual temperature from a daily average is approximately -11.8°C. The month with the maximum mean daily is July (11.2°C) while January presents the minimum mean daily (-32.4°C). The extreme maximum temperature (33.6°C) was recorded in July 18 of 1989, while the extreme minimum (-50.6°C) was recorded in January 20 of 1975.

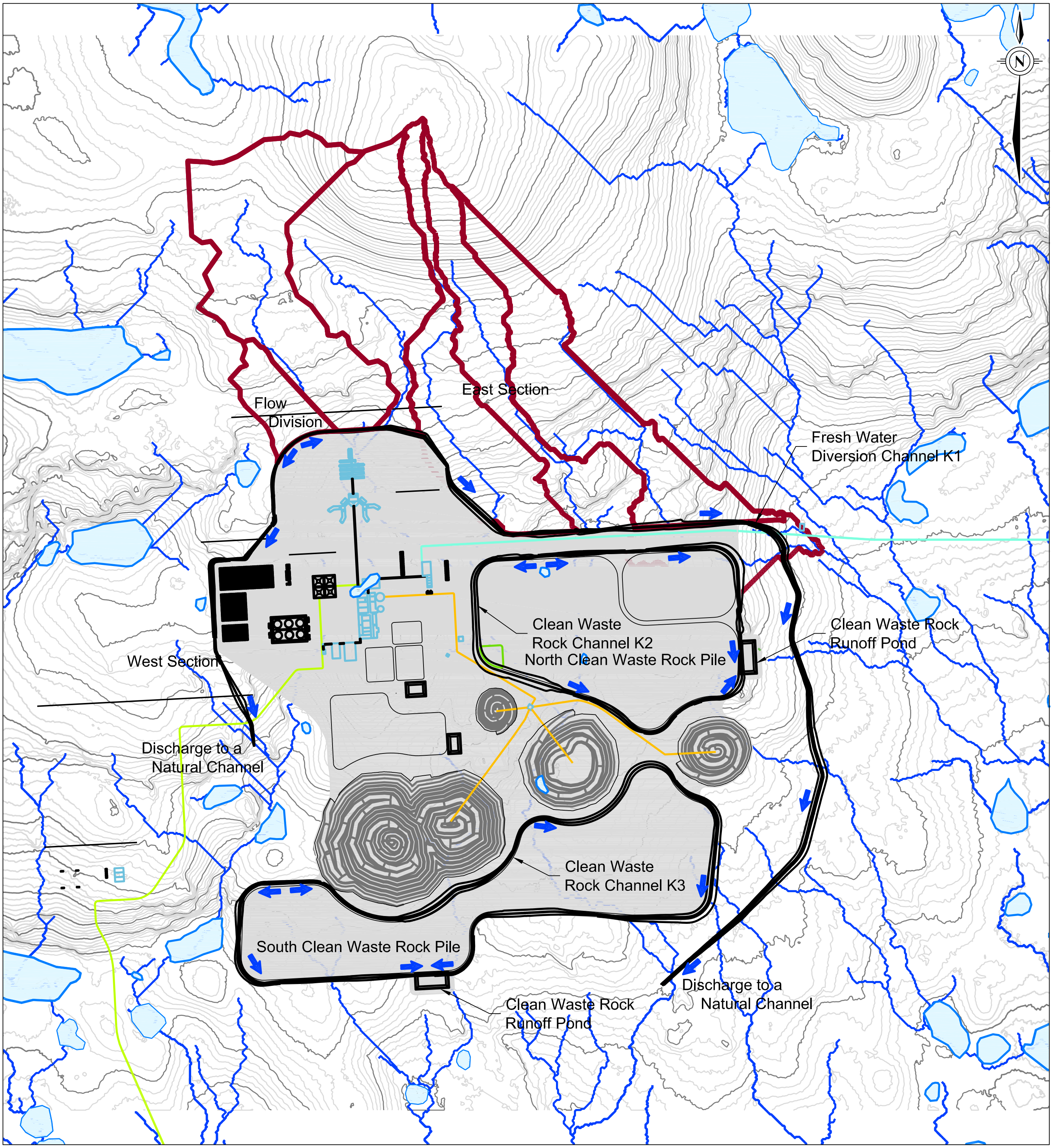
The average wind speed ranges from 16.9 km/h in June to 23.9 km/h in January, with the most frequent wind direction is from the north and northwest. A maximum hourly speed of 124 km/h was recorded in February 19 of 1959. Permafrost conditions are expected to be similar to those found at the Diavik Mine, where the seasonal active layer is expected to be between 1.5 to 2.0 m deep in till deposits, about 2 to 3 min well drained granular deposits, but in poorly drainage areas the active zone is expected to be less than 1 m depth (Nishi-Khon/SNC - Lavalin 1999).

4.0 KIGGAVIK SITE

The runoff management strategy within the site consists of the construction of drainage channels around the north and south clean waste rock piles to collect runoff water for passive treatment in exterior sediment ponds to reduce potential sediment loads prior to releasing flow to the natural receiving drainages. Runoff generated from outside the core facilities area, but draining toward the site will be collected in a diversion channel and redirected around the site to be discharged to the same natural pre-development drainage system. Figure 1 illustrates the main water management features at the Kiggavik site including the freshwater diversion and clean waste rock collection channels, topographic surfaces, drainage boundaries and runoff pathways.

Strong topographic gradients direct drainage from north toward the Kiggavik site from upland areas, while areas to the west and east side will drain primarily away from the site (Figure 1). Therefore, a diversion channel is required along the north side to collect all the runoff from the northern drainage areas and the channel will be aligned around the east and west sides of the site to reach the natural streams which will carry the runoff to Pointer Lake.

For the clean waste rock piles, channels to collect runoff will be located along the pile perimeter. These channels will collect runoff and direct discharge to the sedimentation ponds, which will drain to natural drainage pathways.



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SCALE 1:25,000 METRES

Legend

- Topographic Contour (1m Interval)
- Drainage Pathway
- Watershed Boundary
- Proposed Diversion Channel

Note:
Contours derived from LIDAR Survey, 2010

Reference:
Site Layout provided by AREVA, December 2010
NTS Mapsheet 66A05
NAD83 UTM Zone 14

PROJECT

AREVA

KIGGAVIK PROJECT

TITLE

KIGGAVIK SITE - DRAINAGE AREAS, STREAM FLOW PATHS, AND DIVERSION CHANNEL ALIGNMENTS

DRAFT

Golder Associates
Saskatoon, Saskatchewan

PROJECT	09-1362-0610	FILE No.	
DESIGN		SCALE AS SHOWN	REV. 0
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FIGURE: 1

G:\2009\1362\09-1362-0610 AREVA Kiggavik Baseline and EIA\KI08_Environment\D_Hydrology\CAD\ Drawing file: KI08D145 - Site Layout with Drainage Lines.dwg Sep 27, 2011 - 8:43am

4.1 Fresh Water Diversion Channel (K1) and Contribution Areas

Drainage areas reporting to the northern boundary of the Kiggavik site is provided in Figure 1. Runoff from the uplands to the north drains down slope toward the northern border of the site through numerous small flow pathways, and stream channels. The freshwater diversion channel, referred to as K1, will be located along the west, north and east boundary of the Kiggavik site footprint to collect water from all the natural pathways draining downslope. The highest elevation of the diversion channel invert is at the northwest corner of the site boundary. From this point, the flow in the diversion channel will be directed either east or south. The section flowing south passes around the west side of the core facilities area and is aligned with a natural channel approximately 1,500 m downstream of the high point in the channel. Once in the natural channel, flow passes southward through a series of small interconnected waterbodies which border the western side of the site. Flow continues southward through well established natural channels, ultimately discharging to Pointer Lake, approximately 2 km downstream.

The channel section flowing initially eastward turns south along the eastern margin of the site. The channel passes around the east side of the south clean waste rock pile and discharges to a natural channel that also drains to Pointer Lake and is the receiving channel that carries most of the flow passing through the footprint area under natural conditions.

The channel alignment and stationing is provided in Appendix I, Figure 001. The total length of the fresh water diversion channel is approximately 6,200 m. This channel stationing begins at the west side where the west segment discharges to the natural drainage system (station 0+000) and extends around the site to the southern outlet (station 6+184). The channel flow direction divide is located at station 1+471 and thus the direction of the flow would be from Station 1+471 to Station 0+000 on the west side (West Section in Figure 1), and from station 1+471 to station 6+184 at the north and east sides (East Section in Figure 1). East Section (K1)

This portion of the diversion channel will be constructed around the north and east boundary of the Kiggavik site as shown in Figure K1. Runoff contribution to the north ditch section is from a series of drainage pathways that flow from an uplands area and are intercepted by the diversion channel. Most of the runoff reporting to the east boundary is collected from drainages north of the site footprint. Once the diversion channel turns southward addition flow is intercepted from small drainages occurring between the east site footprint boundary and the diversion channel.

For design purposes, small drainage areas are delineated and channel sub-sections are defined for the cumulative increase in discharge along the channel length. The first section starts at station 1+470 and collects runoff from the westernmost of the north drainage areas. Diversion channel inflow increases as the channel passes eastward and additional drainage pathways are intercepted. The discharge for the new sections will be the combination of the local runoff plus the discharge contributed from sections upstream. The same rational is used for the southward flowing end of the diversion channel where three small drainages are intercepted. A summary of the local contributing areas for each of the sub-sections (K1-1E to K1-12E) is provided in Table 1. This table also includes the proposed slope for the channel bottom in each section. The total channel length of the East Section is approximately 4,920 m.

Table 1: East Segment Channel Sections and Contributing Drainage Areas

Channel Sub-section	From Station	To Station	Length (m)	Proposed Channel Bottom Slope (m/m)	Local Contributing Area (km²)
K1-1E	1+470	1+796	326	0.007	0.10
K1-2E	1+796	1+994	198	0.007	0.57
K1-3E	1+994	2+253	259	0.007	0.48
K1-4E	2+253	2+680	427	0.022	-
K1-5E	2+680	3+130	450	0.022	0.38
K1-6E	3+130	3+393	263	0.022	0.36
K1-7E	3+393	3+495	102	0.030	-
K1-8E	3+495	3+908	413	0.030	0.47
K1-19E	3+908	4+130	222	0.006	-
K1-10E	4+130	4+800	670	0.006	0.08
K1-11E	4+800	5+280	480	0.006	0.09
K1-12E	5+280	6+390	1110	0.006	0.16

Flow direction: from K11E to K1-12E; Channel Sub-section 11E receives the discharge from the north waste pile sediment pond.

4.1.1 West Section (K1)

This portion of the diversion channel will be constructed around the west boundary of the Kiggavik site as shown in Figure 1. As illustrated in the figure, comparatively small drainage areas report to the channel along this segment and the channel is sub-parallel to the natural drainage direction, so less runoff is intercepted.

For designing purposes the west segment is divided in two main sections (Table 2). The highest channel invert elevation in the west section is located at station 1+470, and the channel flow direction is south to station 0+000, where the diversion channel discharges to a natural channel. The design flow for section K1-1W is the runoff reported from the local drainage area along the length of the section, while for section K1-2W includes local runoff draining directly to the channel plus the discharge from section 1W. The overall length of the west channel is 1,470 m.

Table 2: West Segment Channel Sections and Contributing Drainage Areas

Channel Sub-section	From Station	To Station	Length (m)	Proposed Channel Bottom Slope (m/m)	Local Contributing Area (km²)
K1-1W	1+470	0+550	920	0.012	0.05
K1-2W	0+550	0+000	550	0.039	0.01

Flow direction: from 1W to 2W.

4.2 Clean Waste Rock Channels

Drainage channels will be constructed around the clean waste rock piles with gradients generally following natural topography with the highest channel invert consistent with the area of highest topographic elevation around the pile perimeter. The channels will be constructed to flow in two directions from the channel flow divide location and terminating in a sedimentation pond at the lowest topographic location. The channel flow divide for both, the north and south waste rock piles, is at the northwest corners (Figure 1). The sedimentation ponds are at the south and at the east for the south and north piles, respectively. It is assumed that the piles will develop with a side slope 4H:1V but not higher than 50 m; therefore the runoff reporting to the ditches will increase with distance from the channel divide to the sedimentation ponds. The north clean waste rock pile channel has an approximately length of 3,500 m, while the length of the south clean waste rock pile channel is 5,600 m (Appendix I, Figure 001).

Sub-sections with changes in channel cross-section area due to gradual increase in discharge are defined. Due to the symmetry of the waste rock piles, runoff is expected to reach the channels at a uniform rate but contributes to flow at the outlet at varying times. For design purposes, the channels are divided in sub-section lengths of approximately 200 m to 300 m, to accumulate the gradual increase of discharge along the ditch from its headwater to its outlet at the sedimentation pond.

4.2.1 North Pile Clean Waste Rock Pile (K2)

The north pile clean waste rock runoff collection channel is referred to as K2. The stationing for the channel begins near the sedimentation pond (station 0+000) and ends near the sedimentation pond (station 3+3444) in counter clockwise direction. The channel flow divide is near station 1+600 (Appendix I, Figure 001). The channel is divided in 16 sub-sections as show in Table 3 and the direction of flow will be from sub-section K2-7 to sub-section K2-1 and from sub-section K2-8 to sub-section K2-16. The total drainage area is the clean waste pile surface area. For modeling purposes the runoff contributing area to each channel sub-section is equal to the sub-section length and upslope to the midpoint along the long axis of the top of the pile. The design flow for successive downstream sub-sections consists of runoff from the sub-section, plus the discharge from upstream sub-sections. Runoff from the north clean waste pile is discharged into the sedimentation pond located at the east side of the pile. Outflow from the sedimentation pond will be directed into a channel that drains to the freshwater diversion channel (Appendix I, Figure 001).

Table 3: Channel Sections K2 and Contributing Drainage Areas for the North Clean Waste Pile

Channel Sub-section	From Station	To Station	Length (m)	Proposed Channel Bottom Slope (m/m)	Contributing Area (km²)
K2-1	0+000	0+250	250	0.020	0.054
K2-2	0+250	0+500	250	0.020	0.054
K2-3	0+500	0+750	250	0.020	0.054
K2-4	0+750	0+900	150	0.020	0.032
K2-5	0+900	1+150	250	0.007	0.054
K2-6	1+150	1+400	250	0.007	0.054
K2-7	1+400	1+610	210	0.007	0.045
K2-8	1+610	1+750	140	0.011	0.030
K2-9	1+750	1+950	200	0.011	0.043
K2-10	1+950	2+100	150	0.011	0.032
K2-11	2+100	2+350	250	0.044	0.054
K2-12	2+350	2+615	265	0.002	0.057
K2-13	2+615	2+800	185	0.002	0.040
K2-14	2+800	3+000	200	0.002	0.043
K2-15	3+000	3+250	250	0.002	0.054
K2-16	3+250	3+444	194	0.002	0.042

4.2.2 South Clean Waste Rock Pile (K3)

The south clean waste rock channel is referred to as K3. Stationing for the south clean waste rock pile begins near the sedimentation pond at 0+00 and ends at 5+593. The flow divide is at station 4+300 with stationing in a counter clockwise direction. The channel is divided in 22 sub-sections as show in Table 4. The direction of flow is from sub-section K3-17 to sub-section K3-1, and from sub-section K3-18 to sub-section K3-22. The total drainage area associated with the pile surface is divided into sections proportional to the length of the sub-section to the midpoint on the long axis of the top of the pile. The design flow for sub-sections downstream consists of runoff reporting to the sub-section area, plus the discharge from sub-sections upstream. Runoff from the south clean waste pile is discharges to a sedimentation pond located on the south side of the pile. Outflow from the sedimentation pond will drain to a natural flow pathway leading to Pointer Lake (Appendix I, Figure 001).

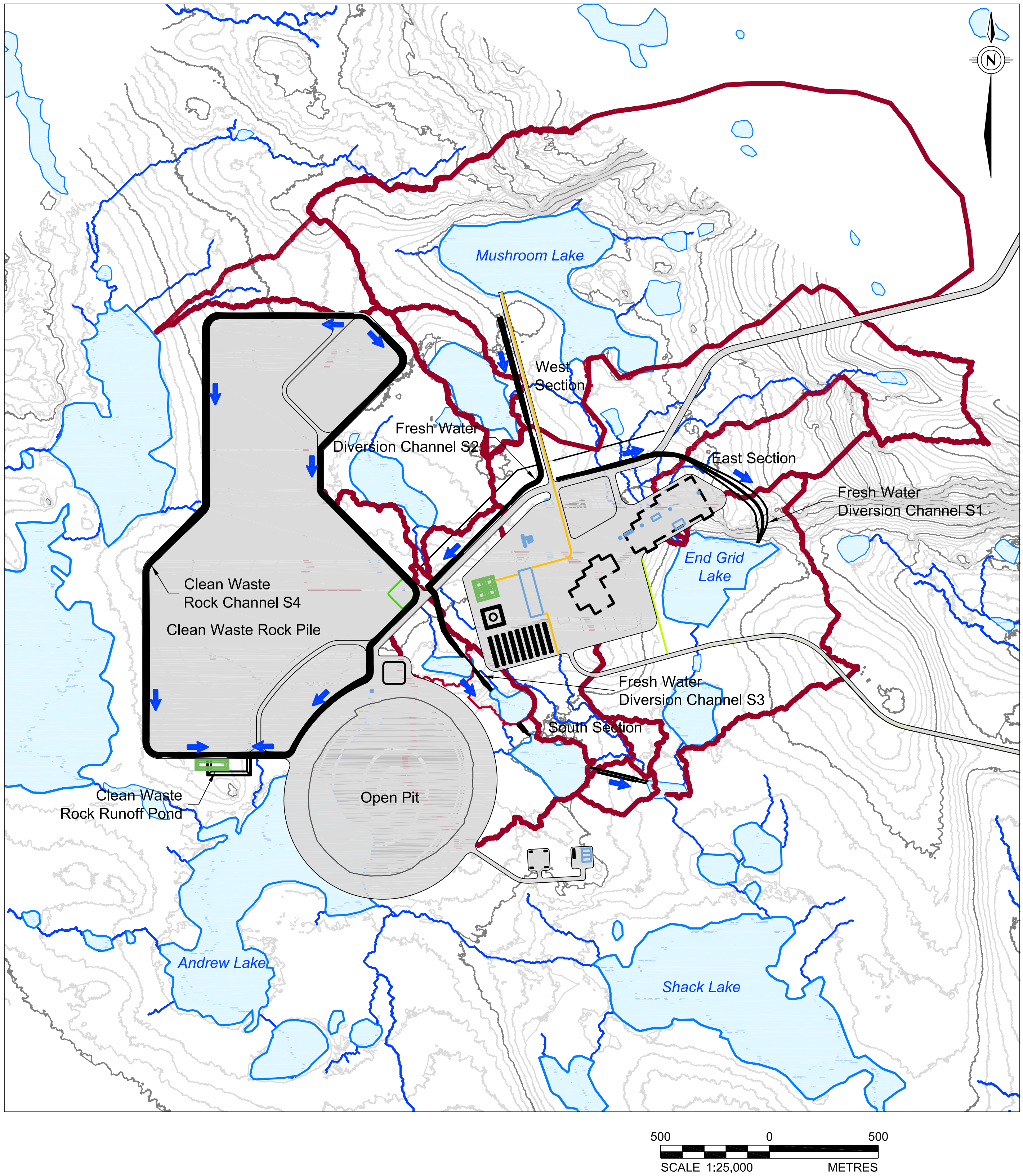
Table 4: Channel Section K3 and Contributing Drainage Areas for the South Clean Waste Pile

Channel Sub-section	From Station	To Station	Length (m)	Proposed Channel Bottom Slope (m/m)	Contributing Area (km²)
K3-1	0+00	0+250	250	0.004	0.038
K3-2	0+250	0+500	250	0.004	0.038
K3-3	0+500	0+750	250	0.004	0.038
K3-4	0+750	1+050	300	0.004	0.045
K3-5	1+050	1+250	200	0.003	0.030
K3-6	1+250	1+500	250	0.003	0.038
K3-7	1+500	1+800	300	0.003	0.045
K3-8	1+800	2+100	300	0.003	0.045
K3-9	2+100	2+250	150	0.001	0.023
K3-10	2+250	2+500	250	0.001	0.038
K3-11	2+500	2+750	250	0.001	0.038
K3-12	2+750	3+000	250	0.001	0.038
K3-13	3+000	3+250	250	0.001	0.038
K3-14	3+250	3+500	250	0.001	0.038
K3-15	3+500	3+750	250	0.007	0.038
K3-16	3+750	4+000	250	0.007	0.038
K3-17	4+000	4+300	300	0.007	0.045
18	4+300	4+600	300	0.030	0.045
19	4+600	4+750	150	0.006	0.023
20	4+750	5+000	250	0.006	0.038
21	5+000	5+300	300	0.006	0.045
22	5+300	5+593	293	0.006	0.044

5.0 SISSONS SITE

The Sissons site is located approximately 20 km southwest of the Kiggavik site. The main water management features include a runoff collection channel around a clean waste rock pile area and two fresh water diversion channels that intercepts flow from natural channels draining from the north. Based on LiDAR topography and an assessment using the GIS application ARC-Hydro, drainage toward the mine footprint area typically from the north and east. Areas south and west drain away from the site (Figure 2).

The freshwater diversion channel has three main sections, one flowing eastward around the core facilities area and reporting to Grid Lake , the second flowing initially south and then west to discharge to the third section that flows southward through a series of small ponds, and discharges to a natural stream channel which reports to Shack Lake. The clean waste rock pile area is located at the west side of the site and will have a runoff collection channel (S4) around the perimeter that drains to a sedimentation pond on the south side. Outflow from the sedimentation pond will flow to Andrews Lake.



Legend
- Topographic Contour (1m Interval)
- Drainage Pathway
- Watershed Boundary
- Proposed Diversion Channel

Note:
Contours derived from LIDAR Survey, 2009

Reference:
Site Layout provided by AREVA, December 2010
NTS Mapsheet 66A05
NAD83 UTM Zone 14

PROJECT
AREVA
KIGGAVIK PROJECT

TITLE
SISSONS SITE - DRAINAGE AREAS, STREAM FLOW PATHS, AND DIVERSION CHANNEL ALIGNMENTS

Golder Associates
Saskatoon, Saskatchewan

PROJECT		09-1362-0610	FILE No.	
DESIGN			SCALE AS SHOWN	REV. 0
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CHECK				
REVIEW				

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G:\2009\1362\09-1362-0610 AREVA Kiggavik Baseline and EIA\KI08_Environment\D_Hydrology\CAD\ Drawing file: KI08D145 - Site Layout with Drainage Lines.dwg Sep 28, 2011 - 2:08pm

5.1 Fresh Water Diversion Channel and Contribution Areas

A detail of the topography, drainage areas and flow pathways reporting to the north border of the Sissons site are illustrated in Figure 2. Details for the channel alignment and stationing are provided in Appendix I, Figure 007.

5.1.1 East Section – S1

This section of the channel will collect runoff from the drainages north of the site, including the Mushroom Lake outflow channel. The length of this channel section is approximately 1,200 m. Stationing for the this section begins at its discharge end at Grid Lake (station 0+000) and ends at station 1+200. The channel intercepts Mushroom Lake outflow at approximately at station 0+900. The channel continues another 300 m (station 1+200) westward to collect runoff from a small area east of the proposed road to Mushroom Lake (Figure 2). The site access road will cross the channel at station 0+750, likely using corrugated steel pipes (CSP) for cross-drainage.

A large rock ridge along the north side of Grid Lake requires that large excavation will be required to construct the channel draining flows down to Grid Lake. The existing natural channel gradient has been used as an analogue for the gradient design of the lower 500 m of this section down to Grid Lake. The objective of matching this gradient is to reduce the likelihood that Mushroom Lake and Grid Lake would become isolated from one another in terms of fish access.

For design purposes, the length of this section of the channel is divided in six sub-sections to evaluate the gradual increase in the discharge downstream or to indicate channel gradient changes. A summary of the sub-sections and the local contributing areas for each is provided in Table 5.

Table 5: East Sections S1 and Contributing Drainage Areas

Channel Sub-section	From Station	To Station	Length (m)	Proposed Slope (m/m)	Local Contributing Area (km²)
S1-1	1+210	0+890	320	0.002	0.056
S1-2	0+890	0+743	147	0.002	2.7
S1-3	0+743	0+587	156	0.002	0.22
S1-4	0+587	0+297	290	0.0071	0.48
S1-5	0+297	0+160	137	0.0071	0.23
S1-6	0+160	0+000	160	0.0278	-

Flow direction: from sub-section 1E to 6E.

5.1.2 West Section (S2)

This section of the channel collects runoff from the area immediately west of the proposed road to Mushroom Lake including the small lake that currently appears to drains in two directions, though the channels are not well defined. The headwater of this section of the diversion channel occurs south of Mushroom Lake. The channel extends south following the proposed road to Mushroom Lake, turning southwest until reaching the southeast corner of the clean waste rock pile. The stationing begins near Mushroom Lake at 0+000 and extends to 1+478 near the south east corner of the clean waste rock pile (Apendix1, Figure 007). A short natural channel connecting draining a peanut shaped waterbody also flows to the outlet of the west section. Cross-drainage at the road near the end of channel section S2 would likely be provided with CSP's.

For design purposes, the length of this section of the channel is divided in five sub-sections which mark the gradual increase in discharge from a combination of additional local runoff plus the discharge contributed from sections upstream. A summary of the local contributing areas for each of the sections is provided in Table 6. This table also include the proposed slope for the sections.

Table 6: West Segment Channel Sections and Contributing Drainage Areas

Channel Sub-section	From Station	To Station	Length (m)	Proposed Slope (m/m)	Local Contributing Area (km^2)
S2-1	0+000	0+310	310	0.002	0.034
S2-2	0+310	0+515	205	0.002	0.192
S2-3	0+515	0+768	253	0.002	0.032
S2-4	0+768	1+080	312	0.002	0.032
S2-5	1+013	1+478	398	0.004	0.042

Flow direction: from sub-section 1W to 5W.

5.1.3 South Section (S3)

This section of the freshwater diversion channel follows a series of poorly defined channels and seepage pathways connecting three shallow waterbodies east and south of the clean waste rock pile. The outlet of the channel reports to a small unnamed waterbody south of the site, which also receives flow from Grid Lake. Flow from the unnamed waterbody drains to Shack Lake, and ultimately to Judge Sissons Lake (Figure 2). The south channel section receives flow from the west section (S2), plus inflow from small adjacent drainage areas east of the clean waste rock pile and northeast of the open pit. The length of the section is approximately 1,500 m, including the shallow waterbody surface lengths.

For design purposes, four channel sub-sections are identified with the end of sub-section at the outlet of the waterbodies along the channel alignment. The design is simplified to estimate the flow cross-sectional area required to convey the peak flow reported to the beginning of the section assuming that the small shallow waterbodies do not offer much attenuation capacity. A summary of the sub-sections is provided in Table 7.

Table 7: South Segment S3 Channel Sections and Contributing Drainage Areas

Channel Sub-section	From Station (m)	To Station (m)	Length (m)	Proposed Slope (m/m)	Local Contributing Area (km²)
S3-1	0+000	0+446	413	0.006	0.48
S3-2	0+446	0+761	160	0.017	0.06
S3-3	0+761	1+176	140	0.006	0.08
S3-4	1+176	1+146	370	0.009	0.13

Flow direction: from sub-section 1S to 5S.

5.2 Clean Waste Rock Channels (S4)

The clean waste rock pile has a perimeter length of approximately 6,000 m (Apendix1, Figure 007). Following the natural topography the highest channel invert elevation is at the northeast corner of the pile, while the proposed location for the sedimentation pond is at the low point along the south pile boundary. It is assumed that the pile height will increase to 50 m with a side slope of 4H:1V.

For design purposes, two main sections are considered for the channel; both starting with a gradual increase in runoff discharge from the flow divide location. The channels are divided in sub-sections that range from 200 m to 300 m in length, The subsections are based on the channel bottom gradient which is optimised to balance cut and fill requirements, depending on topography along the alignment. Runoff is generated to each subsection from an area based on the length of the channel to consider the gradual increase in flow along the channel.

The stationing begins east of the sedimentation pond near the southeast corner of pile (station 0+000) and ends at 5+600 near the sediment pond in a counter clockwise direction. The highest elevation point (flow divide point) is approximately at station 2+600. The ditch is divided in 25 sections as show in Table 8. The total drainage area associated to the pile is distributed into the sections proportional to the length of the section. The design flow for sections downstream corresponds to the runoff from the local area associate to the section, plus the discharge from sections upstream.

Table 8: Channel Sections and Contributing Drainage Areas for the Sissons Clean Waste Rock Pile

Channel Sub-section	From Station	To Station	Length (m)	Proposed Slope (m/m)	Local Contributing Area (km^2)
S1-1	5+600	5+750	150	0.002	0.048
S4-2	5+750	6+000	250	0.002	0.080
S4-3	6+000	6+100	100	0.002	0.032
S4-4	0+000	0+250	250	0.0042	0.080
S4-5	0+250	0+500	250	0.0042	0.080
S4-6	0+500	0+750	250	0.0042	0.080
S4-7	0+750	1+000	250	0.0042	0.080
S4-8	1+000	1+250	250	0.0042	0.080
S4-9	1+250	1+412	162	0.0042	0.052
S4-10	1+412	1+750	338	0.002	0.076
S4-11	1+750	2+000	250	0.002	0.056
S4-12	2+000	2+136	136	0.002	0.030
S4-13	2+136	2+400	264	0.006	0.059
S4-14	2+400	2+582	182	0.006	0.041
S4-15	2+582	2+738	156	0.0025	0.035
S4-16	2+738	3+200	462	0.008	0.104
S4-17	3+200	3+500	300	0.006	0.067
S4-18	3+500	3+727	227	0.006	0.051
S4-19	3+727	4+000	273	0.002	0.061
S4-20	4+000	4+200	200	0.002	0.045
S4-21	4+200	4+500	300	0.002	0.096
S4-22	4+500	4+750	250	0.002	0.080
S4-23	4+750	5+000	250	0.002	0.080
S4-24	5+000	5+250	250	0.002	0.080
S4-25	5+250	5+600	350	0.002	0.112

Flow direction: from sub-section 14 to 1 and from sub-section 15 to 25.

6.0 SURFACE WATER MANAGEMENT GUIDELINES

Section 4.2.3 of the *Construction Guidelines for Pollution Control Facilities at Uranium Mining and Milling Operations* developed by Saskatchewan Environment and Resource Management (SERM 2000) outlines criteria for surface water runoff management from clean waste rock piles:

- Drainage should be diverted to site surface water runoff collection pond, where possible, otherwise drainage should be directed to a sedimentation pond to settle out solids prior to the water entering a surface water body.

6.1 Extreme Rainfall Events

Rainfall intensity duration-frequency curves (IDF) were developed for Baker Lake, approximately 80 km west of the mine site. These data were developed by Environment Canada (2010) and are based upon historical rainfall records. The rainfall event with a 1 in 100 year return period and 24-hour duration for the Baker Lake area is

74.7 mm. The PMP event is estimated following the method described by Hopkinson (1994 and 1999) and WMO (1986). The estimated value for the Kiggavik area is 184 mm over a 24 hour period. The detail evaluation of the PMP is provided in Golder (2010). The PMP value is used for sizing freshwater diversion channels and for channels around clean waste rock piles to reduce the risk of clean water coming in contact with potential contaminants within the footprint area.

6.2 Storm flow Hydrologic Analysis

A hydrologic analysis is undertaken to estimate the storm flow event in the fresh water diversion channel and in the clean waste rock pile ditches resulting from a 24-hour extreme rainfall event on the contributing areas.

The 24-hour storm is distributed on time (the storm hyetograph) using the instantaneous intensity method, also known as the *Chicago* Storm distribution. The Chicago Storm hyetograph is estimated based in the IDF curves. The method assumes that IDF curve can be expressed by the following relationship:

$$i = \frac{a}{(t+b)^c}$$

Where "i" is intensity (mm/hr), a, b, and c are IDF parameters and "t" is the time distribution (minutes). The time to storm peak is determined from:

$$tp = r * td$$

Where "tp" is the time to peak and "r" is the ratio of time to peak versus storm duration (td), also known as the storm advance coefficient that normally ranges from 0.3 to 0.5. In this assessment "r" is assumed to be equal to 0.33. The parameter a, b and c are estimated using the IDF curves for Baker Lake. Specifically intensities associate 1-hr, 2-hr, 6-hr, 12-hr and 24-hr duration and a 100-year return period are used (Table 9). The following values were estimated:

$$a = 126.44; \quad b = 0; \quad c = 0.501$$

Results of the hourly rainfall distribution as a percentage for a 24 hour storm period (either a 1:100 year storm or a PMP) are provided in Figure 3. This hyetograph is applied to the 24-hr PMP storm estimated for the Kiggavik area.

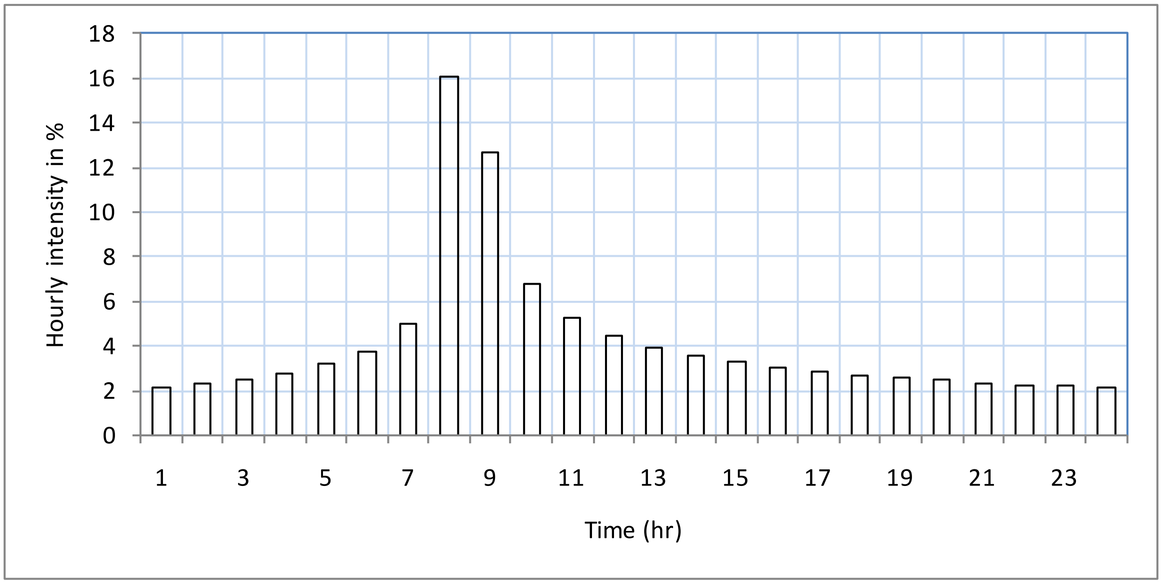

Figure 3: Hourly distribution of intensity in percentage for a 24-hr storm

6.3 Peak Flows and Total Runoff Volumes

The hydrological modeling system HEC-HMS, developed by the U.S. Army Corps of Engineers is used to simulate runoff from the 24-hour PMP event, to derive the peak flows and volumes as the design basis of the freshwater diversion channels and for the channels around the clean waste rock piles. Parameter and input information for the HEC-HMS were as follows:

- Estimates of drainage areas contributing runoff were based on available LiDAR for the site.
- The initial and constant loss methods were implemented in the model and were used to account for cumulative losses.
- The Soil Conservation Services (SCS) method in the HEC-HMS model was used to transform the precipitation excess into runoff. Overland flow length, surface slope and topographic characterization based on the LiDAR data were taken into account to estimate the approximate Lag-Time for peak flow, initial losses (depression storage and infiltration) and constant loss (infiltration) during the PMP event. Specifically the Lag-Time is estimated as 60% of the time of concentration as recommended by SCS.
- Time of concentrations for areas of interest is estimated using the Washington State Department of Transportation (WSDOT 2006) formula, i.e.,:

$$Tc = \frac{L}{k1\, S^{0.5}}$$

Where "Tc" is the time of concentration of a particular outlet in a basin in minutes (min), L is the length of the longest flow path in metres (m), k1 is a ground cover coefficient (m), and S is the surface slope (m/m). For this specific analysis the area of interest is basically bare ground. Consequently, a ground cover coefficient (k1) of 200 is used (WSDOT 2006).

- The Kinematic Wave routing model in HEC-HMS was used for flow routing through diversion channels and ditches. A standard trapezoidal flow cross-section was adopted to estimate the flow depth associated with peak flows.

7.0 HYDROLOGIC ANALYSIS RESULTS

The highest runoff scenarios for the site will occur under the presence of a rain PMP event or the rapid melting of large volumes of snow during the spring freshet. However, snowmelt is a much slower process when compared with a rainfall PMP event, i.e., the spring freshet would occur over several weeks, while the rain PMP event occurs over a period of 24 hrs. Consequently, it would be expected that the highest peak flow would occur under the PMP event of 24 hr duration (Figure 4). Based on snowcourse data from Baker Lake over the period 1965 to 2006, the maximum snow depth recorded was 188 mm (snow water equivalent) (SOCC 2008 internet site). This is similar to the PMP value but this snow volume would runoff over several weeks rather than 24 hours.

For the summer period, due to the permafrost and the gentle relief in the area, it would be expected soil moisture may be fairly high with surface drainage mainly confined within the active zone. For the spring freshet period the active zone has not been developed and a relative fast melting occurs over a frozen ground.

Due to the characteristics of a PMP event, i.e., high rainfall intensities in a relative short period, an initial loss of 10% of the PMP (i.e., 18 mm) and a constant loss rate of 0.5 mm/hr during the PMP are considered for the modeling process. These losses are comparatively small given the PMP magnitude of 184 mm. The initial loss may vary depending on when the event occurs i.e., early or late summer, because the active layer will be deeper and potentially more storage will be available.

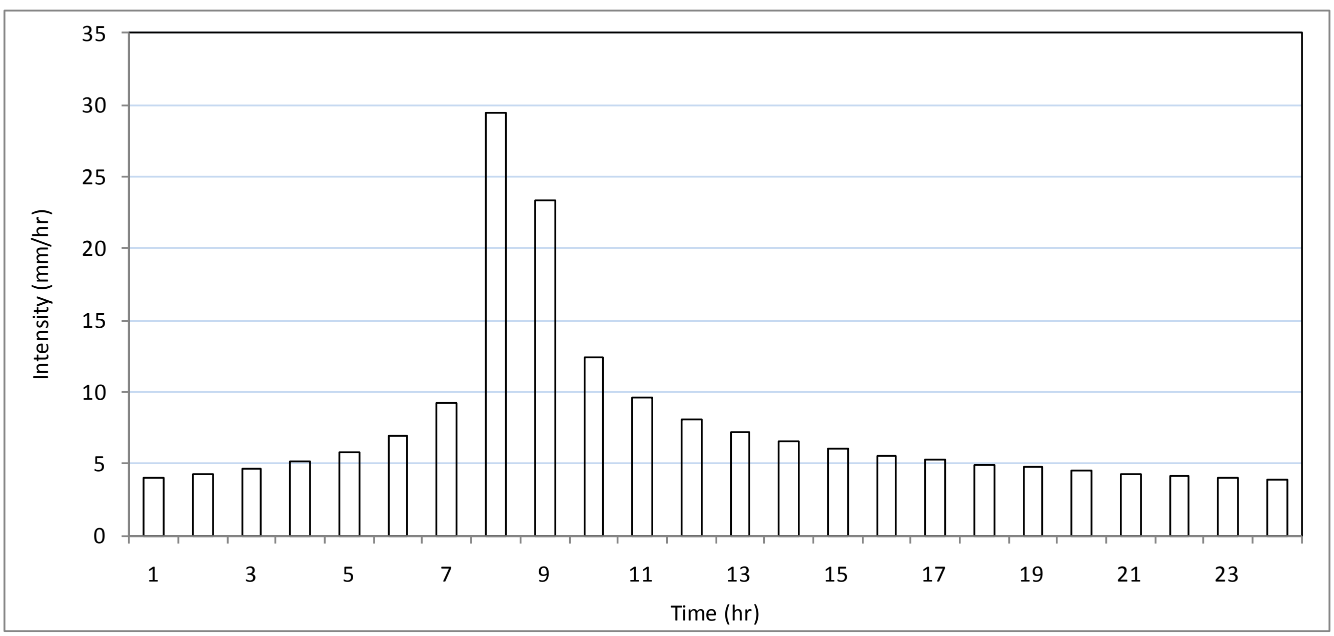

Figure 4: Distribution of Intensity versus Time for PMP 24-hour Storm at Kiggavik

7.1 Kiggavik Site

7.1.1 Freshwater Diversion Channel K1

Modeled peak flow and cross-sectional flow area results for each of the sub-sections considered for the diversion channel under the PMP distribution as show in Figure 4 are provided in Table 9. In this table, sub-section identifiers contain "E" to indicate the east section of the channel, while the west sections contain "W". Discharge hydrographs at the points where the diversion channels report to the natural drainage system are provided in Figure 5 for both sections.

Table 9: Freshwater Diversion Channel K1- Results for a PMP 24-hour Precipitation Event

Channel Sub-section	From Station	To Station	Total Contributing Area (km^2)	Peak Flow (m^3/s)	Cross-sectional Flow Area (m^2)	Proposed Slope %
K1-1E	1+470	1+796	0.10	1.4	1.36	0.68
K1-2E	1+796	1+994	0.67	4	2.94	0.68
K1-3E	1+994	2+253	1.15	7.3	4.50	0.68
K1-4E	2+253	2+680	1.15	7.3	2.96	2.22
K1-5E	2+680	3+130	1.53	9.8	3.64	2.22
K1-6E	3+130	3+393	1.89	12.2	4.26	2.22
K1-7E	3+393	3+495	1.89	12.2	3.83	2.99
K1-8E	3+495	3+908	2.36	15.5	4.54	2.99
K1-9E	3+908	4+130	2.36	15.5	8.05	0.61
K1-10E	4+130	4+800	2.44	15.9	8.20	0.61
K1-11E	4+800	5+280	2.53[a]	20.1	9.73	0.61
K1-12E	5+280	6+390	2.69[a]	20.4	9.83	0.61
K1-1W	1+470	0+550	0.05	0.8	0.72	1.15
K1-2W	0+550	0+000	0.06	0.9	0.52	3.86

[a] Sub-sections K1-11E and K1-12E receive runoff from the north clean waster rock pile.

Flow direction from subsection K1-1E to K1-12E and from sub-section K1-1W to K1-2W.

The discharge increases gradually in the east diversion channel from sub-sections K1-1E to K1-12E. Table 9 includes the expected peak flow in each of the sections together with the required cross-sectional flow area to convey the peak discharge. Sections at the west side of the core facilities area will have small peak flows to convey; therefore the cross-section geometry of this portion of the channel is much smaller and the design is more for constructability rather than for hydraulic requirements.

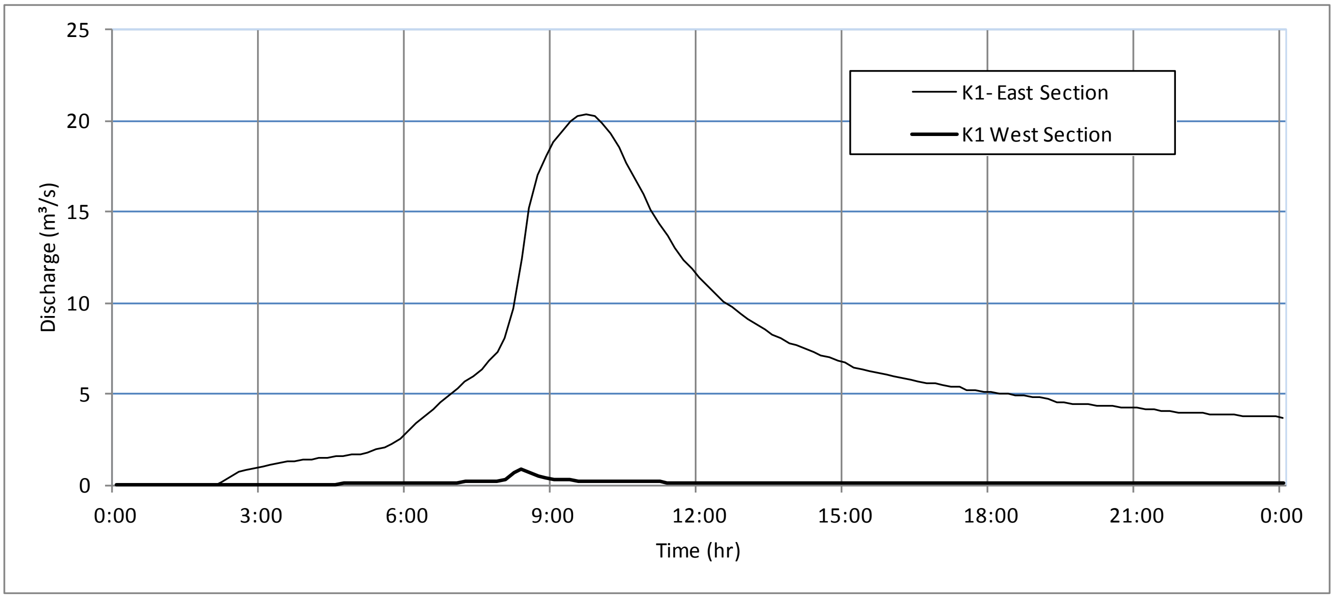

Figure 5: Hydrograph from the PMP 24-hour Storm for both East and West Sections of the Diversion at their Respective Outlet Locations

7.1.2 Channels for the Clean Waste Rock Piles

A similar procedure followed for the diversion channel is used for estimating the peak design flow for the ditches around the clean waste rock piles.

7.1.2.1 North Clean Waste Rock Pile K2

Peak flow and cross-sectional flow area for each of the 16 sub-sections defined for the north clean waste rock pile channel resulting from a PMP event are provided in Table 10. Both, sub-sections K2-1 and K2-16 discharge into the clean waste sedimentation pond located near station 0+000 and station 3+444 respectively, at the southeast end of the pile. Discharge hydrographs at the locations where the channels report to the sediment and the outflow from the sediment pond are provided in Figure 6. The peak flow under a PMP event from the sedimentation pond is 7.7 m^3/s.

Table 10: North Waste Rock Pile Channel K2 - Results for a PMP 24-hour Precipitation Event

Channel Sub-section	From Station	To Station	Total Contributing Area (km²)	Peak Flow (m³/s)	Cross-sectional Flow Area (m²)	Proposed Slope %
K2-1	0+000	0+250	0.345	5.1	2.2	2.0
K2-2	0+250	0+500	0.292	4.3	2.0	2.0
K2-3	0+500	0+750	0.238	3.6	1.7	2.0
K2-4	0+750	0+900	0.185	2.8	1.4	2.0
K2-5	0+900	1+150	0.152	2.4	1.9	0.7
K2-6	1+150	1+400	0.099	1.6	1.4	0.7
K2-7	1+400	1+610	0.045	0.7	0.8	0.7
K2-8	1+610	1+750	0.030	0.5	0.5	1.1
K2-9	1+750	1+950	0.073	1.2	1.0	1.1
K2-10	1+950	2+100	0.105	1.7	1.3	1.1
K2-11	2+100	2+350	0.159	2.6	1.0	4.4
K2-12	2+350	2+615	0.216	3.4	3.9	0.2
K2-13	2+615	2+800	0.256	3.8	4.2	0.2
K2-14	2+800	3+000	0.299	4.3	4.6	0.2
K2-15	3+000	3+250	0.352	4.8	5.0	0.2
K2-16	3+250	3+444	0.394	5.1	5.2	0.2
K2-17	-	-	0.739	7.7	2.7	2.6

Flow direction: from sub-section K2-7 to K2-1 and from sub-section K2-8 to K2-16.

Sub-section K2-17 is the release from the sediment pond to the north clean waste rock pile.

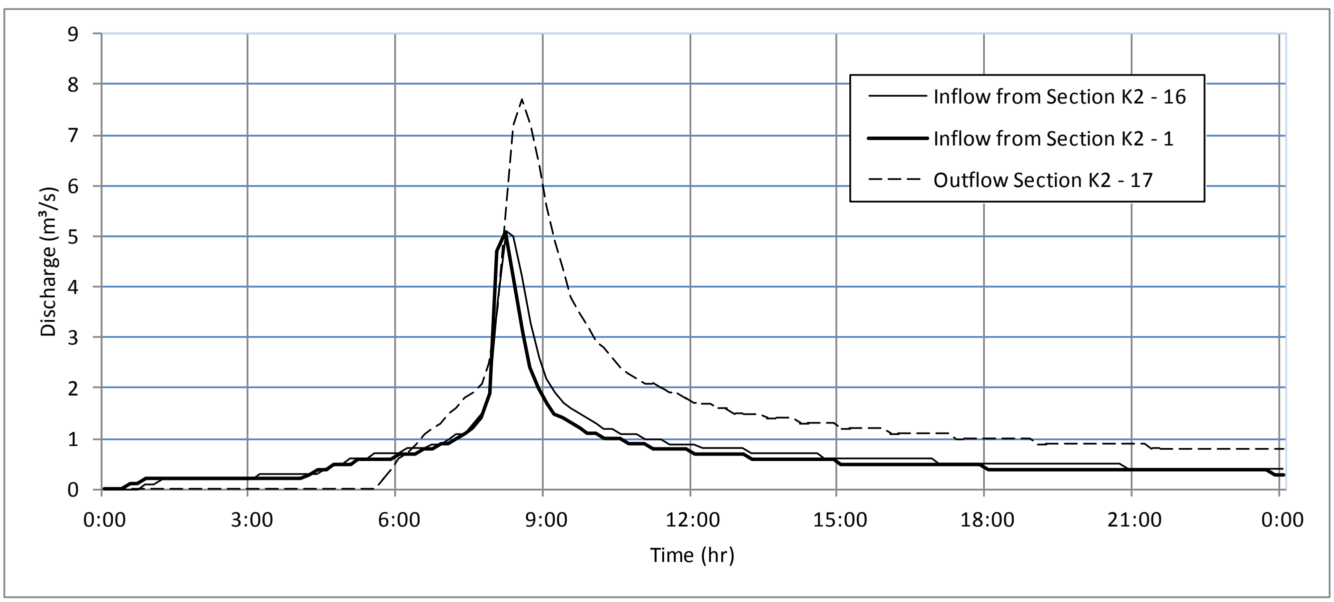

Figure 6: Hydrograph from the PMP 24-hour Storm for the Section K2- 1 and K2-15 at the Discharge Point to the Sediment Pond for the North Waste Rock Pile

7.1.3 South Clean Waste Rock Pile K3

Peak flow and cross-sectional flow area results for each of the 22 sub-sections defined for the collection channel around the south clean waste rock pile channel under the PMP event are provided in Table 11. In this table, sections labels increase numerically in counter clockwise direction. The direction of the flow is clockwise from Station 4+200 to Station 0+00, i.e., from section 17 to section 1, and counter clockwise from station 4+200.00 to station 6+602.00, i.e., from section 18 to section 22. Both, sections 1 and 22 discharge into the clean waste sediment pond located near station 0+00 along the south side. Discharge hydrographs at the points where the ditch channels report to the sediment pond are provided in Figure 7.

Table 11: South Waste Rock Pile Ditch - Results for a PMP 24-hour Precipitation Event (184 mm)

Channel Sub-section	From Station	To Station	Total Contributing Area (km²)	Peak Flow (m³/s)	Cross-sectional Flow Area (m²)	Proposed Slope %
K3-1	0+000	0+250	0.646	6.0	4.6	0.7
K3-2	0+250	0+500	0.608	5.7	4.4	0.7
K3-3	0+500	0+750	0.571	5.4	4.2	0.7
K3-4	0+750	1+050	0.533	5.1	4.1	0.2
K3-5	1+050	1+250	0.488	4.8	4.1	0.2
K3-6	1+250	1+500	0.458	4.6	4.0	0.2
K3-7	1+500	1+800	0.421	4.3	3.8	1.0
K3-8	1+800	2+100	0.375	4.0	3.6	0.3
K3-9	2+100	2+250	0.330	3.7	5.1	0.3
K3-10	2+250	2+500	0.308	3.6	5.0	0.3
K3-11	2+500	2+750	0.270	3.4	4.8	0.2
K3-12	2+750	3+000	0.233	3.0	4.4	0.2
K3-13	3+000	3+250	0.195	2.6	3.9	0.2
K3-14	3+250	3+500	0.158	2.4	3.7	0.2
K3-15	3+500	3+750	0.120	1.8	1.5	0.2
K3-16	3+750	4+000	0.083	1.3	1.2	0.2
K3-17	4+000	4+300	0.045	0.7	0.8	0.2
K3-18	4+300	4+600	0.045	0.8	0.5	3.0
K3-19	4+600	4+750	0.068	1.1	1.2	0.4
K3-20	4+750	5+000	0.105	1.6	1.5	0.4
K3-21	5+000	5+300	0.150	2.3	2.0	0.4
K3-22	5+300	5+593	0.194	2.9	2.3	0.4

Flow direction: from sub-section 17 to 1 and from sub-section 18 to 22.

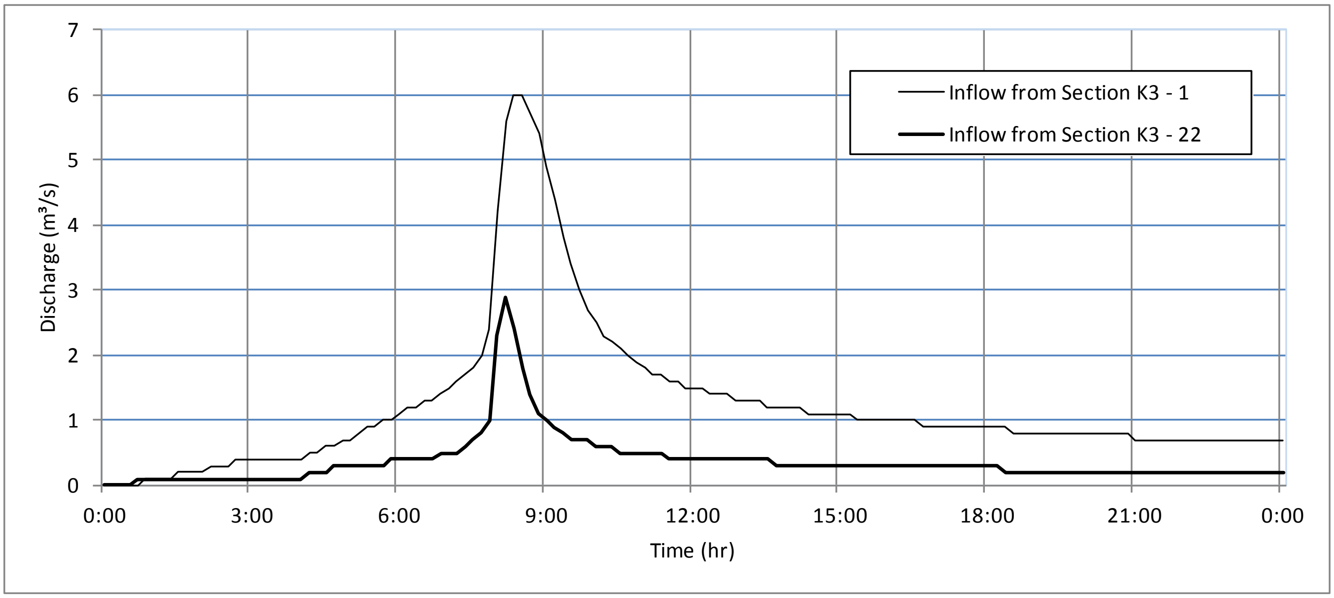

Figure 7: Hydrograph from the PMP 24-hour Storm for the Section 1 and 22 at the Discharge Point to the Sediment Pond for the South Waste Rock Pile

7.2 Sissons Site

7.2.1 Diversion Channel

Peak flow and cross-sectional flow area results are presented in Table 12 for each of the three main sections of the freshwater diversion channel. Peak flows are based on a PMP event. Diversion channel S1 is a separate channel, while channels S2 and S3 are connected (Figure 2, and Appendix I, Figure 007). Discharge hydrographs at the points where the diversion channels report to the natural drainage system are provided in Figure 8.

The discharge increases gradually into the east diversion channel from sections S1-1 to S1-6. Channel Section S1-2 receives the discharge for the large drainage area north of the site plus any amount form S1-1; therefore after S1-2 large discharges are observed downstream. Channel section S2 receives the discharges from three small lakes and their associated drainages (Figure 2) and transfers the flow to the S3 channel. Table 12 includes the expected peak flow in each of the sections together with the required cross-sectional flow area required to convey the peak. The peak flow at the outlet of channel S1 is 14m^3/s and 5.6 m^3/s at the outlet of channel S3.

Table 12: Freshwater Diversion Channels (S1 to S3) - Results for a PMP 24-hour Precipitation Event

Channel Sub-section	From Station	To Station	Total Contributing Area (km²)	Peak Flow (m³/s)	Cross-sectional Flow Area (m²)	Proposed Slope %
S1-1	1+210	0+890	0.056	0.7	1.3	0.2
S1-2	0+890	0+743	2.978	11.8	9.8	0.2
S1-3	0+743	0+587	3.462	13.4	10.8	0.2
S1-4	0+587	0+297	3.697	14.0	7.0	0.7
S1-5	0+297	0+160	3.697	14.0	7.4	0.7
S1-6	0+160	0+000	3.697	14.0	4.6	2.8
S2-1	0+000	0+310	0.034	0.3	0.7	0.2
S2-2	0+310	0+515	0.226	1.0	1.6	0.2
S2-3	0+515	0+768	0.258	1.1	1.8	0.2
S2-4	0+768	1+080	0.290	1.3	2.1	0.2
S2-5	1+013	1+478	0.332	1.7	2.0	0.4
S3-1	0+000	0+220	0.922	4.0	3.0	1.0
S3-2	0+275	0+325	0.981	4.3	2.3	1.7
S3-3	0+450	0+575	1.058	4.8	3.5	2.3
S3-4	0+770	0+825	1.189	5.6	3.4	1.5

Flow direction: from sub-section S1-1 to S1-6; S2-1 to S2-5 and for S3-1 to S3-4.

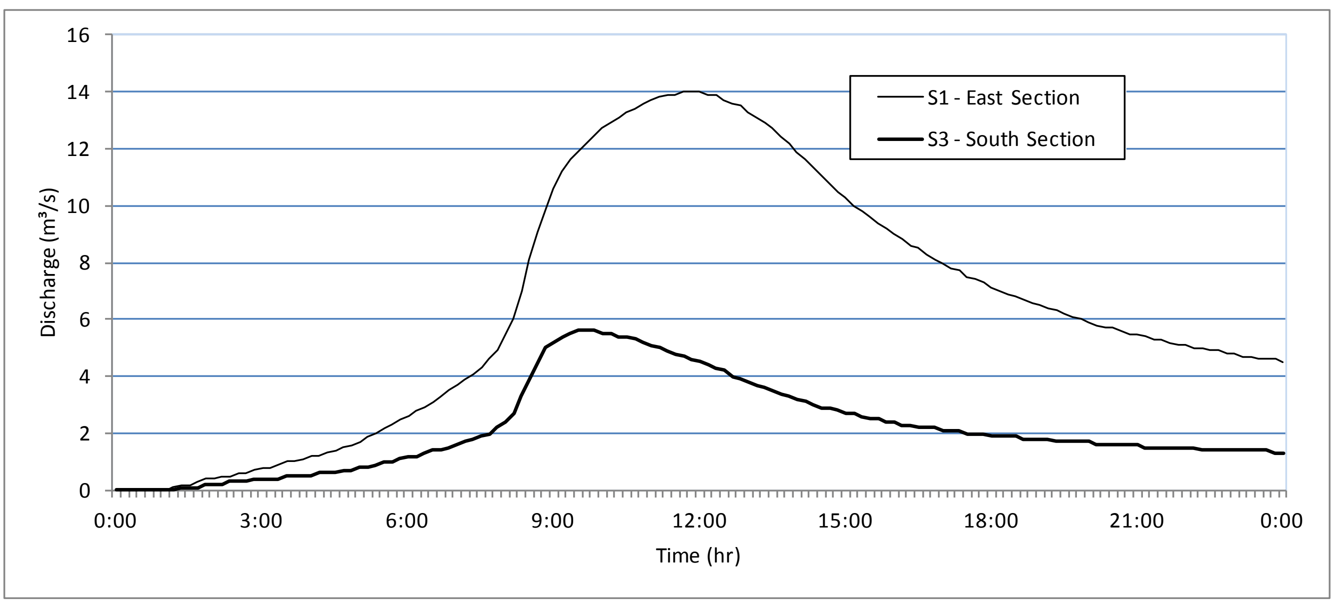

Figure 8: Hydrograph from the PMP 24-hour Storm for both Sections of the Diversion Channel Reporting to the Natural System. – Sissons Site

7.2.2 Channel for the Clean Waste Rock Pile S4

Peak flow and cross-sectional flow area results for each of the 25 sub-sections of the clean waste rock pile channel under a PMP event are provided in Table 13, and shown graphically in Figure 4. In this table, sub-sections labels increase numerically in counter clockwise direction. The direction of the flow would be clockwise from channel section S4-14 to channel section S4-1 and counter clockwise from station from channel sub-section S4-15 to sub-section 25. Both, channel sub-sections S4-1 and S4-25 discharge into the clean waste sediment pond located near station 5+600 at the south border of the pile. Discharge hydrographs at the points where the ditch channels report to the sediment pond are provided in Figure 9.

Table 13: Waste Rock Pile Channel S4 - Results for a PMP 24-hour Precipitation Event (184 mm)

Channel Sub-section	From Station	To Station	Total Contributing Area (km^2)	Peak Flow (m^3/s)	Cross-sectional Flow Area (m^2)	Proposed Slope %
S4-1	5+600	5+750	0.88	10.4	8.85	0.2
S4-2	5+750	6+000	0.83	9.9	8.53	0.2
S4-3	6+000	6+100	0.75	9.2	8.08	0.2
S4-4	0+000	0+250	0.71	9	6.03	0.4
S4-5	0+250	0+500	0.63	8.1	5.58	0.4
S4-6	0+500	0+750	0.55	7.3	5.16	0.4
S4-7	0+750	1+000	0.47	6.3	4.63	0.4
S4-8	1+000	1+250	0.39	5.4	4.13	0.4
S4-9	1+250	1+412	0.31	4.4	3.55	0.4
S4-10	1+412	1+750	0.26	3.9	4.27	0.2
S4-11	1+750	2+000	0.19	2.9	3.43	0.2
S4-12	2+000	2+136	0.13	2	2.61	0.2
S4-13	2+136	2+400	0.10	1.6	1.49	0.6
S4-14	2+400	2+582	0.04	0.7	0.83	0.6
S4-15	2+582	2+738	0.03	0.6	1.01	0.3
S4-16	2+738	3+200	0.14	2.3	1.75	0.8
S4-17	3+200	3+500	0.21	3.2	2.47	0.6
S4-18	3+500	3+727	0.26	3.8	2.80	0.6
S4-19	3+727	4+000	0.32	4.6	4.83	0.2
S4-20	4+000	4+200	0.36	5	5.13	0.2
S4-21	4+200	4+500	0.46	6	5.88	0.2
S4-22	4+500	4+750	0.54	6.8	6.45	0.2
S4-23	4+750	5+000	0.62	7.6	7.01	0.2
S4-24	5+000	5+250	0.70	8.4	7.55	0.2
S4-25	5+250	5+600	0.81	9.5	8.27	0.2

Flow direction: from sub-section S4-14 toS4-1 and from sub-section S4-15 to S4-25.

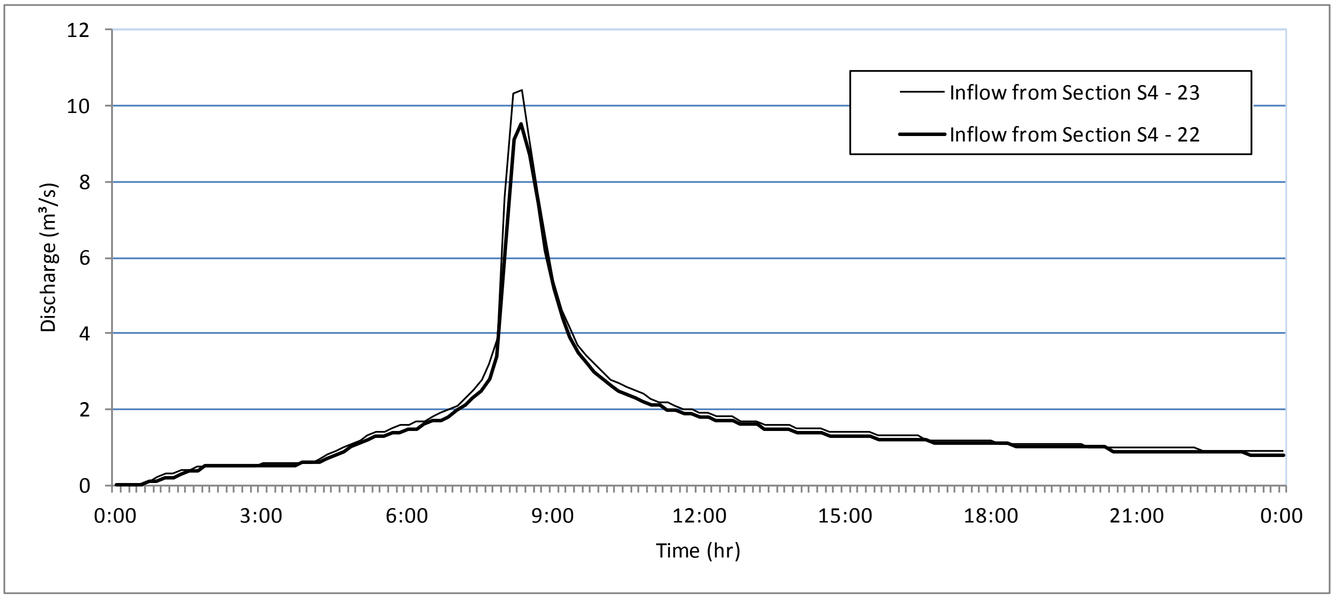

Figure 9: Hydrograph from the PMP 24-hour Storm for the Section 22 and 23 at the Discharge Point to the Sediment Pond. Waste Rock Pile - Sissons Site

7.3 General Consideration for Freshwater Diversion Channels

Details for the diversion channel, i.e. channel alignment, cross-sections and channel invert profiles are provided in Appendix A. A summary of the general considerations for the design of the diversion channels is as follows:

1) Channels are generally trapezoidal in shape with 3H:1V side slopes, though the natural ground may be used as one channel side when the channel is transverse across a slope and a berm is constructed on the opposite side to contain the flow.

2) The diversion channels will be constructed in one of three ways depending topography and geotechnical conditions. These are channels with invert at existing grade with built-up berms to contain the flow, channels with excavation in overburden, and channels with excavation in bedrock.

3) There is potential for erosion and sediment transport in the constructed diversion channels and the degree to which this occurs depends on mainly soil type, channel gradient, channel geometry and flow magnitude. At present, geotechnical investigations along the proposed channel alignment has not been undertaken but it is expected that each to the three construction cases indicated above will occur at various locations along channel alignments. The potential for erosion and sediment transport is greatest in the first two cased and is much less where the excavation occurs in bedrock. Where the channel is built-up or excavated through overburden, the soil type will be identified and evaluated with respect erosion potential under peak flow conditions. Where peak flow velocities exceed soil material resistance (allowable to shear stress), riprap armouring overlying a geotextile will be placed on the channel bottom and sideslopes. Hydraulic models will be used to use to determine the appropriate median diameter of the riprap to resist the flow velocity and the lift thickness will be about 1.5 times the median diameter. Rip rap will consist of clean waste rock or pit run material. These measures will greatly reduce likelihood of erosion and sediment transport in the constructed diversion channels (Nishi-Khon/SNC-Lavalin 1999).

4) As the channels are constructed in a permafrost environment there is potential for deformation in the constructed channel, and while detailed geotechnical investigations have not been conducted in the vicinity of the proposed channel it is assumed that the active layer thickness is 1.5 to 2 m, and channels will be constructed according to one or more of the three cases listed above. If the channel invert is cut to or into bedrock, then there is little concern with channel deformation. If the channel is constructed in till, to a depth of 1.5 to 2 m then there is potential for melting some permafrost below the adjacent active layer. If the permafrost below the pre-construction active layer is ice-rich (contains more frozen water than is required to fill the pore spaces) then likelihood and degree of deformation in the channel is greater and a modified design is required. General design approaches for the channel construction in ice-poor vs. ice-rich till is as follows:

   a. Ice-poor – the channel is cut with the geometry depending on local topography and required flow capacity. If riprap is required then the channel is over excavated an addition ~0.3 m to allow space for the riprap while maintaining the required cross sectional area

   b. Ice rich – The channel is over-excavated by 1 to 2 m deeper into the permafrost on the base and sides and compacted till placed in the oversized channel and built back up to the required channel geometry. Little deformation is expected in the in the ice-rich permafrost below the compacted fill.

   In addition to the design considerations implemented to reduce deformation in the channel due to permafrost melting, an ongoing monitoring and maintenance program will be in place (Nishi-Khon/SNC-Lavalin 1999).

8.0 SUMMARY

The draft conceptual designs and channel alignments provided in this document are intended to redirect fresh water around the core facilities areas to limit the amount of water which must be managed on the Kiggavik and Sissons sites and to maintain natural flow pathways where possible. All structures are designed to convey the PMP 24 hour storm. Further information regarding ground conditions and material types will be required to refine the design for these channels.

9.0 CLOSURE

We trust this submission meets your requirements. Should you have any questions or require further information please contact the undersigned. We appreciate the opportunity to conduct this work on your behalf.

Report Signature Page

Saul Marin, Ph.D.
Engineer-in-Training

Brent Topp, B.Sc., P.Geo
Associate, Senior Hydrologist

BT/SM/pls

n:\active\2009\1362\09-1362-0610 areva kiggavik 2009 baseline and deis\8000 hydrology 2010\miscellaneous reporting\kiggavik&sissons_design\diversion&ditches\report\09-1362-0610 rpt 11 sept 30 ditches and diversions_draft.docx

10.0 REFERENCES

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APPENDIX I

Diversion Channel Details

AREVA

KIGGAVIK PROKECT

SITE DRAINAGE
ISSUED FOR REVIEW

DRAWING NO.	DRAWING SHEET TITLE	REVISION NO.
0913620610-000	SITE DRAINAGE TITLE SHEET	A
0913620610-001	KIGGAVIK SITE DRAINAGE PLAN VIEW	A
0913620610-002	KIGGAVIK SITE DRAINAGE PROFILE VIEW	A
0913620610-003	KIGGAVIK SITE DRAINAGE PROFILE VIEW	A
0913620610-004	KIGGAVIKE SITE DRAINAGE K1 SECTION VIEW	A
0913620610-005	KIGGAVIK SITE DRAINAGE K2 SECTION VIEW	A
0913620610-006	KIGGAVIK SITE DRAINAGE K3 SECTION VIEW	A
0913620610-007	SISSONS SITE DRAINAGE PLAN VIEW	A1
0913620610-008	SISSONS SITE DRAINAGE PROFILE VIEW	A1
0913620610-009	SISSONS SITE DRAINAGE PROFILE VIEW	A1
0913620610-010	SISSONS SITE DRAINAGE S1 SECTION VIEWS	A
0913620610-011	SISSONS SITE DRAINAGE S2 SECTIONS VIEWS	A
0913620610-12	SISSONS SITE DRAINAGE S3 SECTION VIEWS	A
0913620610-13	SISSONS SITE DRAINAGE S4 SECTION VIEWS	A

NOTES:
1. SITE LAYOUT PROVIDED BY AREVA, JUNE, 2011
2. NTS MAPSHEETS 66A, 66B

DRAFT

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Saskatoon, Saskatchewan

REFERENCE

REVISIONS	No.	BY	DATE	APPROVED	DESCRIPTION
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SCALE: AS SHOWN
DRAWN:
CH'D:
APP'D:
DATE ISSUED
DATE

FUNCTION SITE DRAINAGE
ACTIVITY TITLE SHEET
SECTION
JOB

PROJECT NO. 09-1362-0610
FILE NAME. KI08D149 - Title Sheet for Site Drainage.dwg
DRAWING NO. 0913620610-000

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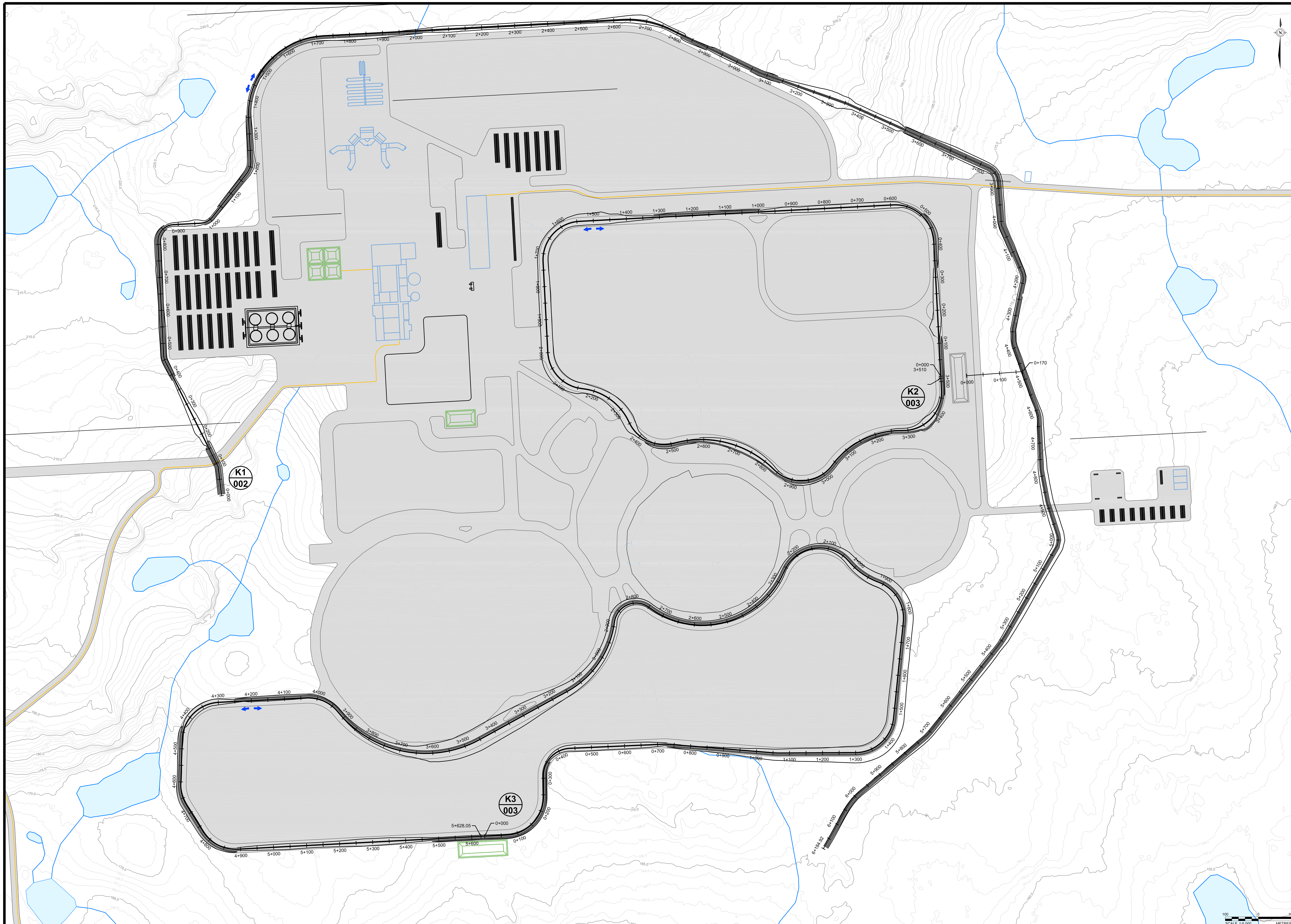

NOTES:
1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.
2. SITE LAYOUT PROVIDED BY AREVA, DECEMBER 2010.
3. NTS MAPSHEET 66A05.

LEGEND
CONTOUR (1m INTERVAL)
PROPOSED DIVERSION CHANNEL

DRAFT

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No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	17/03/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CH'D:
APP'D:
DATE ISSUED / DATE

FUNCTION: KIGGAVIK SITE DRAINAGE
ACTIVITY: PLAN VIEW
SECTION
JOB

PROJECT NO. 09-1362-0610
FILE NAME. KI08D140 - Kiggavik Site Drainage REV 4.dwg
DRAWING NO. 0913620610-001

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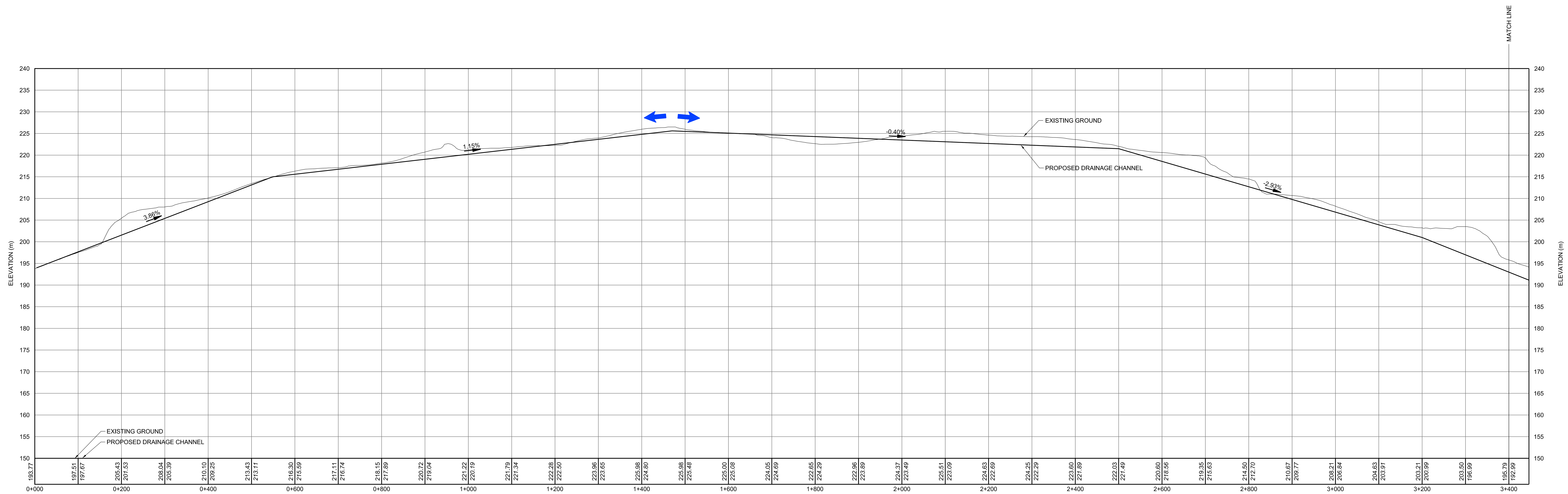

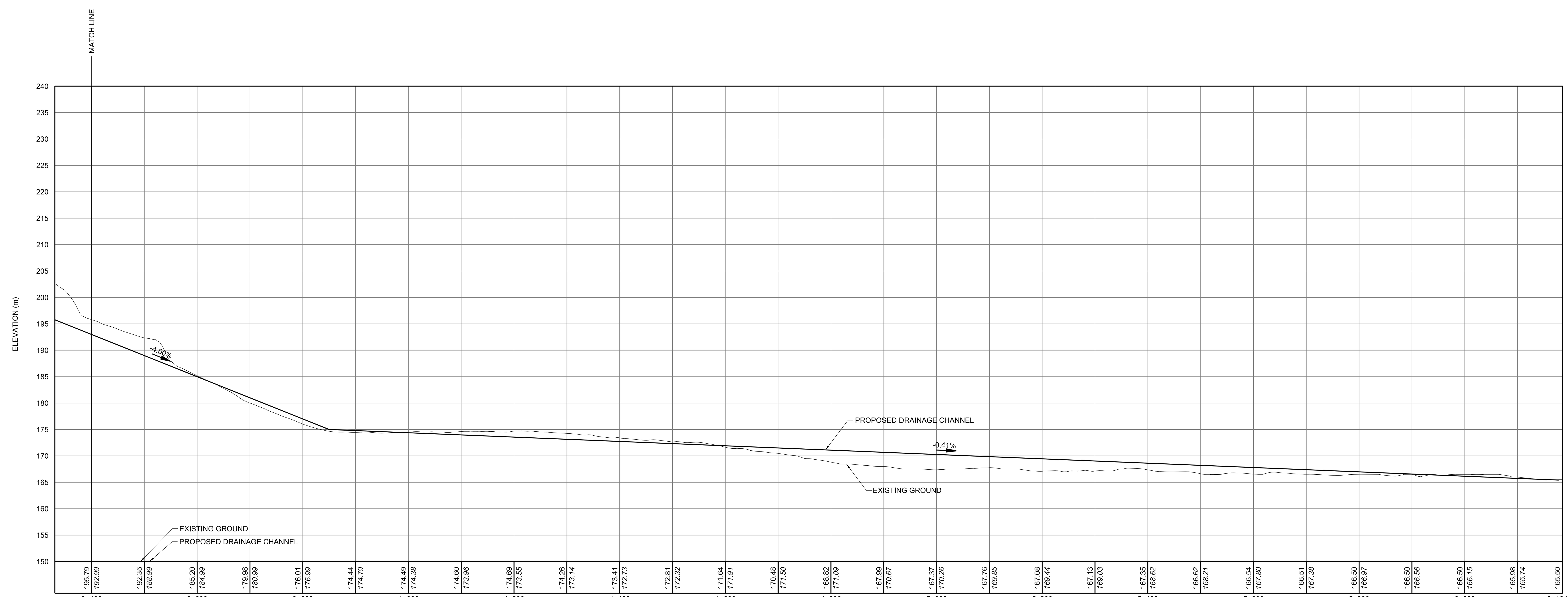

K1 / 001 **PROFILE K1**

VERTICAL — SCALE 1:500 METRES (10 0 10)

HORIZONTAL — SCALE 1:5,000 METRES (100 0 100)

DRAFT

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No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	17/03/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CHK'D:
APP'D:
DATE ISSUED / DATE

FUNCTION: KIGGAVIK SITE DRAINAGE
ACTIVITY: PROFILE VIEW
SECTION:
JOB:

PROJECT NO. 09-1362-0610
FILE NAME. KI08D140 - Kiggavik Site Drainage REV 4.dwg
DRAWING NO. 0913620610-002

REFERENCE
REVISIONS

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NOTES:
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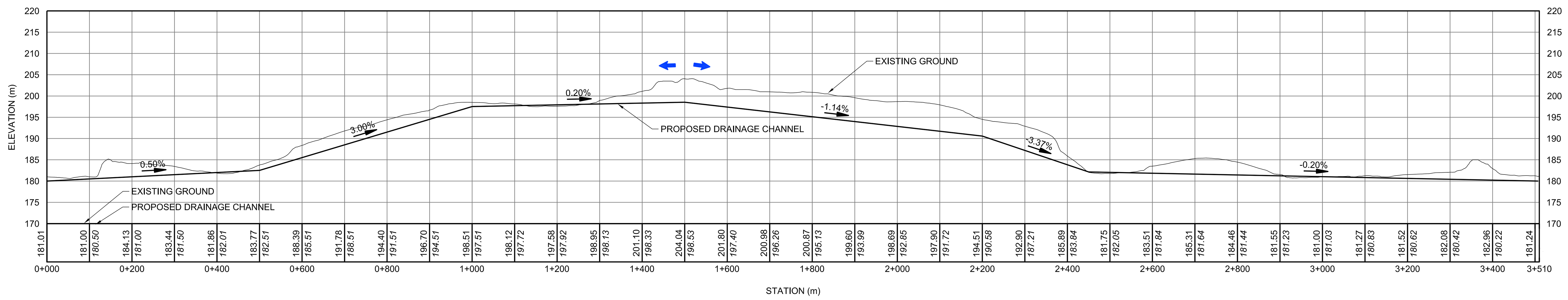

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K2 / 001

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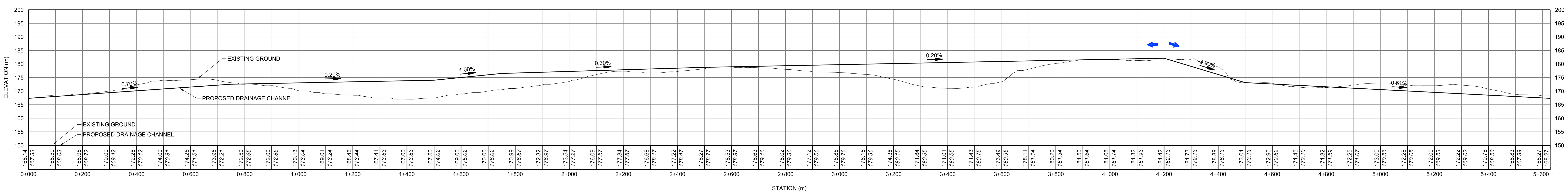
HORIZONTAL — SCALE 1:7,500 — METRES



PROFILE K3

K3 / 001

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HORIZONTAL — SCALE 1:7,500 — METRES

DRAFT

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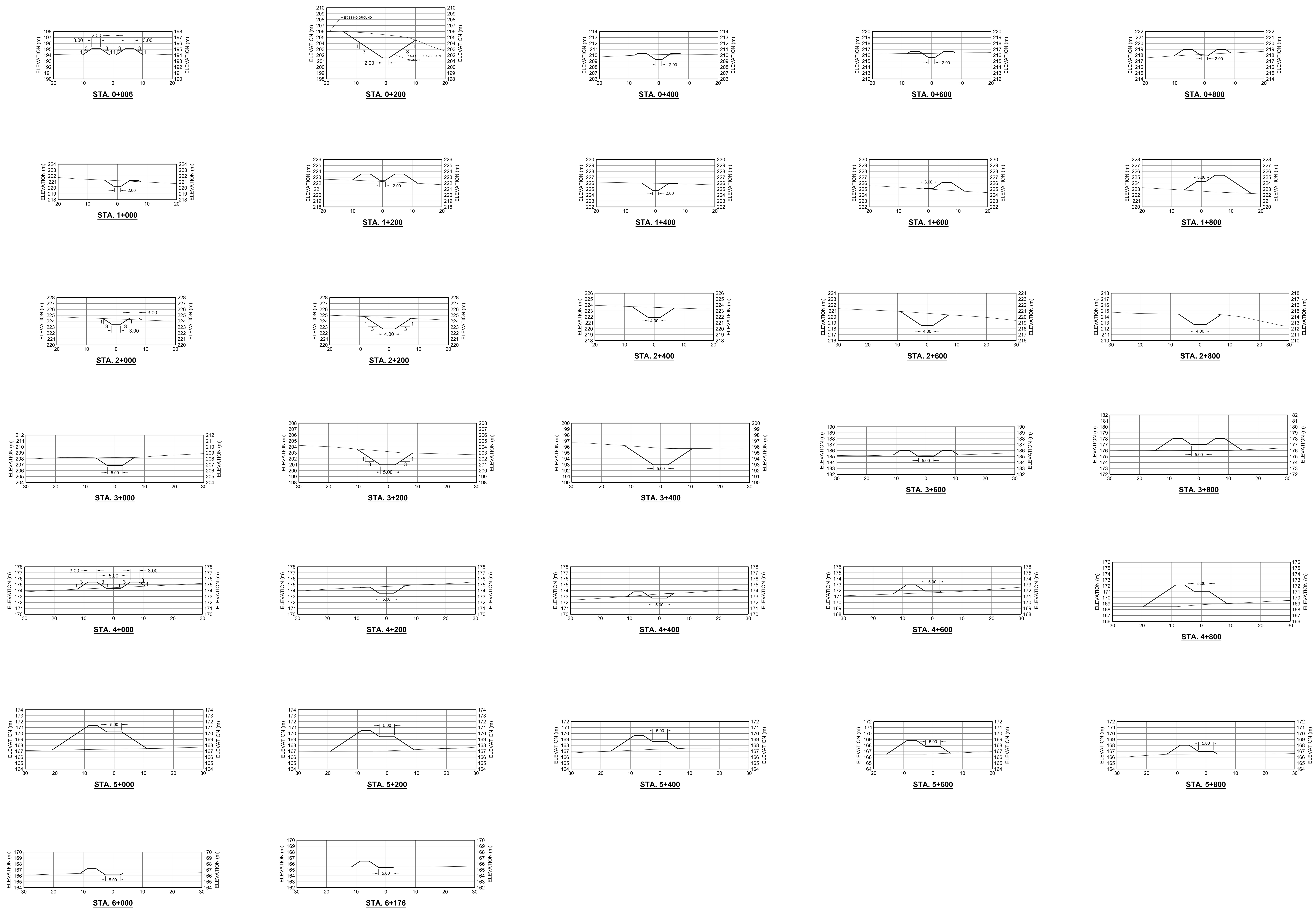
REVISIONS No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	05/04/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CHK'D:
APP'D:
DATE ISSUED / DATE

FUNCTION: KIGGAVIK SITE DRAINAGE
ACTIVITY: PROFILE VIEW
SECTION:
JOB:

PROJECT NO. 09-1362-0610
FILE NAME: KI08D140 - Kiggavik Site Drainage REV 4.dwg
DRAWING NO. 0913620610-003



NOTES:
1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.
2. ALL BERMS HAVE 3m CRESTS AND 3:1 SIDE SLOPES. CHANNEL BOTTOMS VARY AS SHOWN.

DRAFT

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No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	05/04/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CHK'D:
APP'D:
DATE ISSUED / DATE

FUNCTION: KIGGAVIK SITE DRAINAGE
ACTIVITY: K1 SECTION VIEW
SECTION:
JOB:

PROJECT NO. 09-1362-0610
FILE NAME: KI08D140 - Kiggavik Site Drainage REV 4.dwg
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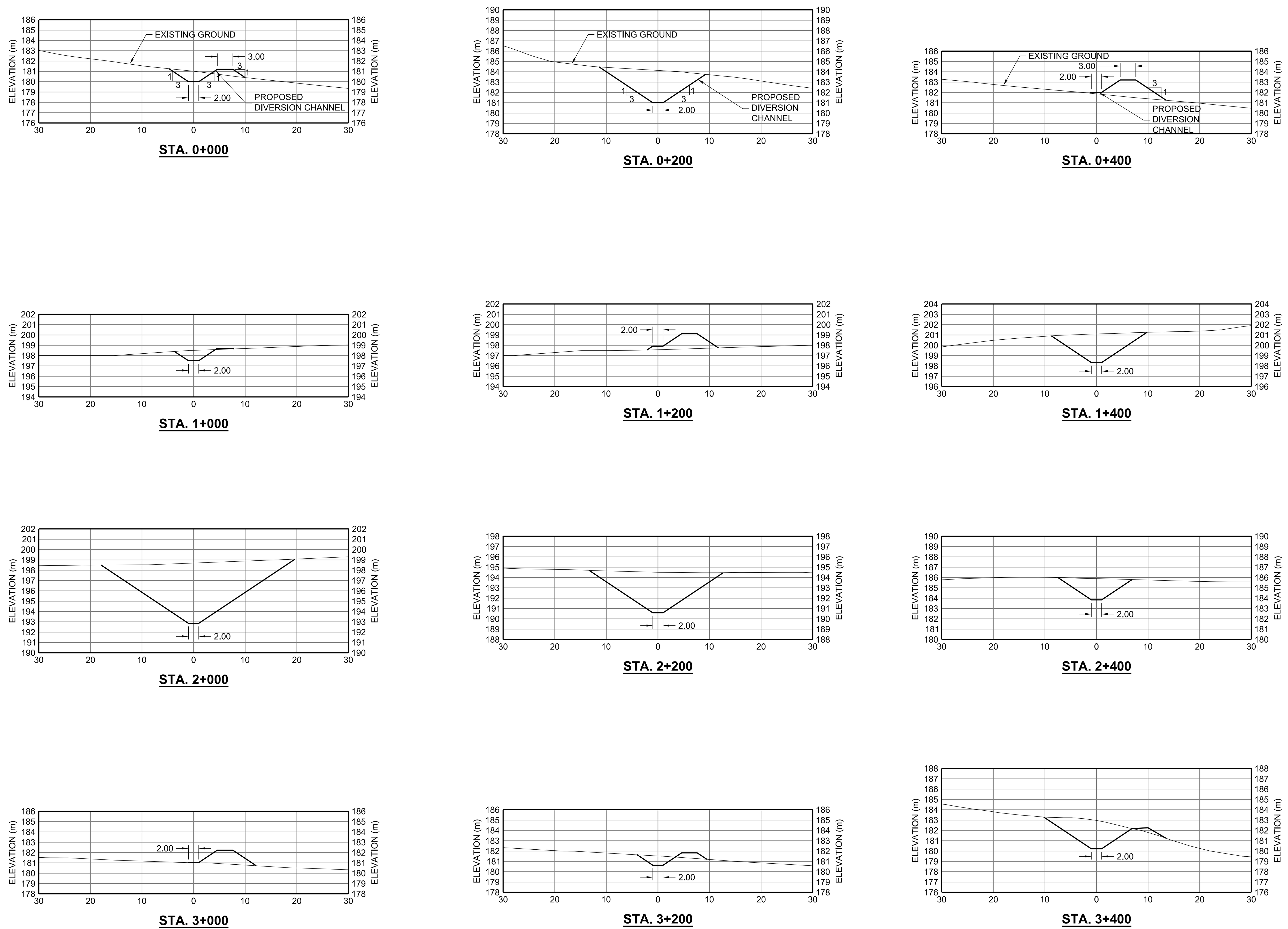
NOTES:
1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.
2. ALL BERMS HAVE 3m CRESTS AND 3:1 SIDE SLOPES. CHANNEL BOTTOMS VARY AS SHOWN.



DRAFT

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VERTICAL SCALE 1:300 METRES
HORIZONTAL SCALE 1:600 METRES

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REVISIONS No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	17/03/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CH'D:
APP'D:
DATE ISSUED DATE

FUNCTION KIGGAVIK SITE DRAINAGE
ACTIVITY K2 SECTION VIEW
SECTION
JOB

PROJECT NO. 09-1362-0610
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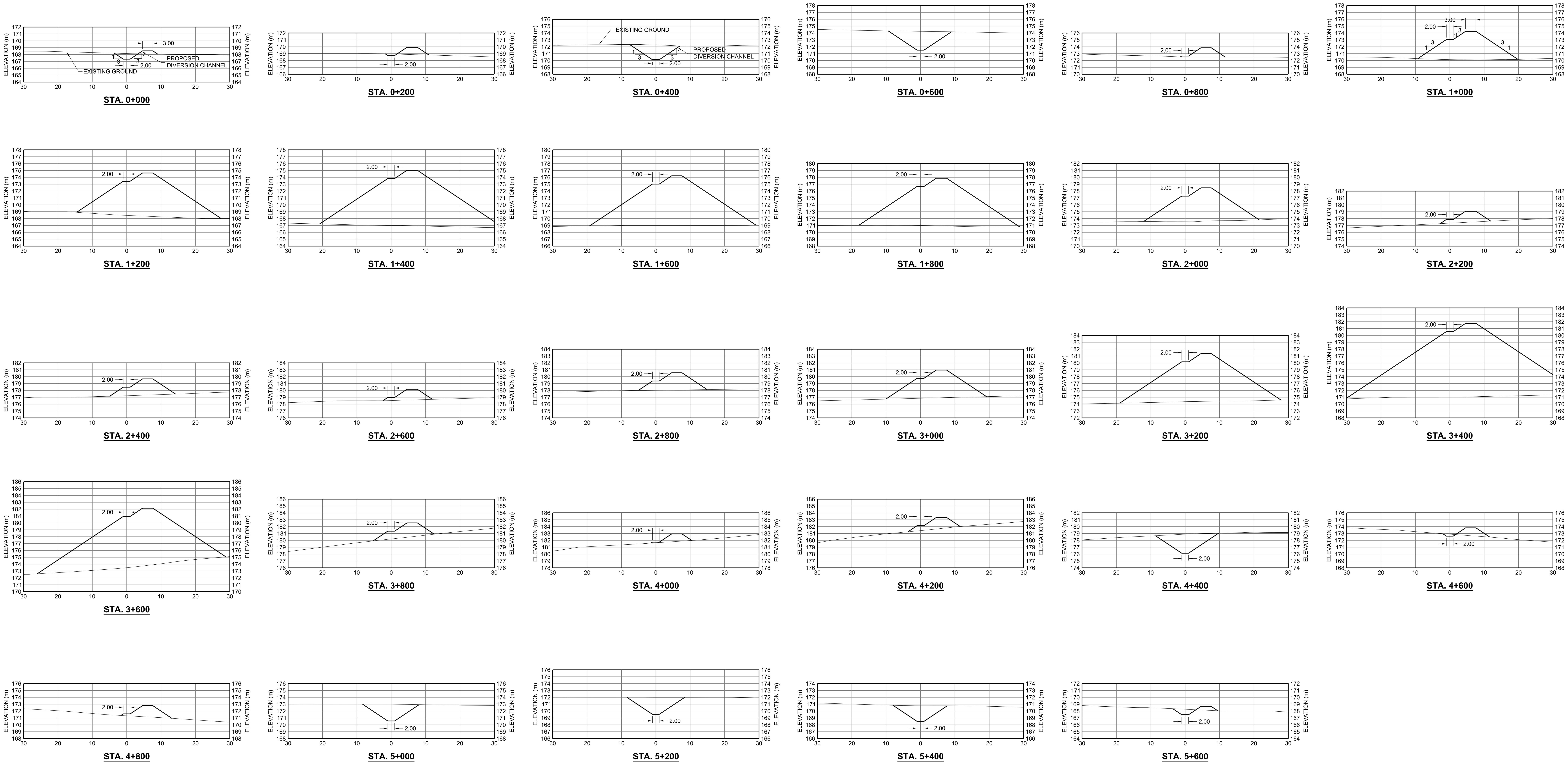
NOTES:

1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.
2. ALL BERMS HAVE 3m CRESTS AND 3:1 SIDE SLOPES. CHANNEL BOTTOMS VARY AS SHOWN.



DRAFT

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc) ARE BASED ON 24"X36" FORMAT DRAWINGS

VERTICAL SCALE 1:300 METRES

HORIZONTAL SCALE 1:600 METRES

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REVISIONS					
A	TAH	17/03/11		ISSUED FOR REVIEW	
No.	BY	DATE	APPROVED	DESCRIPTION	

SCALE:	AS SHOWN
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APP'D:	
DATE ISSUED	DATE

FUNCTION: KIGGAVIK SITE DRAINAGE
ACTIVITY: K3 SECTION VIEW
SECTION:
JOB:

PROJECT NO. 09-1362-0610
FILE NAME. KI08D140 - Kiggavik Site Drainage REV 4.dwg
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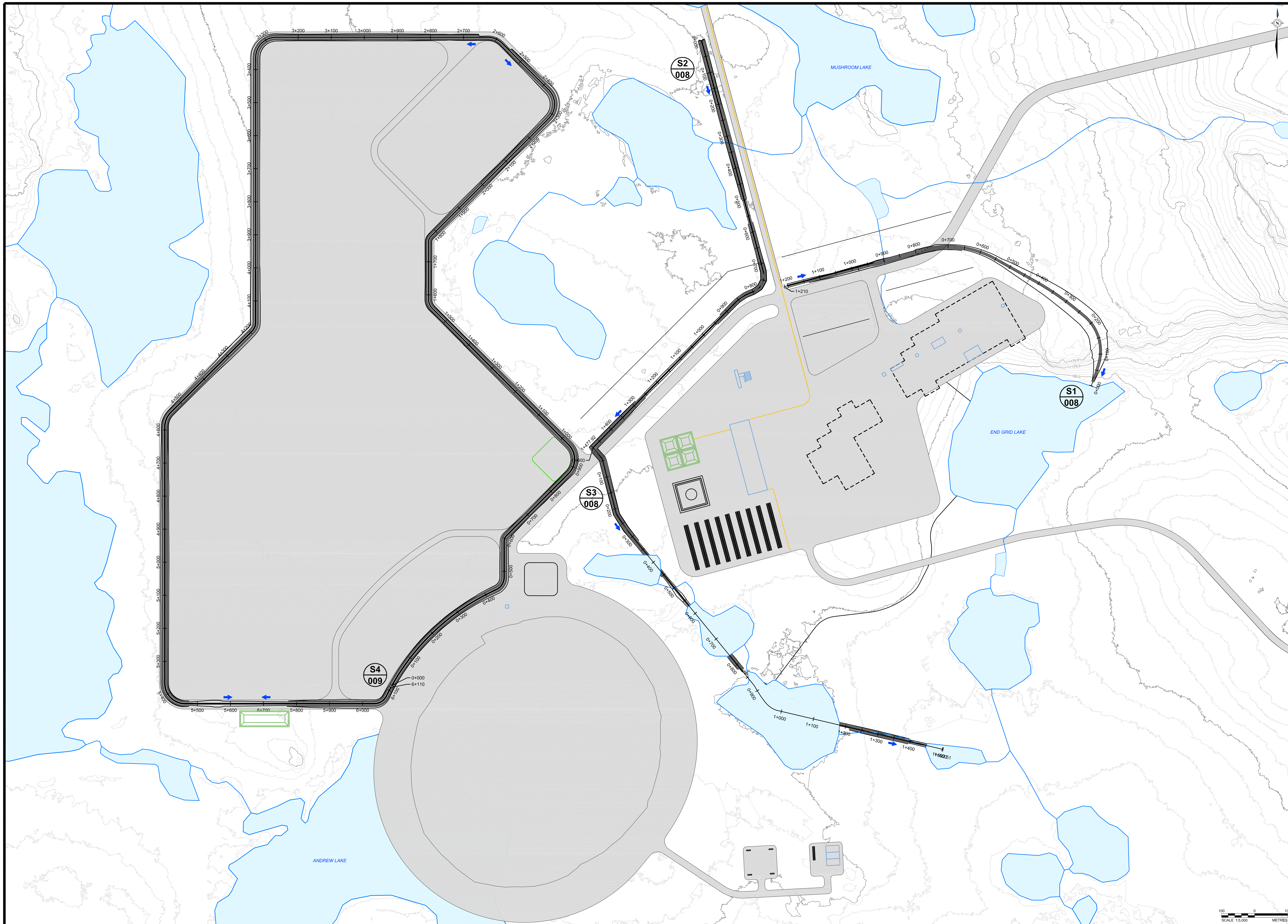

NOTES:
1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.
2. SITE LAYOUT PROVIDED BY AREVA, DECEMBER 2010.
3. NTS MAPSHEET 66A05.

LEGEND
CONTOUR (1m INTERVAL)
PROPOSED DIVERSION CHANNEL

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CH'D:
APP'D:
DATE ISSUED DATE

FUNCTION SISSONS SITE DRAINAGE
ACTIVITY PLAN VIEW
SECTION
JOB

PROJECT NO. 09-1362-0610
FILE NAME. KI08D143 - Sissons Site Drainage REV 5.dwg
DRAWING NO. 0913620610-007

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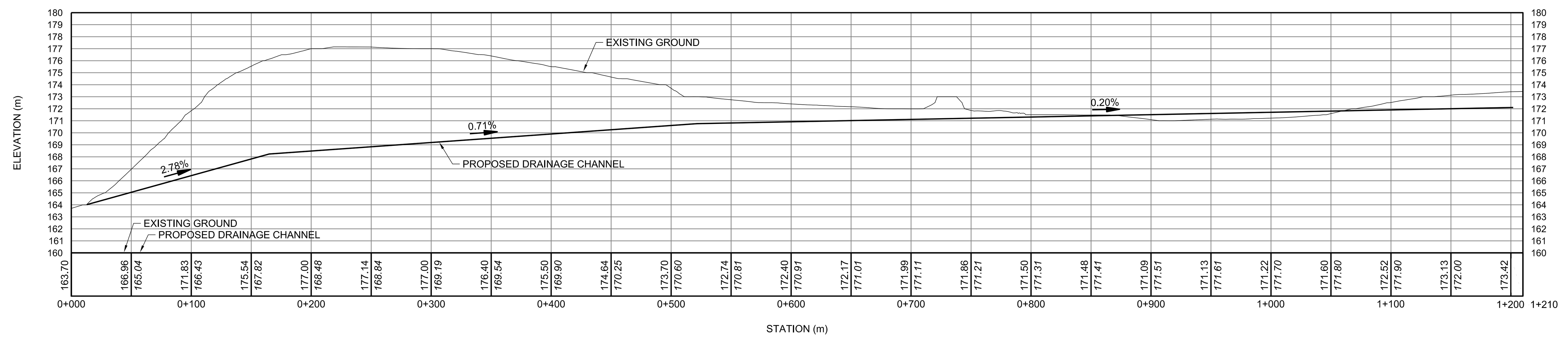

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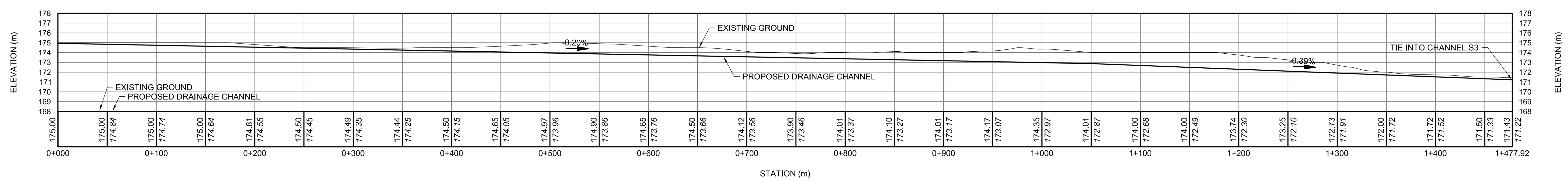

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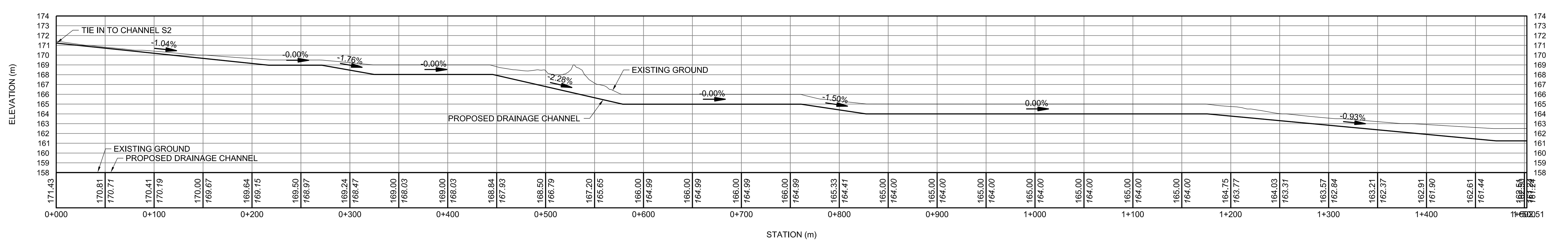

S3 / 007 PROFILE S3

VERTICAL — SCALE 1:300 METRES

HORIZONTAL — SCALE 1:3,000 METRES

DRAFT

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No.	BY	DATE	APPROVED	DESCRIPTION
A1	TAH	05/04/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CHT'D:
APP'D:
DATE ISSUED — DATE

FUNCTION: SISSONS SITE DRAINAGE
ACTIVITY: PROFILE VIEW
SECTION:
JOB:

PROJECT NO. 09-1362-0610
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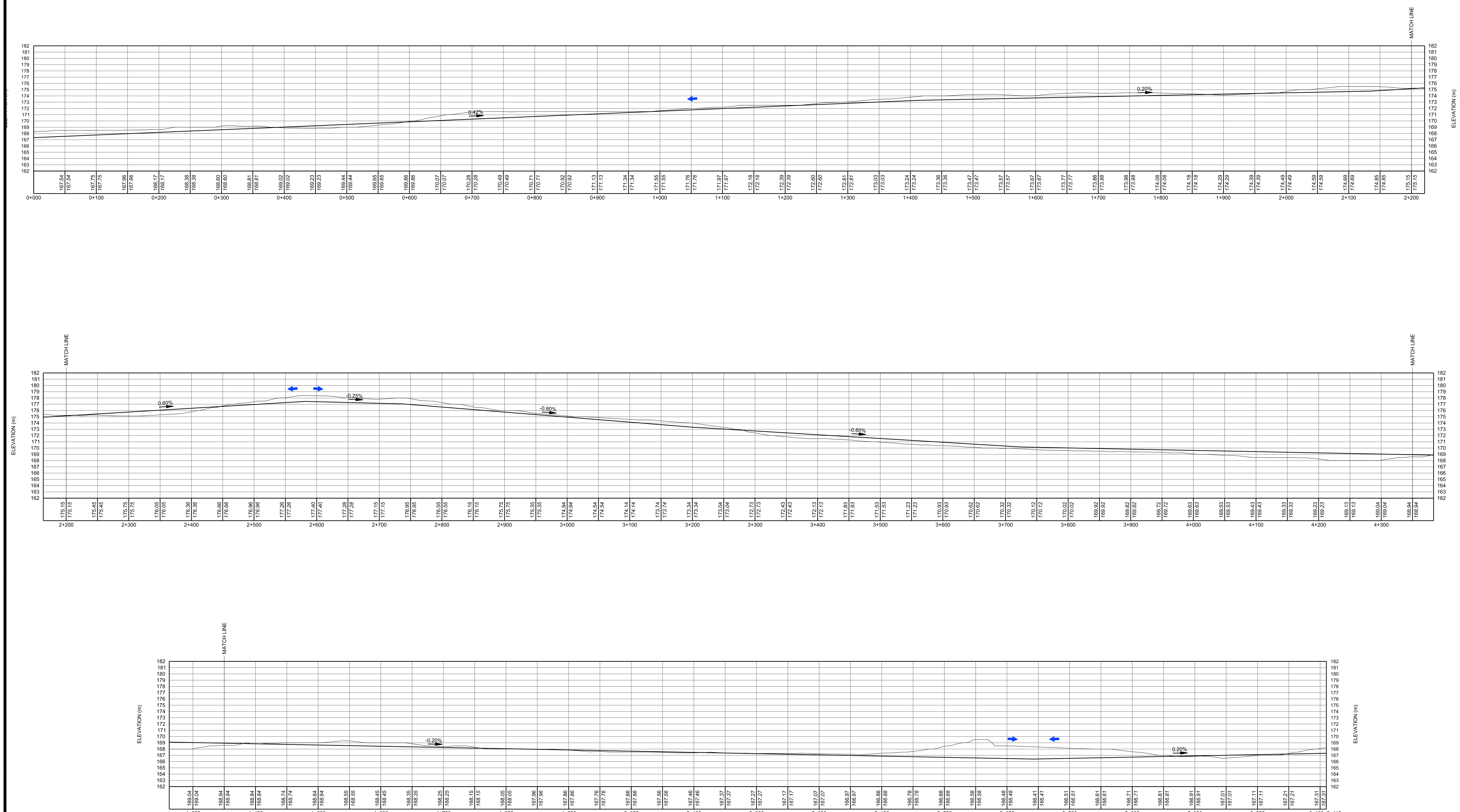
1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.



S4
007
PROFILE S4

VERTICAL SCALE 1:300 METRES

HORIZONTAL SCALE 1:3,000 METRES

DRAFT

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REFERENCE	

REVISIONS	No.	BY	DATE	APPROVED	DESCRIPTION

REVISIONS	No.	BY	DATE	APPROVED	DESCRIPTION
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CHT'D:	
APP'D:	
DATE ISSUED	DATE

FUNCTION	SISSONS SITE DRAINAGE
ACTIVITY	PROFILE VIEW
SECTION	
JOB	

PROJECT NO.	09-1362-0610
FILE NAME.	KI08D143 - Sissons Site Drainage REV 5.dwg
DRAWING NO.	0913620610-009

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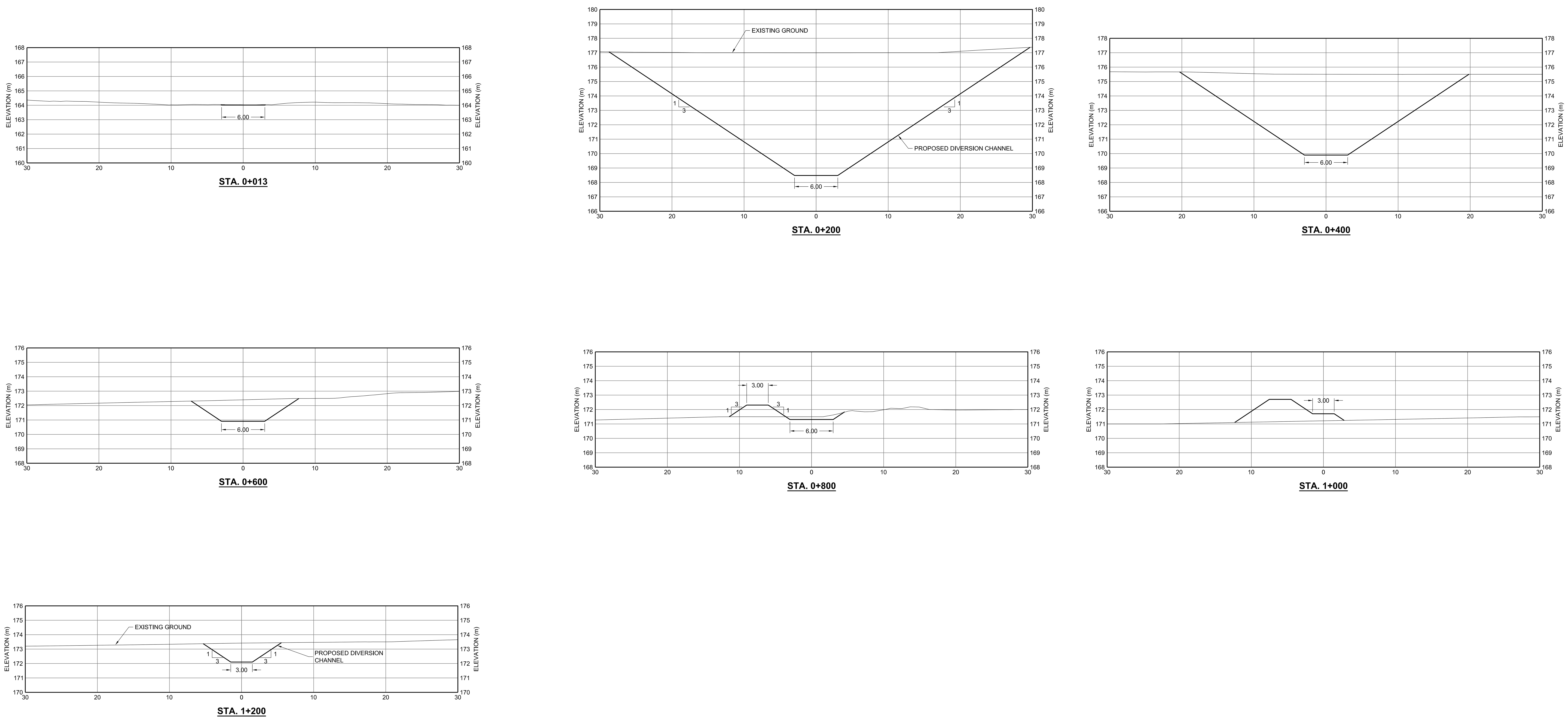
NOTES:

1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.
2. ALL BERMS HAVE 3m CRESTS AND 3:1 SIDE SLOPES. CHANNEL BOTTOMS VARY AS SHOWN.



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THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc) ARE BASED ON 24"X36" FORMAT DRAWINGS

VERTICAL — SCALE 1:150 METRES

HORIZONTAL — SCALE 1:300 METRES

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No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	17/03/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CH'D:
APP'D:
DATE ISSUED — DATE

FUNCTION: SISSONS SITE DRAINAGE
ACTIVITY: S1 SECTION VIEWS
SECTION:
JOB:

PROJECT NO. 09-1362-0610
FILE NAME. KI08D143 - Sissons Site Drainage REV 5.dwg
DRAWING NO. 0913620610-010

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NOTES:
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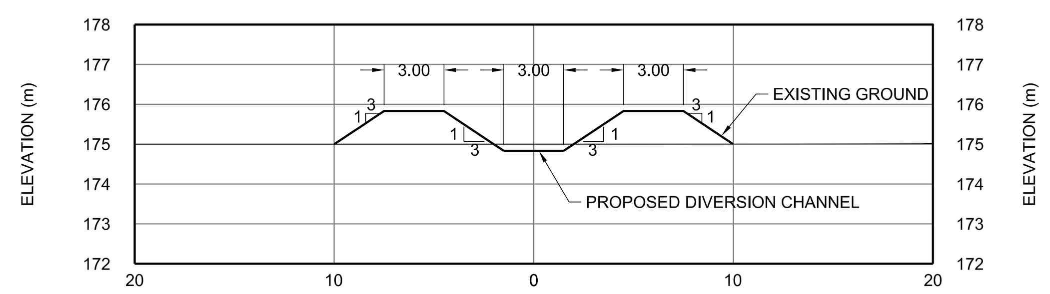
2. ALL BERMS HAVE 3m CRESTS AND 3:1 SIDE SLOPES. CHANNEL BOTTOMS VARY AS SHOWN.



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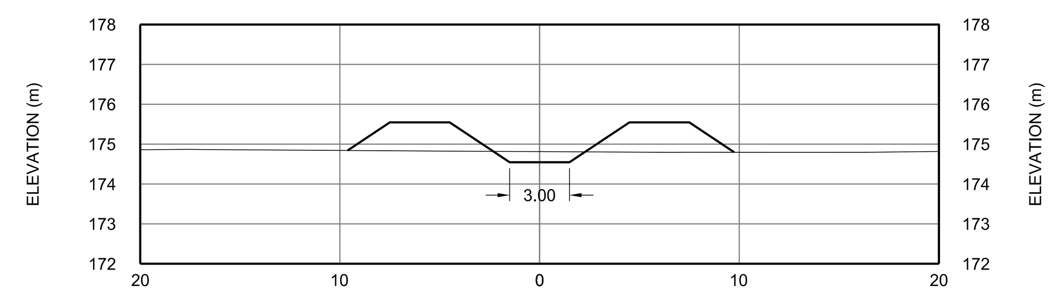

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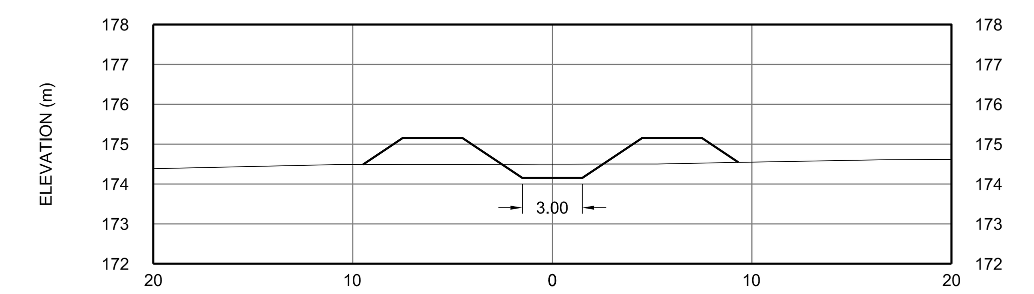

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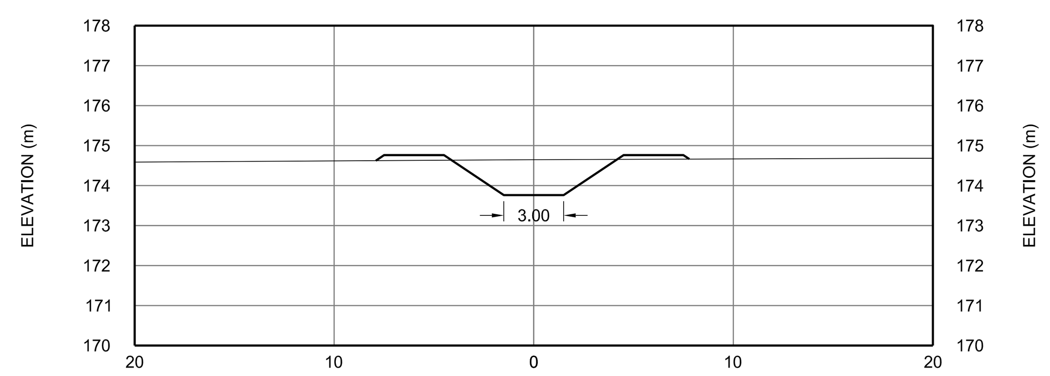

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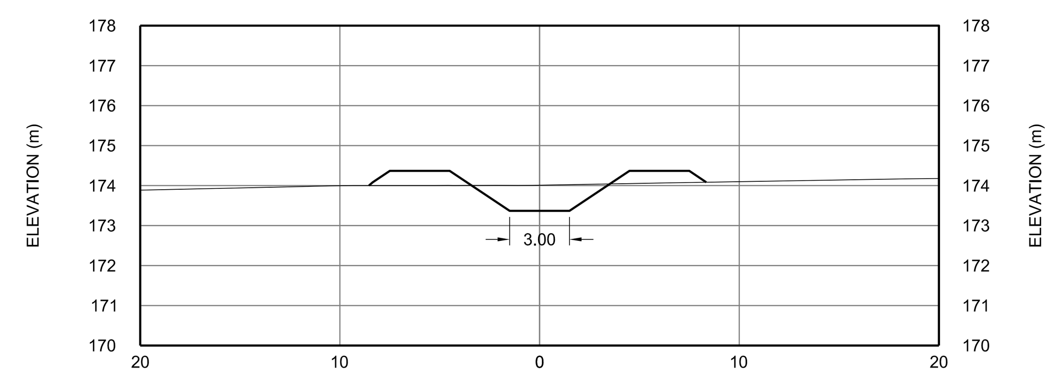

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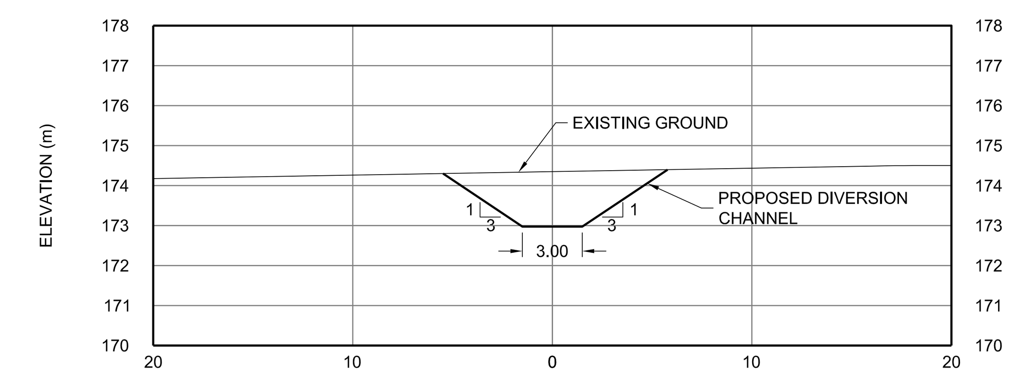

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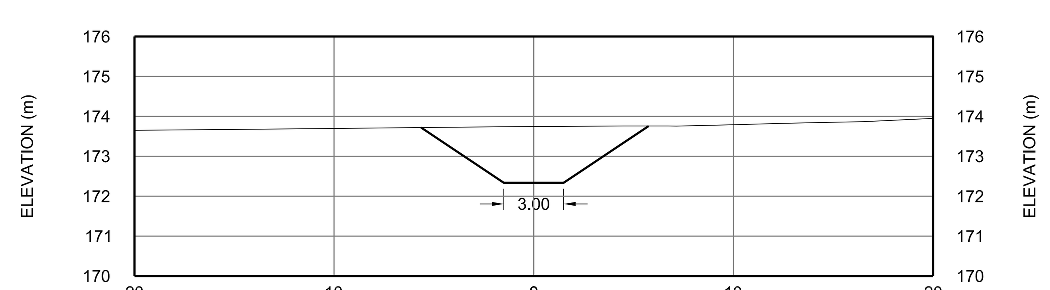

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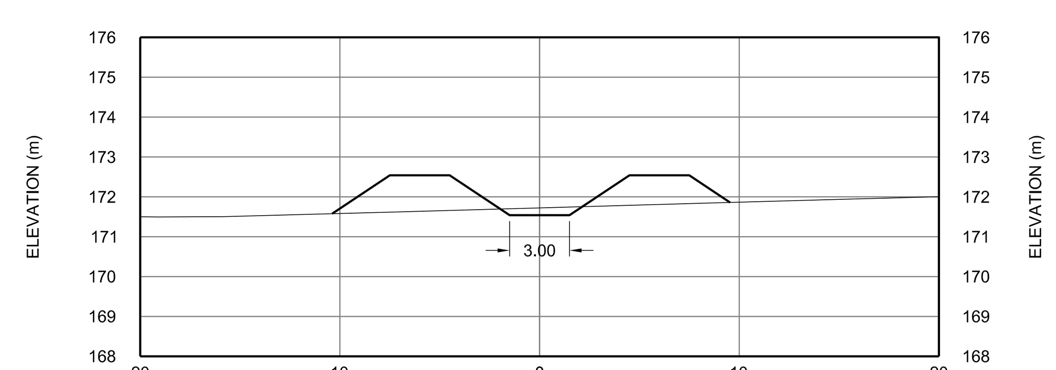

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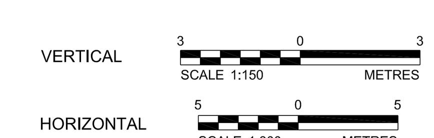
DRAFT

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc) ARE BASED ON 24"X36" FORMAT DRAWINGS



Golder Associates
Saskatoon, Saskatchewan

REVISIONS				
No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	17/03/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CHK'D:
APP'D:
DATE ISSUED DATE

FUNCTION: SISSONS SITE DRAINAGE
ACTIVITY: S2 SECTION VIEWS
SECTION
JOB

PROJECT NO. 09-1362-0610
FILE NAME. KI08D143 - Sissons Site Drainage REV 5.dwg
DRAWING NO. 0913620610-011

REFERENCE

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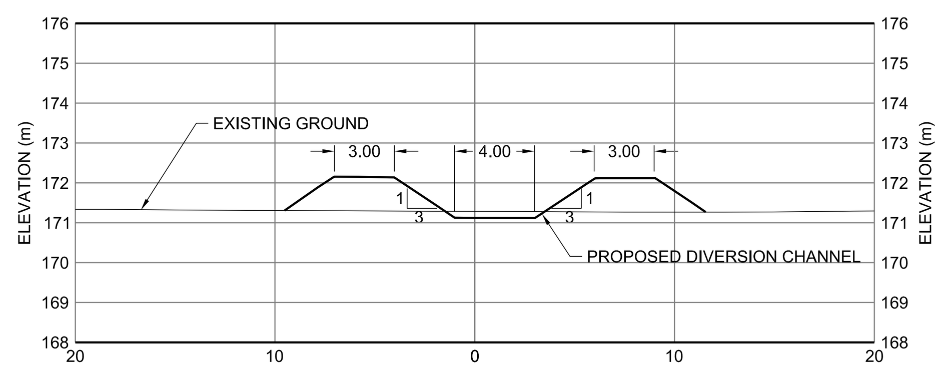
NOTES:
1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.
2. ALL BERMS HAVE 3m CRESTS AND 3:1 SIDE SLOPES. CHANNEL BOTTOMS VARY AS SHOWN.



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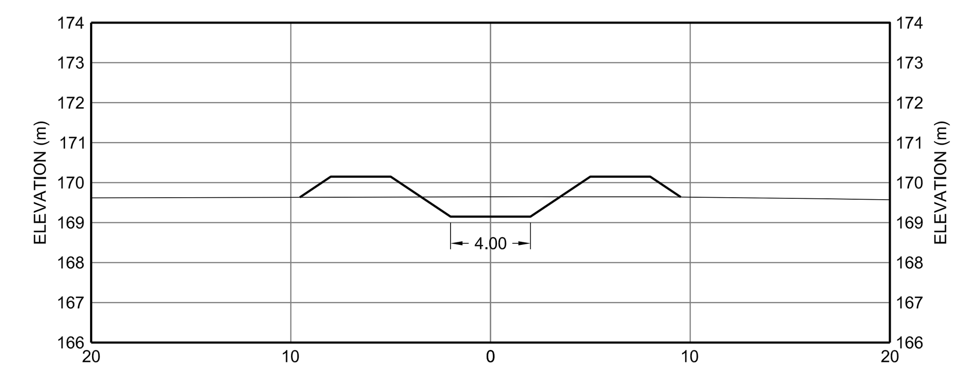

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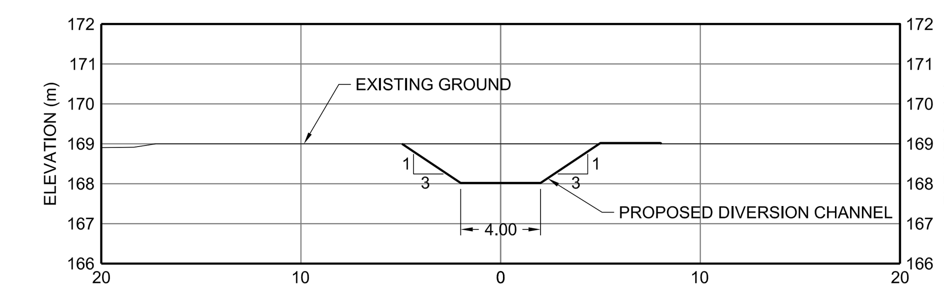
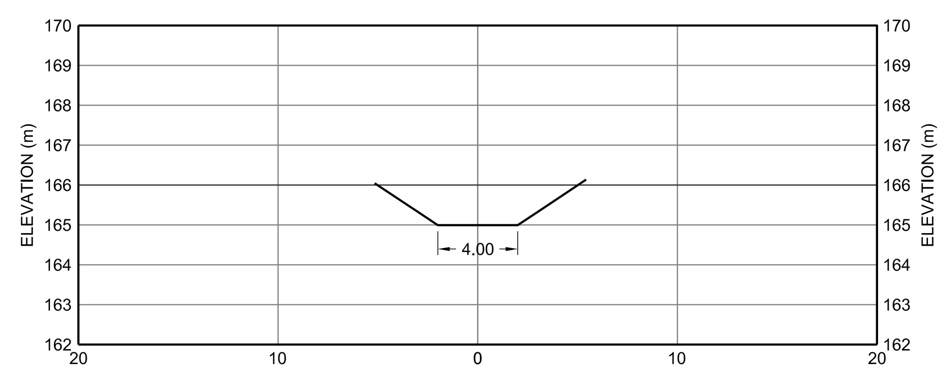


STA. 0+400



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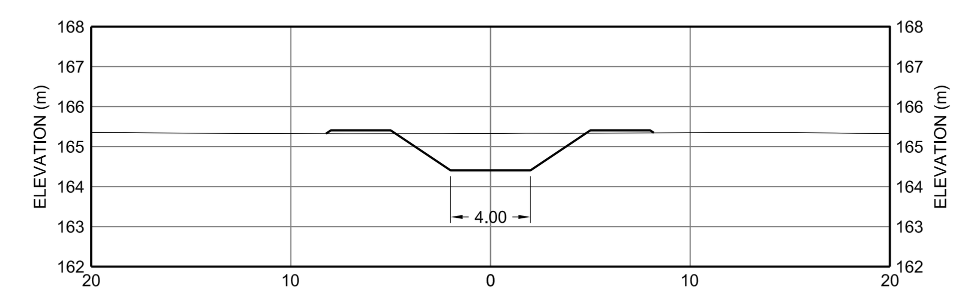

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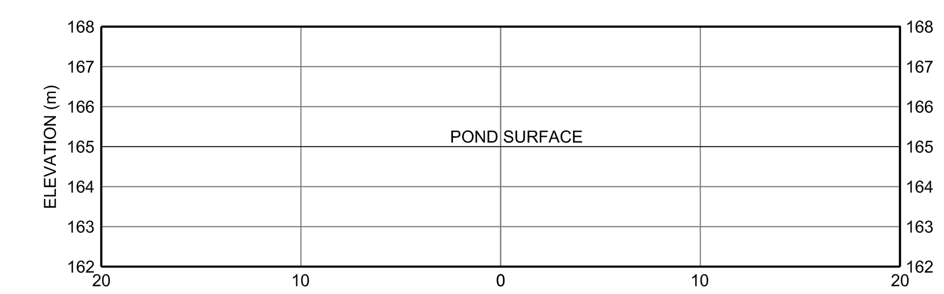
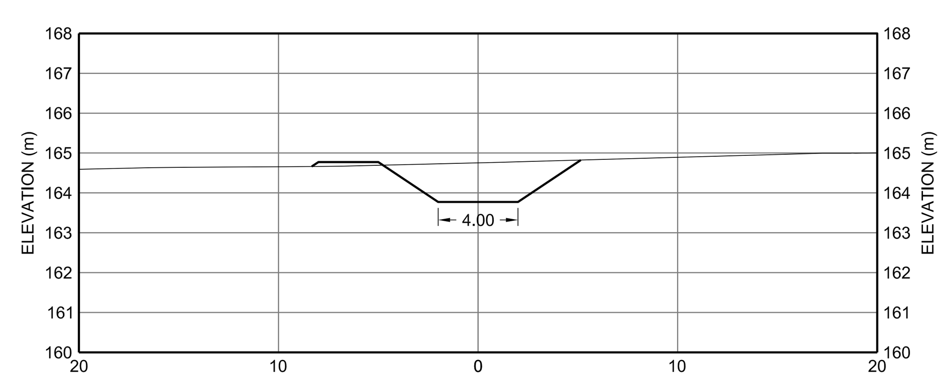
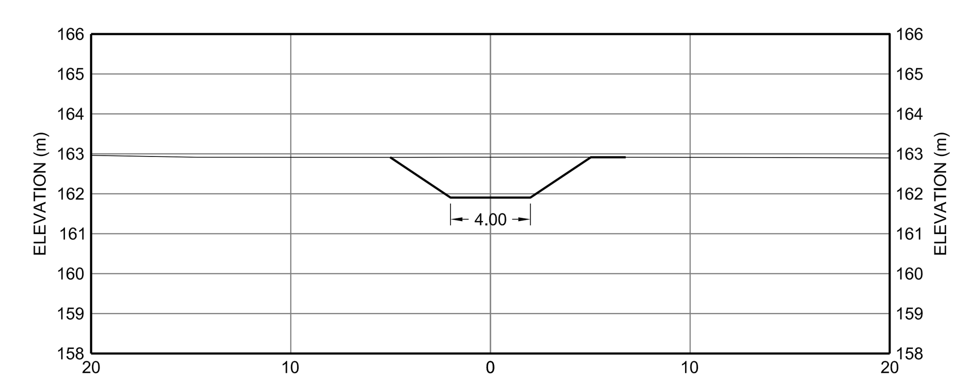


STA. 1+000



STA. 1+200



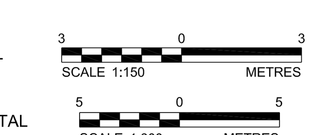
STA. 1+400

DRAFT

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc) ARE BASED ON 24"X36" FORMAT DRAWINGS

VERTICAL

HORIZONTAL



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Saskatoon, Saskatchewan

REVISIONS No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	17/03/11		ISSUED FOR REVIEW

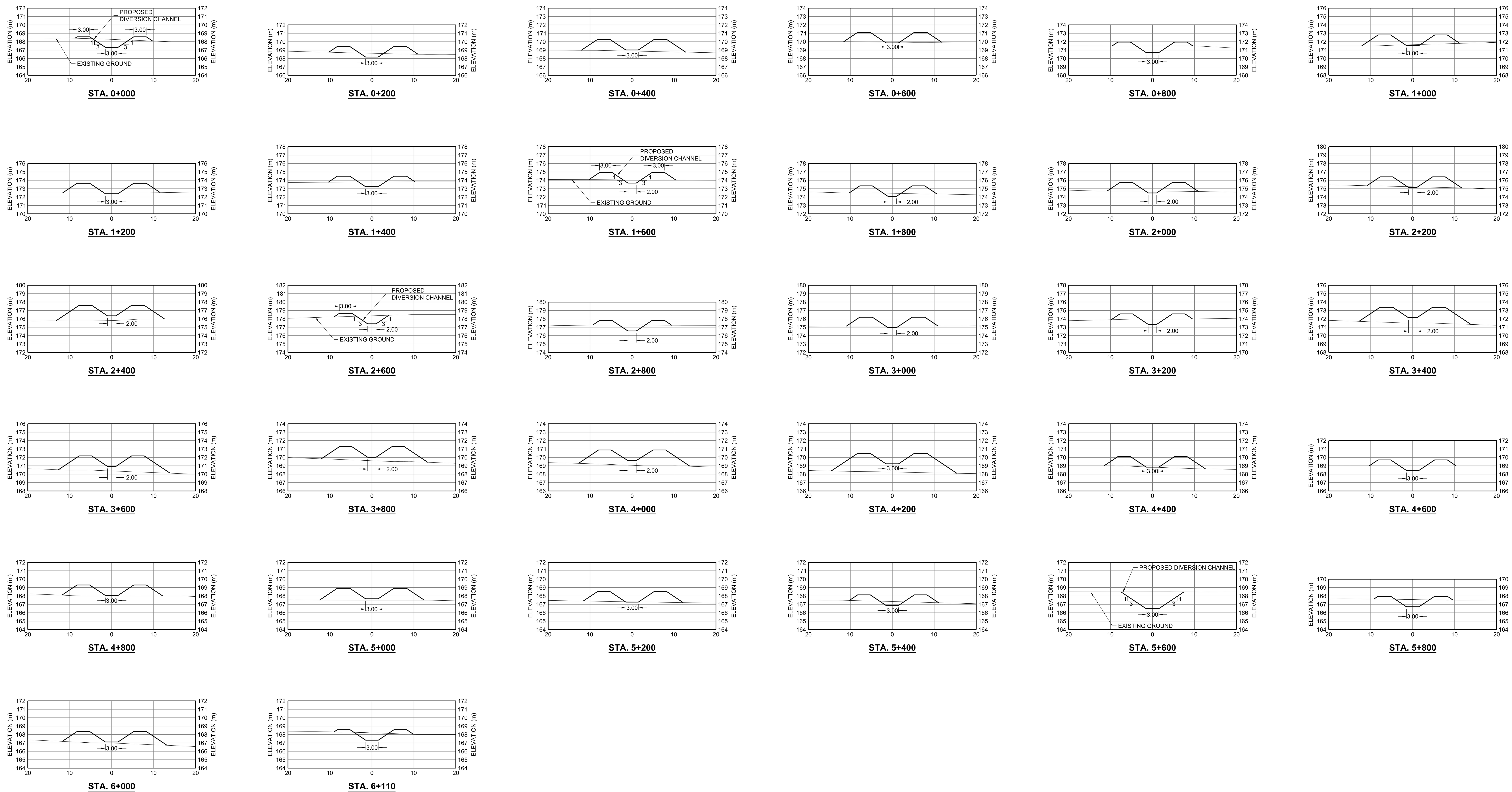
SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CH'D:
APP'D:
DATE ISSUED DATE

FUNCTION: SISSONS SITE DRAINAGE
ACTIVITY: S3 SECTION VIEWS
SECTION
JOB

PROJECT NO. 09-1362-0610
FILE NAME. KI08D143 - Sissons Site Drainage REV 5.dwg
DRAWING NO. 0913620610-012

G:\2009\1362\09-1362-0610 AREVA Kiggavik Baseline and EIA\KI08_Environment\D_Hydrology\CAD\ Drawing file: KI08D143 - Sissons Site Drainage REV 5.dwg Apr 05, 2011 - 3:34pm

NOTES:
1. CONTOURS DERIVED FROM LIDAR SURVEY, 2009.
2. ALL BERMS HAVE 3m CRESTS AND 3:1 SIDE SLOPES. CHANNEL BOTTOMS VARY AS SHOWN.



DRAFT

THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED (i.e. 1:1000 etc) ARE BASED ON 24"X36" FORMAT DRAWINGS

VERTICAL: SCALE 1:250, METRES
HORIZONTAL: SCALE 1:500, METRES

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No.	BY	DATE	APPROVED	DESCRIPTION
A	TAH	04/04/11		ISSUED FOR REVIEW

SCALE: AS SHOWN
DRAWN: TAH 07/01/11
CHK'D:
APP'D:
DATE ISSUED / DATE

FUNCTION: SISSONS SITE DRAINAGE
ACTIVITY: S4 SECTION VIEWS
SECTION
JOB

PROJECT NO. 09-1362-0610
FILE NAME: KI08D143 - Sissons Site Drainage REV 5.dwg
DRAWING NO. 0913620610-013

G:\2009\1362\09-1362-0610 AREVA Kiggavik Baseline and EIA\K08_Environment\D_Hydrology\CAD\ Drawing file: KI08D143 - Sissons Site Drainage REV 5.dwg Apr 05, 2011 - 3:33pm

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