4 – ARMSHOW SOUTH SITE

4.1 SITE DESCRIPTION

The Armshow South site is also located on the west side of Frobisher Bay in the South Baffin region of Baffin Island, Nunavut. The site is approximately 25 km southwest of Iqaluit. A general arrangement of the site is shown in Figure 4.1.

The Armshow South site is at about 40 to 240 masl. The site is referred to as “Armshow South” to distinguish the project as being located on a south tributary of the Armshow mainstem.

The site consists of an upper lake that will be dammed to create a reservoir (Appendix A; Table A.2, Photo 1). The river considered in this site is similar to the Jaynes Inlet site in that it flows into Frobisher Bay, is U-shaped, has rock outcrops throughout the valley, is moderately steep with some waterfalls and rapids in the reaches immediately below the dam sites and, at lower elevations, the valleys become wider and flatter with more alluvial deposits.

The proposed dam site is located at the main outlet to the north end of the lake (Photo 2). The left abutment has bouldery till over bedrock that is estimated to be about one to three m thick. The till is predominantly sand and gravel with boulders. There is bedrock exposed high in the left abutment about 20 m above the dam crest. The bedrock comprises light grey slightly weathered fine to medium grained granite with medium to widely spaced tabular joints.

Downstream of the dam site on the left bank is an approximately 7 m high mound of fine to coarse sand with gravel and trace cobbles. There is a narrow band of bouldery cobbles on the south side of the mound, which is associated with an ephemeral watercourse. As such, the left bank at the dam has been identified as a possible spillway alignment. Further to the south the hillside is blanketed in bouldery glacial till.

The right abutment has a thick blanket (greater than 5 m thick) of bouldery till on moderate slopes. There are no indicators of bedrock on the slope, although there is rock exposed at the top of the right bank approximately 200 m above the river. Small terraces were observed on the hillsides that are interpreted to be the result of solifluction (downslope movement of seasonally thawed soil over the permafrost). This is considered to be a high risk dam site due to the unknown depth to bedrock in the right abutment.

The riverbed is broad with alluvial gravel, cobbles and boulders. A surface diversion channel is proposed adjacent to the broad riverbed, as there are no obvious locations for a diversion tunnel.

The proposed penstock route is along the right bank of the river emptying the lake (Photos 3 and 4). The first 3.0 km of the penstock route would be in moderate slopes of bouldery till. A thick deposit (greater than 5 m thick) is anticipated for the first 1.5 km of the alignment. This material is potentially frost susceptible and is showing signs of solifluction movement. The entire hillslope may be creeping towards the river. Maintenance of a penstock on this material may present a design challenge.

After 3.0 km, the penstock route would be in sound rock with small soil zones. The terrain is rough and undulating requiring significant blasting and a number of bends in the penstock to find a suitable alignment (Photos 5 and 6).

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TRANSMISSION LINE TO IQALUIT
COBBLEY BOULDERS SOME SAND, SOME GRAVEL
POWERHOUSE
TO BARGE LANDING
DISCHARGE OUTFALL
TAILRACE PIPE
ACCESS ROAD
ARMSHOW RIVER
TRANSMISSION LINE TO JAYNES INLET
MOUND (APPROX. 15 m HIGH OF BOULDERS, SOME COBBLES, TRACE SAND AND GRAVEL
ACCESS ROAD
SURFACE MOUNTED PENSTOCK
FLOW
FLOW
SPILLWAY
DAM CREST EL. 254
INTAKE
MAXIMUM STORAGE LEVEL EL 250 m
LOW LEVEL OUTLET
ARMSHOW SOUTH LAKE

LEGEND:

- POWERHOUSE
- RESERVOIR INUNDATION AREA
- WINTER POOL
- ARMSHOW ALTERNATIVE PENSTOCK ROUTE
- TRANSMISSION LINE
- ACCESS TRAIL
- GEOLOGICAL BOUNDARY
- FAULT LINE
- DEBRIS FLOW HAZARD
- ROCK AVALANCHE HAZARD
- ROCKFALL HAZARD
- SNOW AVALANCHE HAZARD
- (R) ROCK AT OR VERY CLOSE TO GROUND SURFACE
- SOLIFLUCTION LOBES
- DEBRIS FAN
- TALUS
- SCREE

NOTES:

1. COORDINATE GRID IS UTM NAD83 ZONE 19 N.
2. CONTOUR INTERVAL IS 5 METRES.
3. ELEVATIONS MEASURED ABOVE SEA LEVEL.

NOT FOR CONSTRUCTION

SCALE A 200 100 0 200 400 600 800 1000 m

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	12FEB'13	ISSUED WITH REPORT	SRM	AS	RAC	SRM

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IQALUIT HYDROELECTRIC PROJECT

ARMSHOW SOUTH GENERAL ARRANGEMENT

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FIGURE 4.1 | REV 0

The powerhouse will be situated along the shore of the mainstem of the Armshow River (Photo 7).

The proposed barge landing and access road arrangements near the mouth of the Armshow River is shown in Photo 8.

4.2 DAM AND INTAKE STRUCTURES

An asphalt-core rockfill dam is proposed at the outlet of the existing lake due to the potentially low strength foundations (Figure 4.2). It is possible that suitable foundations will not be found without considerable excavation. A possible alternative is an earthfill dam that can be constructed over the in situ till. The construction of earthfill dams on permafrost foundations has many risks.

The spillway would pass water over the dam on the left bank. The proposed dam will be about 30 m high at the outlet of the southern lake, with a full supply level of about 250 masl. The dam will raise the current lake level by a maximum of approximately 25 m.

It is proposed that the intake structure be located through the base of the dam near the southeast bank.

4.3 WATER CONVEYANCE

The penstock route would follow the right back at a minimum grade for the first 3 km (Figure 4.1). The surface soils are potentially deep glacial tills that appear to be creeping. These foundation conditions could damage the penstock due to movement. Similar to the Jaynes Inlet Site penstock, the entire Armshow South penstock will be surface-mounted on concrete pedestals (Figure 4.3). The penstock will be welded steel and will be thermally insulated and heat-traced over its entire length to reduce the risks of the water inside it freezing. Concrete anchor and thrust blocks may be required at the major bends. The surface-mounted penstock will be approximately 5.96 km in length and 1.4 m in diameter. It will connect the intake at approximately 226 masl elevation to the powerhouse located at an elevation of 50 masl.

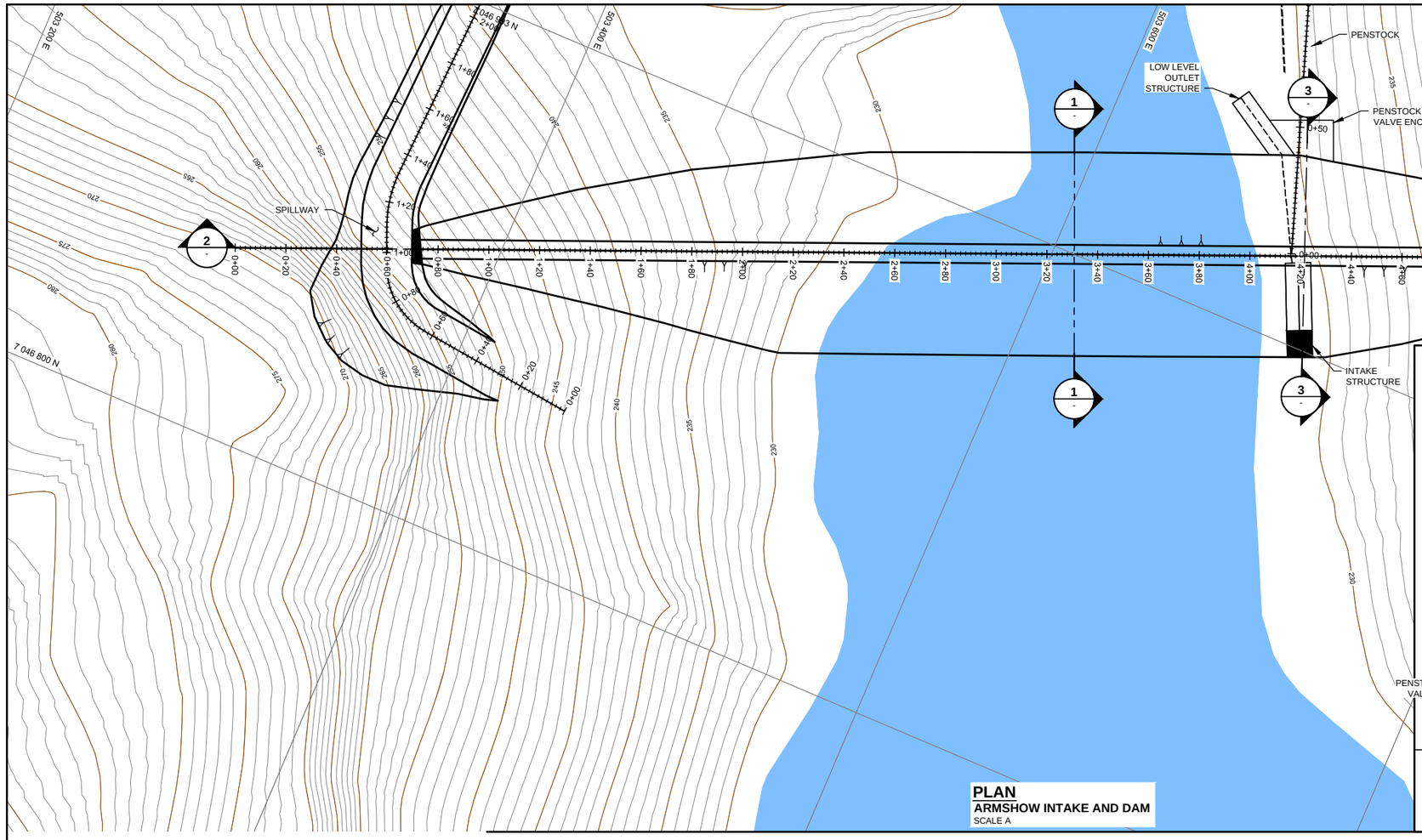
4.4 POWERHOUSE

A suitable powerhouse location was identified at an elevation of about 50 masl on the right bank between observed bedrock outcrops upstream and compact glaciofluvial soils downstream. It is anticipated that the bedrock would not be far below the surface.

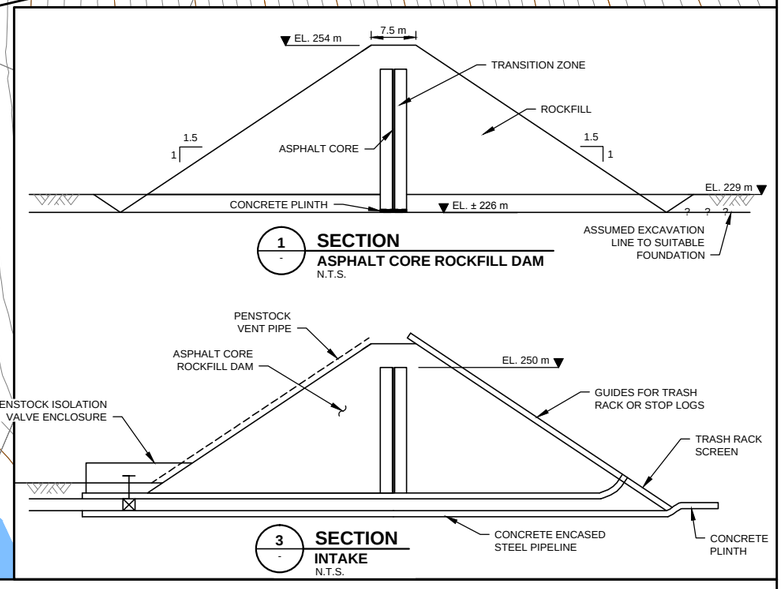
Similar to the Jaynes Inlet Site Powerhouse, the Armshow South Powerhouse will include a reinforced concrete substructure and a prefabricated steel superstructure (Figures 4.4 and 4.5). It will house two identical Pelton turbine generator units, control room, loading bay and overhead service crane. The two Pelton turbines will each be rated at between 3 and 4.4 MW.

The Powerhouse will also house a bypass facility. This bypass facility will allow water to continue to flow through the penstock when both the turbine generating units are out of service. This will prevent the water from freezing in the pipe. This bypass facility is likely to only be required during the extremely cold winter months on the rare occasion when both units are out of services.

The powerhouse will have a gate that opens during the open water season to discharge water to the stream.

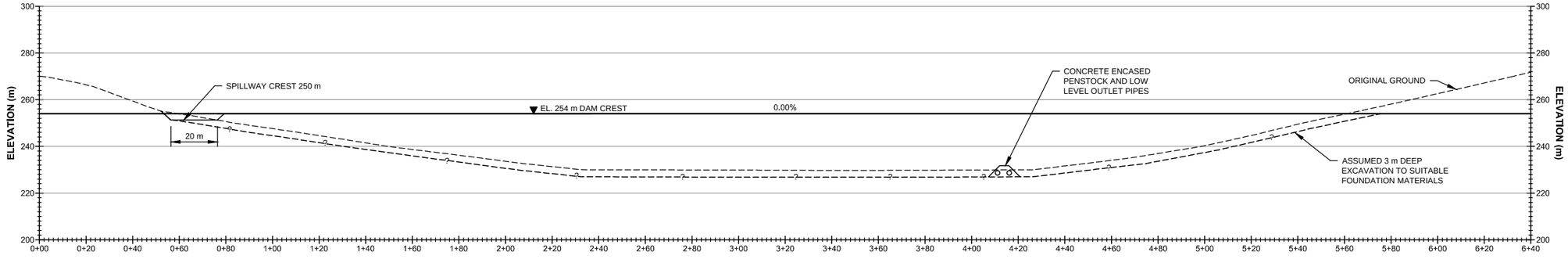


PLAN
ARMSHOW INTAKE AND DAM
SCALE A



1 SECTION
ASPHALT CORE ROCKFILL DAM
N.T.S.

3 SECTION
INTAKE
N.T.S.



2 LONGITUDINAL SECTION
INTAKE AND DAM
SCALE A

LEGEND:
- ORIGINAL GROUND
- EXCAVATION LINE
- RIVER/STREAM/DRAINAGE
- MAJOR CONTOUR
- MINOR CONTOUR

NOTES:
1. COORDINATE GRID IS UTM NAD83 ZONE 19.
2. CONTOUR INTERVAL IS 1 METRE.
3. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
4. ROCK TRENCH CUT AT 1V:0.25H, 6 m RISES WITH 0.6 m BENCH.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	12FEB'13	ISSUED WITH REPORT	SRM	AS	RAC	SRM

NOT FOR CONSTRUCTION

SCALE A: 20 10 0 20 40 60 80 100 m
SCALE B: 10 5 0 10 20 30 40 50 m

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IQALUIT HYDROELECTRIC PROJECT

ARMSHOW SOUTH INTAKE AND EMBANKMENT DAM PLAN AND SECTION

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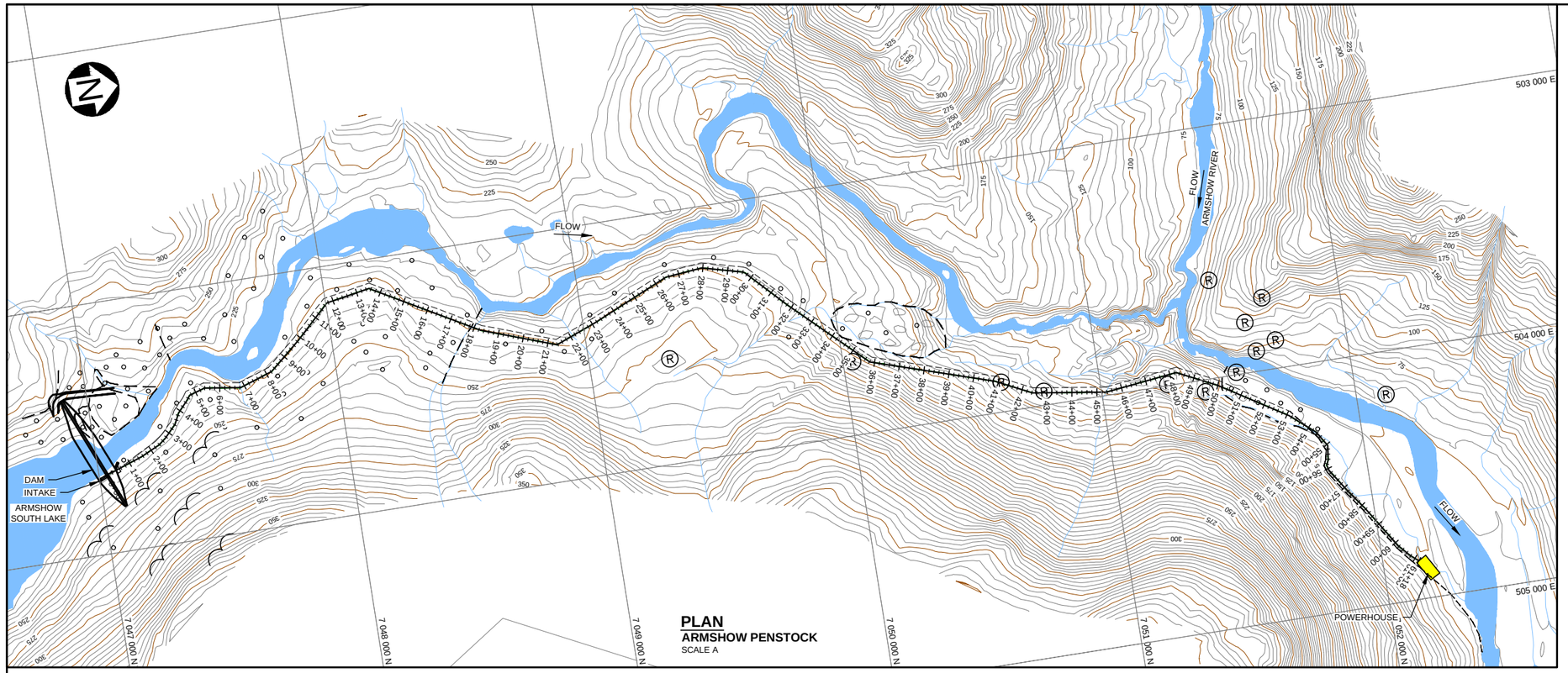
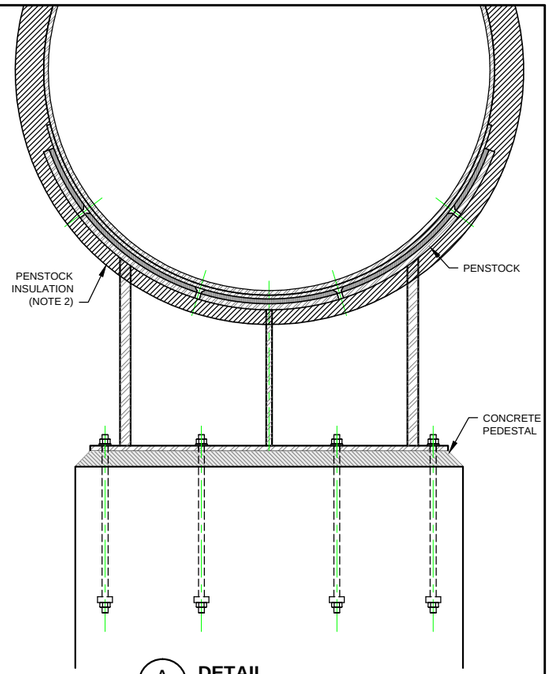
P/A NO.	REF NO.
NB103-137/8	1

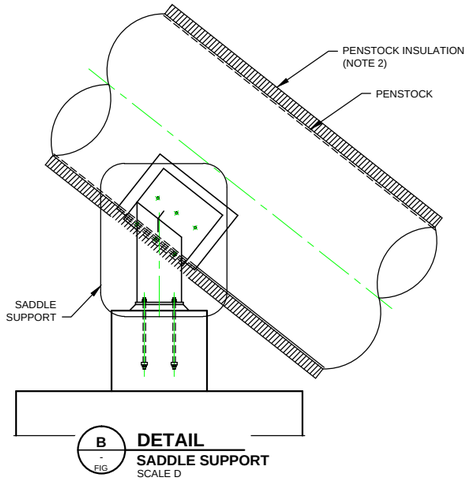
FIGURE 4.2 REV 0



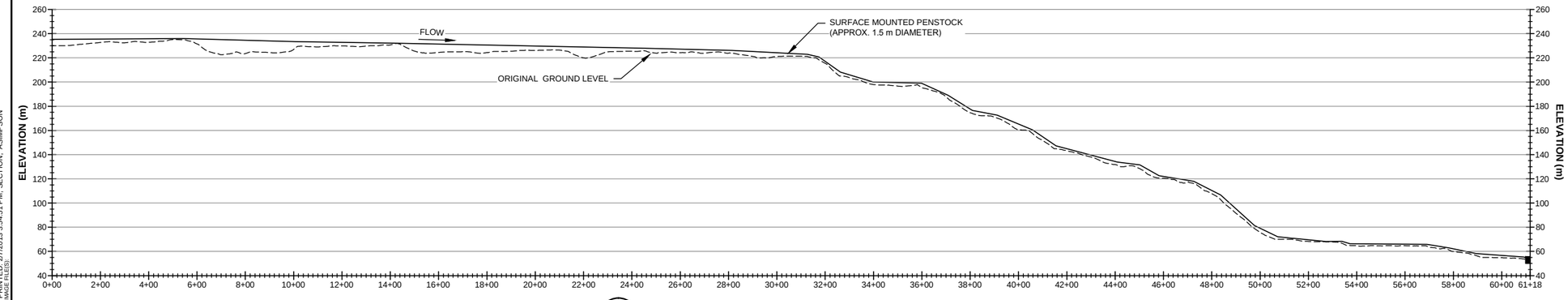
PLAN
ARMSHOW PENSTOCK
SCALE A



A - FIG **DETAIL**
SADDLE SUPPORT
SCALE C



B - FIG **DETAIL**
SADDLE SUPPORT
SCALE D



1 - FIG **SECTION**
ARMSHOW SOUTH PENSTOCK
HORIZONTAL: SCALE A
VERTICAL: SCALE B

SCALE A	200	100	0	200	400	600	800	1000 m
SCALE B	40	20	0	40	80	120	160	200 m
SCALE C	0.2	0.1	0	0.2	0.4	0.6	0.8	1 m
SCALE D	0.5	0.25	0	0.5	1.0	1.5	2.0	2.5 m

LEGEND:

- WATER
- POWERHOUSE SITE
- SOLIFLUCTION LOBES
- ROCK AT OR VERY CLOSE TO GROUND SURFACE
- ACCESS TRACK/ROAD
- GEOLOGICAL BOUNDARY
- CONTOUR MAJOR
- CONTOUR MINOR

NOTES:

1. COORDINATE GRID IS UTM NAD83 ZONE 19N.
2. PENSTOCK INSULATION TO BE 150 mm RIGID POLYURETHANE WITH GALVANIZED STEEL OUTER JACKET.
3. PENSTOCK TO BE HEAT TRACED ALONG ITS ENTIRE LENGTH.
4. CONTOUR INTERVAL IS 5 METRES.

NOT FOR CONSTRUCTION

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	12FEB'13	ISSUED WITH REPORT	SRM	AS	RAC	SRM

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IQALUIT HYDROELECTRIC PROJECT

ARMSHOW SOUTH PENSTOCK
PLAN AND SECTION

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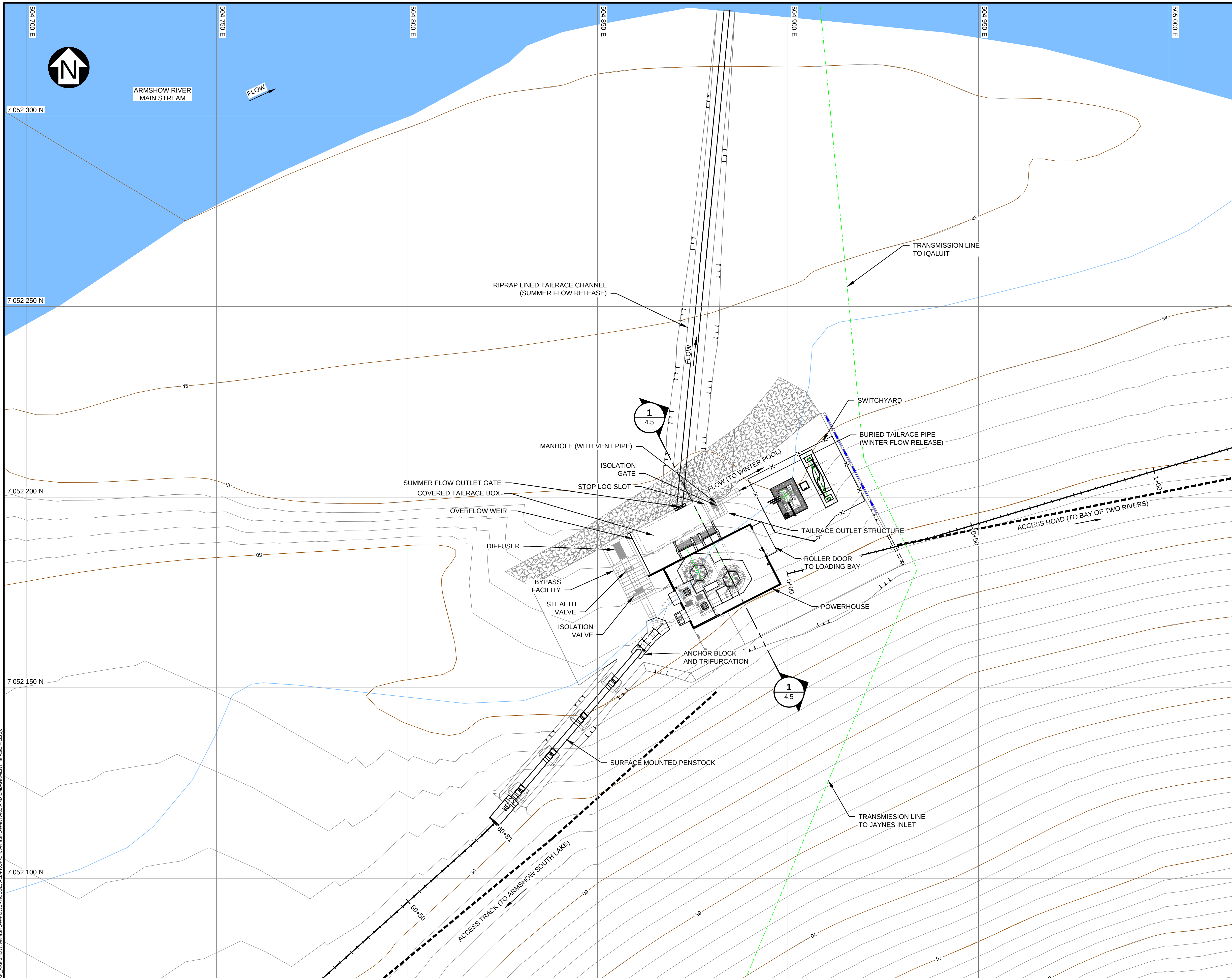
FIGURE 4.3 | REV 0



0	12FEB'13	ISSUED WITH REPORT	SRM	AS	RAC	SRM
REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D

LEGEND:

- ORIGINAL GROUND
- RIVER/STREAM/DRAINAGE
- MAJOR CONTOUR
- MINOR CONTOUR
- GEOLOGICAL BOUNDARY
- TRANSMISSION LINE

NOTES:

1. COORDINATE GRID IS UTM NAD83 ZONE 19.
2. CONTOUR INTERVAL IS 5 METRES.
3. DIMENSIONS AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

NOT FOR CONSTRUCTION

SCALE A: 10 5 0 10 20 30 40 50 m

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ARMSHOW SOUTH POWERHOUSE PLAN

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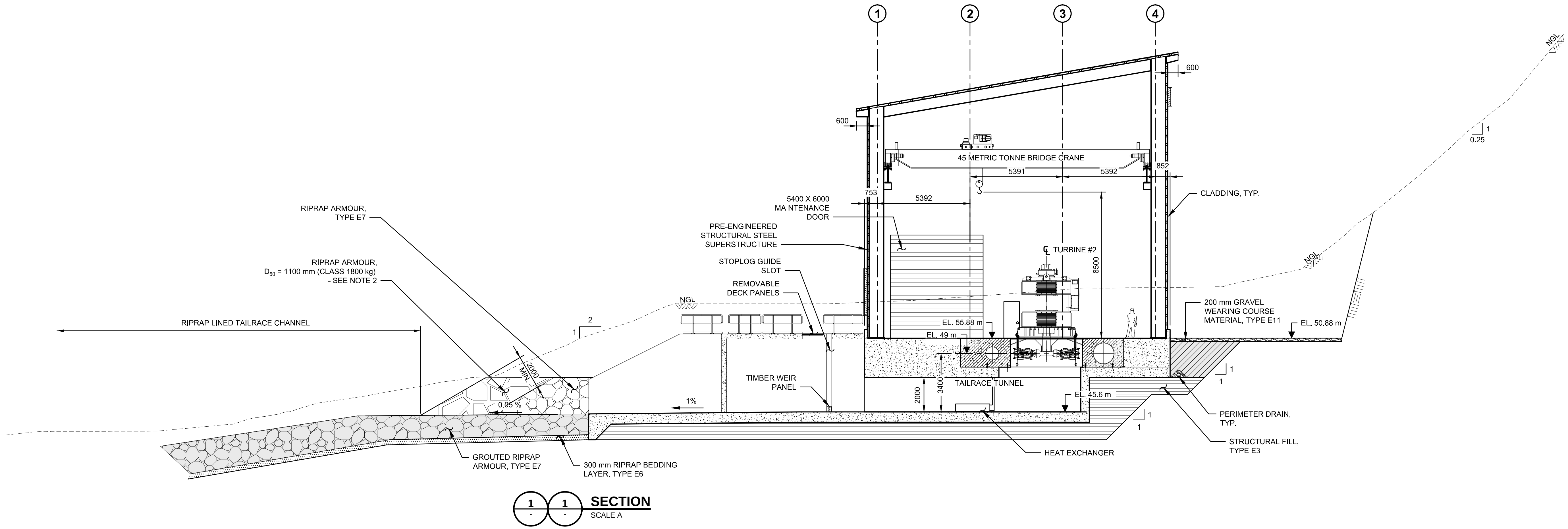
NB103-137/8	1

FIGURE 4.4 REV 0



1 / 1 SECTION
SCALE A

LEGEND:

- STAGE 1 CONCRETE
- STAGE 2 CONCRETE
- PIPE BEDDING MATERIAL - TYPE E1
- PIPE ZONE MATERIAL - TYPE E2
- STRUCTURAL FILL - TYPE E3
- SELECT FILL - TYPE E4
- RIPRAP BEDDING LAYER - TYPE E6
- RIPRAP - TYPE E7
- GENERAL FILL - TYPE E9
- GRAVEL WEARING COARSE MATERIAL - TYPE E11

NOTES:

1. DIMENSIONS ARE IN MILLIMETRES AND ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.
2. RIPRAP ARMOUR AT OUTLET OF TAILRACE CHANNEL TO TIED IN AND MATCH EXISTING RIPRAP SIZE FOR RIVER CHANNEL ARMOURING. CREEK BANK RIPRAP ARMOUR SHALL NOT BE SMALLER THAN D_{50} = 1100 mm (CLASS 1800 kg) ROCK WITH 2000 mm LAYER THICKNESS.
3. NGL = NATURAL GROUND LEVEL

NOT FOR CONSTRUCTION

SCALE A: 2500 1250 0 2500 5000 7500 10000 12500 mm

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ARMSHOW SOUTH
POWERHOUSE GENERAL ARRANGEMENT
SECTION 1

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FIGURE 4.5 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	12FEB'13	ISSUED WITH REPORT	SRM	AS	RAC	SRM

4.5 TAILRACE AND OUTFALL

A tailrace pipeline, approximately 0.6 km in length and 1.2 m in diameter, will discharge water from the powerhouse to a winter pool in the river during the winter months (Figure 4.6). The tailrace pipeline will be buried over its entire length, discharging into the river through the tailrace outfall structure that includes an energy diffuser. During the summer months, the water discharging from the powerhouse will exit the tailrace box directly adjacent to the powerhouse via an open channel and be returned to the stream downstream of the boulder mound.

The river discharges directly into the Bay of Two Rivers, which separates Baffin Island from Faris Island.

4.6 CONSTRUCTION METHODOLOGY

Construction of the Armshow South facility will be carried out in a similar manner to that described for the Jaynes Inlet facility. Equipment and materials will be delivered by sealift each open water season during the construction phase. The sealift vessels will anchor at a suitable location within Frobisher Bay, and shallow draft barges will shuttle supplies into the Bay of Two Rivers at the location identified on Figure 1.4. The barges will arrive at high tide and beach next to the alluvial terraces where a construction camp and laydown area will be established. It is expected that little to no shoreline alteration will be required to unload the barges.

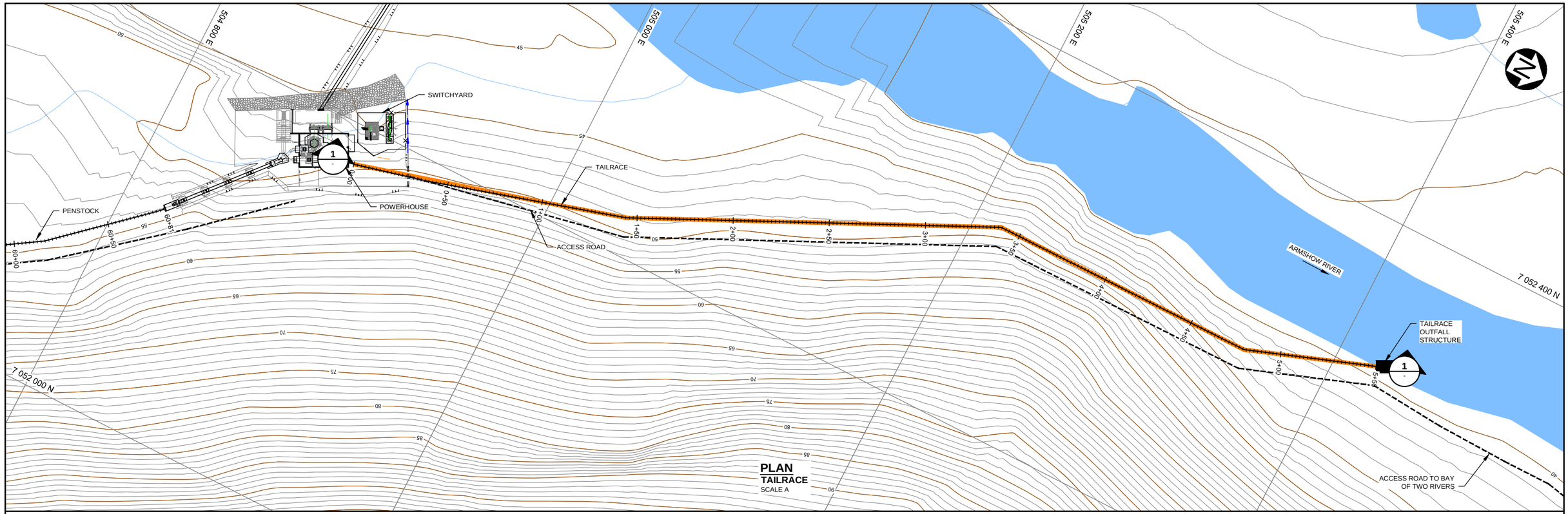
Initial site capture at the Armshow South site will be easier than Jaynes Inlet due to the alluvial terraces that can be used to establish a camp and laydown. A road will be constructed from the construction camp area to the powerhouse and then alongside the penstock alignment to the dam and intake. (Figure 1.4).

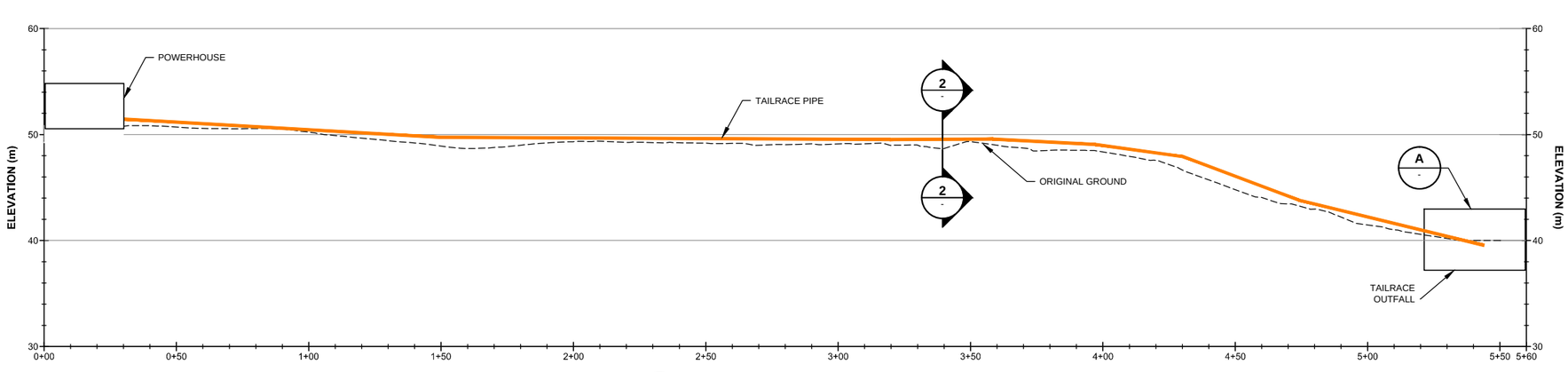
Construction activities will include the following:

- Establishing a rock quarry near the dam location
- Possible excavation of overburden at the dam site to competent bedrock
- Dam construction, including the placement of rockfill and the production and placement of bitumen asphalt
- Installation of the surface penstock, surface tailrace, and outfall into the channel of the Armshow mainstem
- Construction of the powerhouse

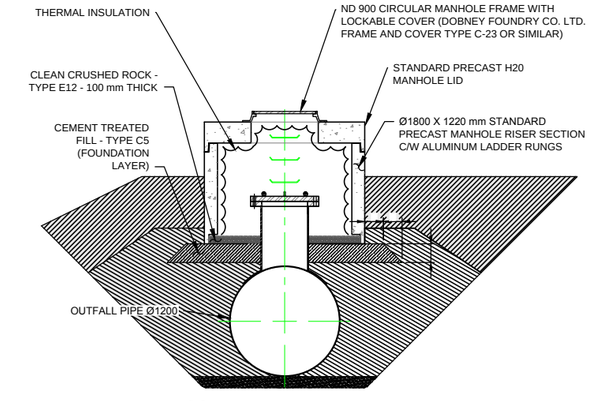
A 75-person trailer camp (approx.) will be established at the designated construction camp and laydown area at the river mouth (Figure 1.4). Water for the camp will be drawn from the Armshow mainstem during open water and the upper lake during winter. Sewage will be treated in a packaged sewage treatment plant and discharged to the Bay of Two Rivers. The camp will be equipped with a modern incinerator to dispose of food wastes, other combustible and non-hazardous wastes. All other wastes will be stored in containers for annual shipment off-site by sealift. A summary of waste volumes and disposal methods is provided in Table 3.1.

Fuel will be delivered to site on the sealift in full 20,000 L capacity double-walled iso-containers. An estimated 20 iso-containers of diesel and 5 iso-containers of Jet A fuel will be delivered each construction season. The iso-containers will be moved across the site using a boom-truck and fuel may be delivered using smaller containers by helicopter.

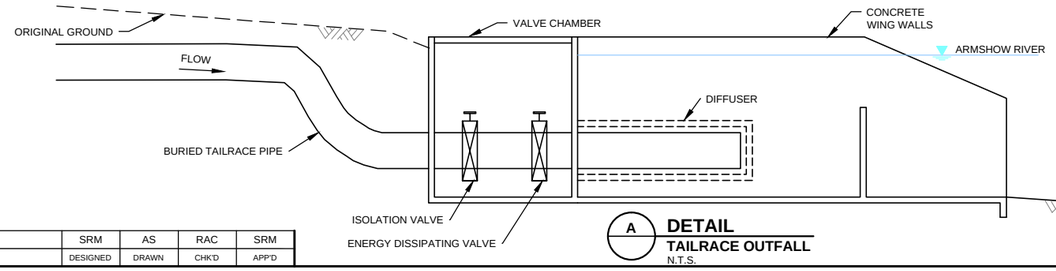




1 **SECTION**
TAILRACE
HORIZONTAL: SCALE A
VERTICAL: SCALE B



2 **TYPICAL SECTION**
ACROSS MANHOLE
(BURIED TAILRACE PIPE/OUTFALL)
SCALE C



A **DETAIL**
TAILRACE OUTFALL
N.T.S.

LEGEND:
- ACCESS ROAD
- TAILRACE PIPELINE

NOTES:
1. COORDINATE GRID IS UTM NAD83 ZONE19.
2. CONTOUR INTERVAL IS 5 METRES.

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHK'D	APP'D
0	12FEB'13	ISSUED WITH REPORT	SRM	AS	RAC	SRM

NOT FOR CONSTRUCTION

SCALE A 20 10 0 20 40 60 80 100 m
SCALE B 5 2.5 0 5 10 15 20 25 m
SCALE C 0.8 0.4 0 1 2 3 4 m

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ARMSHOW SOUTH TAILRACE
PLAN AND SECTION

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FIGURE 4.6 | REV 0

The anticipated construction equipment fleet is presented in Table 3.2.

With regard to helicopter use, it will be necessary to utilize low-level flying around the Project site throughout the construction phase. However, during longer transits, such as to and from Iqaluit, a minimum flight altitude of 600 m will be followed, unless low cloud cover requires lower flight altitudes for safety reasons.

4.7 FACILITY OPERATION AND MAINTENANCE

As discussed in Section 3.7, the facilities will most likely be remotely controlled from QEC headquarters in Iqaluit. It is also likely that there will be one or two full time caretakers at each of the facilities to respond to minor outages and maintenance requirements. Operator's accommodation will be provided adjacent to each powerhouse site.

With the onset of freshet each year and the accumulation of water from precipitation over the open water season, the upper lake will raise a maximum of 25 m, from its current height of 225 masl to the spillway elevation of 250 masl. Since the project operates with a discharge of approximately 4.8 m^3/s, the water level in the upper lake will drop slowly over the winter. Water from the powerhouse will discharge via a buried tailrace pipeline and discharge to what is currently a winter pool within the Armshow mainstem. It is anticipated that the constant discharge of water to the river at the onset of winter will create the conditions for an enlarged persistent ice-covered pool extending further downstream to the tidal flats.

Annual maintenance inspections will be carried out by specialist dam safety, structural, mechanical and electrical engineers. This will likely take place over a single week each year. There will also be environmental monitoring requirements at intervals throughout the year to help ensure the project is being operated in accordance with the approved regulatory requirements. There will also be regular maintenance inspections (four times per year) along the transmission line. During the summer months, these inspections will likely be conducted via helicopter, and during the winter months via snow mobile. An 8 to 10-person permanent camp will be established, similar to the Jaynes Inlet site, to facilitate access to the site for the various personnel. The permanent camp services will include running water, fuel storage, sewage collection/incineration, waste removal/incineration, security and backup power.

Every 10 to 15 years there will be a major maintenance inspection and servicing of the projects. This will likely take place over a four week period in the summer, with up to ten technicians and engineers involved. The same will be applicable to the transmission lines, with major maintenance inspections and servicing taking place every 10 to 15 years with a crew of about ten to fifteen technicians and engineers.

4.8 FACILITY DECOMMISSIONING

The facilities have an anticipated operational life of at least 40 years. If maintained and with necessary retrofits, it is expected that the Project will continue to produce electricity for the City of Iqaluit indefinitely.

If/when the Project must be decommissioned, it is anticipated that all aboveground components will be dismantled and removed, the intake plugged, the dam removed, and the area returned to its

pre-development state. The powerhouse could be decommissioned through removal of the electrical and mechanical equipment, dismantling of the structure and disposal (or recycling) of the metal and other construction materials. Materials will either be disposed of on-site in a landfill or off-site. Some below-ground components such as concrete foundations may remain in place to minimize disturbance if they do not pose a risk to the environment or potential land users.