MADRID-BOSTON PROJECT FINAL ENVIRONMENTAL IMPACT STATEMENT

Volume 1 Annex V1-7 Type A Water Licence Applications

Package P5-19

Hope Bay Project: Madrid Water Management Design





Hope Bay Project Madrid Water Management Engineering Report

Prepared for

TMAC Resources Inc.



Prepared by SPK CONSULTING

SRK Consulting (Canada) Inc. 1CT022.013 November 2017

Hope Bay Project Madrid Water Management Engineering Report

November 2017

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1 Introduction

1.1 Background

The Hope Bay Project (the Project) is a gold mining and milling undertaking of TMAC Resources Inc. The Project is located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory, and is situated east of Bathurst Inlet. The Project comprises of three distinct areas of known mineralization plus extensive exploration potential and targets. The three areas that host mineral resources are Doris, Madrid, and Boston.

The Project consists of two phases: Phase 1 (Doris project), which is currently being carried out under an existing Water Licence, and Phase 2 which is in the environmental assessment stage. Phase 1 includes mining and infrastructure at Doris only, while Phase 2 includes mining and infrastructure at Madrid and Boston located approximately 10 and 60 km due south from Doris, respectively.

Mining and infrastructure at Madrid will comprise of two separate areas; Madrid North and Madrid South, located approximately 5 km apart via an all-weather road. Each of these mining areas will have a single mine portal for accessing separate underground mines, not interconnected with any of the other belt-wide mines. These areas are not self-contained mining complexes like Doris, but rather satellite facilities focused on supporting mining activities with final processing (including tailings) and camp services relied upon at Doris.

A Type "B" Water Licence (No. 2BB-MAE1727; TMAC – Madrid Advanced Exploration Program) for the Madrid site was approved in May 2017. The preliminary designs and drawings for development of the Madrid water management infrastructure for Phase 2 as presented in this report builds on the infrastructure approved under this license.

This report provides preliminary engineering design details of the Madrid surface water management infrastructure.

This report does not cover the water management infrastructure that remain unchanged under existing licences. Such as, the windy lake freshwater intake near the old windy camp, the Doris-Windy all-weather road or the Madrid South all-weather road and associated stream crossings which are already approved under Type "B" Water Licence No. 2BB-MAE1727.

2 Design Criteria

2.1 Supporting Information

2.1.1 Hydrology

Hydrologic data used in the design of water management infrastructure was obtained from the Hydrology Report (SRK, 2017a). Reference material includes:

- Rainfall depths for the 24-hour, 100 year return period rainfall event = 55 mm; and
- Maximum daily snowmelt = 18 mm;

Both rainfall and snowmelt values include impacts of climate change through 2040 (SRK, 2017b).

2.1.2 Topography and Site Layout Drawings

Design and layouts are based on 1.0 m vertical resolution contour maps produced from satellite imagery supplied by Hope Bay Mining Limited.

2.1.3 Water Balance

The site-wide water management described in this report is subservient to, and has been informed entirely by, the site-wide water and load balance for the Project (SRK, 2017c).

2.2 Water Classification

Water on-site is categorized into five management types as described in Table 2-1. Each type of site water is managed separately.

Table 2-1: Water Classification

Туре	Contact Surface	Management Approach	Discharge Approach
Non-Contact Water	Undisturbed runoff, and runoff from access roads and overburden piles.	Manage sediment where required according to Best Management Practice (BMPs)	Discharge to natural catchment downstream of sediment controls (if required)
Mine Water	line Water Water which enters the underground workings Pumped to Marine Mixing Box at Doris Discharged to		Discharged to Roberts Bay
Contact Water	Runoff in contact with waste rock, ore stockpiles, and tailings	Contained in diversion channels and storage ponds, transferred via pumped pipelines	Used in the concentrator as make-up water or pumped to the TIA
Freshwater	Freshwater from lake	Pumped from Windy Lake existing or proposed intake systems for potable and industrial use. Pumped from Doris Lake for concentrator make-up water	Not applicable
Treated Sewage water	Domestic sewage	Treated on-site	Trucked to Doris

2.3 Hydrotechnical Design Criteria

The hydrotechnical design criteria for the Project include a combination of Best Management Practices (BMPs) and specified criteria based on engineering and operational judgement and/or constructability considerations. Two classes of water management infrastructure are required at Madrid, and have the design criteria presented in the following sections.

2.3.1 Contact Water Ponds

The contact water ponds will be event ponds that will intercept all contact water runoff from the waste rock pile, ore pads, mine and processing pads, and portal pads. Specific design criteria are listed below:

- Ponds will be normally empty (i.e., the pond will be kept in a dry state);
- Maximum residence time for ponded water is two weeks (i.e., 14 days);
- Design life is 20 years;
- Effects of climate change during the 2011 to 2040 time frame are considered;
- The ponds have the capacity to contain at a minimum the contact water from the 1:100 year, 24-hour storm event (55 mm), and the maximum daily snowmelt (18 mm), (SRK, 2017a);
- Ponds have operational freeboard of 1.3 m; and
- Permafrost damage within the ponds should be minimized.

2.3.2 Stream Crossings

SRK has defined a stream in this study as a preferential flow path for surface freshet melt water and rainfall such that it may contain water seasonally or permanently and frequently links permanent water bodies. Stream crossing details are presented in the Stream Crossing Design Brief in Appendix A.

Madrid-Boston All-Weather Road

The Madrid-Boston all-weather road was surveyed during a reconnaissance of proposed crossings in 2011 (EBA, 2011). Four different crossing types have been identified at a total of 14 crossing locations:

- Three single, or twinned non-fish bearing culverts;
- Four fish bearing culverts; and
- Seven fish bearing clear span bridges with pile foundations.

Madrid North - TIA All-Weather Road

The access road linking Madrid North and the TIA is expected to require three stream crossings:

- Two non-fish bearing culverts; and
- One fish-bearing clear span bridge with pile foundations.

3 Water Management Plan

The Madrid South site is located within the Doris Watershed. The Madrid North site is located in the Doris and Windy watersheds. Windy Lake flows through Glenn Lake to Roberts Bay. At post-closure, the Madrid sites will be reclaimed with the restoration of natural flow. The operations water management plan for the Madrid site is presented in Drawing MWM-02, Appendix B. Figure 1 presents a flow diagram for the Madrid sites.

3.1 Freshwater and Treated Sewage Water

Freshwater including potable and raw water for industrial use (brine mixing, and dust suppressant), will be sourced from Windy Lake via the existing water intake near the old Windy Camp, or if required from the Windy Lake North Fresh Water Intake (SRK, 2017d) as depicted in Drawing MWM-02, Appendix B Make-up water for the concentrator at Madrid North will be pumped from Doris Lake.

There will not be a camp at the Madrid North or South sites. A portable wash car containing toilets, washbasins and showers will be equipped with heated black and grey water day tanks. These tanks will be emptied via a vacuum sewage truck and transported to a holding tank at the Doris Site for blending into the Doris Site sewage treatment facility. At closure, water withdrawal from Windy Lake will cease.

3.2 Mine Water

The Madrid North mine will intercept the talik below Patch, Windy, and Imniagut lakes, and mining at Madrid South mine is expected to intercept the talik below Wolverine and Patch Lakes (SRK, 2017e). This intercepted mine water is expected to be high in salinity (similar to the Doris Mine groundwater inflows). Mine water will be pumped or hauled to the Doris Mine for transfer to the marine mixing box (MMB) and discharged to the ocean, as described in the Groundwater Management Plan (TMAC, 2017a). At post-closure, drawdown through the Madrid North and Madrid South mines will cease.

3.3 Non-Contact Water Runoff

BMPs will be put in place during construction of access roads and pads to ensure that sediment loading after initial material placement is controlled.

3.4 Contact Water Runoff

Contact water consists of tailings water, process water, waste rock and ore stockpile runoff.

A concentrator will be constructed at the Madrid North site to process a portion of the Madrid North ore through a flotation circuit. The resulting tailings will be pumped via pipeline and deposited in the Doris TIA. The concentrate will be trucked to the Doris process plant for gold extraction. Process water and tailings water are internally recycled in the concentrator as much as practical. Excess water is pumped to the TIA in the tailings stream (i.e. tailings at a higher moisture content).

Contact water runoff from the waste rock piles, ore storage areas, and all other surface infrastructure pads will be collected in Contact Water Ponds (CWPs). These CWPs will normally be maintained empty by pumping to the concentrator for use as make-up water to reduce the freshwater draw from Windy Lake; or pumping to the Doris TIA via the tailings discharge line; or pumping to the MMB via the mine water line.

The Madrid North CWP will capture contact water from the Madrid North concentrator area, ore stockpile, and waste rock pile. The pond will be situated against the contact water berm and access road, and is discussed in more detail in the Contact Water Pond Berm Thermal Modelling report (SRK, 2017f). A plan view of the pond is presented in Drawing MWM-03, Appendix B, and typical sections on Drawing MWM-05.

The Madrid South Primary and Secondary CWPs, presented in Drawing MWM-04, Appendix B, capture contact water within the Madrid South site. The Primary CWP is contained against the contact water berm access road (SRK, 2017f), and is located west of the waste rock pile. The Secondary CWP captures runoff from the portal laydown area and is confined by berms to the north and east, including the Portal Haul road. Storm flows captured in the Secondary CWP are pumped to the Primary CWP. Typical sections through the CWPs and berms are presented in Drawing MWM-05, Appendix B.

The Madrid North and Madrid South CWPs will be decommissioned at closure and the flow previously reporting to these ponds will flow to Wolverine, Patch and Windy lakes based on catchment delineation.

4 Preliminary Design

4.1 Concepts

The drawing set in Appendix B presents plans, typical cross-sections and details for all containment structures.

The following overarching design concepts have been adopted in developing the preliminary designs presented in Appendix B:

- Because the Property is in the continuous permafrost region of Canada, excavation into non-bedrock controlled areas should as far as practical be avoided to minimise long term permafrost degradation and associated sediment release consequences; and
- Construction materials for the structures will be geochemically suitable quarry rock.
 Suitable material sizing will be by means of crushing and screening.

4.2 Catchment Delineation

The Madrid North and South sites were delineated into catchments associated with the ponds. The areas for each catchment were used to size water management infrastructure, and verify that the catchment structures would not overtop during specified design storm events.

Catchments were delineated in AutoCAD (AutoDesk) using available PhotoSat topography and 1.0 m vertical resolution contour maps produced from satellite imagery supplied by Hope Bay Mining Limited. Table 4-1 presents the catchment areas for Madrid, which are also presented in the design drawings in Appendix B.

Table 4-1: Madrid Sites Catchment Area Summary

Catchment Description	Surface Area (km²)		
Madrid North Contact Water Pond	110,000		
Madrid South Primary Contact Water Pond	65,200		
Madrid South Secondary Contact Water Pond	24,600		

4.3 Hydrologic Approach

Pond inflows were calculated based on the respective catchment area and the design precipitation, as summarized in Section 2. Total inflows were calculated for each pond using the following equation

$$V = A x C x (Pp_{100vr}^{24hr} + S_{avg})$$
 Eq. 1

Where V is the total storm inflow, m³

A is the catchment area of the pond, m²

C is the runoff coefficient, unitless

 Pp_{100yr}^{24hr} is the rainfall accumulating over 24-hour during the 100 year return period event, mm

Savg is the 24-hour daily maximum snowmelt, mm

The design storm for pond sizing purposes is assumed to take place at a time when the ground is frozen, during which losses associated with infiltration, storage and evapotranspiration are close to zero. To simplify, a runoff coefficient of 1.0 was applied to each catchment area.

4.4 Pond Design

4.4.1 Pond Sizing

Ponds at Madrid will include

- One contact water pond at Madrid North, collecting runoff from waste rock pile, ore stockpile and portal pads; and
- Two contact water ponds at Madrid South, collecting runoff from the waste rock, ore pads and portal pads.

Madrid North

There will be one unlined CWP at Madrid North. The pond will contain the hydrologic inflow requirement, and will be dewatered over a two-week period. Dewatering of the pond will be by pumping to the concentrator for use as make-up water to reduce the freshwater draw from Windy Lake; or pumping to the Doris TIA via the tailings discharge line; or pumping to the MMB via the mine water line.

Madrid South

There will be two unlined contact water ponds at Madrid South. The Primary CWP will be located downstream of the waste rock pile and ore stockpile, and the Secondary CWP will be located downstream of the portal and brine mixing facility.

Water within the primary CWP will be pumped to Madrid North via the mine water pipeline or an independent contact water pipeline, where it will then be pumped to the concentrator for use as make-up water to reduce the freshwater draw from Windy Lake; or to the Doris TIA via the tailings discharge line; or to the marine mix box via the mine water line. Storm flows captured in the Secondary CWP are pumped to the Primary CWP.

Table 4-2 summarizes the Madrid pond hydrologic inflow requirements and the available capacities based on the contact water berm configurations, as well as the associated pumping rates. The locations of each of the ponds are illustrated on Drawing MWM-02, Appendix B.

Table 4-2: Madrid Pond Capacity and Pumping Rate Summary

Description	Hydrologic Inflow Capacity (m³)	Total Available Capacity (m3)	Pumping Rate (L/s)
Madrid North CWP	8,041	11,700	6.7
Madrid South Primary CWP	4,766	5,400	3.9
Madrid South Secondary CWP	1,798	2,300	1.5

Available capacities of all ponds are larger than the hydrologic inflow requirement, which provides additional freeboard against the contact water berms.

Pumping rates for the contact water ponds were calculated by dividing total hydrologic inflow volume by the design dewatering period (14 days). The tailings line and mine water line will be designed to accommodate the additional capacity of the contact water flow rates presented in **Error! Reference source not found.** Table 4-2.

4.4.2 Contact Water Pond Alternatives

Two design alternatives were considered for the Madrid contact water ponds. These ponds are event ponds, (i.e., they are intended to be empty except immediately following a precipitation event). Design alternatives are presented in Table 4.3.

Table 4.3: Alternative Contact Water Pond Designs

Alternative	Details
Lined Pond (Geomembrane)	The pond is fully lined with a geomembrane. The advantages of this design is it is a conventional lined pond that will not be affected by climate change, and it is also the less complex alternative. The disadvantage of this design is that the geomembrane and bedding layers on the pond floor will thaw the permafrost, which may create a depression resulting in water accumulation and more thaw after the geomembrane is removed at closure. Additionally, placement of the liner could be challenging depending of the terrain.
Unlined Pond (Permafrost)	Water is contained within the unlined pond by permafrost on the bottom of the pond and a geomembrane within the berm. This design is dependent on the base of the berm remaining frozen. The advantages of this design are that provided the pond is properly managed, the permafrost and vegetation on the pond floor should not be degraded, reducing potential issues at closure. The disadvantages of this design are that thick berms are required to ensure the geomembrane tie-in remains frozen. This design is also dependant on the expected temperature changes due to climate change, higher than expected temperature increases would require modification of the berms to ensure the liner tie-in remains frozen.

The unlined pond is the preferred alternative. The advantage of not placing a geomembrane on the floor of the pond is believed to overcome the disadvantages of thicker berms. Thermal performance of the unlined contact water berms has been calculated and shown to perform (SRK, 2017f). Any uncertainties in thermal performance of the berms can be addressed by a monitoring program, and additional material can be placed if deemed necessary to protect the thermal integrity of the liner tie-in.

4.5 Stream Crossings

Stream crossing locations and classification in terms of type of culvert are summarized in a separate memo in Appendix A. The final designs of each crossing will include peak flows and culvert sizing specification. These will include validation of fish passage requirements based on the identified species in each watercourse. The analysis will include modelling peak flows for ultimate culvert conveyance, and average summer flow during the migratory month for the identified fish species, which will be completed in the detailed design phase.

4.6 Mine Water

Mining through talik zones will result in groundwater inflows from defined geological features. The mine inflows will be made up of fresh water from lake infiltrations and hypersaline water from the surrounding rock, with a water quality dominated by high salinity, specifically chloride (SRK, 2017e). Mine water will be collected in underground sumps and pumped to surface, as described in the Groundwater Management Plan (TMAC, 2017a), from where it will be discharged to a marine outfall diffuser in Roberts Bay via the MMB, or via the TIA.

4.7 Additional Water Management Measures

4.7.1 Fuel Facility Sumps

A sump will be situated at the base of each fuel storage facility (one at each site), which will be dewatered by vacuum trucks as required. This water will be tested in the on-site laboratory prior to discharge. If the water quality meets the licenced limits for discharge, the water will used for dust suppression or discharged to the tundra at a location approved by the inspector. If water quality is not acceptable, a truck will transfer the dewatered volume to the TIA.

4.7.2 Quarry Inflows

The development of each quarry will proceed in a manner that ensures all water entering the quarry is retained within quarry boundaries. Quarry floors will be sloped towards a natural low area within the quarry and, if required, a sump will be constructed to collect water and provide storage for sedimentation. If the sump or quarry floor requires pumping, a water quality sample will be taken to test whether water is suitable for direct discharge, as described in the Quarry Management Plan (TMAC, 2017b). In this case, a pump will dewater the sump to the downstream environment. If water quality is not acceptable, a truck will transfer the dewatered volume to the TIA.

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All data used as source material plus the text, tables, figures, and appendices of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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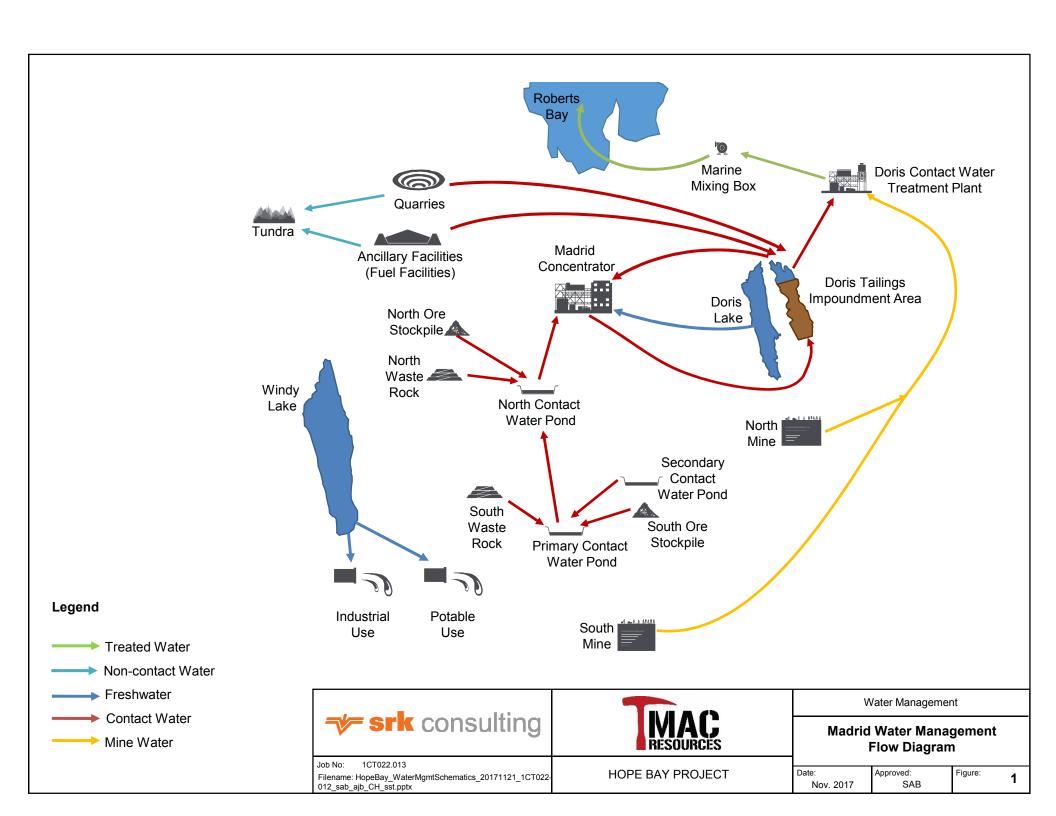
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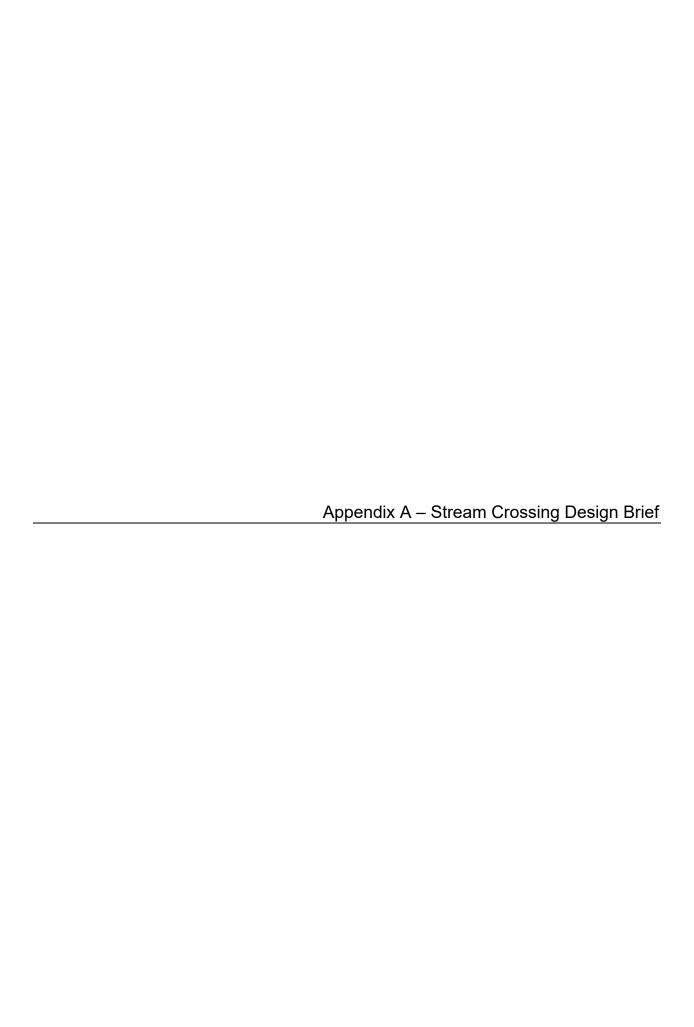
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TMAC Resources Inc.

November 30, 2017

Memo

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Subject: Hope Bay Project: Stream Crossing Preliminary Design Brief

Project No: 1CT022.013

Client:

Date:

1 Introduction

The Hope Bay Project (the Project) is a gold mining and milling undertaking of TMAC Resources Inc. The Project is located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory, and is situated east of Bathurst Inlet. The Project comprises of three distinct areas of known mineralization plus extensive exploration potential and targets. The three areas that host mineral resources are Doris, Madrid, and Boston.

The Project consists of two phases; Phase 1 (Doris project), which is currently being carried out under an existing Water Licence, and Phase 2 (Madrid-Boston project) which is in the environmental assessment and regulatory stage. Phase 1 includes mining and infrastructure at Doris, while Phase 2 includes mining and infrastructure at Madrid and Boston located approximately 10 and 60 km due south from Doris, respectively.

Phase 2 includes the design and construction of a 51 km long all-weather road connecting Madrid and Boston, identified as the Madrid-Boston all-weather road. The primary function of the road is to link the mining areas to allow year-round transport of supplies and equipment. A 5.4 km long single lane all-weather road will also connect the Doris tailings impoundment area (TIA) to the Madrid process plant, identified as the Madrid North TIA all-weather road. The primary function of the road is to provide a direct access corridor for the proposed tailings conveyance and water reclaim lines between Madrid North and the TIA.

This report describes the design criteria and identification of the stream crossings along the two all-weather roads. Crossings along the Doris-Windy all-weather road and Madrid South all-weather road are not included as these were presented in the Type "B" water license application No. 2BB-MAE1727 (TMAC, 2017)

2 Approach

SRK has defined a stream in this study as a preferential flow path for surface freshet melt water and rainfall, such that it may contain water seasonally or permanently and frequently links permanent water bodies.

2.1 Madrid-Boston All-Weather Road

The Madrid-Boston all-weather road design is described in a separate technical design brief (SRK, 2017a), and was surveyed during a recognisance of proposed crossings in 2011 (EBA, 2011). EBA identified thirteen potential crossings along the proposed road alignment. SRK has refined the crossing locations and lengths based on air photo interpretation, topography, available hydrology data, and photos and descriptions from previous studies. Two crossings identified in previous work have been relocated to more favorable locations, which allow for shorter, more easily constructed bridges. These changes to the road alignment have resulted in the need for one additional culvert crossing.

Four different crossing types have been identified at a total of 14 crossing locations:

- Single or twinned non-fish bearing culverts;
- Fish bearing culverts;
- Fish bearing clear span bridges with pile foundations, and
- Fish bearing clear span bridges with frozen abutment foundations.

Geotechnical investigations consisting of drillholes will be carried out at all of the proposed bridge abutments prior to detailed design. Crossing locations are identified in Drawing SCD-02, Attachment 1.

2.2 Madrid North TIA All-Weather Road

The Madrid North TIA all-weather road design is described in a separate technical design brief (SRK 2017b).

There are three stream crossings along the proposed Madrid North TIA all-weather road alignment. Fish bearing streams with minimal flow, fish bearing culverts have been sized to allow fish passage. This crossing will require a single end-bearing pile bridge at chainage 4+775 m east from the existing road. An end-bearing bridge was selected for this location based on stream characteristics and geometry, abutment geometry, and topography. Frozen abutment bridges could not meet the stream exclusion zone requirements without exceeding the maximum single span bridge length. End-bearing pile bridges will consist of end-bearing piles extending to bedrock, and road fill material will be held in place by a gabion wall.

The remaining two crossings have confirmed fish presence and will be fish-bearing culverts. Crossing locations are identified in Drawing SCD-01, Attachment 1.

3 Design Criteria

General design criteria for stream crossings are listed below.

- Stream crossings confirmed not to be fish habitat will be spanned using culverts if the peak flow is sufficiently low;
- Large fish-bearing streams will be spanned using clear span bridge structures;
- Fish-bearing streams of very low flow will be spanned using culverts sized for passage of the expected fish species, during normal flow conditions (1:2 year, 24-hour storm event);
- Streams have been identified as fish bearing or non-fish bearing based on baseline assessments (personal communication Philip Lee of ERM April 19, 2016); and
- To be consistent with crossings on existing roads (SRK, 2017a) crossings will be designed for loaded CAT 773 haul trucks.

Design criteria for clear span crossings are based on the Northwest Territories Clear-Span Bridges Operational Statement prepared by Fisheries and Oceans Canada (2007), and thermal modelling criteria (SRK, 2017a). The clear span crossing design criteria are listed below:

- The underside of the bridge deck must be a minimum of 2 m above the ordinary high-water mark (HWM);
- Abutments must be a minimum of 1.5 m from the HWM on either side of the stream;
- The HWM is defined as the usual or average level to which a body of water rises at its
 highest point and remains at this level long enough to change the land characteristics.
 For rivers and streams, this is the flow generated from a 1:2 year, 24-hour storm;
- For ease of construction and material transportation, all clear-span structures are assumed to have a maximum deck length of 20 m;
- The minimum road fill thickness at the bridge abutments is 2.0 m;
- Bridges should have solid decks to prevent material from falling into the stream; and
- For frozen abutment bridges the abutment shall consist of a concrete sill resting on a bridge support pad. The bridge support pad should extend a minimum of 3 m beyond the concrete sill, and will have minimum slopes of 1.5H:1V (34°).

4 Preliminary Design

Table 4.1 provides details on all stream crossings. A drawing package in Attachment 1 presents locations. Additional road design details are presented in the respective road design reports.

Table 4.1: Stream Crossing Details

Road	Crossing ID	Crossing Type	Minimum Span Length* (m)	Comments	
	C-MBR-7	End bearing pile bridge	15 m	Fish presence confirmed (Arctic Grayling & Ninespine Stickleback)	
	C-MBR-8	End bearing pile bridge	14 m	Fish presence confirmed (Arctic Grayling & Ninespine Stickleback)	
	C-MBR-9	End bearing pile bridge	20 m	Fish presence confirmed (Ninespine Stickleback)	
	C-MBR-10	Culvert	N/A	Generally wet area; preferential flow path not identified; likely non-fish-bearing	
	C-MBR-11	Fish-bearing culvert	N/A	Generally wet area; preferential flow path not identified; fish presence confirmed (Ninespine Stickleback)	
	C-MBR-12	End bearing pile bridge	20 m	Fish presence confirmed (Arctic Grayling & Ninespine Stickleback)	
Madrid-	C-MBR-13	Fish-bearing culvert	N/A	Very small stream; assumed fish-bearing	
Boston All- Weather	C-MBR-14	Culvert	N/A	Generally wet area; preferential flow path not identified; likely non-fish-bearing	
Road	C-MBR-15	End bearing pile bridge	12 m	Fish presence confirmed (Ninespine Stickleback)	
	C-MBR-16	End bearing pile bridge	10 m	End bearing pile span would reduce the required width; fish presence confirmed (Arctic Grayling & Ninespine Stickleback)	
	C-MBR-17	Fish-bearing culvert	N/A	Very small stream; fish presence confirmed (Ninespine Stickleback)	
	C-MBR-18	Culvert	N/A	Generally wet area; preferential flow path not identified; likely non-fish-bearing	
	C-MBR-19	End bearing pile bridge	12 m	Fish presence confirmed (Lake Trout, Burbot, Slimy Sculpin, Arctic Grayling & Ninespine Stickleback)	
	C-MBR-20	Fish-bearing culvert	N/A	Very small stream; fish presence confirmed (Ninespine Stickleback, Arctic Grayling & Slimy Sculpin)	
Madrid North - TIA All- Weather Road	C-MNR-04	Fish-bearing culvert	N/A	Fish presence confirmed (Ninespine Stickleback)	
Madrid- Boston	C-MNR-05	Fish-bearing culvert	N/A	Fish presence confirmed (Ninespine Stickleback)	
All- Weather Road	C-MNR-06	End bearing pile bridge	15 m	Fish presence confirmed (Lake Trout, Lake Whitefish, Cisco & Ninespine Stickleback)	

Notes: *Typical supplier bridge span lengths will be used where possible to avoid custom manufacturing

Low flow stream crossings confirmed not to be fish habitat will be spanned using two 1 m diameter culverts. For fish bearing streams with minimal flow, culverts that have been sized to allow fish passage will be used. A typical fish bearing culvert will have a minimum diameter of 1 m and riprap will be placed inside the culvert to dampen the flow velocity to allow the passage of fish. Drawing SCD-20 (Attachment 1) shows a typical section for non-fish bearing and fish-bearing culvert crossings. Culvert diameter and riprap size will vary depending on the catchment area reporting to the crossing and the type of fish expected.

Currently, no frozen abutment bridge crossings have been specified (Table 4.1); however, should detailed design determine crossings currently identified as fish bearing culverts cannot meet the requirements for fish passage, then frozen abutment bridges will be used instead.

Drawing SCD-21 (Attachment 1) provides a typical plan view and cross section.

End bearing bridges were selected for these locations based on stream characteristics, abutment geometry, and topography. Frozen abutment bridges could not meet the stream exclusion zone requirements without exceeding the maximum bridge length. End-bearing pile bridges will consist of end-bearing piles extending to bedrock, and road fill material will be held in place by a gabion wall. Drawing SCD-22 (Attachment 1) provides a typical schematic design.

For the first few years after construction, silt fences will be installed along the toe of the roadway to ensure that sediments do not enter the streams. The silt fences will start a minimum of 3 m before the abutment of the clear-span structure.

Final culvert sizing will be consistent with the approach followed for the Roberts Bay discharge access road crossing design (SRK, 2016).

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

5 References

EBA. (2011). Site Reconnaissance on Winter Road Routes, Hope Bay Project. Prepared for Hope Bay Mining Ltd.

- SRK Consulting (Canada) Inc., 2016. Hope Bay Project Roberts Bay Discharge Access Road Culvert Crossing Design Brief. Prepared for TMAC Resources.
- SRK Consulting (Canada) Inc., 2017a. Hope Bay Project: Madrid-Boston All-Weather Road Preliminary Design. Prepared for TMAC Resource Inc. Project No. 1CT022.013.
- SRK Consulting (Canada) Inc., 2017b. Hope Bay Project: Madrid North Tailings Impoundment Area All-Weather Road Preliminary Design. Prepared for TMAC Resources Inc. Project No 1CT022.013.
- TMAC Resources Inc., 2017. Type "B" Water License Madrid Advanced Exploration Program. No. 2BB-MAE1727.



Engineering Drawings for the Stream Crossing Design Drawings, Hope Bay Project, Nunavut, Canada

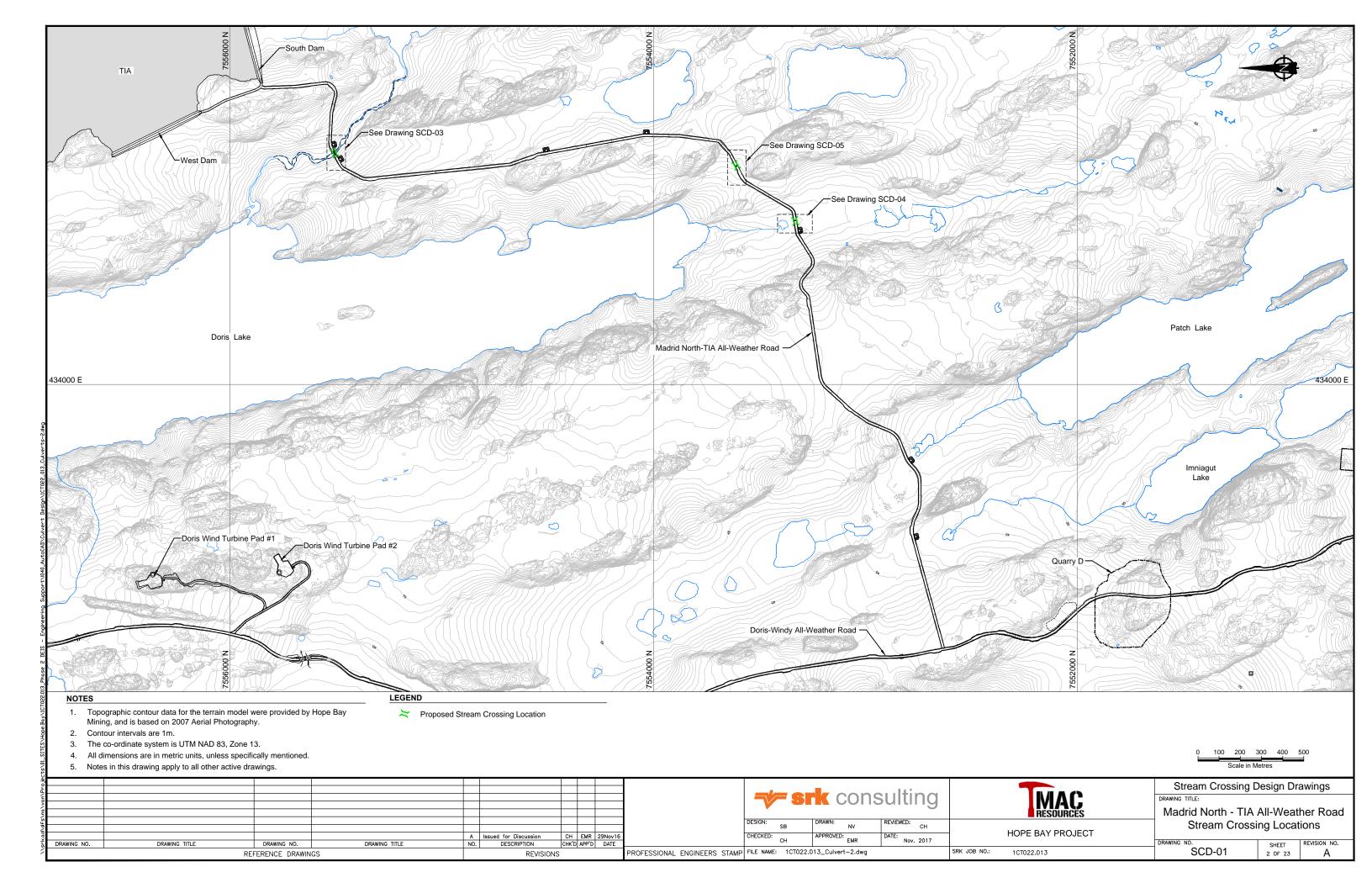
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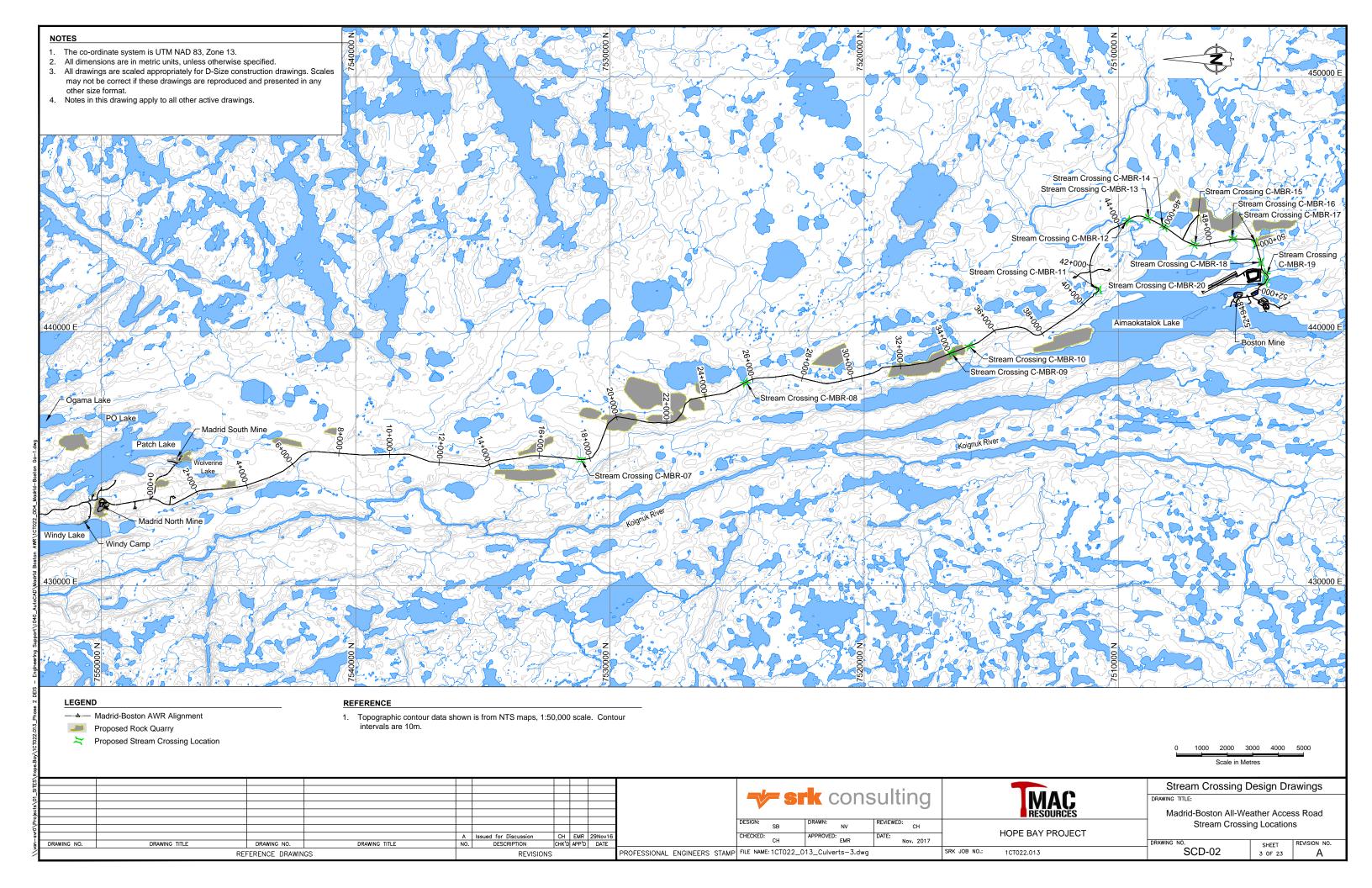
DWG NUMBER	DRAWING TITLE	REVISION	DATE	STATUS
SCD-00	Engineering Drawings for the Stream Crossing Design Drawings, Hope Bay Project, Nunavut, Canada	A	Nov. 29, 2017	Issued for Discussion
SCD-01	Madrid North - TIA All-Weather Road Stream Crossing Locations	Α	Nov. 29, 2017	Issued for Discussion
SCD-02	Madrid-Boston All-Weather Access Road Stream Crossing Locations	Α	Nov. 29, 2017	Issued for Discussion
SCD-03	Stream Crossing C-MN-04 (End Bearing Pile Span)	Α	Nov. 29, 2017	Issued for Discussion
SCD-04	Stream Crossing C-MN-05 (Culvert Crossing)	Α	Nov. 29, 2017	Issued for Discussion
SCD-05	Stream Crossing C-MN-06 (Culvert Crossing)	Α	Nov. 29, 2017	Issued for Discussion
SCD-06	Stream Crossing C-MBR-7 (End Bearing Pile Span)	Α	Nov. 29, 2017	Issued for Discussion
SCD-07	Stream Crossing C-MBR-8 (End Bearing Pile Span)	Α	Nov. 29, 2017	Issued for Discussion
SCD-08	Stream Crossing C-MBR-9 (End Bearing Pile Span)	Α	Nov. 29, 2017	Issued for Discussion
SCD-09	Stream Crossing C-MBR-10 (Culvert Crossing)	A	Nov. 29, 2017	Issued for Discussion
SCD-10	Stream Crossing C-MBR-11 (Culvert Crossing)	Α	Nov. 29, 2017	Issued for Discussion
SCD-11	Stream Crossing C-MBR-12 (End Bearing Pile Span)	Α	Nov. 29, 2017	Issued for Discussion
SCD-12	Stream Crossing C-MBR-13 (Culvert Crossing)	A	Nov. 29, 2017	Issued for Discussion
SCD-13	Stream Crossing C-MBR-14 (Culvert Crossing)	Α	Nov. 29, 2017	Issued for Discussion
SCD-14	Stream Crossing C-MBR-15 (End Bearing Pile Span)	A	Nov. 29, 2017	Issued for Discussion
SCD-15	Stream Crossing C-MBR-16 (End Bearing Pile Span)	Α	Nov. 29, 2017	Issued for Discussion
SCD-16	Stream Crossing C-MBR-17 (Culvert Crossing)	A	Nov. 29, 2017	Issued for Discussion
SCD-17	Stream Crossing C-MBR-18 (Culvert Crossing)	A	Nov. 29, 2017	Issued for Discussion
SCD-18	Stream Crossing C-MBR-19 (End Bearing Pile Span)	A	Nov. 29, 2017	Issued for Discussion
SCD-19	Stream Crossing C-MBR-20 (Culvert Crossing)	Α	Nov. 29, 2017	Issued for Discussion
SCD-20	Culvert Crossings Typical Sections	Α	Nov. 29, 2017	Issued for Discussion
SCD-21	Typical Frozen Abutment Bridge Crossing Plan and Section	Α	Nov. 29, 2017	Issued for Discussion
SCD-22	Typical End Bearing Pile Section and Thermistor Bead Spacing Detail	Α	Nov. 29, 2017	Issued for Discussion

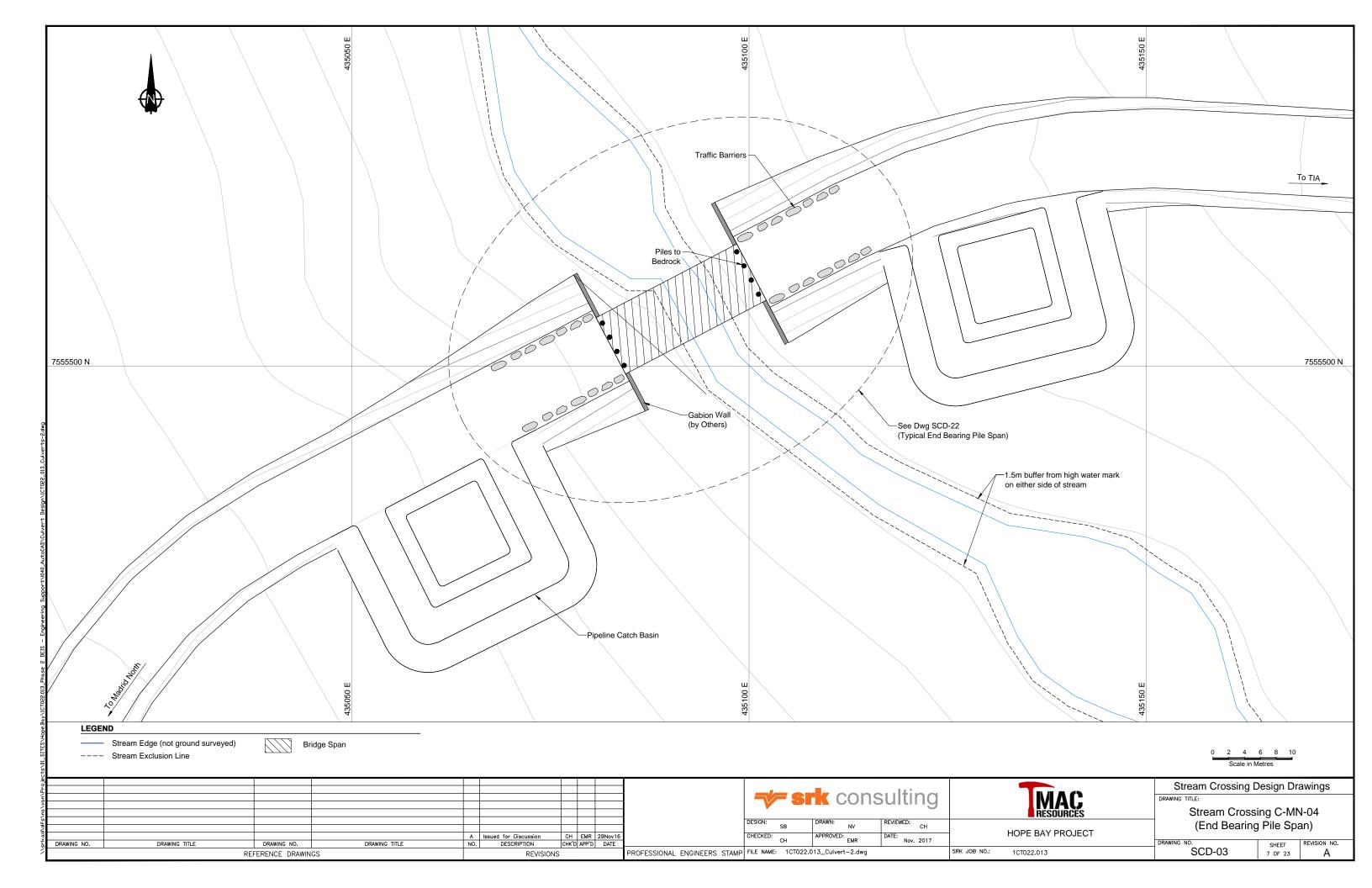


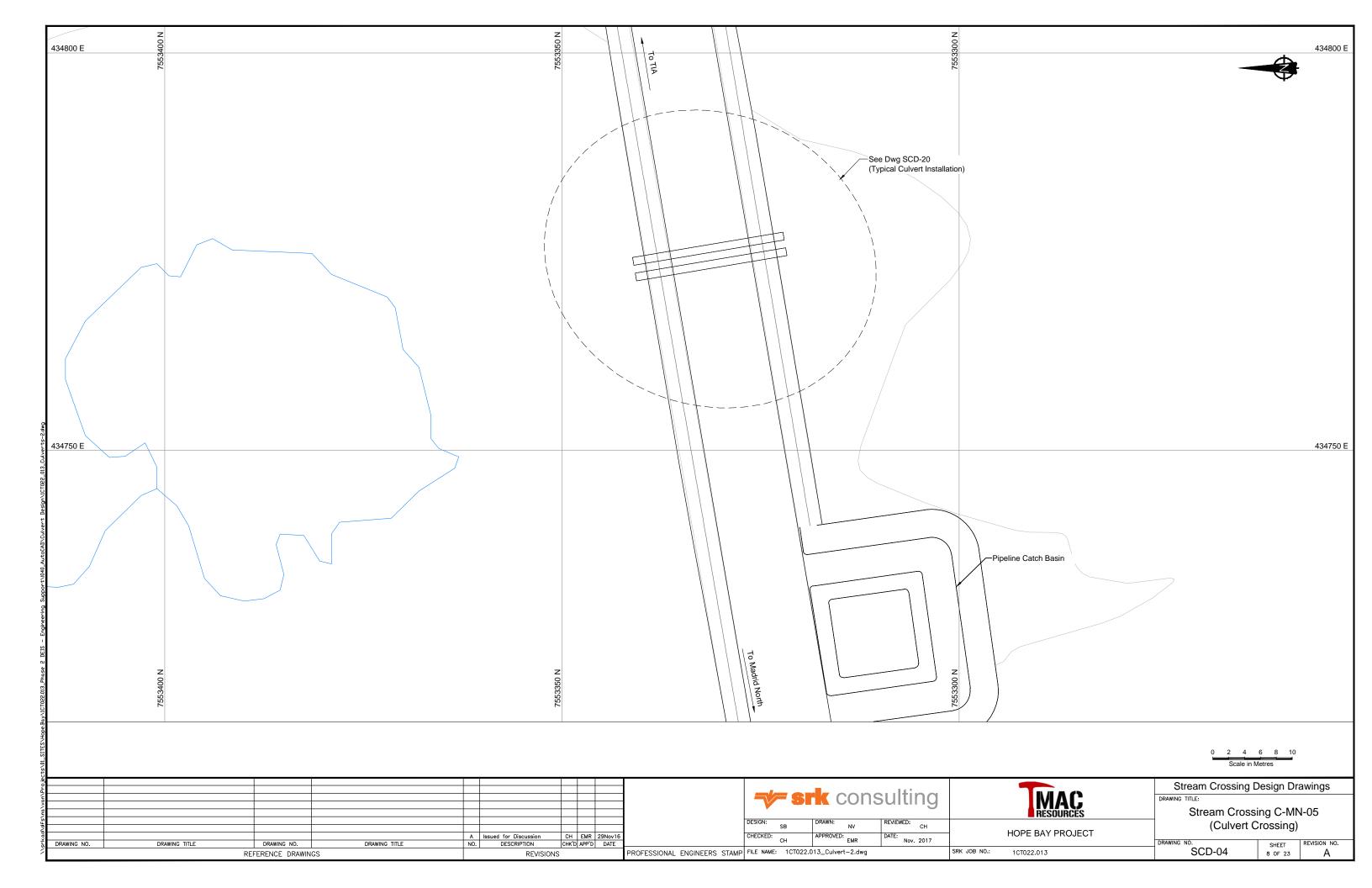


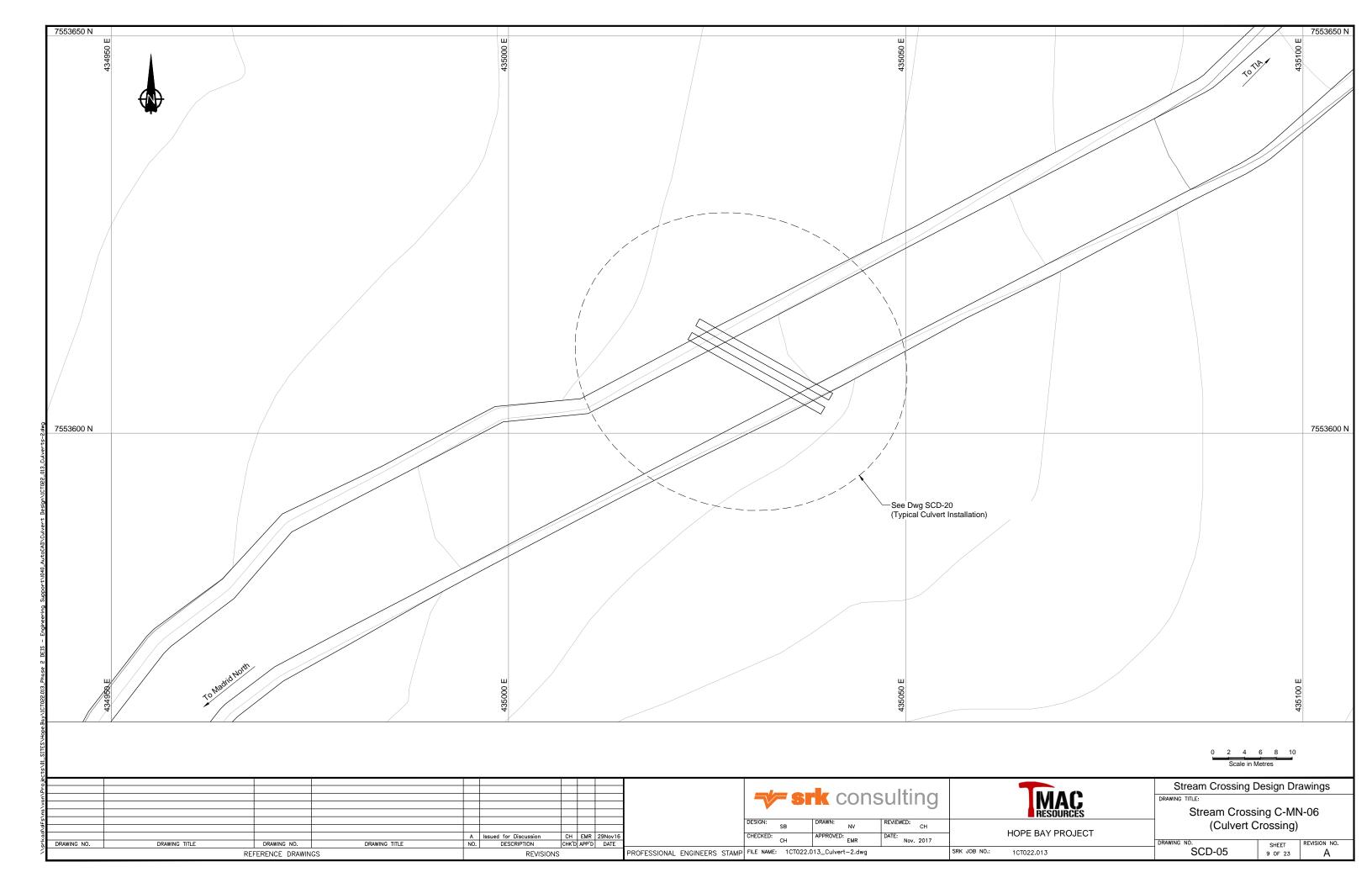
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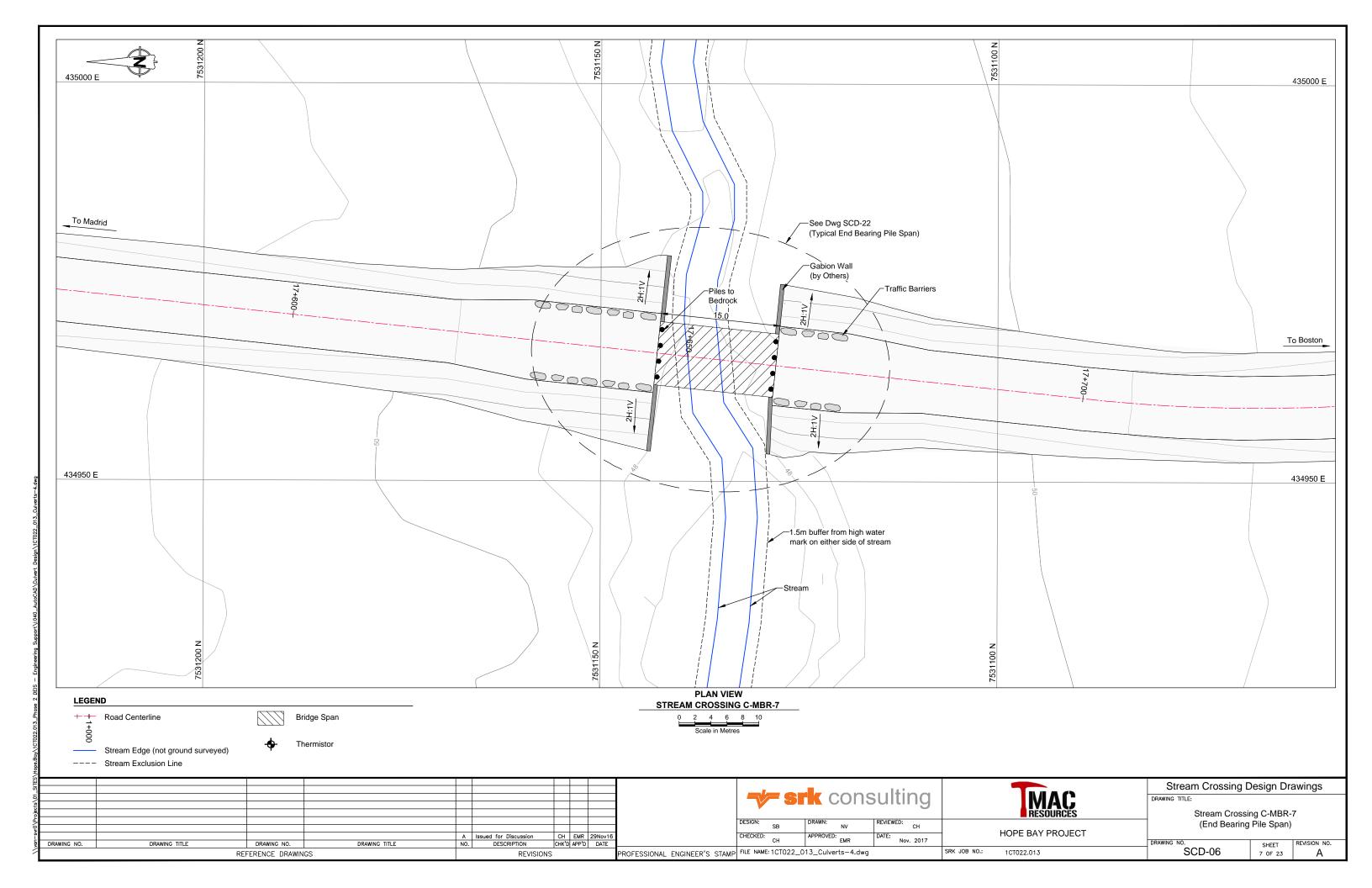


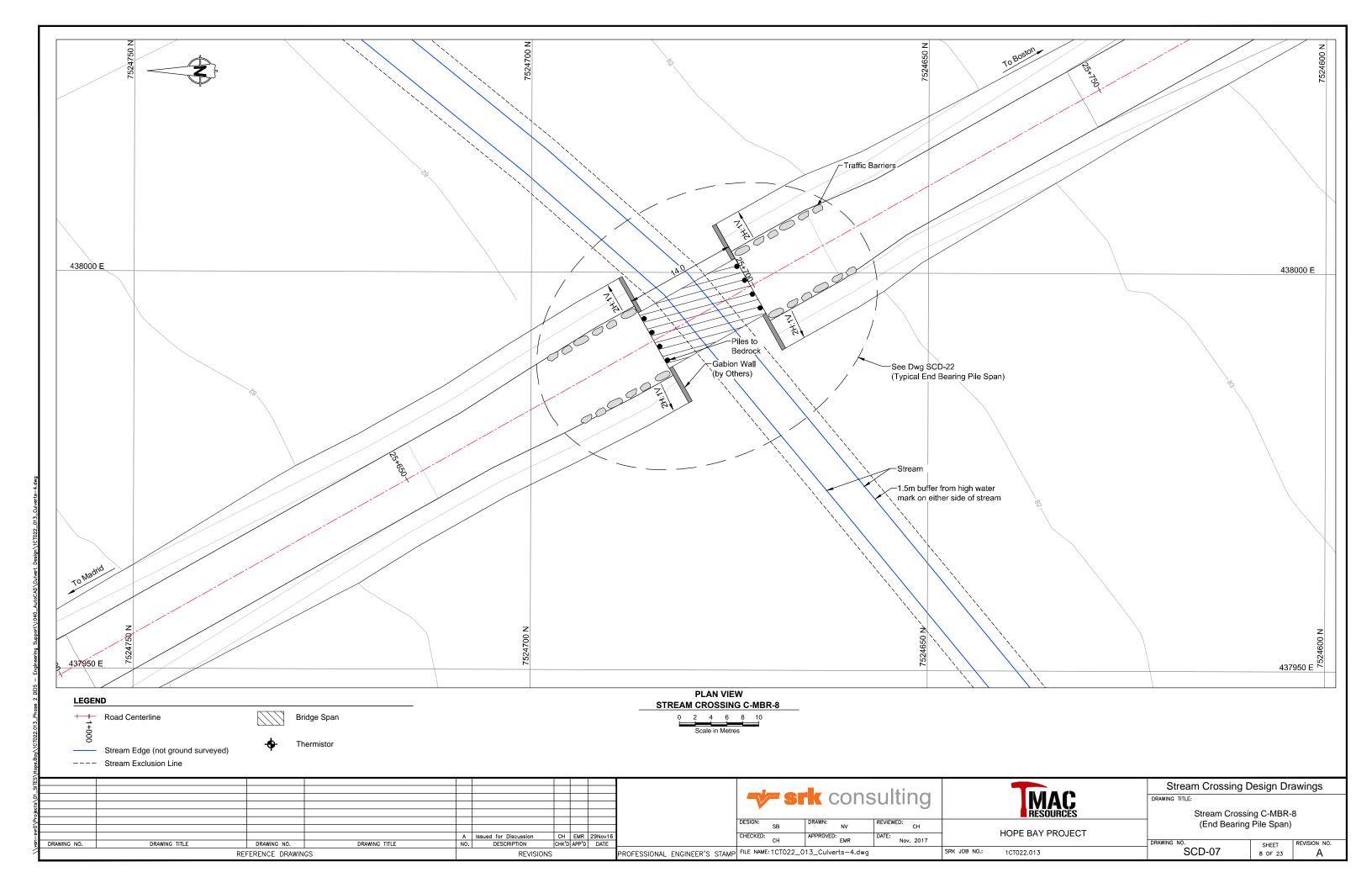


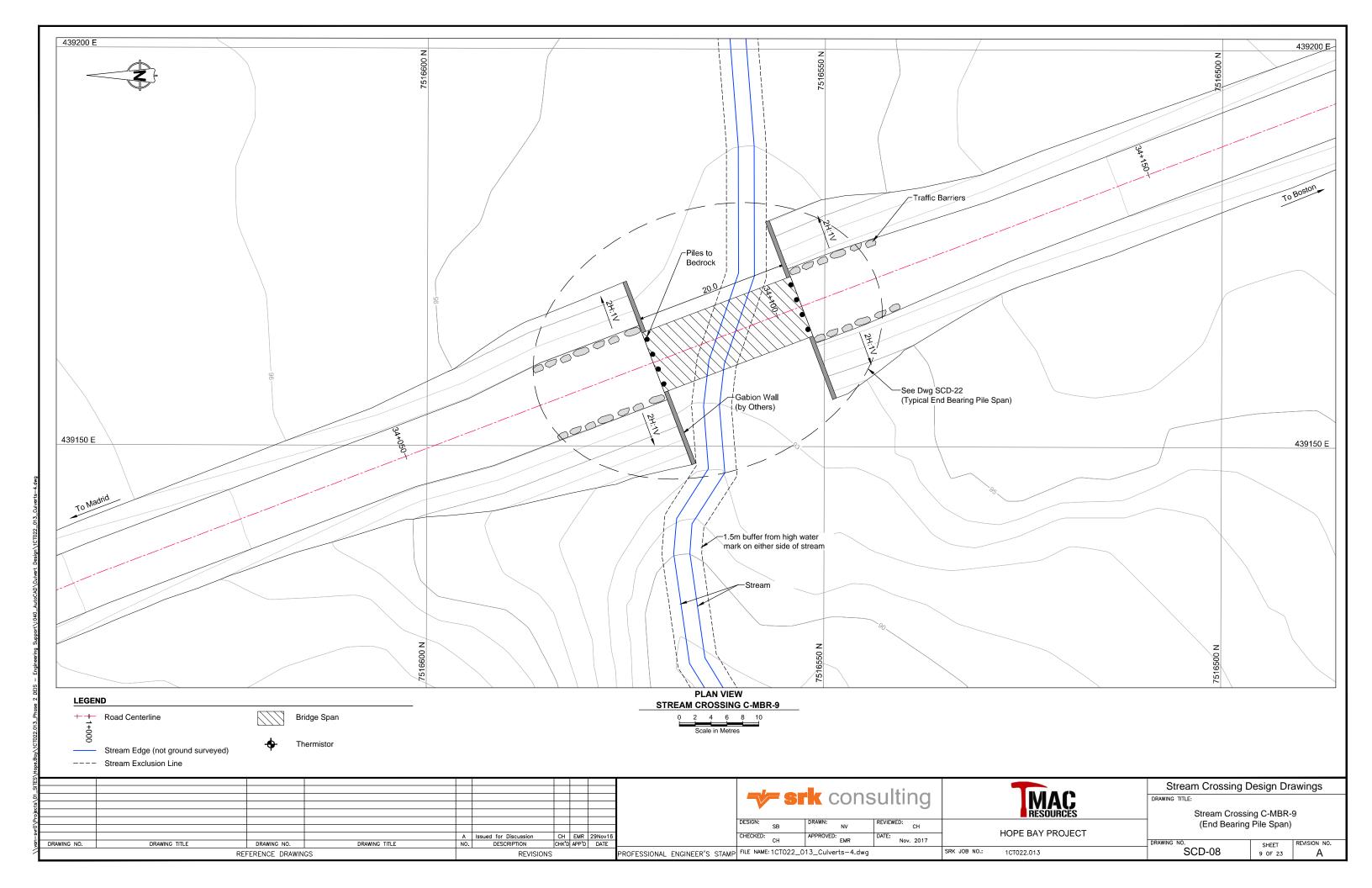


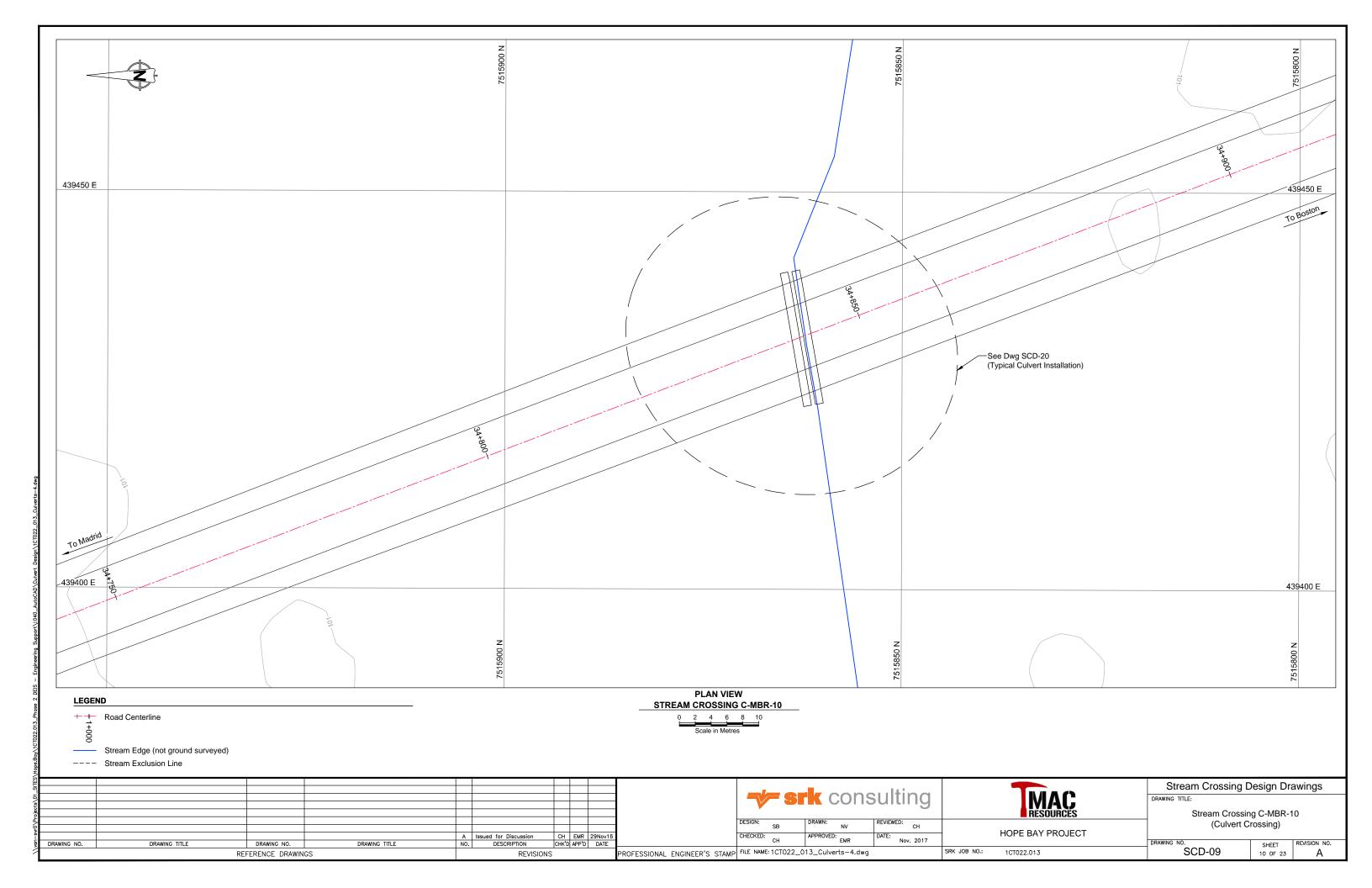


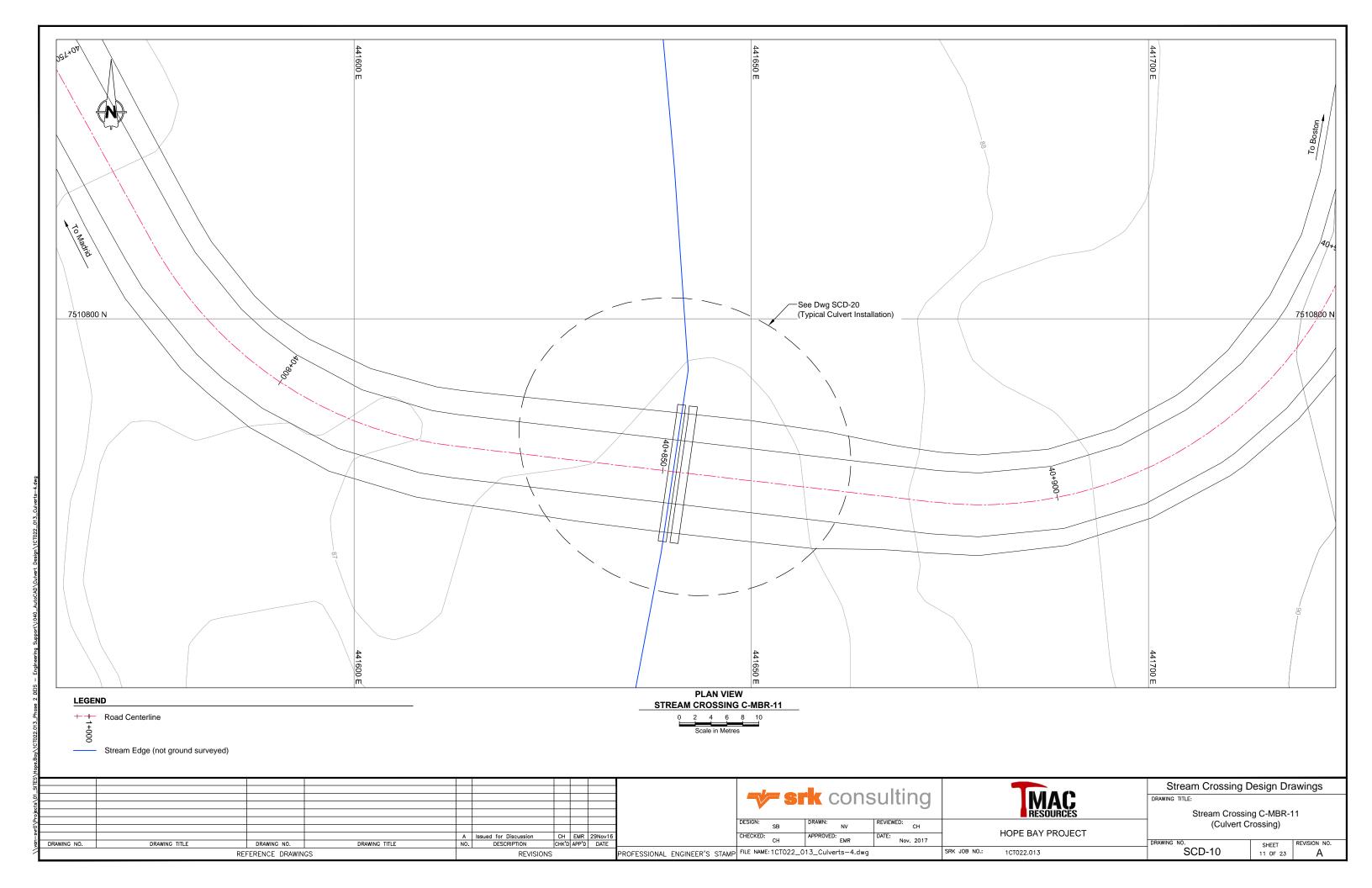


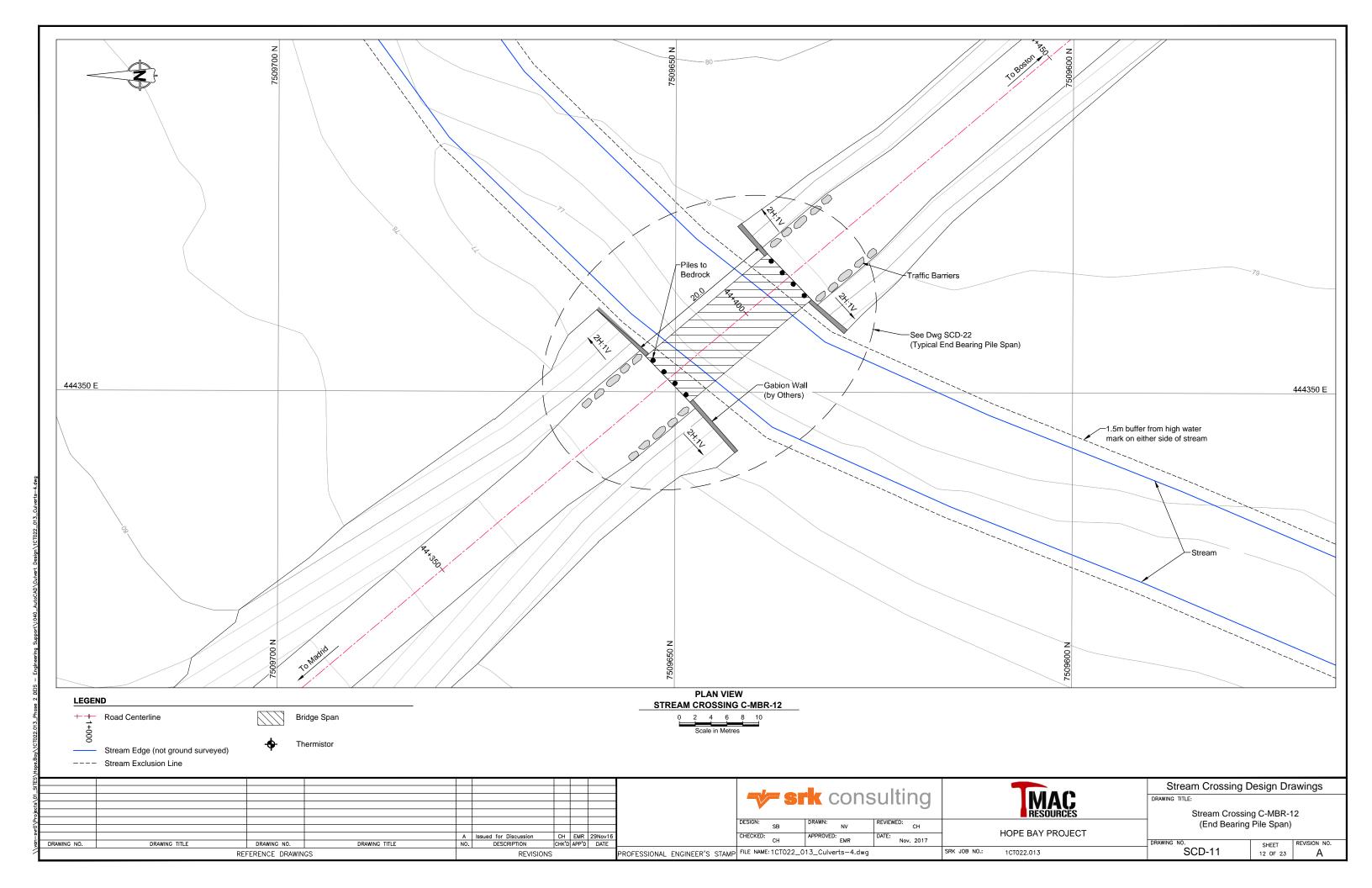


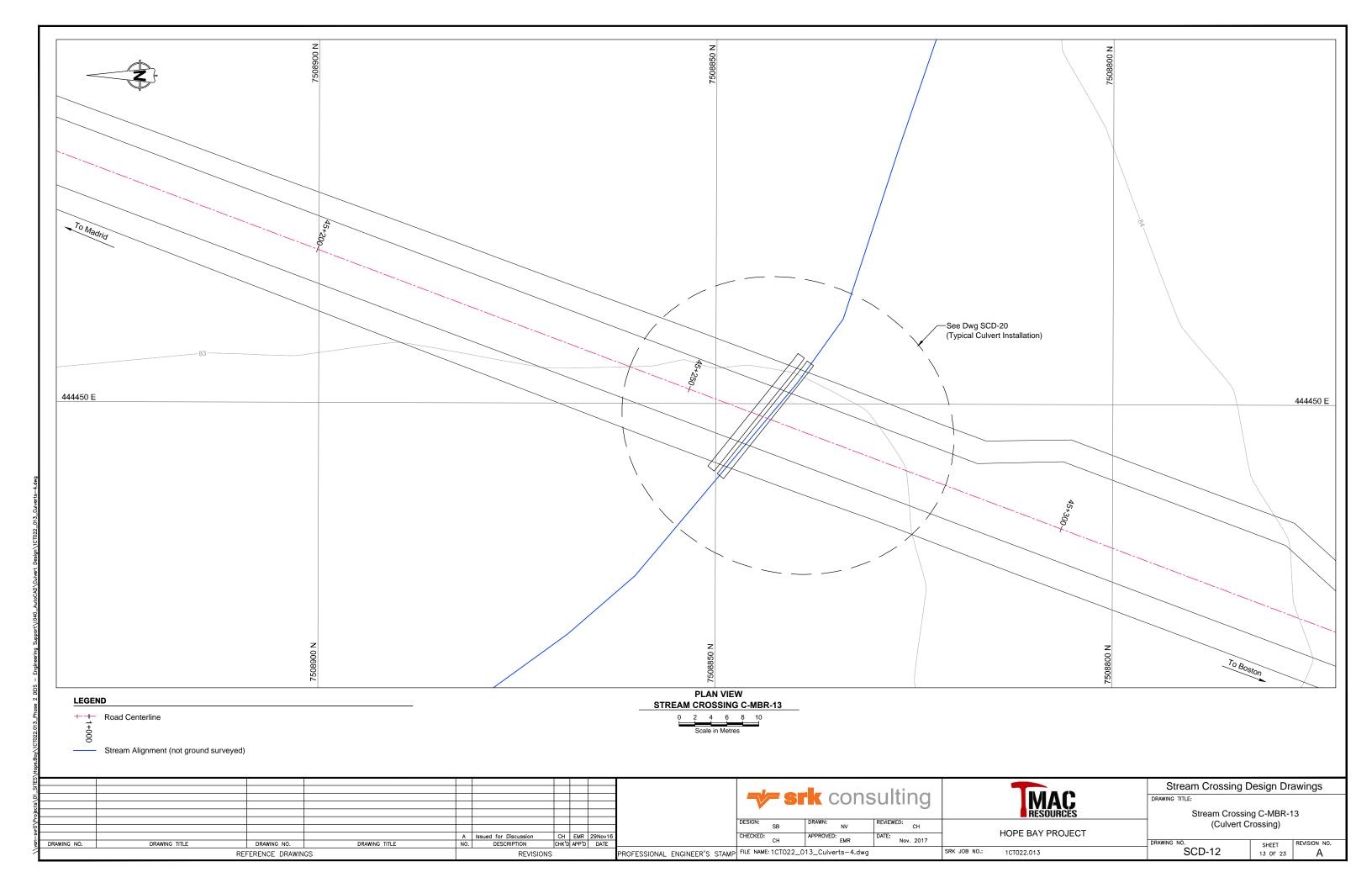


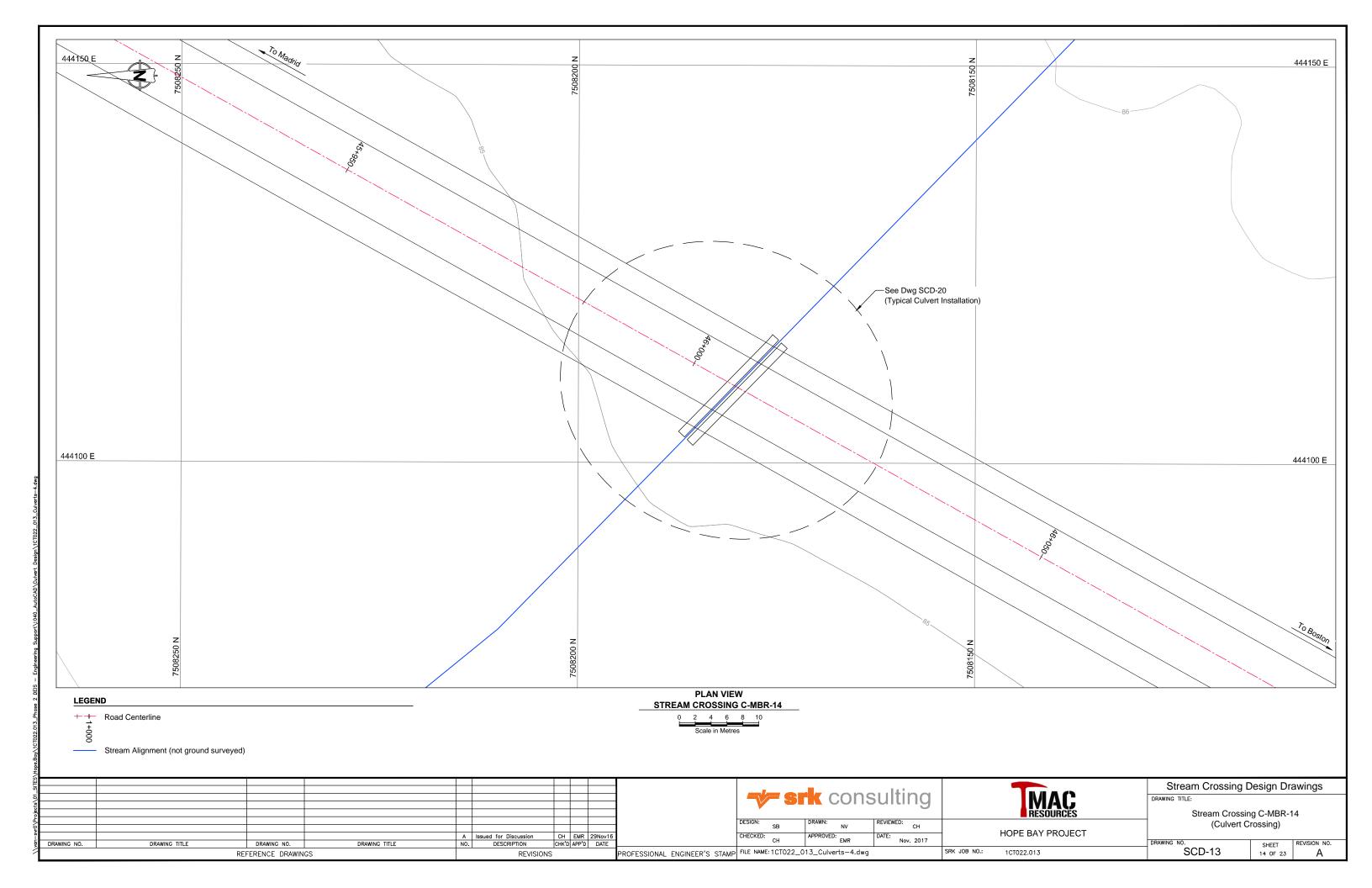


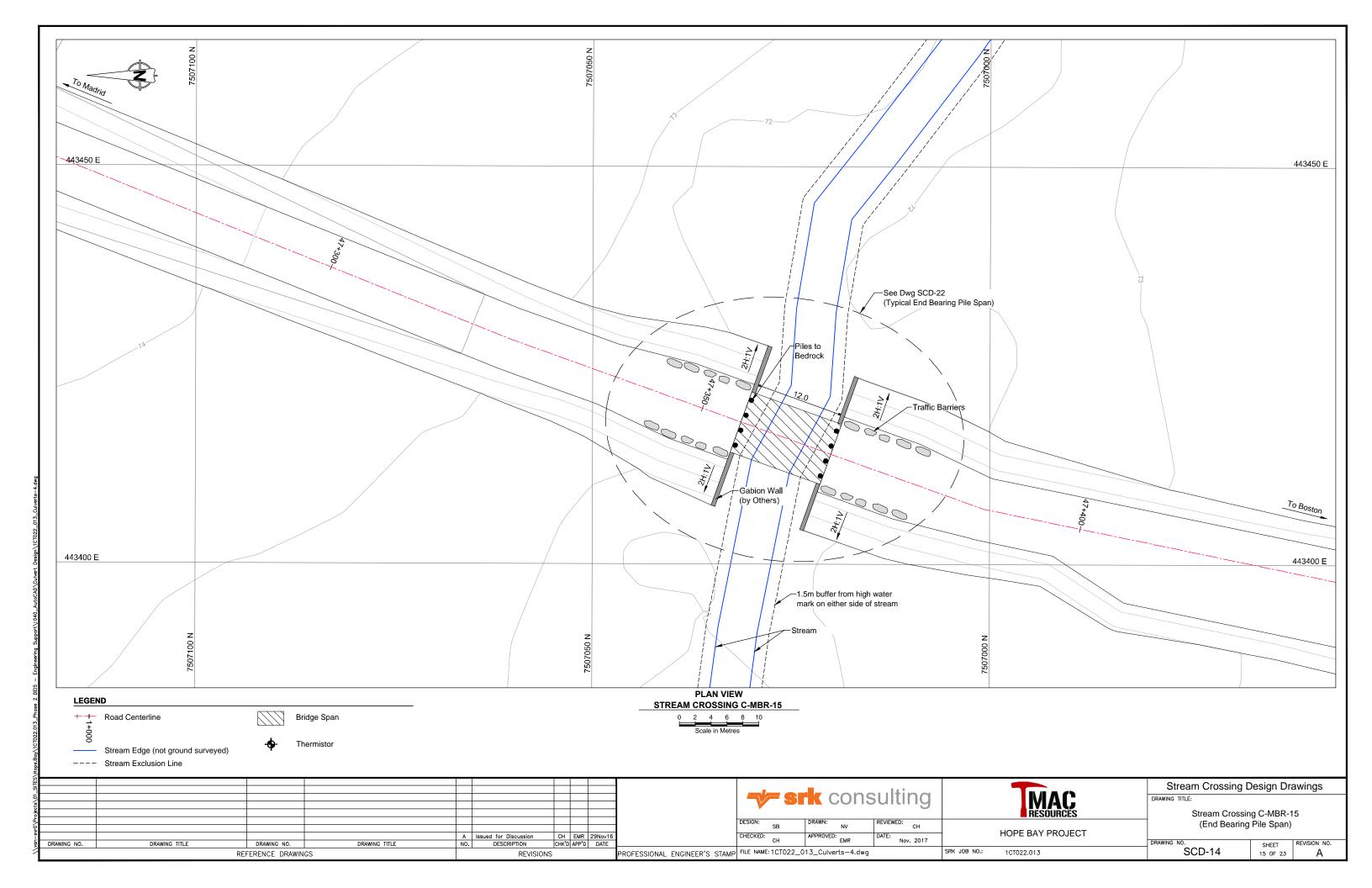


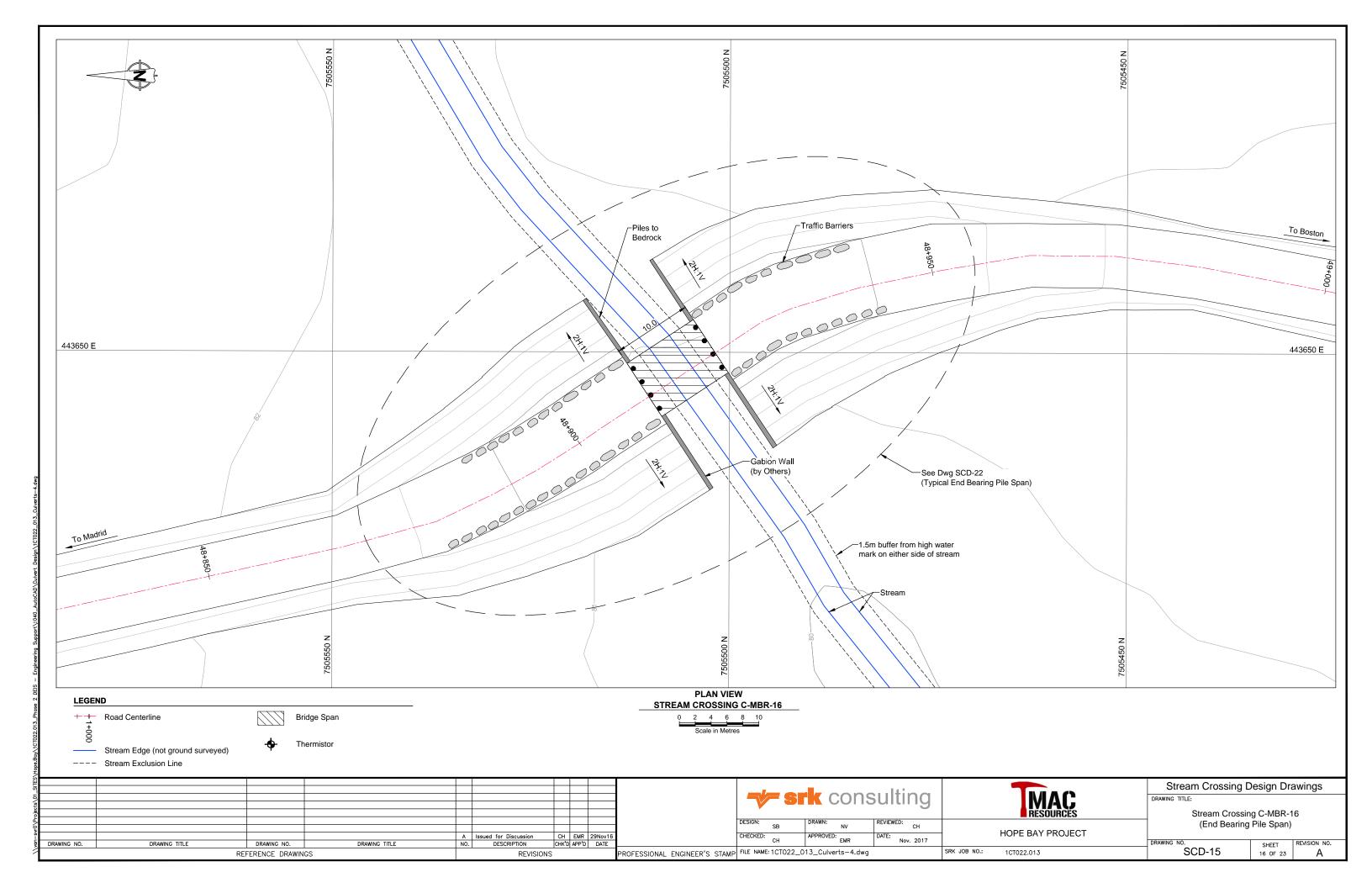


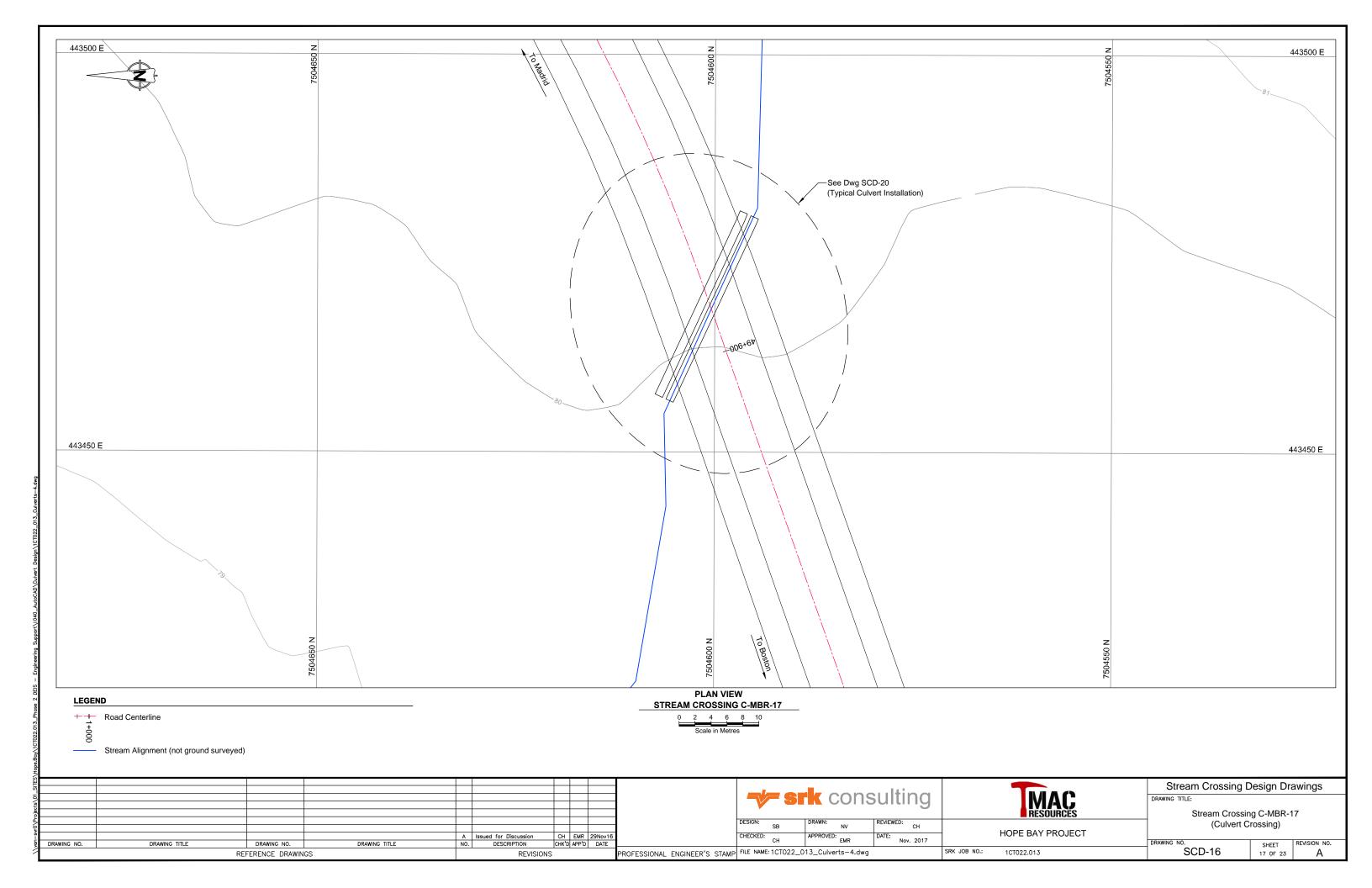


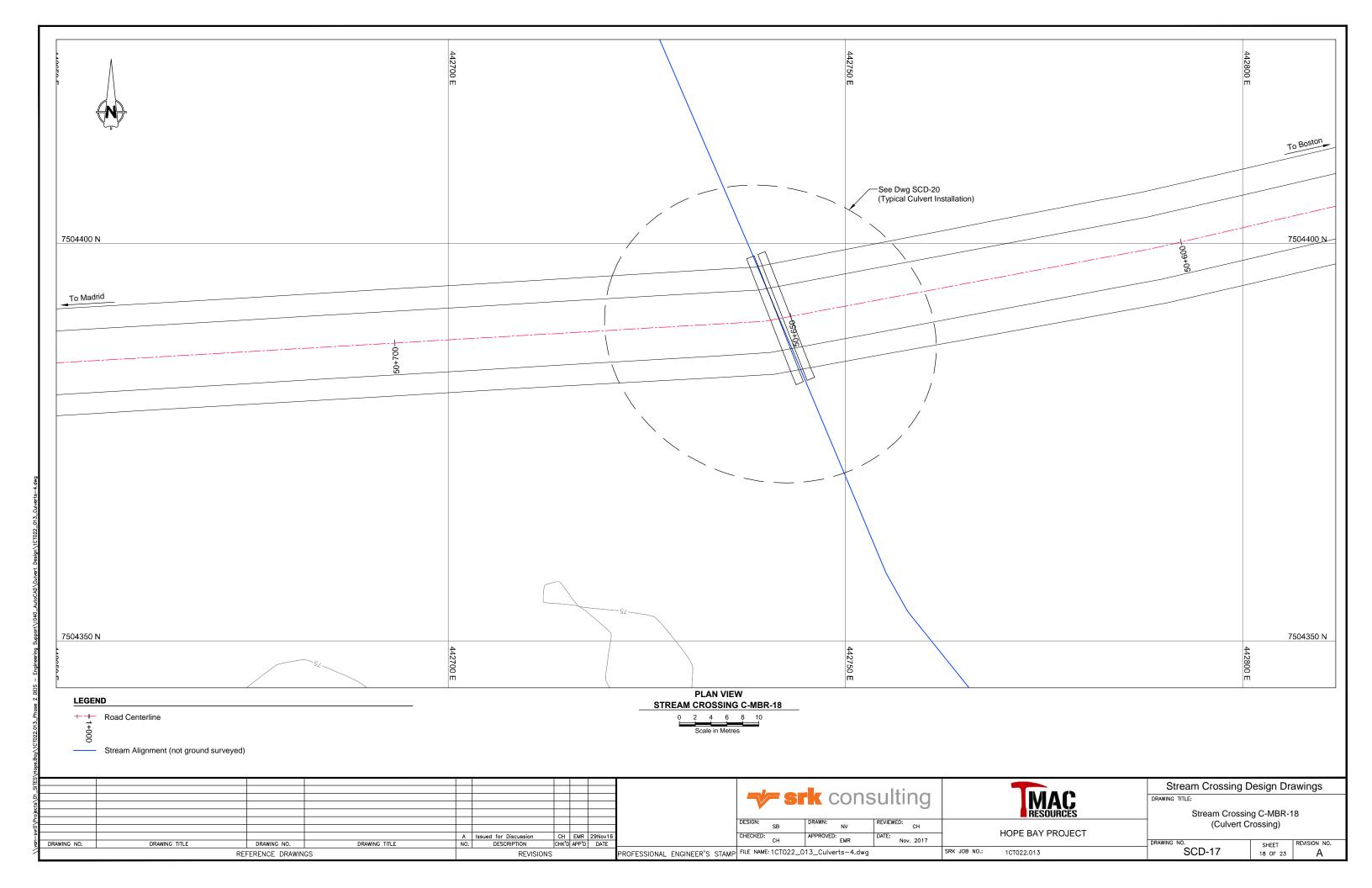


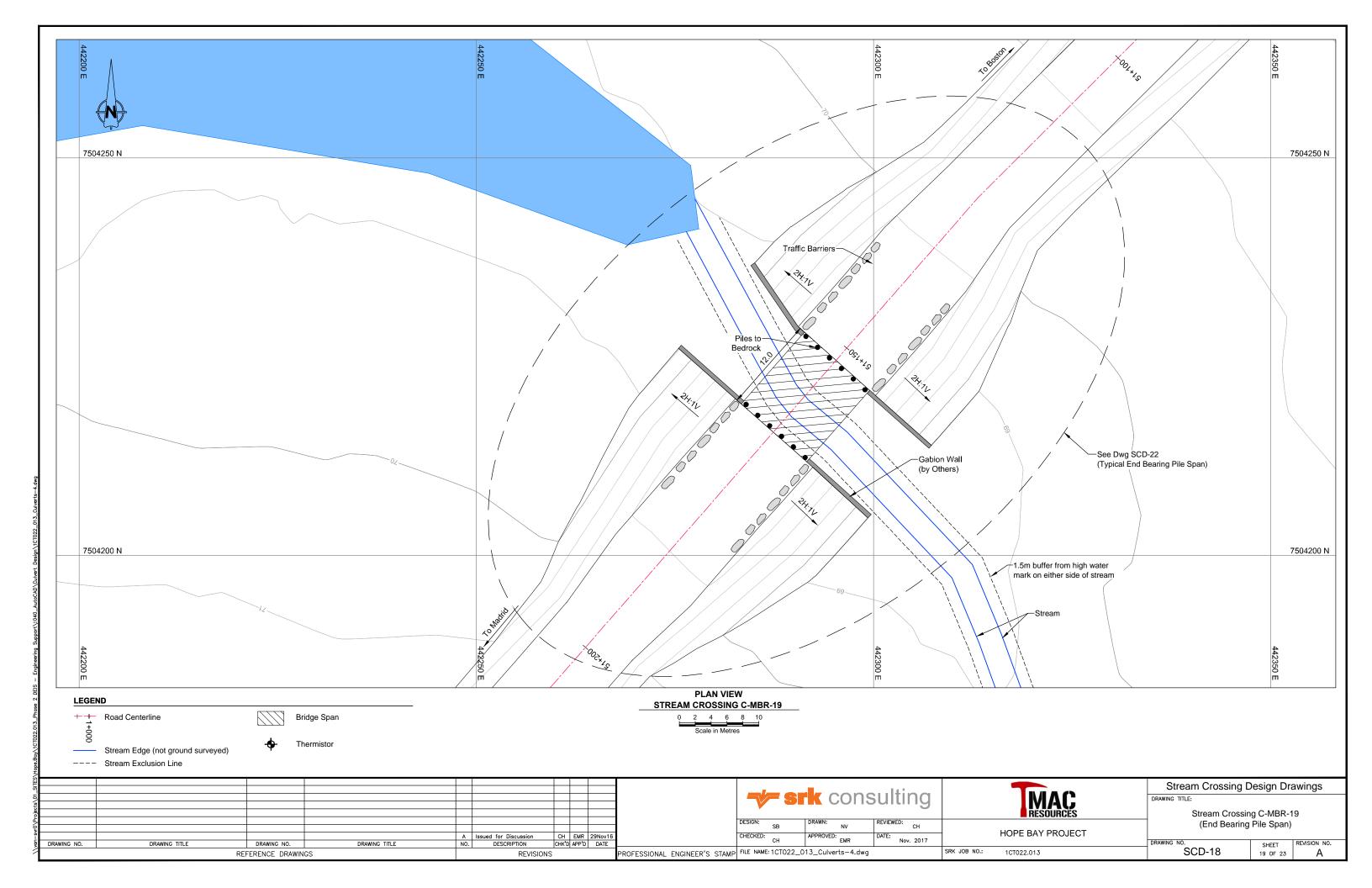


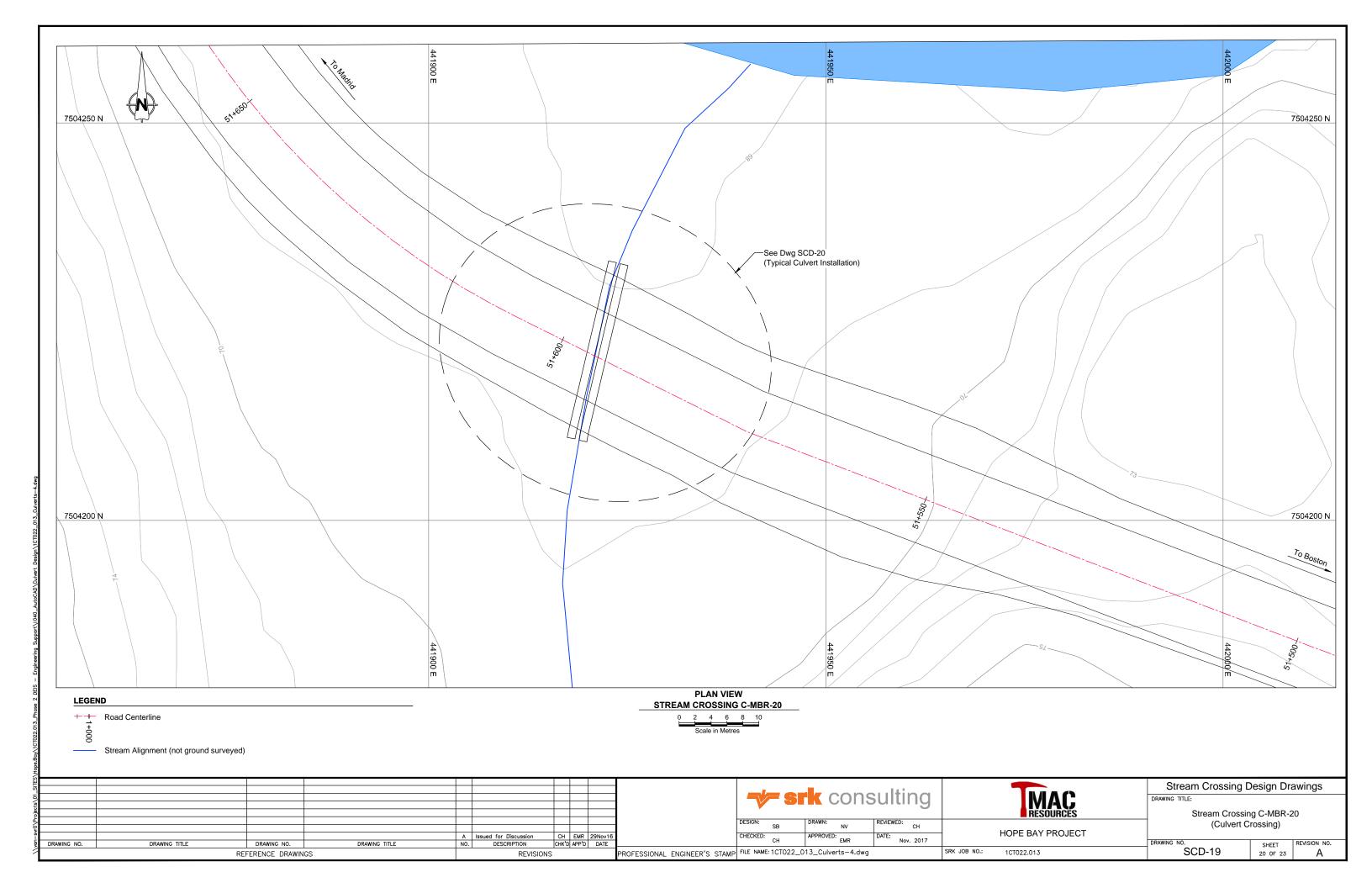


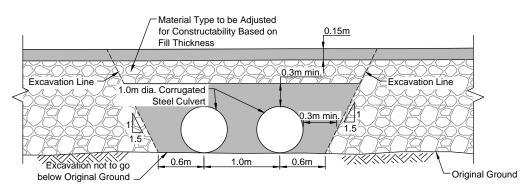




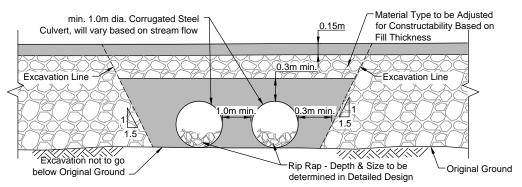








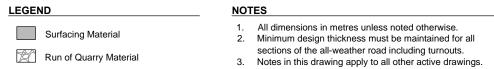
DETAIL 1 TYPICAL CROSS SECTION OF NON-FISH-BEARING STREAM CULVERT CROSSING NOT TO SCALE

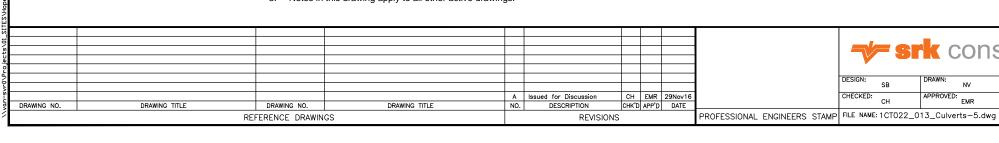


DETAIL 2 TYPICAL CROSS SECTION OF FISH-BEARING STREAM CULVERT CROSSING NOT TO SCALE

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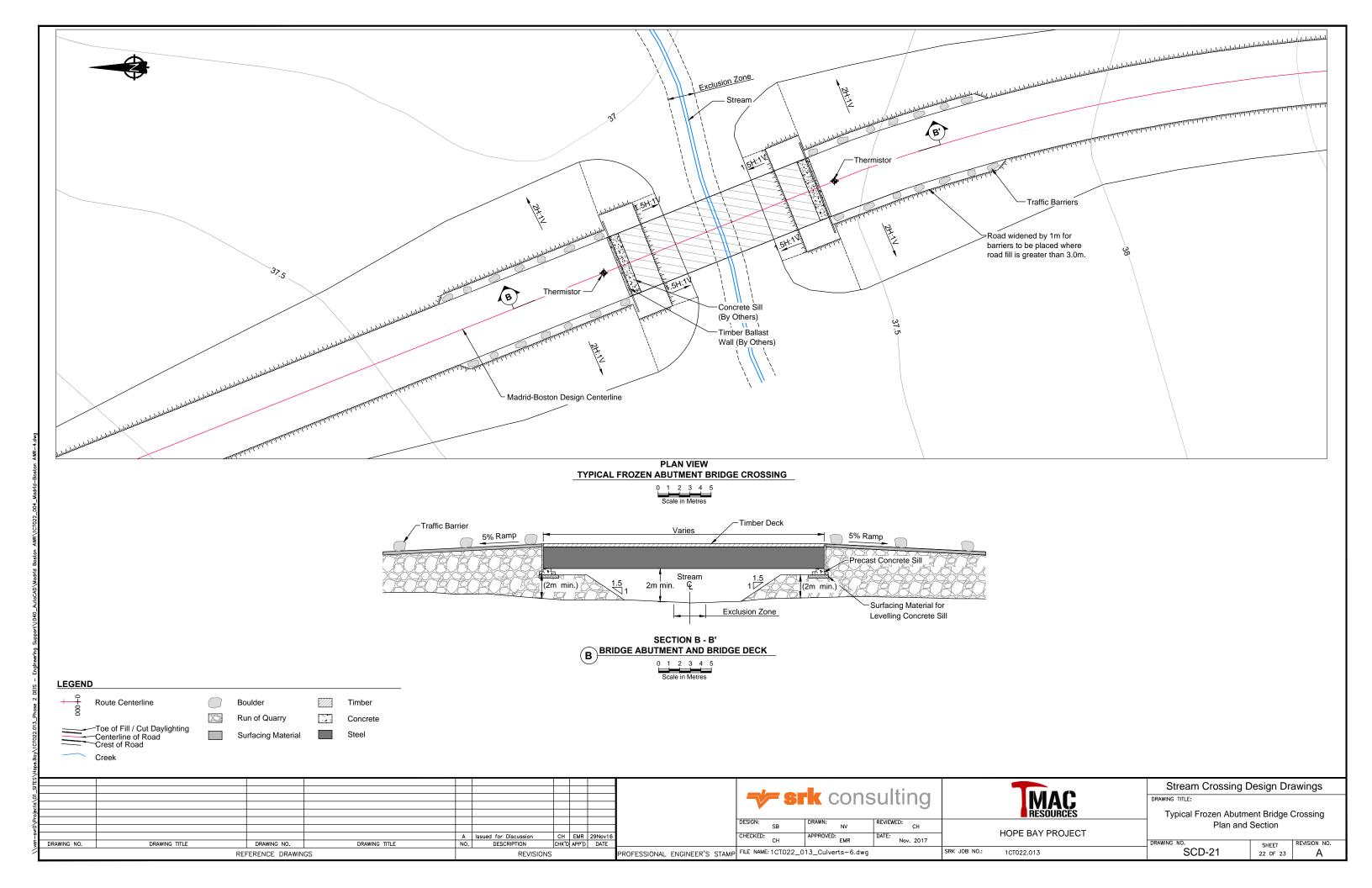


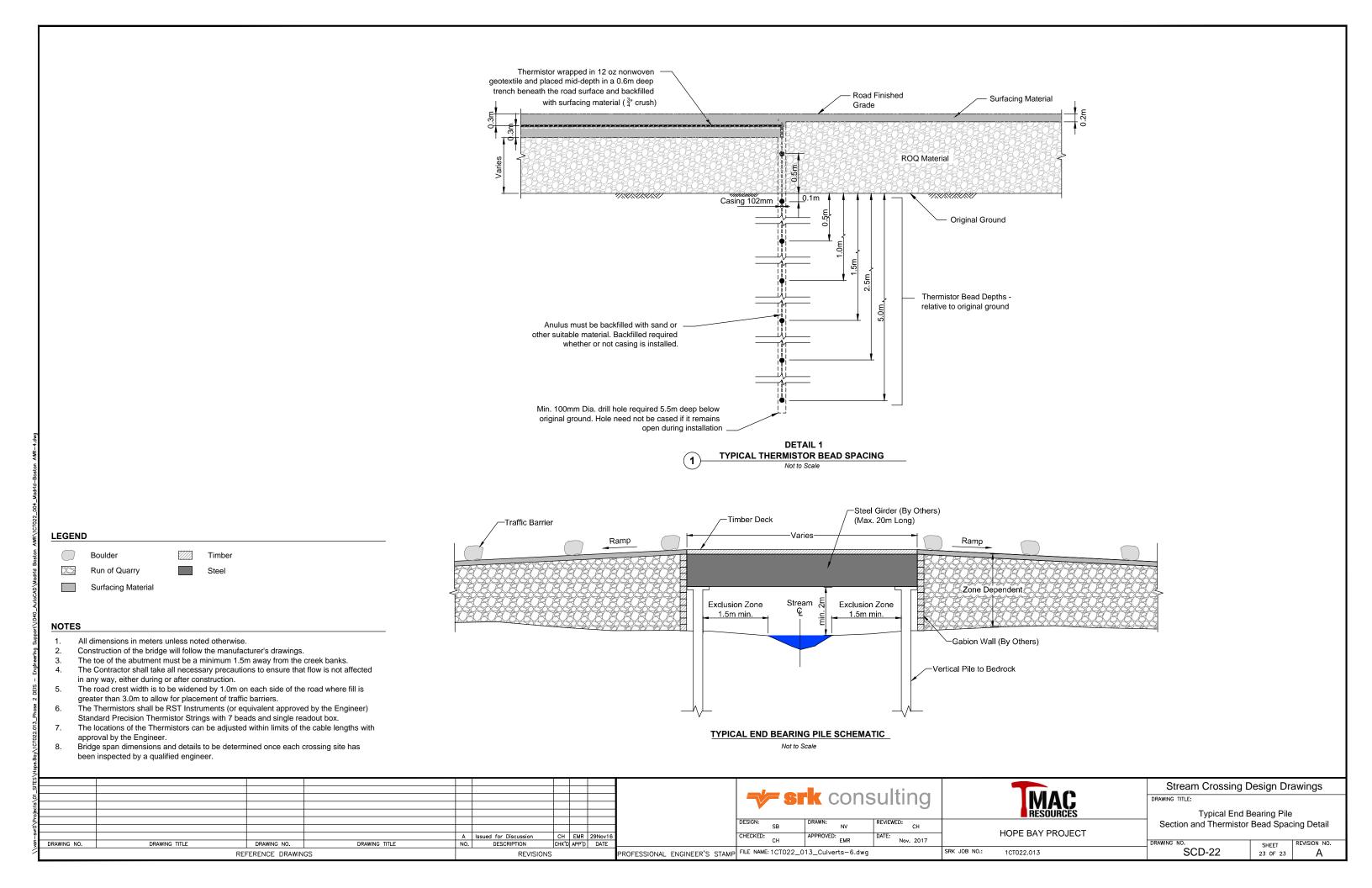


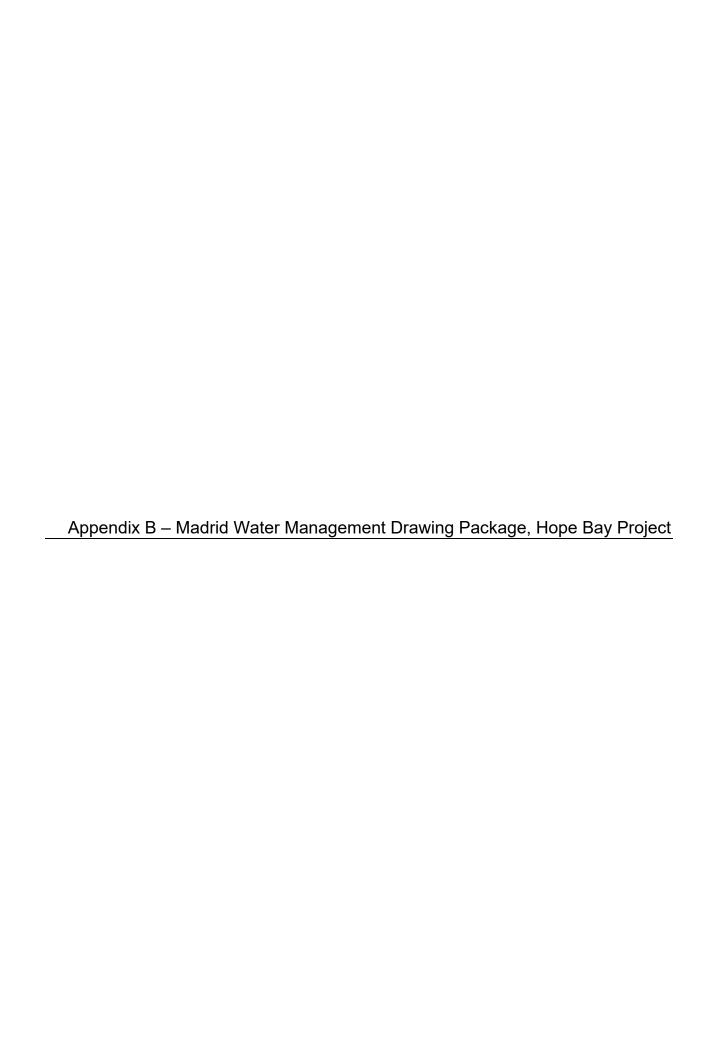


Stream Crossing Design Drawings DRAWING TITLE: **Culvert Crossings Typical Sections** HOPE BAY PROJECT

REVISION NO. SHEET SCD-20 21 OF 23 Α







Engineering Drawings for the Madrid Water Management, Hope Bay Project, Nunavut, Canada

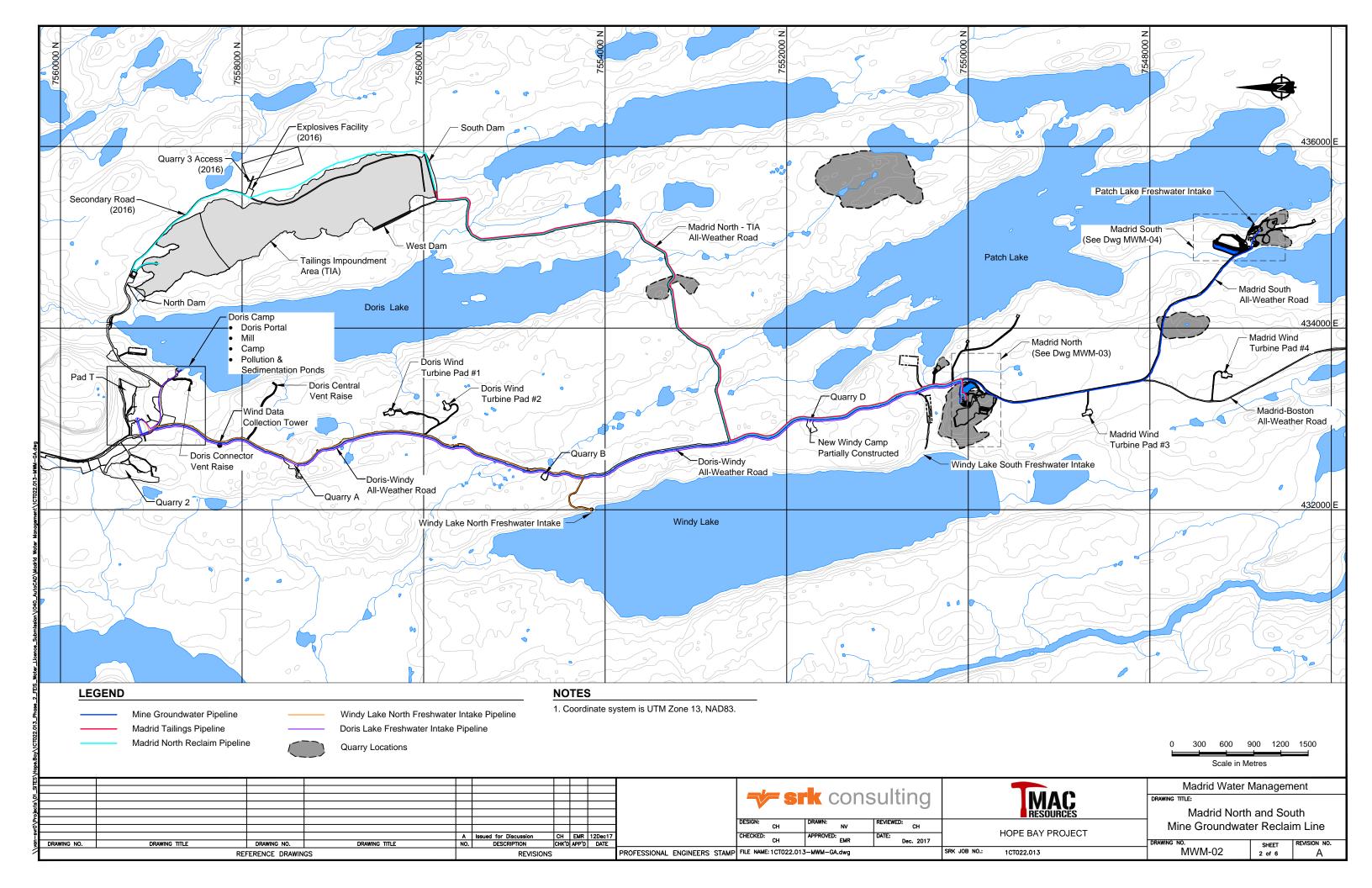
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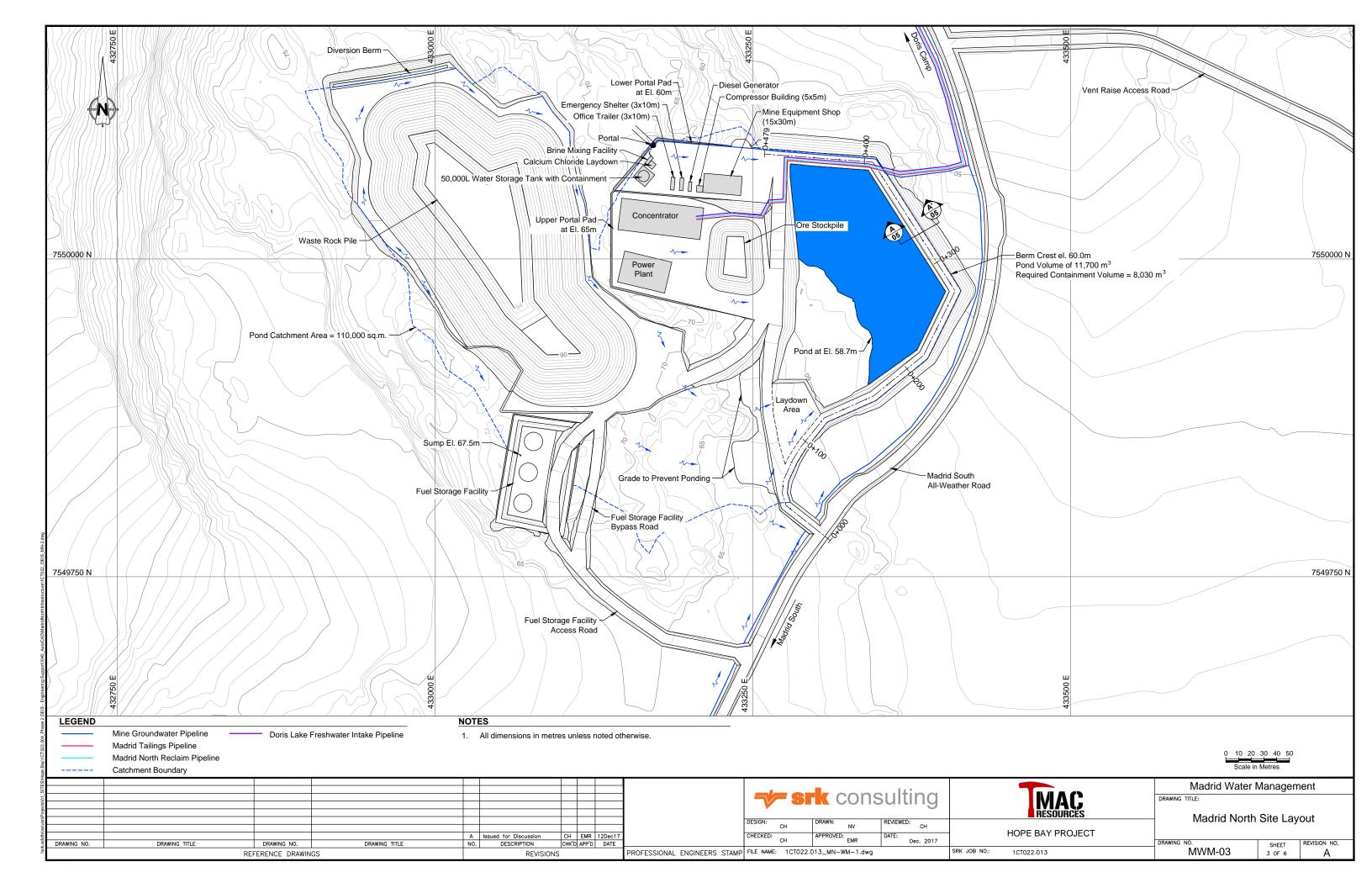
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MWM-01	Engineering Drawings for the Madrid Water Management, Hope Bay Project, Nunavut, Canada	Α	Dec. 12, 2017	Issued for Discussion
MWM-02	Madrid North and South Mine Groundwater Reclaim Line	Α	Dec. 12, 2017	Issued for Discussion
MWM-03	Madrid North Site Layout	Α	Dec. 12, 2017	Issued for Discussion
MWM-04	Madrid South Site Layout	Α	Dec. 12, 2017	Issued for Discussion
MWM-05	Typical Pond Berm Sections A, B, and C	Α	Dec. 12, 2017	Issued for Discussion
MWM-06	Details and Material Quantities	Α	Dec. 12, 2017	Issued for Discussion

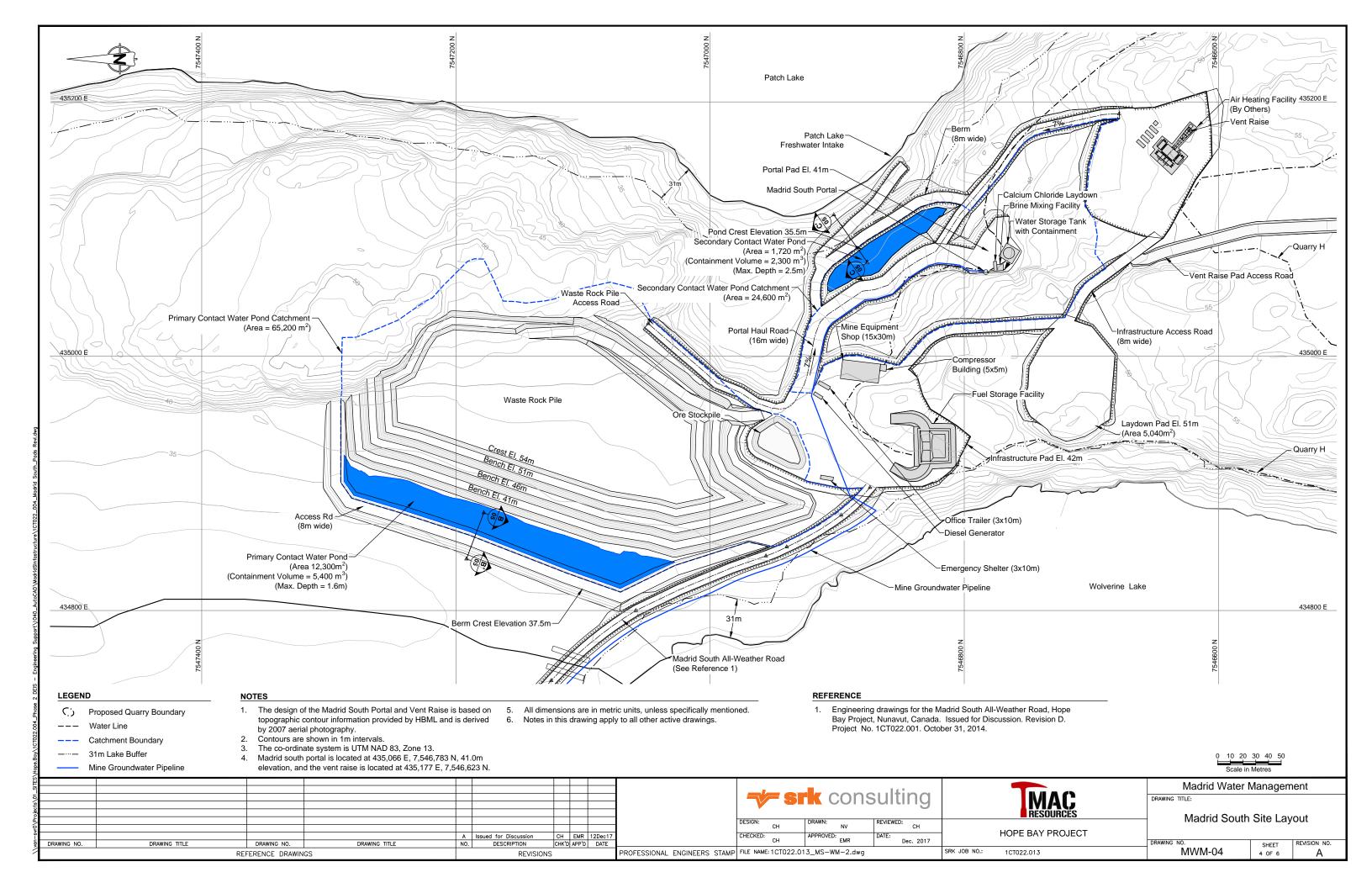


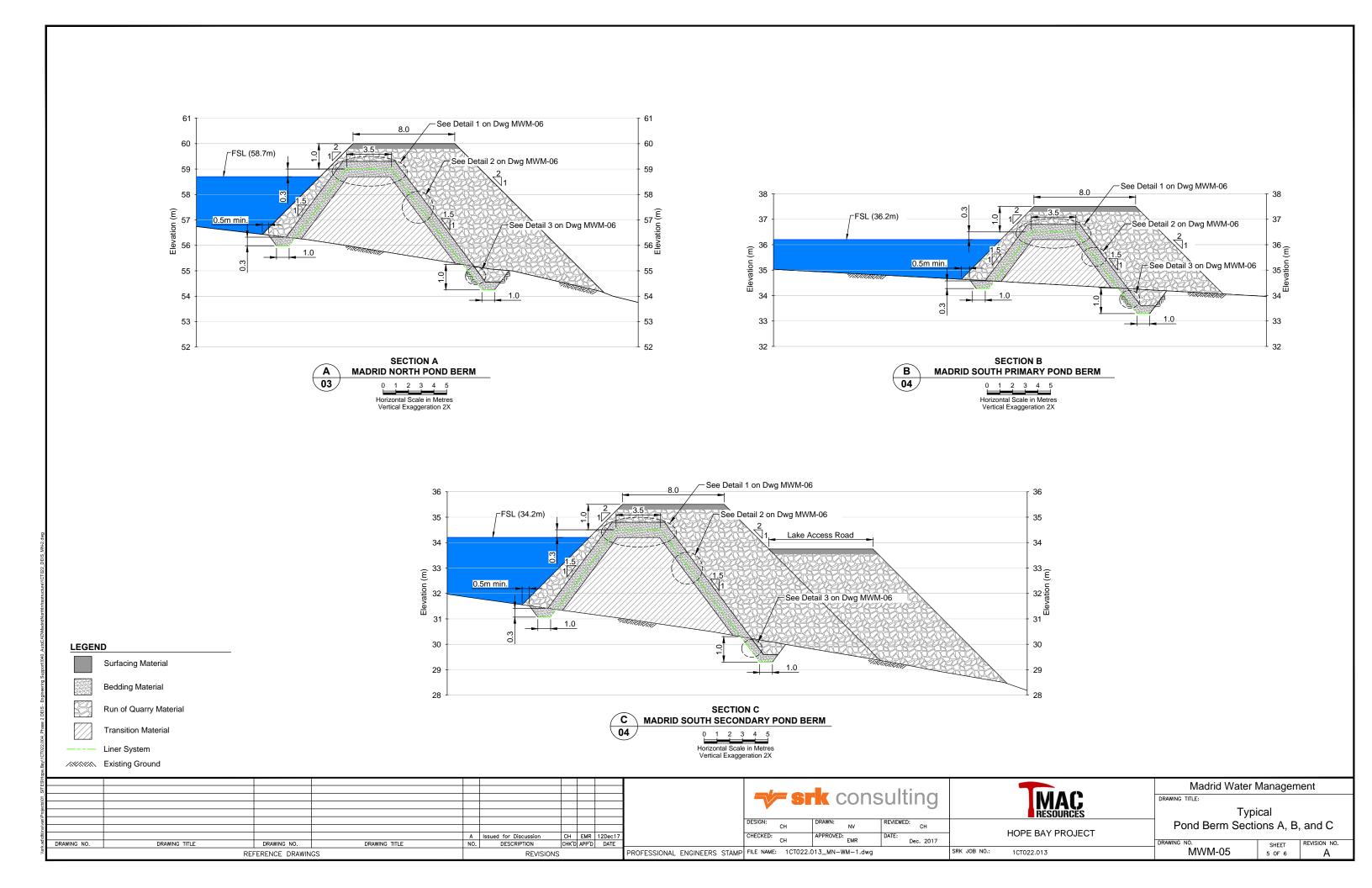


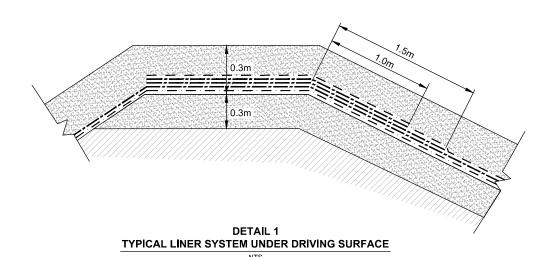
PROJECT NO: 1CT022.013 Revision A December 12, 2017 Drawing MWM-01

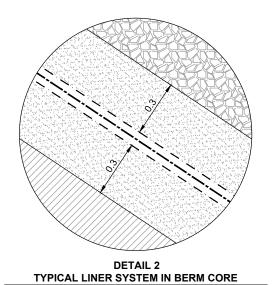


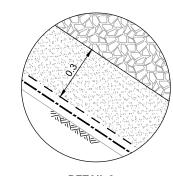












DETAIL 3
TYPICAL LINER SYSTEM IN KEYTRENCH

NTO

Materials List and Quantities for Madrid North Pond Berm

Item	Quantity / Area / Volume	Description
Run of Quarry Material	11,960 m³	Approximate In-Place Neat-line Volume
Surfacing Material	490 m³	Volumes approximated by typical section lengths
Transition Material	6,140 m³	Volumes based on liner surface areas
Bedding Material	3,370 m³	Volumes based on liner surface areas
Liner	5,570 m ²	Volumes based on liner surface areas Textured HDPE 60 mil or Equivalent
Geotextile	9,800 m ²	12 oz. Non Woven

Materials List and Quantities for Madrid South Primary and Secondary Pond Berms

Item	Quantity / Area / Volume	Description
Run of Quarry Material	13,730 m³	Approximate In-Place Neat-line Volume
Surfacing Material	770 m³	Volumes approximated by typical section lengths
Transition Material	6,300 m³	Volumes based on liner surface areas
Bedding Material	4,370 m³	Volumes based on liner surface areas
Liner	8,330 m ²	Volumes based on liner surface areas Textured HDPE 60 mil or Equivalent
Geotextile	14,590 m ²	12 oz. Non Woven

LEGEND

Surfa

Surfacing Material



Bedding Material



Run of Quarry Material

Transition Material

Textured HDPE Liner



12oz. Non-woven Geotextile



******** Existing Ground

NOTES

1. Dimensions in metres unless noted otherwise.

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HOPE BAY PROJECT	

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	Madrid	Water	Management
DRAWING	TITLE:		

Details and Material Quantities

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