MIRAMAR
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June 13, 2007

Ms. Stephanie Briscoe
Executive Director
Nunavut Impact Review Board
P.O. Box 2379
Cambridge Bay, NU
X0B 0C0

Dear Ms. Briscoe:

Re: Doris North Water License Application – Project Modifications Arising from Ongoing Detailed Engineering

The following information on modifications to the Doris North Project arising from ongoing detailed engineering was provided to the Nunavut Water Board and other regulatory agencies on June 08th and were discussed during the Water Board Technical Hearings held in Cambridge Bay on June 11th and 12th. The Nunavut Water Board staff asked MHBL to provide this information directly to the NIRB to ensure that this information was put on record at the earliest possible opportunity. NWB staff indicated that they will be communicating directly with NIRB on these modifications at their earliest possible opportunity.

The Doris North Project (the Project) is currently in the detailed engineering phase. Miramar Hope Bay Ltd. (MHBL) has appointed SNC-Lavalin Engineers and Constructor's Ltd. as the Project construction manager and design engineer. SRK remain the engineer of record for all of the Project earthworks (i.e., the roads, pads, airstrip and tailings dams) and are overseeing construction QA/QC for the site pre-development work that is currently underway at Roberts Bay.

As the Project moves through detailed engineering, there are number of modifications/changes being brought forward by the engineers that modify the Project components from those described in the Final Environmental Impact Statement for the project ("FEIS") and in the April 2007 Revised Water License Application Support Document. This letter is intended to communicate these modifications/changes to the Nunavut Water Board, the Kitikmeot Inuit Association, Nunavut Tunngavik Inc., Indian and Northern Affairs Canada, the Government of Nunavut Department of Environment, Fisheries and Oceans Canada, Environment Canada, Natural Resources Canada, Health Canada, Transport Canada and to all other intervening parties. We also provide our assessment on: if these modifications/changes affect the environmental impact of the Doris North Project; and if so, how. We recognize that a number of these modifications/changes have no water related consequences and are thus outside the scope of the Water License process, however MHBL felt that this was an opportune time and method to inform all parties on the modifications/changes occurring as engineering proceeds. In MHBL's opinion, only items 2b, 4, 7, 8, 9 and 10 have a water related consequence.

In our opinion each of these modifications/changes does not significantly alter the Project as reviewed under the NIRB assessment process. MHBL requests that all regulatory agencies incorporate these proposed modifications/changes in their respective authorizations, licenses, and leases previously applied for by MHBL.

The specific modifications/changes are as follows:

1. The amount of planned electrical generating capacity to be installed at the Doris North Project has increased to 11.0 MW from 4.0 MW. This capacity will consist of 6 x 1.5 MW generator sets to be installed in the fixed power plant plus 2.0 MW in combined portable generator units to be installed: at Roberts Bay for barge offloading and fuel transfers; at the airstrip for runway lighting; at the accommodation camp as emergency backup power (also used during early construction to power the camp); and at the mill as emergency backup power). These portable generators will also provide the power source during the construction phase until the fixed power plant is installed and commissioned. SNC-Lavalin are working on electrical load balances and are considering recommending that the fixed plant be downgraded to 5 x 1.5 MW generator sets. The outcome of this work will be communicated to the NWB as soon as possible.

   The power draw provided in the FEIS did not include the portable generator units (this was an oversight) and underestimated the load balance required for the mill. The actual average daily power draw is expected to be much lower than the installed 11.0 MW. The emergency power requirements (2.0 MW) will not be drawn on a regular basis. The portable generators at Roberts Bay and at the airstrip are expected to only operate part time (less than 5% of the time – i.e., expected to be 350 hours per year at Roberts Bay and 400 hours per year at the airstrip). The mill power draw has to allow for power draw spikes that will occur when starting up the major load items, specifically the grinding circuit and the crushing plant. The start up power draw on these large motors can represent up to double the operating load thus requiring that the installed power generating capacity be sufficient to meet these intermittent peak loads.

   The main consequence of this increase in installed electrical generating capacity is the transport, handling and consumption of more diesel fuel which in turn results in the generation of a higher volume of greenhouse gases from the Project. This impact is discussed further in the next sections. A benefit is that MHBL will be using the heat from the fixed generating plant (from the diesel engines) to heat the mill and crushing plant buildings using a closed loop glycol heating system, thus eliminating the burning of diesel fuel to provide winter heat in these facilities.

2. The total projected annual consumption of diesel fuel at the Doris North Project has increased from 7.5 million to between 10 and 12 million litres per year, directly related to the increase in fuel consumed to generate electrical power for the Project. The effects of this change fall under two categories:

    a. Air Emissions – The amount of air emissions (SO_2, NO_x and greenhouse gases (GHG)) from the Project will increase by between 30 to 60% from that previously predicted. In the FEIS it was projected that the Doris North Project would result in a GHG emission of 7.7 kt ECO_2/yr. The change in diesel fuel consumed will now increase this to a maximum of 12.3 kt ECO_2/yr. The most recent public data available from by Environment Canada on the inventory of GHG emissions in Nunavut is for 1990 through 2004 (http://www.ec.gc.ca/pdb/ghg/inventory_report/2004_report/ann12_e.cfm). This inventory projected that total GHG emissions in Nunavut would be 549 kt ECO_2/yr in 2005. Consequently these increases in total fuel consumption at the Doris North Project will at a maximum increase this projected GHG emission by 4.6 kt ECO_2/yr (a 0.8% increase in the projected 2005 total GHG emission in Nunavut). Natural Resources Canada projected that national GHG emissions for 2005 in Canada would be 728,000 kt ECO_2/yr. Thus this increase GHG emission from this increase in fuel consumption will be fairly negligible on a national scale (~0.0006%).

       In Nunavut the increase is more noticeable but is still relatively small. Overall the environmental effect from this increase in total fuel consumption on air quality is rated not significant using the criteria put forward in Section 10.3 of the October 2005 FEIS, specifically no residual reduction in air quality within 10 km of the plant site and GHG emission that are less than 0.1% on a national scale. There will still be no projected exceedances of territorial SO_2 air standards resulting from the Doris North Project. MHBL has commissioned Golder Associates to update the previous 2005 Air Quality model for the Doris North Project to reflect this increased fuel consumption and will forward the results as soon as they become available.

b. Fuel Storage Capacity and Handling Procedures – SNC-Lavalin has recommended that the amount of on-site fuel storage capacity should be increased from a 12 month to a 14 month supply to ensure continuity in operation and allow for contingency in the event of a colder winter or other change that results in higher fuel consumption. Consequently SNC-Lavalin has recommended that a new additional fuel tank farm be constructed within the footprint of Quarry 1 at Roberts Bay. This facility would be designed to accommodate a single storage tank with a 5.7 million litre capacity and would be sited further than 150 m back from the water. The fuel transfer station would be relocated into this new fuel storage facility so that all fuel trucks would be loaded inside the bermed containment liner.

SNC-Lavalin pointed out that with the increase in annual fuel delivery from 7.5 to 12 million litres it will be impractical to “immediately” transfer the fuel from the arriving sea lift barges to the tank farm facility at the plant site without either doubling the number of trucks hauling fuel or doubling the demurrage time that the barge remains on site, consequently SNC-Lavalin suggested that a new 5.7 million litre fuel storage tank within a bermed and lined containment facility be constructed at Roberts Bay. In their opinion this would lower the risk created by operating double the number of transfer tank trucks over the single lane road between Roberts Bay and the plant site over a tight time schedule while the barges are at site.

MHBL has requested that SNC-Lavalin design this second fuel storage facility to be located in Quarry 1 at Roberts Bay. The facility will include the fuel truck transfer station that was previously intended to be constructed adjacent to the Roberts Bay beach laydown area. A copy of this design will be forwarded as soon as it becomes available. Under this new arrangement fuel will be pumped from the arriving barge through a fixed permanent piping (double walled piping for self containment) that runs along the jetty and over to the new storage tank in Quarry 1. It should be noted that this is not a new piping system but an extension (~400 m) of the originally proposed piping link between the jetty and the original location of the fuel transfer station. The filling of transfer tank trucks would be done from this new tank at a fuelling station constructed within the containment liner. In this way the fuel tanks at the plant site would be filled as previously planned with the additional fuel placed within the new storage tank at Quarry 1 allowing the current off-loading schedule to be maintained.

The new fuel tank farm will be in a containment liner and fuel transfers will be via a double walled pipeline for self containment. With these mitigation measures, it is MHBL’s opinion that the risk of accidental spillage from this handling of additional fuel will not significantly increase. MHBL’s overall environmental assessment of this modification is that the environmental impact of this additional fuel storage facility is neutral given its proposed placement within the footprint of Quarry 1. There is no additional project footprint resulting from this modification and the additional storage capacity will reduce stress during the annual fuel offloading by providing a storage buffer at Roberts Bay between the barge offloading and the movement of fuel to the plant site by tank truck.

3. Roberts Bay Jetty – Barge Anchoring Blocks - SNC-Lavalin has recommended that the proposed on-shore concrete blocks used to tie up the sea lift barges be replaced with an on-shore concrete piling placed in the same locations but set into holes drilled into the ground. This change reduces the amount of concrete required and reduces the risk of friction moving one of the tie up concrete blocks. MHBL and SRK are in agreement with this modification and have indicated that SNC-Lavalin should proceed with their alternate design. In MHBL’s opinion this modification does not result in any change in the potential environmental impact of these two on shore barge tie up points. It does not create any further ground disturbance or impact the permafrost in this area and has a neutral overall environmental impact.

4. Doris Lake Fresh Water Intake – SNC-Lavalin has recommended that the proposed 4” HDPE DR 17 fresh water pipe intake to be sited on the bottom of Doris Lake feeding an on-shore wet well, be replaced with a floating barge system with an approximate in-lake footprint of 10 feet square. The floating pump house barge will be equipped with an aerator bubble system to keep the barge from freezing solidly in place. SNC-Lavalin feels that the floating barge system is more suitable for the small volume of water to be drawn from Doris Lake and easier to install and maintain. SNC-Lavalin cites successful use of similar pumping systems at other sites in the North. In this way the entire system can be fabricated off-site and shipped as module for direct placement. This modification will remove any lake bottom impacts potentially associated with the HDPE pipe laid along the lake bottom and anchored in place with clean rockfill. There would be no change in the volume of water drawn from Doris Lake and the bubbling system will only affect the ice within 6 inches of the floating barge and thus does not create any new hazards to wildlife or humans traveling on the frozen lake in winter. This modification will remove any potential impact on fish habitat caused by a pipe on the lake bottom. Overall in MHBL’s opinion the potential environmental effect from this change is positive as it eliminates any impact on the lake bottom. This

style of pump intake is in line with that previously requested by DFO during the NIRB process.

5. Jetty – Access Road to Construct Shorefast Rock Spurs – As part of its planned fish habitat compensation measures, MHBL has agreed to build six rock fill spurs along the foreshore immediately to the east of the Roberts Bay jetty to provide 600 m^2 of new fish habitat. To move the rockfill to this area MHBL has to construct a spur road of approximately 100 m in length from the jetty access road to the foreshore. The proposed alignment of the road is shown in Figure 1. The road is needed to access this area without rutting the underlying permafrost. The spurs must be placed under open water conditions and so summer access to the shore at this point is required to allow a backhoe to place the rockfill on the bottom of the bay. The width of the road will be 6 m and built to a minimum standard required to protect the underlying tundra (approximately 1 m in height). This access road will not be required once the shoreline habitat spurs are constructed however the rockfill will not be removed as excavating this rockfill will in MHBL's opinion result in disturbance to the underlying tundra and could cause erosive damage if removed. This road will add an additional 0.06 hectares to the 62 hectare project footprint. In MHBL's opinion this additional short road will not have a significant environmental impact and thus this change is seen as being neutral.

6. Roberts Bay Access Road – Construction Turnouts – The current access road design calls for a single lane road between Roberts Bay and the plant site with passing turnouts sited at 1 km intervals. This remains unchanged, however SNC-Lavalin has pointed that in constructing a single lane road, a number of construction turnouts will be required to allow the construction dump trucks to safely turn around to dump their loads. The contractor will install these turnouts where they are needed for safe turning of the trucks. This is a safety requirement and a change in the road design submitted to the NWB. It is estimated that approximately 35 of these turnouts will be needed to allow for safe construction of the Roberts Bay access road (turnouts will not be needed for the widened airstrip portion of the road). Each turnaround will be approximately 6m x 12m (72 sq m). The total additional surface footprint from these turnouts will be approximately 0.25 hectares which is still significantly less than if the width of the road had been increased to a double lane road. In MHBL's opinion these additional road turnouts will not have a significant environmental impact and thus this change is seen as being neutral.

7. Site Roads – Replacement of Culverts by Coarse Rock Drains – SNC-Lavalin has recommended that all culverts, planned where the site roads cross low flow (less than 0.25 m^3/s) ephemeral drainages that have no fish access potential, should be replaced by rock drains. This recommendation

is based on their experience at other Northern sites where typically the culverts remain frozen after the freshet flow commences in the spring turning the culverts into flow obstructions until they can be thawed using applied heat. SNC-Lavalin proposes that these culverts be replaced with rock drains consisting of coarse rock that has been screened to remove fines. In their experience these rock drains perform better in the North at passing the spring freshet flows. These will only be used where the drainage pathways have no defined stream and thus no potential for fish access and where flow is expected to be less than 0.25 m^3/s. SNC-Lavalin has prepared a typical rock drain design and specification. This design is based on an approved GNWT Highway design used on SNC-Lavalin's design build contract for NWT Highway 3 near Yellowknife. SNC-Lavalin has forwarded the design to SRK who will review its application at Doris North. Once an agreeable design has been completed this typical rock drain design and specification will be forwarded to the NWB. In the interim a copy of the GNWT approved rock drain design is attached as Figure 2. A copy of the GNWT approved specification for the rock drains is attached as Appendix A. In MHBL's opinion this replacement of culverts by a rock drains for the low flow ephemeral crossings has a neutral overall environmental impact as these ephemeral drainages have no fish passage potential.

8. Underground Mine Ventilation Raise Service Access Road – Construction of the Doris North underground mine requires the construction of three ventilation raises that will come to surface (See Section 4.8.1 in the FEIS). The first raise is to be located approximately 500 m ramp length from surface where a temporary ventilation raise/escape way (Vent #1) will be driven to surface. At the top of the vent raise, a large diameter low pressure 45 kW (60 HP) main fan will be installed to force 47 m^3/s (100,000 cfm) up the main ramp. As the ramp development reaches the northern and southern extents of the mine, two additional ventilation raises/escape way (Vent #2 and Vent #3) will be driven to surface. The temporary raise (Vent #1) will then be sealed off and the two new raises (Vent #2 and Vent #3) will each have a low pressure large diameter 45 kW (60 HP) fan mounted on top of them.

   An 800 m long x 6 m wide service road will have to be constructed to allow maintenance access for these fans at Vent Raise #1 and #2. The road will run to the northeast of the mine portal along the east side of the mesa as shown in the attached Figure 3. This new road will add an additional 0.48 hectares of surface disturbance to the overall project footprint of 62 hectares. Raise #3 will be accessed from the main road going to Tail Lake. This service road will see minimal traffic (estimated at 1 vehicle trip per day) but will also allow for a secondary egress route from the mine for mining personnel in the event of an underground emergency that may block safe access up the ramp. This road was inadvertently overlooked by

MHBL during the assessment phase although the ventilation fans were included in the assessment. The three vent raise service stream crossings shown on Figure 3 are all ephemeral drainage runoff paths and do not represent year round streams and thus do not allow for fish access. MHBL proposes that rock drains be installed at these three points to allow unimpeded passage of surface runoff through these drainage pathways.

The construction and operation of this road is not expected to have any significant environmental impact. It will not impede water flow, will not impact any aquatic life, will not hinder wildlife access and will not significantly increase noise levels due to the expected minimal traffic. The road will ensure that service access to vent raise #1 and #2 during mine operations is restricted to the road and does not create further ground disturbance on the surrounding tundra.

9. Cyanide Destruct Process - MHBL retained CyPlus (a subsidiary of Degussa) to conduct further cyanide destruction testing and to provide process design criteria to SNC-Lavalin. CyPlus were asked to evaluate the Caro's Acid process, their CombinOX process and the SO_2-Air Cyanide destruction process with the constraint that they meet or better the Caro's Acid performance presented in the October 2005 FEIS (the Bateman Engineering work of September 2003). CyPlus was also asked to evaluate the logistics for each of the three cyanide destruction processes as well as operating and capital costs.

   Performance results:
   CyPlus reported comparable results between the CombinOX and the SO_2-Air process which in turn had better metal reduction rates than the Caro's Acid Process.

   Logistics and operating cost results:
   CyPlus found that logistics of transporting and storing drums of sulphuric acid to be used in the manufacture of Caro's Acid proved to be difficult and expensive. To prevent freezing under winter temperatures common at the Doris North Project site a maximum sulphuric acid concentration of ~30% would be required, thereby tripling the volume of drums of sulphuric acid that would have to be shipped, stored and handled at site (sulphuric acid freezes at higher temperatures when at full strength with the freezing point going down as the concentration decreases). CyPlus found that in mixing a 30% concentration of sulphuric acid with hydrogen peroxide resulted in a much weaker strength Caro's Acid even after adjusting the stoichiometric volumes mixed to equal the use of full strength sulphuric acid. This had an adverse effect on kinetics and consequently performance when using Caro's Acid performance to destroy the residual cyanide.

The CombinOX and SO_2-Air process provided similar logistical problems with a slightly lower operating cost for the SO_2-Air process.

Based on their test work CyPlus recommended on the basis of performance, operating cost and logistics that the Project would be best served by selecting the SO_2-Air Process using sodium metabisulphate as the SO_2 source. MHBL has thus moved from Caro's Acid to the SO_2-Air process as the selected cyanide destruction process for the Doris North Project.

The SO_2-Air is a simpler process and has a good track record at numerous other gold mines across Canada and around the world while the CombinOX process is relatively new in comparison. The CyPlus optimized results for the SO_2-Air process are compared with the Bateman Caro's Acid results that were used in the SRK Water Quality Model 2007 Update as follows:

CyPlus SO_2-Air Optimized Cyanide Destruction Test Results (May 2007)

			SOLUTION ASSAYS						**REAGENT ADDITIONS**		
TEST	STREAM	RET'N TIME (hours)	CN_{WAD} (ppm)	$*CN_{TOT}$ (ppm)	Cu (ppm)	Ni (ppm)	Fe (ppm)	pH	SO_2 (g / g CN_{WAD})	$Ca(OH)_2$ (g /g CN_{WAD})	Cu^{2+} (ppm)
	FEED – CN Leach Residue (sol'n)		631.7	1,510	81.60	1.99	314.3	10.5			
SO_2/AIR #1 (Optimum)	C.I.L. Tails (sol'n)	2	0.76	1.85	0.07	0.13	0.39	8.5	6.0	2.05	800 (Fe + 167 ppm)

Bateman Engineering Caro's Acid Cyanide Destruction Test results (Sep 2003)*

			SOLUTION ASSAYS					
TEST	**STREAM**		**CN_{WAD} (ppm)**	**$*CN_{TOT}$ (ppm)**	**Cu (ppm)**	**Ni (ppm)**	**Fe (ppm)**	**pH**
	FEED		153	220	40.4	0.38	3.61	10.17
Caro's Acid	C.I.L. Tails (sol'n)		0.25	2.50	0.14	0.62	0.17	7.86

*Source: Table 3.11 SRK Water Quality Model Report, March 2007 – Page 40

Effects on Water Quality Management:

The results show that the SO_2-Air process provided treated effluent water that is similar, if not slightly better, in quality than that predicted in October 2005 FEIS. CyPlus are currently completing their report. A draft copy has been appended to this letter as Appendix B. The report is still in Draft form as CyPlus are still completing capital and operating cost estimates. A full set of solutions from the optimized CyPlus test have been shipped to Cantest Ltd (formerly BC Research) for a full parameter analyses and for a one month ageing test to see what happens to the treated solution as it ages.

The effluent quality results from the CyPlus SO_2-Air (optimized) test were input by John Chapman into the SRK water quality model to test the validity of previous predictions with these new results. The modeling verified that the water management strategy as proposed by MHBL in the Water License application will remain valid. The CyPlus testing demonstrates that with the switch from Caro's Acid to the SO_2-Air cyanide destruct process can be achieved without adversely affecting the planned water management strategy.

Consequently it is MHBL's opinion that the switch from Caro's Acid to the SO_2-Air Process has a neutral effect and does not change the previous environmental predictions. The switch eliminates the use and consequently the need to transport and store sulphuric acid and hydrogen peroxide to site and replaces these chemicals with dry sodium metabisulphate which will be shipped in 1 tote plastic lined tote bags placed inside containers.

10. Sewage Treatment – SNC-Lavalin have recommended that MHBL switch the packaged sewage treatment plant from the rotary biological contactor type of plant as described in the April 2007 Water License application to a SaniBrane Membrane bio reactor similar to the units installed at the Snap Lake and Diavik Diamond Mine Projects. These newer membrane bioreactor sewage treatment systems are reported to be easier and cheaper to maintain and operate in Northern Climates and to achieve better treatment levels than the rotary biological contactors. A copy of the manufacturer's brochure on the membrane bioreactor treatment system provides more detail on the proposed sewage treatment system and is attached as Appendix C. The basic operating theory behind membranes is conventional biological treatment combined with a semi permeable barrier that precludes mixed liquor suspended solids from being discharged from the biological reactor. At Snap Lake the SaniBrane Membrane Bioreactor sewage treatment plant is reported to be achieving BOD levels below the 5 mg/L detection level, less than 2 mg/L Total Suspended Solids and fecal coliform concentrations less than the 15 F.C./100 ml detection limit. In MHBL's opinion this change in sewage treatment plant technology is neutral from an environmental impact assessment point of view and does not significantly alter previous assessment predictions related to wastewater treatment at the Doris North Project.

> As part of this change/modification all sewage sludge will now be filtered, bagged, dried and then incinerated on site rather than being pumped to the tailings containment area for co-disposal with the tailings. The treated grey water will still report to Tail Lake as previously planned. The volume of dried sludge to be incinerated is small and is not expected to have any significant impact on air quality emissions from on-site camp incinerator.

In summary MHBL feels that these proposed modifications/changes do not result in any significant difference in the environmental impacts previously predicted for the Doris North Project (October 2005 FEIS). The changes are either neutral or result in insignificant incremental impact.

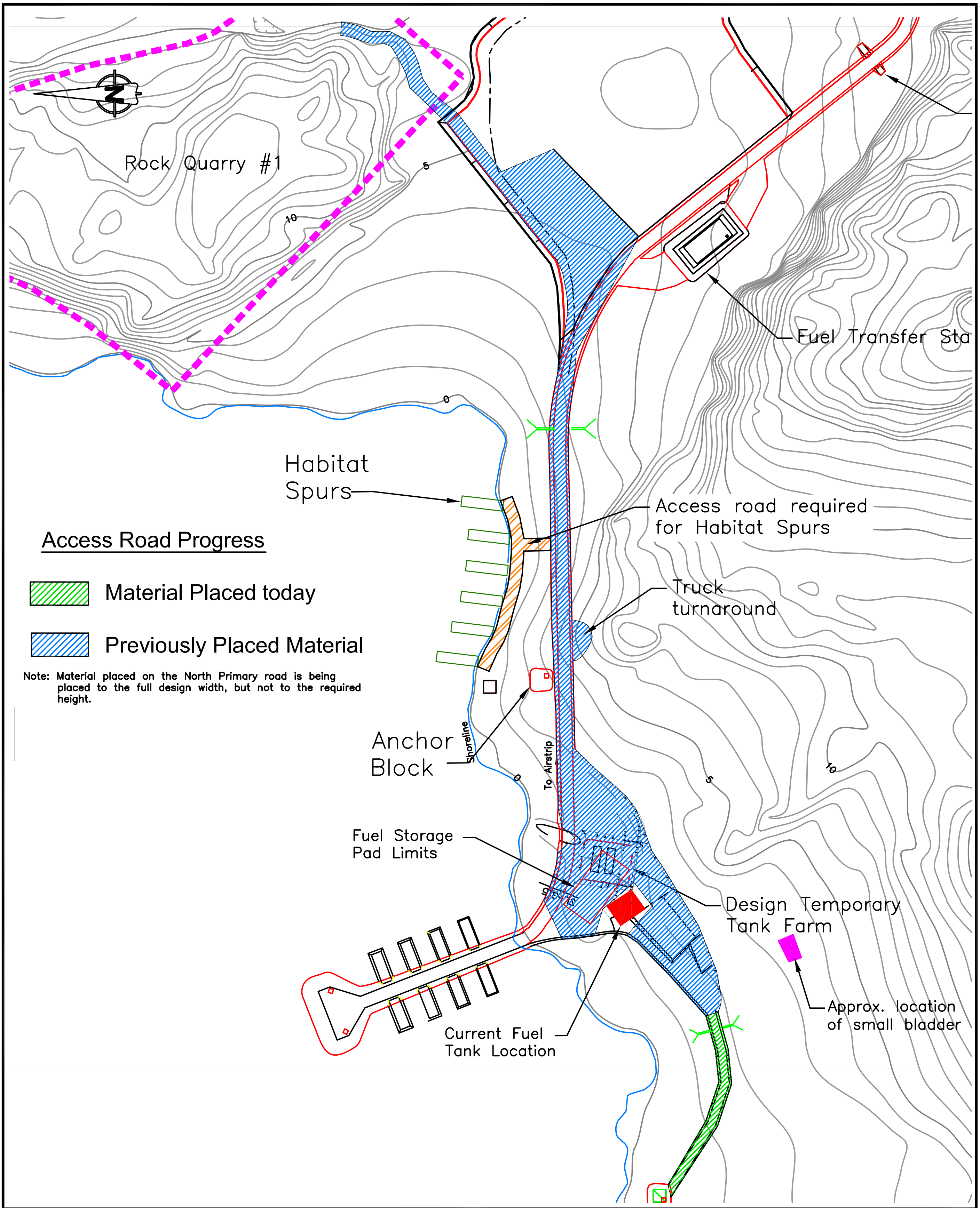
Please feel free to call on the undersigned for any additional information. It is MHBL's intent to present these changes to all interveners at the scheduled Doris North Water License Technical Hearing scheduled for Cambridge Bay on June 11th.

Regards
Miramar Hope Bay Ltd.

Larry Connell

Larry Connell
General Manager, Environment

cc: - NWB



Access Road Progress

🟩 Material Placed today

🟦 Previously Placed Material

Note: Material placed on the North Primary road is being placed to the full design width, but not to the required height.

SRK Consulting
Engineers and Scientists
Vancouver

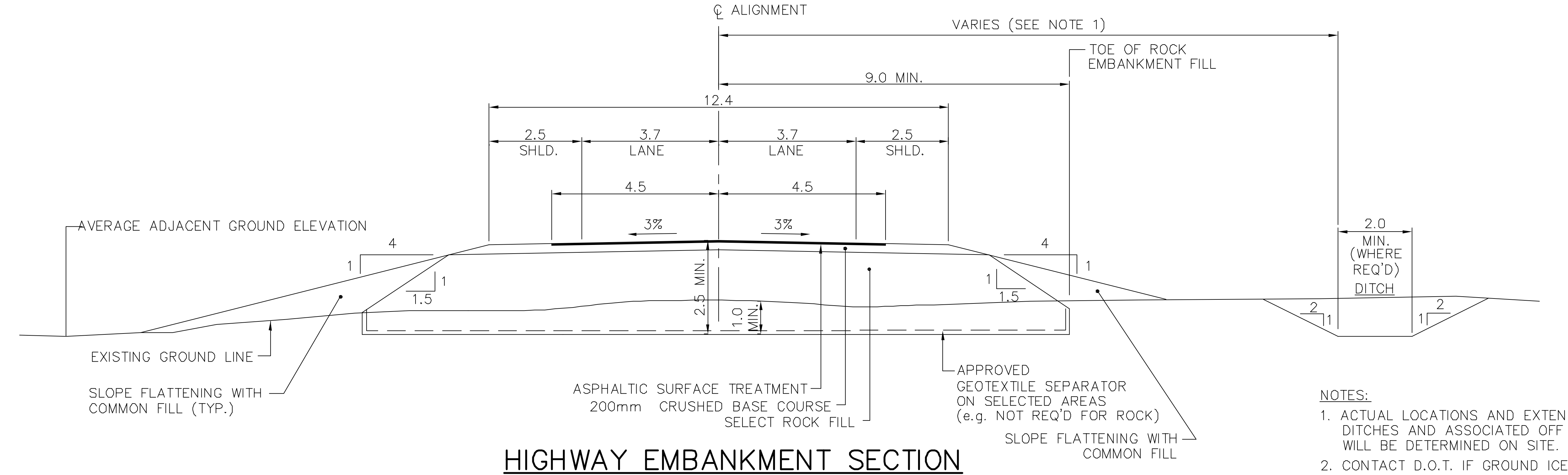
MIRAMAR HOPE BAY LIMITED

Robert's Bay Construction

Daily Report Progress Summary

PROJECT NO.	DATE	APPROVED	FIGURE
1CM014.011.0500	Jun 4/07		1

Dwg Ref: \\172.17.10.1\shared\Doris North\1CM014.011_Doris North Construction\Roberts Bay Construction Site Folder\ACAD\RB Fuel Tank.dwg

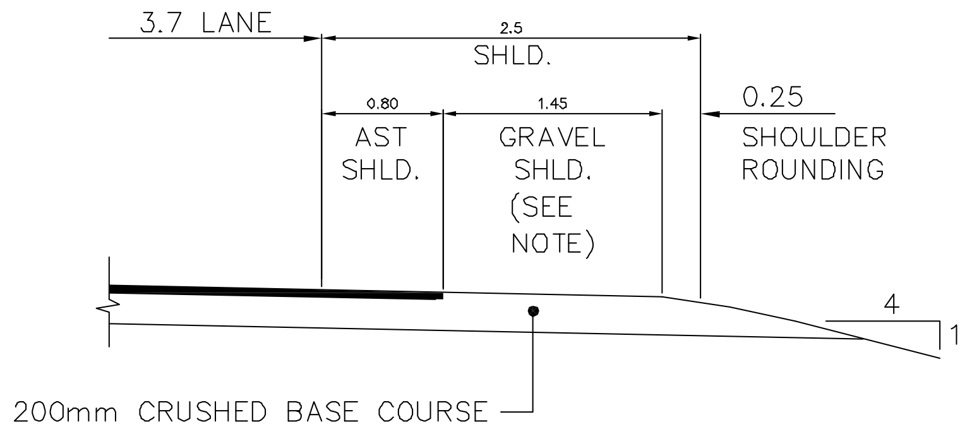


HIGHWAY EMBANKMENT SECTION IN SUB EXCAVATED OVERBURDEN NON–PERMAFROST

0 1:100 5

NOTES:

1. ACTUAL LOCATIONS AND EXTENTS OF LATERAL DITCHES AND ASSOCIATED OFF TAKE DITCHES WILL BE DETERMINED ON SITE.
2. CONTACT D.O.T. IF GROUND ICE IS STILL PRESENT FOLLOWING 1.0m OVER EXCAVATION AND AWAIT FURTHER INSTRUCTIONS.



NOTE: SHOULDER WIDENING FOR GUIDE RAIL LOCATIONS:
3.9m FOR LINE SECTIONS
4.36m FOR END SECTIONS

SHOULDER DETAIL

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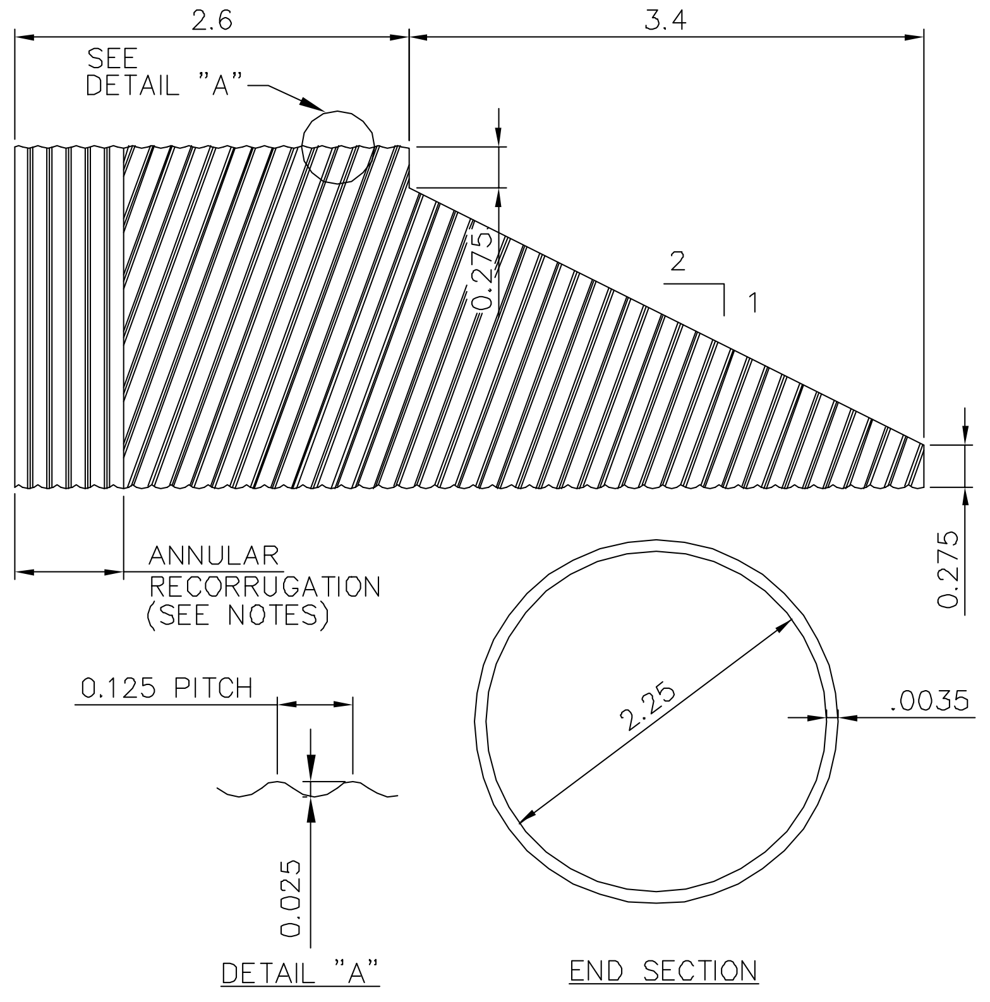

CULVERT DETAIL (SLOPED EDGE SECTION)

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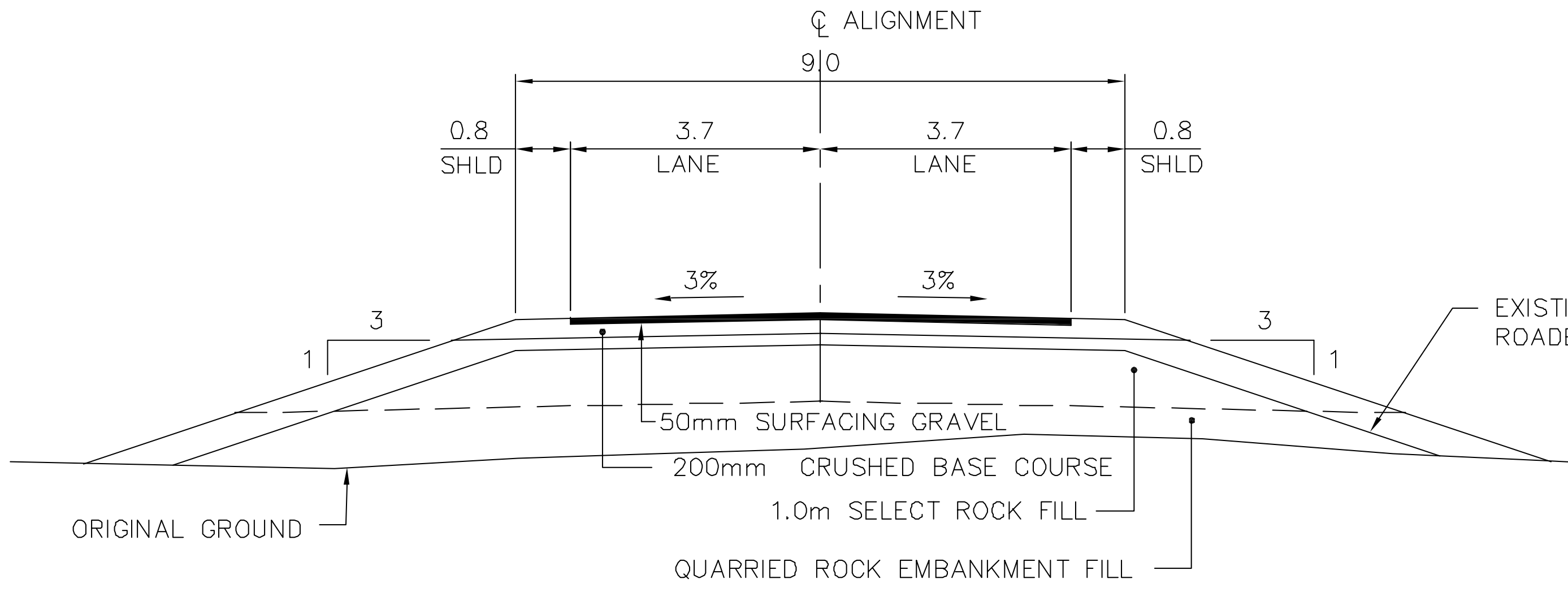
NOTES:

1)THE SUPPLY AND FABRICATION OF ALL GALVANIZED CORRUGATED STEEL PIPE (C.S.P.) SHALL BE IN ACCORDANCE WITH THE LATEST EDITION OF CANADIAN STANDARDS ASSOCIATION CAN3–G401 SPECIFICATIONS AND M36 BRIDGE SPECIFICATIONS; AND IN COMPLIANCE WITH THE RFP.

2)ON PIPE DIAMETERS OF 1000mm OR GREATER, LOCK SEAMS TERMINATING AT THE CUT EDGES OF SLOPES OR SQUARE ENDED SECTIONS SHALL HAVE A 50mm LENGTH FILLET WELD RUN ALONG THE LOCK SEAM AT EACH CUT EDGE.

3)THE HELICALLY CORRUGATED PIPE SHALL HAVE THE PIPE ENDS RECORRUGATED TO PROVIDE ANNULAR CORRUGATIONS FOR COUPLING PURPOSES (AS SHOWN). THE MINIMUM LENGTH WITH ANNULAR CORRUGATIONS SHALL BE 300mm FOR PIPE DIAMETERS OF 900mm OR LESS AND 600mm FOR PIPE DIAMETERS GREATER THAN 900mm.

4)THE COUPLER SHALL BE AN ANNULAR CORRUGATED BAND TYPE WITH A MINIMUM OF 3 BOLTS PER COUPLER FOR PIPE DIAMETERS OF 800mm OR GREATER.



ACCESS ROAD SECTION

(WITHIN HIGHWAY R.O.W. LIMITS)

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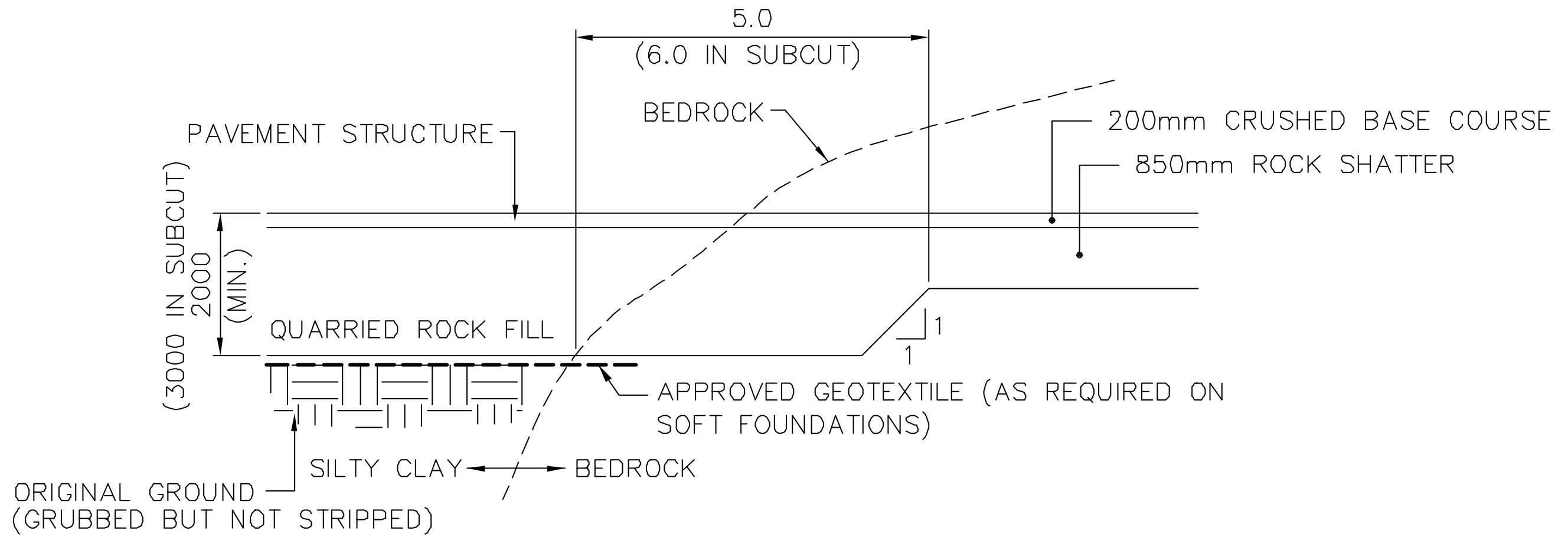

HIGHWAY ROCK TRANSITION PROFILE

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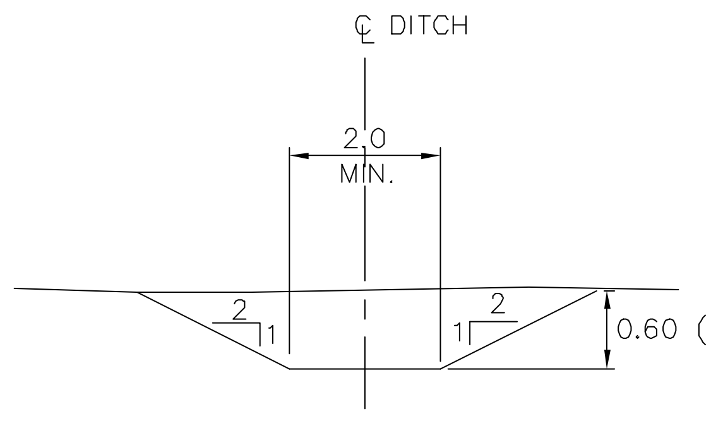

OFF–TAKE DITCH DETAIL

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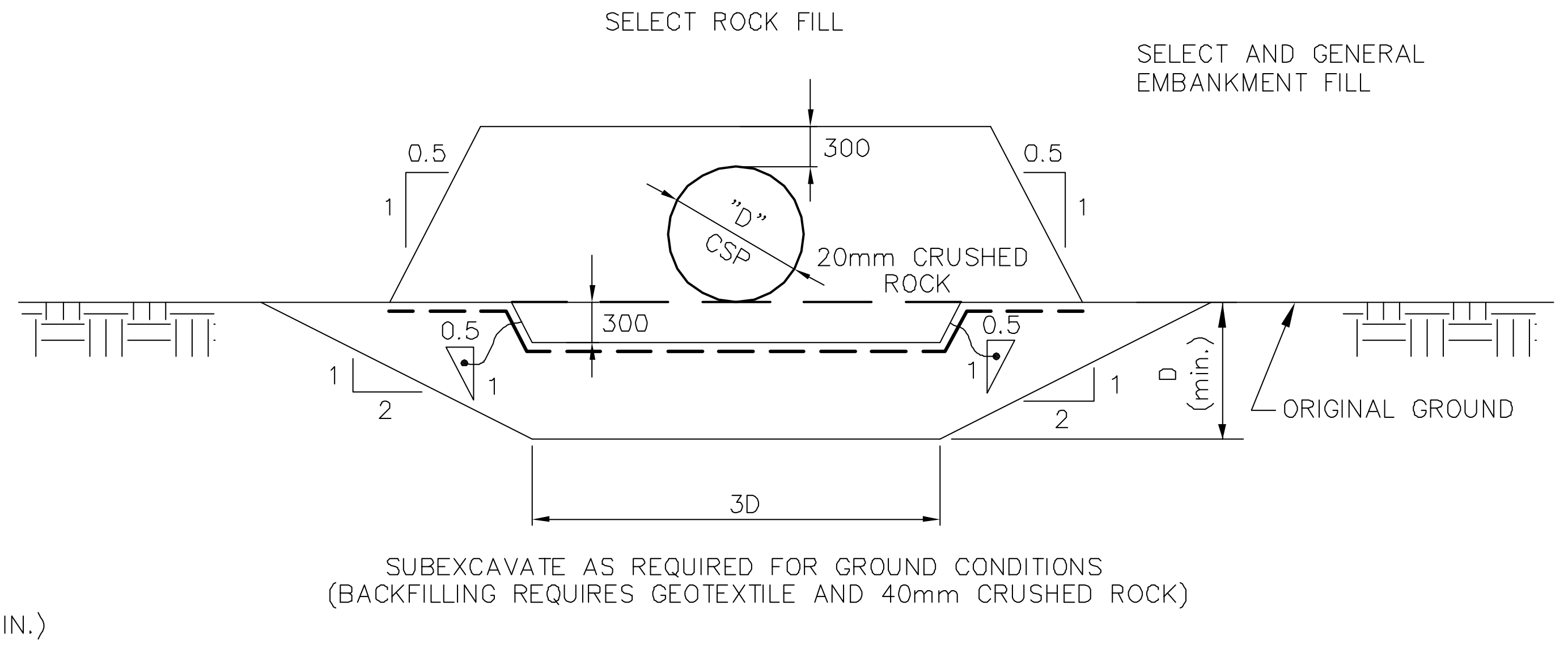

CULVERT INSTALLATION DETAIL IN NON–PERMAFROST

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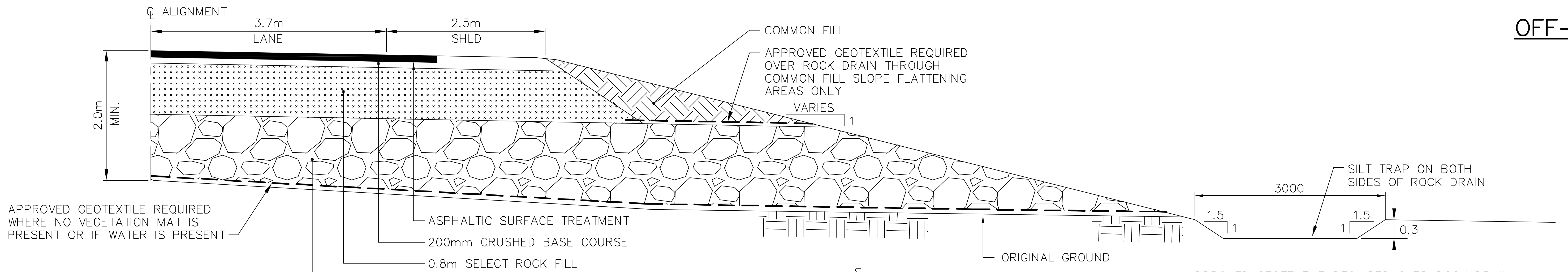

FLOW THROUGH ROCK DRAIN

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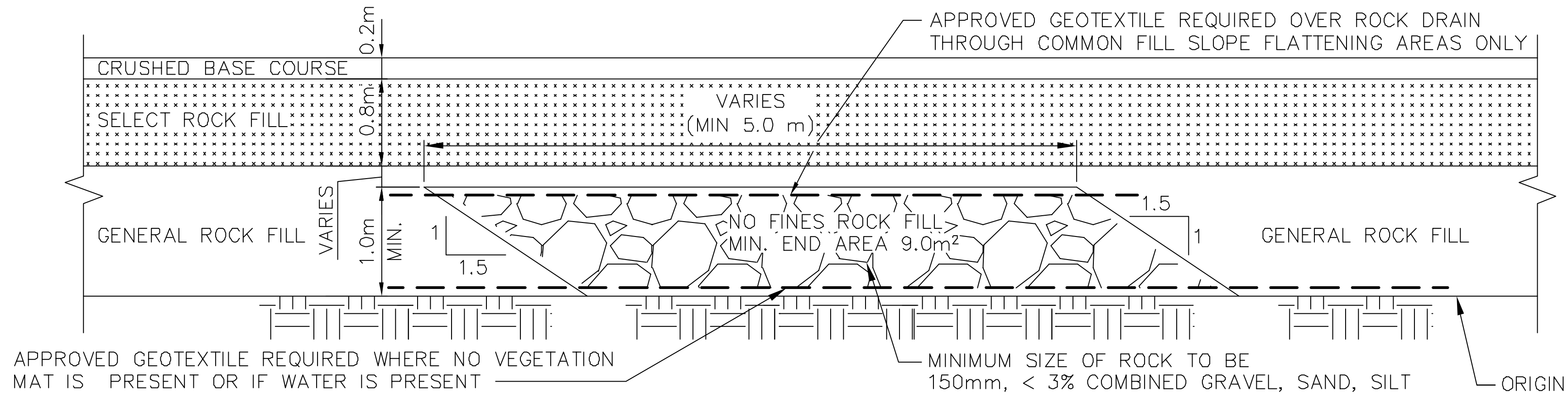

FLOW THROUGH ROCK DRAIN INSTALLATION DETAIL IN PERMAFROST AND NON–PERMAFROST

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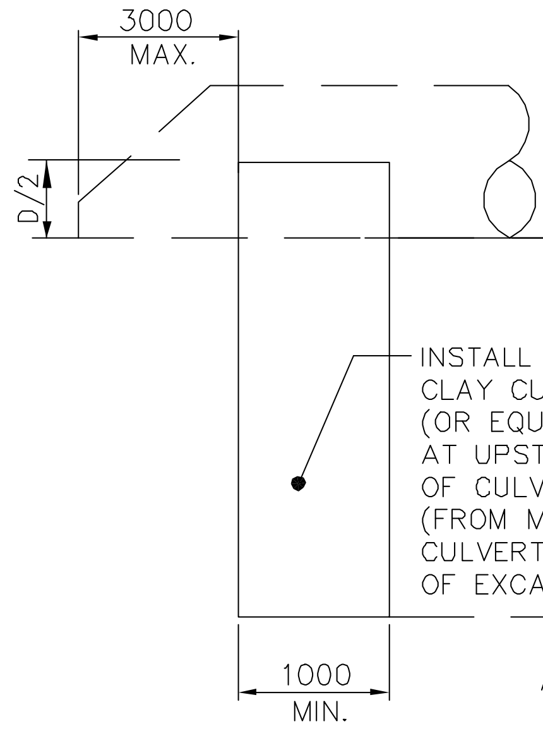
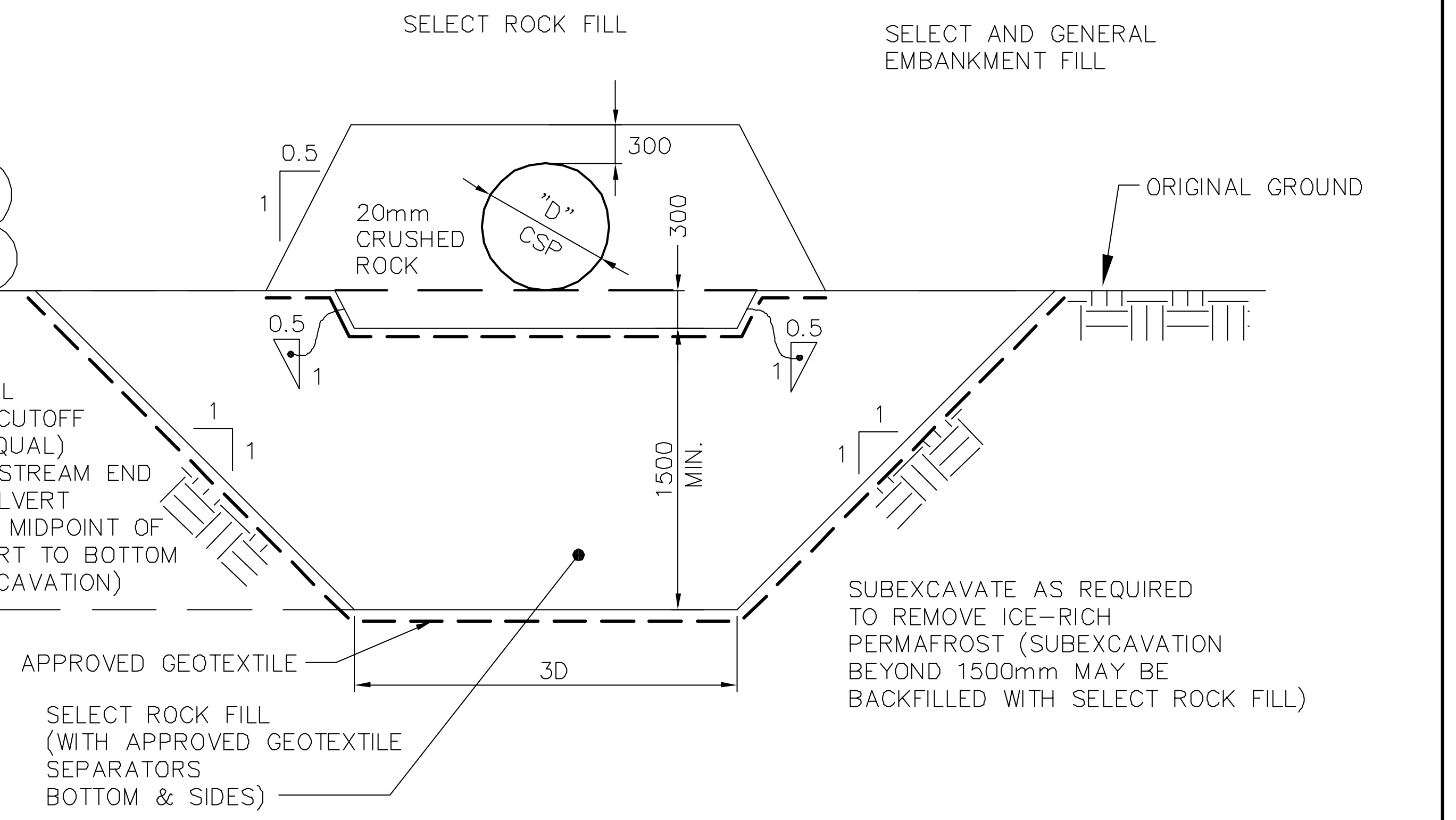


TYPICAL END SECTION IN PERMAFROST



CULVERT INSTALLATION DETAIL IN PERMAFROST

0 1:50 2

NISHI-KHON/SNC-LAVALIN LIMITED
RTL-ROBINSON ENTERPRISES LIMITED

Northwest Territories Transportation

Surveyed by: G.N.W.T. – D.O.T.	Date: 2004	
Designed by: R. WONG	04/04/21	
Drawn by: K. VOKEY	04/04/21	
Checked by: S.S. DEEPAK	04/06/21	
Approved by: A.R. WACHMANN	04/06/24	

Rev.	Date:	Description	Signature
PA	04/06/24	ISSUED PRIOR TO VALUE ENGINEERING	
PB	04/08/11	ISSUED FOR 100% SUBMISSION	

REVISIONS

Title:

Grading, Drainage, Granular Base Course and
Single Asphaltic Surface Treatment
Yellowknife Highway (No.3), N.W.T.
Km 304.60 TO Km 322.65
TYPICAL SECTIONS & CULVERT DETAILS

Scale:	Project No.:	Drawing No.:	Page:	Rev.
AS SHOWN	016930	H300C0200C21	22 of 29	PB

CANCEL PRINTS BEARING PREVIOUS LETTER

DATE: 2004–08–12 – 11:31am (KRUCN)
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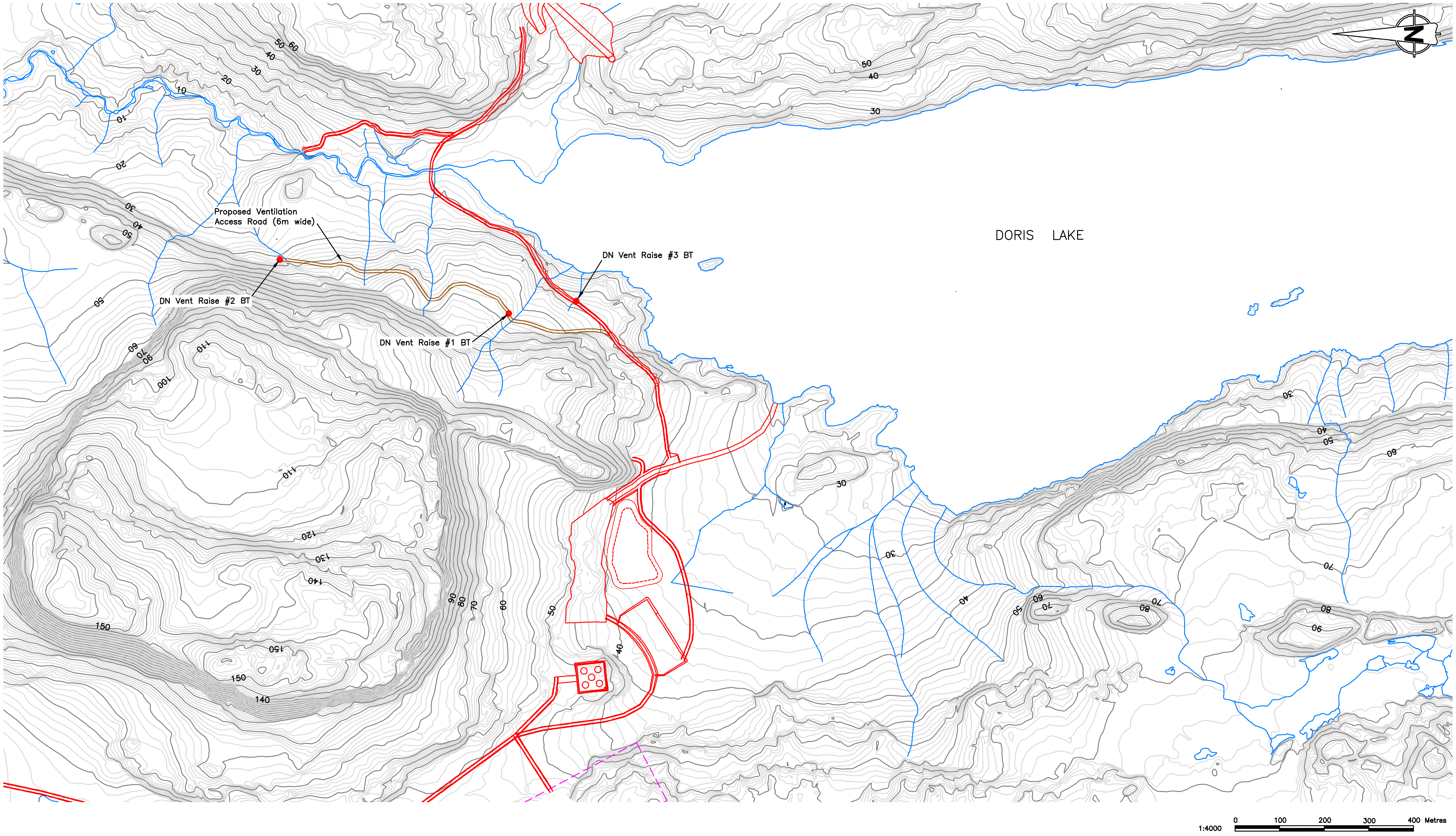
LAYOUT: 21



REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
A	DRAFT			

PROFESSIONAL ENGINEERS STAMP

SRK Consulting
Engineers and Scientists
Vancouver

DESIGN: AT
DRAWN: VY
REVIEWED: EMR
CHECKED: AT
APPROVED: EMR
DATE: June 2007
FILE NAME: Ventilation Raise.dwg

MIRAMAR
HOPE BAY LTD.

DORIS NORTH PROJECT
SRK JOB NO.: 1CM014.011

Doris North Project
DRAWING TITLE:
Proposed Ventilation Raise
Access Road Layout
DRAWING NO. -
SHEET -
REVISION NO. A

Rock Drains

In areas where drainage is required, but the flows are small, flow through rock drains have been provided. Flows for rock drains have been limited to less than approximately 0.25 m^3/s. Where flows are larger, or where fish passage is required, CSP culverts have been provided.

Flow through rock drains are suitable for small watersheds or areas with sheet style runoff in permafrost regions, and have been used on other projects in the Northwest Territories. The basis of the rock drains is a free draining rock fill, with maximum/minimum particle sizes of 1000 mm and 150 mm, respectively, and a maximum of 7% of gravel, sand and silt sized particles. Details of the flow through rock drains are shown on Drawing No. H300CO200C21.

Since, essentially, the entire new embankment will be constructed of similar rock fill, the use of flow through rock drains, where appropriate, will speed the placement of the embankment. Another benefit of the flow through rock drains is that there will be minimal disturbance of the surface layers during placement, as no sub-excavation into the underlying layers is required. Geotextile, as a separation layer, will be placed under the rock drains if there is no vegetation mat present.

Rock drain design will be based on the following criteria:

- Void ratio of 0.5 and porosity of 1.0
- Safety factor of 2.0 for 1 in 50 year design flow, with maximum head at inlet at top of rock drain

Sediment traps will be installed at both ends of the rock drain. Regular inspection and clean out of these sediment traps and debris clean up of the entrance and exits will be necessary. This inspection and maintenance will not be any more extensive than what will be required for the CSP culverts.

As the rock drains are not in areas with significant flow and/or gradient, the long-term effectiveness of the drains should not be comprised by plugging of the voids or debris build with the regular inspection recommended above.

Ditches

The proposed ditch drainage design will provide positive longitudinal drainage with ditch dimensions to current design standards provided in the RFP documents. A typical ditch depth from the road surface is applied throughout, so that the flow direction will follow the road profile grade. Localized deepening of the ditch may be required in order to suit culvert inlet and outlet elevations.

Swales may be required to remove excess water in locations away from the embankment.

The ditch invert elevation generally controls the top of cut line of the roadway cross-section and ultimately defines the proposed right-of-way requirements.

Erosion and Sediment Control

For control of erosion and sediment transport, estimates of soil losses from fills and excavations, and local information from past road construction projects, will be used to determine the intensity of protection required.

Existing creeks or wetlands closely parallel the highway in areas and form part of the ditch-drainage system. Water quality treatment measures, such as silt fences, hay bales, temporary settlement ponds and other means will be utilized to protect against the release of silt-laden water into natural drainage courses. Seeded ditch slopes, seeded swales and rock check dams are also suggested for erosion control and for providing water quality control treatments prior to runoff entering the various creeks and tributaries effected by the project.

The need for erosion control structures and attendant maintenance requirements can be reduced by erosion prevention through re-vegetation. Factors that will be considered in re-vegetation include soil texture and composition, rainfall and drainage, temperature extremes and the slopes of cut or fill.

The standard re-vegetation practices and fertilizer formulations, which the client currently uses for similar types of projects and environment, will be used on this site.

Monitoring of all construction activities for impact on adjacent waters will occur throughout the construction project and appropriate measures will be employed to mitigate potential impacts. Responsibility for this monitoring will be assigned to the Construction Superintendent.

DRAFT #2

Test Program to Evaluate

Cyanide Destruction Options Using

SO_2/AIR, CombinOx® and CyPlus Peroxygen - Based Technologies

For the Treatment of Leach Effluents from the

Doris North Project in Canada

Prepared For: Miramar Mining Corporation
Vancouver, British Columbia
Canada

Prepared By: CyPlus Corporation
Piscataway, New Jersey
U.S.A.

Date: June, 2007

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TABLES

APPENDICES

Statement of Confidentiality

The enclosed report contains confidential information, which is intended solely for the use of the recipient, Miramar Mining Corporation. Terms and conditions respecting the disclosure or release of any of the contained information to any third party, are specified in the February, 2007 Agreement between CyPlus Canada, Inc. and Miramar, relating to the Laboratory Test Program.

1. EXECUTIVE SUMMARY

To be completed when the capital cost figures become available.

2. SCOPE OF WORK

The present test work program was undertaken at the request of Miramar Mining Corporation to evaluate cyanide destruction options for the treatment of leach effluents from the Doris North Project in Canada. The work included investigations of Caro's Acid, the SO_2/AIR process and CombinOx®. The scope of work was based on the February 2007 agreement and subsequent discussions between CyPlus and Miramar, and included the following:

2.1 Cyanide Destruction Sample Preparation

In the February 2007 agreement, the scope of work included procedures to generate and treat a barren bleed stream. It was subsequently determined that this would not be necessary and all work would be carried out on the "Slurry Backfill Detox Feed Sample" alone. CyPlus followed the CLIENT'S metallurgical instructions for the preparation of the concentrate sample to generate suitable cyanide destruction feed samples using the conditions provided below:

Leach Conditions for Cyanide Destruction Concentrate

Percent solids	35%
pH	10.5(using $Ca(OH)_2$)
Preaeration Step	7 hours(subsequently added)
NaCN addition	1,000 mg NaCN / L solution
Maintained CN level	550 ppm CN_F
Carbon addition	20 g/L slurry
Leach (CIL) time	72 hours

2.1.1 Sample Preparation after Leaching to Produce Slurry Backfill Detox Feed Sample

1. Remove carbon from slurry. Save carbon sample.
2. Add NaCN, if necessary, to produce CN_{WAD} concentration of 625 ppm.
3. The pH will be adjusted to 10.5 with $Ca(OH)_2$.

2.2 Cyanide Destruction Laboratory Program

Testwork will be conducted on CLIENT'S **Backfill Slurry** sample, generated using the conditions described above by a team of CyPlus scientists. The cyanide destruction laboratory program will include the following:

- Continuous cyanide destruction optimization by the SO_2/AIR process to determine the effectiveness of the process to the Backfill Slurry effluent.

- Continuous cyanide destruction optimization by the new CyPlus CombinOx® process(es) to determine the effectiveness of the process(es) to the Backfill Slurry effluent.

- Cyanide destruction optimization by the CyPlus Cold Caro's Acid (peroxymonosulphuric acid) process to determine the effectiveness of the process to Backfill Slurry effluent. In order to accommodate the reagents most likely to be used on-site, 37% sulfuric acid and 50% hydrogen peroxide will be used for the treatment and assessed for the production yield of Caro's acid.

- Chemical characterization of all process feed and residual streams, including CN_{WAD} (using the Picric Acid method), CN_T(calculated using CN_{WAD} result and soluble iron), Cu, Ni, Fe, and pH.

The target(s) of the treatment program will be:

- Weak Acid Dissociable Cyanide < 0.5 ppm CN_{WAD}

For the purpose of "typical" reagent and capital cost estimates, the following conditions will be used:

- 600 ppm CN_{WAD}
- Flowrate of 2.8 dry tonnes/hr. at 40% solids

The "Typical" conditions from the February 2007 agreement, shown above, subsequently changed and "Design" conditions were added. Both are shown in **Section 8** and **Tables 5 and 6**.

2.3 Slurry Samples

This sample, weighing approximately 40 kg, was received at the CyPlus Corporation Piscataway, New Jersey laboratory in late January 2007. The sample was received in good condition and there was no sign of tampering during shipment.

The head sample shipped to CyPlus by Miramar consisted of approximately 40 kg of a flotation concentrate that was produced from a Doris North ore sample made from select diamond drill core for Miramar at the Process Research Associate metallurgical laboratory in Vancouver. This sample was received at the CyPlus

Corporation's Piscataway, New Jersey laboratory in late January 2007 in good condition with no signs of tampering during shipment. This concentrate was then subjected to a cyanide leach at the CyPlus Lab using parameters provided to CyPlus by Miramar's metallurgical consultant to generate a fresh cyanide leach residue for cyanide destruct testing with residual cyanide concentrations comparable to those generated by PRA in the metallurgical testing program (consistent with levels expected in the mill), using conditions described above in **Section 2.1**.

3. PROCESS DESCRIPTIONS

3.1 SO_2/AIR PROCESS

The SO_2/AIR process can be applied to the treatment of both cyanide solutions and pulps, however, it is in the area of slurry treatment (CIP/CIL pulps or re-pulped filtercakes from a Merrill-Crowe circuit) where the process has enjoyed a recognized worldwide reputation. Main advantages of the process are the removal of the total cyanide to levels of about 1 mg/L, in a single-stage continuous reactor and low operating costs.

The technology uses sulfur dioxide (SO_2), in various reagent forms, (sodium sulfite, sodium metabisulfite, ammonium bisulfite, liquid SO_2, and SO_2 containing roaster gas or SO_2 from burning elemental sulfur) in combination with air (or pure oxygen). Stoichiometrically, the process requires a ratio of approximately 2.5 g of SO_2/g of CN_{WAD}. The oxidation of cyanide is in accordance with one of the following overall reactions:

$$CN^- + Na_2SO_3 + O_2 \rightarrow OCN^- + Na_2SO_4$$

or:

$$CN^- + \tfrac{1}{2} Na_2S_2O_5 + O_2 + \tfrac{1}{2} H_2O \rightarrow OCN^- + \tfrac{1}{2} Na_2SO_4 + \tfrac{1}{2} H_2SO_4$$

or:

$$CN^- + SO_2 + O_2 + H_2O \rightarrow OCN^- + H_2SO_4$$

As shown above, the oxidation of cyanide produces cyanate (OCN^-) and, depending on the SO_2 reagent, produces sulfuric acid (H_2SO_4) as an intermediate. At the prevailing pH of the process, however, the sulfuric acid is continuously neutralized with lime producing calcium sulfate dihydrate (gypsum), as follows:

$$H_2SO_4 + Ca(OH)_2 \rightarrow CaSO_4 \bullet 2H_2O$$

The process will oxidize free cyanide and all cyanide complexed with copper, nickel, zinc, silver, and cadmium. The oxidation is catalyzed by soluble copper (Cu^{2+}), which, if required, can be supplemented by addition of copper sulfate solution. As cyanide is oxidized, metals are liberated and precipitated out of solution as hydroxides by the following reactions:

$$Me^{+} + OH^{-} \rightarrow MeOH$$

or:

$$Me^{2+} + 2OH^{-} \rightarrow Me(OH)_2$$

Cyanide present in the form of a strong complex, bound with either iron, cobalt, or gold, is not oxidized by the process. Gold cyanide, of course, should not be a concern for a destruction unit, as it is recovered by carbon within the plant. Removal of the iron and cobalt cyanide complexes is achieved by precipitation with copper or zinc, according to the following reactions:

$$2\ Me^{2+} + Fe(CN)_6^{4-} \rightarrow Me_2Fe(CN)_6$$

or:

$$2\ Me^{2+} + Co(CN)_6^{4-} \rightarrow Me_2Co(CN)_6$$

Generally, the SO_2/AIR process works best in the pH range of 8 to 9 and optimum operating pH is determined during the test work program. Optimization of both pH operating range and reagent consumption has proven to be site-specific for all ore types tested to date.

Cyanate produced by oxidation of cyanide slowly hydrolyzes to carbonate and ammonium as follows:

$$OCN^{-} + 2H^{+} + H_2O \rightarrow CO_2 + NH_4^{+}$$

or:

$$OCN^{-} + OH^{-} + H_2O \rightarrow CO_3^{2-} + NH_3$$

depending on pH.

3.2 Hydrogen Peroxide and Caro's Acid

Hydrogen peroxide (H_2O_2) has a well-established reputation as the process of choice for treating clear cyanide solutions. The primary benefit of hydrogen peroxide is that it is a “clean” chemical in the sense that the reaction product of the H_2O_2 itself is simply water. In a peroxide treatment system there will be no appreciable increase in the dissolved solids concentration; scaling and undesirable salting conditions are avoided. This is an important factor in any flowsheet scenario incorporating a filtration stage.

The oxidation of cyanide with peroxide produces cyanate and water as shown in the following equation:

$$CN^- + H_2O_2 \rightarrow OCN^- + H_2O$$

The cyanate subsequently hydrolyzes slowly to produce ammonium and carbonate ions:

$$OCN^- + 2H^+ + H_2O \rightarrow CO_2 + NH_4^+$$

or:

$$OCN^- + OH^- + H_2O \rightarrow CO_3^{2-} + NH_3$$

depending on the pH.

Although ammonia (NH_3) is toxic to fish at low levels, it is almost entirely available in the far less toxic cationic form (NH_4^+) at the natural pH of open waterways.

If excess hydrogen peroxide is present in the treated wastewater, it rapidly decomposes to water and oxygen, presenting no environmental threat:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

Hydrogen peroxide is capable of oxidizing both "free" cyanide (CN_f) and complexes (titratable cyanide):

$$CN^-, HCN, NaCN, KCN, Ca(CN)_2, Cd(CN)_4^{2-}, Zn(CN)_4^{2-}$$

and “weak acid dissociable” cyanide (CN_{WAD}) complexes, which include the above mentioned titratable cyanide species as well as the following metal cyanide species:

$Cu(CN)_2^-$, $Cu(CN)_3^{2-}$, $Cu(CN)_4^{3-}$, $Ag(CN)_2^-$, $Ni(CN)_4^{2-}$

In contrast, the following metal cyanide complexes cannot be oxidized by hydrogen peroxide. These compounds, along with CN_{WAD} complexes, are measured as “total” cyanide (CN_{tot}):

$Au(CN)^{2-}$, $Fe(CN)_6^{3-}$, $Fe(CN)_6^{4-}$, $Co(CN)_6^{4-}$

However, it is still possible to achieve CN_{tot} limits by precipitating the $Fe(CN)_6^{4-}$ with, for example, copper ions:

$Fe(CN)_6^{4-} + 2Cu^{2+} \rightarrow Cu_2Fe(CN)_6$ (solid)

This can normally be accomplished by lowering the pH to 8 to 9 in the presence of copper hydroxide. Occasionally, more copper must be added in the form of copper sulfate to achieve the desired CN_{tot} level.

The cyanide destruction reaction using peroxide is relatively fast in most wastewater samples. The presence of transition metals, especially copper, helps to accelerate the reaction. However, effluents that contain little or no metals may require a catalyst in order to accommodate a treatment circuit with limited effluent retention capabilities. Copper sulfate pentahydrate additions are ideal for this purpose.

Low effluent temperatures will significantly slow down the reaction time. Therefore, cyanide destruction circuits must be designed with sufficient retention time to allow the reaction to go to completion at the lowest possible effluent temperature experienced at a particular site. If shorter retention times are desired, more copper catalyst can be added to reduce the cyanide destruction reaction time.

Hydrogen peroxide can be shipped safely at high concentrations (up to 70% by weight H_2O_2) and stored for long periods of time without appreciable loss of activity, which makes H_2O_2 an ideal choice for remote locations. H_2O_2 has proven invaluable for emergency detoxification programs, where low capital costs and quick start-up are essential requirements.

Caro's Acid, or peroxymonosulfuric acid (H_2SO_5) is simply made from a mixture of hydrogen peroxide and sulfuric acid. Stoichiometrically, the molar ratio of peroxide to H_2SO_4 is 1:1, however, in operating practice, higher additions of acid are the norm. Since Caro's acid is a more powerful oxidizer than hydrogen peroxide, it has proven applicable in the treatment of slurries. In certain cases it can increase the efficiency of the peroxygen/cyanide destruction reaction by quickly oxidizing the free and weak acid dissociable cyanide species to cyanate.

The Caro’s acid solution used for the testwork contained in this report is similar to solutions prepared by a CyPlus/Degussa's DegOX® "Cold” Caro's Acid Generator. These generators produce high yield Caro’s acid, which has proven to significantly reduce the reagent demand compared to other generators available for the mining industry.

Generation of Caro's acid and oxidation of cyanide follow the basic reactions below:

$$H_2O_2 + H_2SO_4 \rightarrow H_2SO_5 + H_2O$$

$$CN^- + H_2SO_5 \rightarrow OCN^- + H_2SO_4$$

Reaction products of Caro's Acid oxidation are essentially the same as for the SO_2/AIR process.

3.3 CombinOx®

The new CyPlus CombinOx® process has been developed through the joint efforts of CyPlus GmbH, CyPlus Corp. and Inco scientists under the framework of a cooperation agreement. The main objective of the effort was to provide the industry with a low cost alternate process for cyanide detoxification achieving the same or lower residual cyanide total targets, as has been common for the SO_2/AIR process. The new process uses both sulfur dioxide (in any of the available product forms) and peroxygen chemicals as reagents and takes advantage of certain synergies between the processes to reduce total reagent requirements. Identical end products are obtained as in both background technologies (SO_2/AIR or Caro's). Soluble copper provides the catalyst; dissociated metals are precipitated as hydroxides and strong cyanide complexes are precipitated as insoluble salts, predominantly in the presence of copper or zinc. The new process can offer some or all of the following advantages:

a) Lower Capital Cost

b) Lower Operating Cost

c) Tremendous flexibility towards changes in cyanide loadings due to higher feed cyanide or mill tonnage increase; i.e. the system can take higher cyanide loads without the need to upgrade the installation.

d) The process can be automated for minimal operator attention. Automation is recommended for ease of operation, however, it is not essential to the process.

e) If designed for higher regulatory limits, such as International Cyanide Management Code tailings pond limits, the process can be readily upgraded to achieve lower residual cyanide and metal concentrations if required at any time in the future.

f) “Process Balancing" to accommodate particular reagent shortages within a prevailing market and/or system component breakdowns or maintenance.

Application of the process will be primarily for slurry treatment options and its suitability will be dependent on prevailing metallurgy of the ore as well as a function of local reagent pricing. CombinOx® technology is exclusively marketed by the CyPlus group of companies.

4. ANALYTICAL PROCEDURES

The following briefly describes the analytical methods employed for assaying solution (<0.45 μm) samples.

Filtered solution samples were immediately processed through a spectrophotometric determination of weak-acid dissociable cyanide (CN_{WAD}) using the buffered picric acid method **(see Appendix A)**. Total cyanide (CN_T) was calculated as CN_{WAD} + 2.795[Fe] where [Fe] represents the iron concentration in solution (units of mg/L). Soluble base metal assays (Cu, Ni and Fe) on both feed and treated effluents were analyzed by atomic absorption spectrophotometry (AAS –Perkin Elmer Analyst 200).

5. FEED PREPARATION FOR CYANIDE DESTRUCTION TESTWORK

5.1 Leach and Au/Ag Extraction

During the course of the testwork, six cyanidation leaches were performed, as described in **Section 2.1**. Carbon was used for gold and silver removal during the 72 hour CIL.

5.2 Feed Chemistry

Since the leach solution chemistry can vary with time, the samples were checked for CN_{WAD} and pH before treatment. Based on the CN_{WAD} analysis and the pH reading, sodium cyanide and calcium hydroxide were added to generate an effluent containing approximately the following:

CIP Tails Slurry

Percent Solids	35.0 %
CN_{WAD}	625 ppm
pH	10.5

After adjusting the sample cyanide levels and pH, the sample was once again analyzed for CN_{WAD}, Cu, Fe, Ni and pH. These results are shown in **Tables 1, 2 and 3** as the “Feed” descriptions above each corresponding detoxification test. A calculated CN_T value is also provided.

6. TEST RESULTS

6.1 Test Procedures

The SO_2/AIR process was carried out in continuous mode in a properly aerated and agitated reactor, as would be the case in typical plant operation. Reagents (sodium metabisulfite, copper sulfate, lime) were added continuously, and the pH was controlled by automatic addition of lime suspension. Tests were carried out at room temperature. Samples of feed and treated effluent were taken at hourly intervals for process monitoring, and final samples were taken at steady state.

CombinOx® treatment tests performed on each feed pulp were conducted in continuous mode, in a properly agitated reactor(s) as described above, with continuous addition of regents. Samples of feed and treated effluent were taken at hourly intervals for process monitoring, and final samples were taken when the system reached steady state.

Caro's Acid tests were conducted batch-wise for the slurry solution samples at room temperature. Representative samples were taken for each test.

For the copper additions shown in **Tables 1 and 2**, an indexed value for copper was provided in parentheses below the actual Cu^{2+} addition, designated as “Fe +___ ppm”. Due to the fluctuations in the copper and especially the iron concentration in the feed, the indexed copper value was set up for comparison purposes and is equal to the theoretical amount of copper remaining after the feed and added copper are consumed by the precipitation of the iron cyanide as represented by the equation below:

$$Fe(CN)_6^{4-} + 2Cu^{2+} \rightarrow Cu_2Fe(CN)_6 \text{ (solid)}$$

This is based on the assumption that all the soluble iron in the feed is present as iron cyanide, and that all this iron cyanide reacts with the copper from the feed and the additional copper to form copper ferrocyanide.

6.2 Treatment Objectives

For all the effluent samples, a treatment target of 0.5 mg CN_{WAD} per liter of solution was set by the client. However, it was established that results as high as 1 ppm would be considered acceptable.

6.3 Treatment Results

6.3.1 SO_2/AIR Process

The SO_2/AIR cyanide destruction tests were performed on the slurry samples at 35% percent (wt%)solids. Results are summarized in **Table 1.**

Results at or below 1 mg CN_{WAD} /L were achieved in tests **SO_2/AIR #1, #3, #4 and #5**. The optimum conditions are shown in test **SO_2/AIR #1** where a 0.76 mg CN_{WAD} /L was achieved at pH 8.5 with a reagent addition of 6.0 g SO_2/g CN_{WAD} and some lime to maintain the pH. An 800 ppm Cu^{2+} addition was also used to catalyze the reaction and to precipitate the iron cyanide. This equates to an indexed copper value of 167 ppm Cu^{2+}. It may also be possible to use less copper as shown in test **SO_2/AIR #4**, with an indexed copper addition of 103 ppm. The 0.5 ppm CN_{WAD} treatment target was surpassed in **SO_2/AIR #5** using an extremely high copper addition.

6.3.2 CyPlus-CombinOx®

CombinOx® cyanide destruction tests were performed on the 35% solids slurry feed samples. Results are summarized in **Table 2**.

Results at or below 1 mg CN_{WAD} /L were achieved in tests **COMB #1 and #3.** The treatment target was exceeded in the optimized test, **COMB #3** with the addition of 4.51 g SO_2 & peroxygen per g CN_{WAD} , and some lime to maintain the pH at 9.0. A 1031 ppm Cu^{2+} addition was also used which equates to an indexed copper value of 75 ppm and required a retention time of 2 hours. The peroxide addition was unusually high.

6.3.3 Caro's Acid Process

Tests relating to Caro's Acid treatment of the 35% slurry were performed using batch treatment methods. Results are summarized in **Table 3.**

Due to site transport and temperature issues that dictated the use of more dilute reagents, the Caro's acid used for this report was generated under cooled conditions using 39% H_2SO_4 and 50% H_2O_2 with a 2:1 molar ratio of sulfuric acid to peroxide. The resulting Caro's acid solution had an exceptionally low conversion rate of peroxide to Caro's acid of just under 25%. Therefore, most of the oxidant was present as peroxide, which appeared to decompose on the iron compounds in the concentrate sample. Typically 70% peroxide and 93% sulfuric acid is used for generating Caro's acid solutions with conversion rates around 80% under cooled conditions.

Even when using a relatively high dose of Caro's acid solution in test **Caro's #5**, at 5.23 g 100% H2O2 and 30.2 g

H_2SO_4 / g $CN_{WAD,}$ the resulting CN_{WAD} concentration was still above 20 ppm at 23.7 ppm.

7. DISCUSSION OF RESULTS

The SO_2/AIR and CombinOx® processes, appear to be effective in the removal of cyanide from the leach slurry, to reach levels of 1 mg CN_{WAD} / L or below. The Caro's acid process, however, could not reach levels below 20 mg CN_{WAD} / L, even when relatively large amounts of reagents were used. This is due in large part to the low reagent concentrations of peroxide and sulfuric acid, where a relatively small amount of the peroxide was converted to Caro's acid during the Caro's acid generation process.

Due to the fluctuations in iron and copper in the feed samples, an "indexed" copper addition was established to help compare the SO_2/AIR and CombinOx® processes. This is described in **Section 6.1**.

Referring to **Table 1**, the SO_2/AIR process worked effectively in test **SO_2/AIR #1** requiring 6 g SO_2 / g CN_{WAD} and an indexed copper addition of 167 ppm of Cu^{2+}(800 ppm actual). This produced a CN_{WAD} concentration of 0.76 ppm and a relatively low copper concentration of 0.07 ppm. Test **SO_2/AIR #4** produced an acceptable 1.01 ppm CN_{WAD} result using less SO_2 and copper on an indexed basis, at 5.5 g SO_2 / g CN_{WAD} and 103 ppm Cu^{2+}. However, the resulting copper and total cyanide values were much higher.

The CombinOx® tests, shown in **Table 2** also proved successful in producing acceptable results below 1 ppm CN_{WAD}. In test **COMB #3**, note the relatively low total cyanide and copper results.

8. OPERATING AND CAPITAL COST ESTIMATES

The laboratory test results and reagent unit cost data were used to provide operating cost estimates, based on the "typical" and "design" figures, for the various treatment options that were tested. A capital cost estimate is also provided based on the "design" conditions. These are summarized in **Tables 4 and 5**.

The operating costs in the tables are based on the reagent unit costs, labor and power costs provided by Miramar and CyPlus. The reagent costs are for delivery on-site.

The "typical" and "design" conditions, used for the operating and capital cost estimates in **Tables 4 and 5**, are shown below:

	Design	**Typical**
Tonnage: Concentrate Feed	67.2 dry tonnes/day	67.2 dry tonnes/day
Weight % Solids	40 %	45 %
CN_{WAD} Concentration	904 mg/L	697 mg/L
Copper	334	181
Iron	167	75
Availability	100%	90%

The information above was provided by Miramar. Note that there are some the differences from the testwork conditions.

9. CONCLUSIONS AND RECOMMENDATIONS

The conclusions and process recommendations given below are based on the laboratory results and operating cost estimates using unit costs and parameters outlined in Section 8 of the report. **NOTE: Changes to reagent unit costs can substantially change operating cost estimates and will impact on process selection.**

1. The testwork indicates that it was possible to treat the leached tails effluent sample to levels at or below of 1 mg CN_{WAD} /L, using SO_2/AIR and CombinOx® processes, as shown in **Tables 1 and 2**. It was not possible to achieve these low levels using Caro's acid, shown in **Table 3**.

2. Based on the operating cost comparison in **Tables 4 and 5**, the SO_2/AIR process would appear to be the most economical in terms of the reagent costs alone, at $15.74 per tonne for "typical" conditions. CombinOx® was about 10% more expensive at $17.50 per tonne. The costs for electrical, manpower and maintenance have yet to be calculated.

3. The capital costs estimates for each process are shown at the bottom of **Tables 4 – 5** have yet to be determined.

Disclaimer

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Table 1
SO_2/AIR Continuous Treatment Results

			SOLUTION ASSAYS						**REAGENT ADDITIONS**		
TEST	**STREAM**	**RET'N TIME (hours)**	**CN_{WAD} (ppm)**	**$^*CN_{TOT}$ (ppm)**	**Cu (ppm)**	**Ni (ppm)**	**Fe (ppm)**	**pH**	**SO_2 (g / g CN_{WAD})**	**$Ca(OH)_2$ (g /g CN_{WAD})**	**Cu^{2+} (ppm)**
	FEED		**631.7**	**1,510**	**81.60**	**1.99**	**314.3**	**10.5**			
SO_2/AIR #1 (Optimum)	C.I.L. Tails	2	0.76	1.85	0.07	0.13	0.39	8.5	6.0	2.05	800 **(Fe + 167 ppm)**
	FEED		**626.1**	**1,246**	**92.72**	**1.39**	**221.8**	**10.5**			
SO_2/AIR #2	C.I.L. Tails	2	51.30	161.7	55.30	1.287	39.50	8.6	5.0	2.24	25 **(Fe + 0 ppm)**
	FEED		**638.5**	**1,626**	**95.93**	**1.42**	**353.2**	**10.5**			
SO_2/AIR #3	C.I.L. Tails	2	0.87	0.87	5.29	1.11	<0.05	8.6	5.0	2.39	1100 **(Fe + 393 ppm)**
	FEED		**649.5**	**1,625**	**95.60**	**1.47**	**349.1**	**10.5**			
SO_2/AIR #4	C.I.L. Tails	2	1.01	6.87	10.20	1.29	2.10	8.5	5.5	2.80	800 **(Fe + 103 ppm)**
	FEED		**637.9**	**2,177**	**197.1**	**1.67**	**550.7**	**10.5**			
SO_2/AIR #5	C.I.L. Tails	2	<0.05	<0.10	0.17	0.15	<0.05	8.5	6.0	2.57	1500 **(Fe + 444 ppm)**

* Calculated Total Cyanide

Table 2
CombinOx® Continuous Treatment Results

			SOLUTION ASSAYS						REAGENT ADDITIONS		
TEST	**STREAM**	**RET'N TIME (hours)**	**CN_{WAD} (ppm)**	**$*CN_{TOT}$ (ppm)**	**Cu (ppm)**	**Ni (ppm)**	**Fe (ppm)**	**pH**	**Total Peroxygen & SO_2 (g / g CN_{WAD})**	**$Ca(OH)_2$ (g /g CN_{WAD})**	**Cu^{2+} (ppm)**
	FEED		**641.5**	**1,517**	**183.9**	**1.61**	**313.5**	**10.5**			
Comb #1	C.I.L. Tails	2	0.94	1.58	5.02	0.49	0.23	9.0	3.10	0.89	1,000 **(Fe + 471 ppm)**
	FEED		**643.5**	**1,037.**	**96.8**	**1.80**	**140.8**	**10.5**			
Comb #2	C.I.L. Tails	2	19.80	46.35	8.72	0.36	9.5	9.0	3.10	0.86	346 **(Fe + 122 ppm)**
	FEED		**649.5**	**1,951**	**102.5**	**1.73**	**465.7**	**10.5**			
Comb #3 (Optimum)	C.I.L. Tails	2	0.22	1.75	0.14	0.45	0.55	9.0	4.51	1.04	1,031 **(Fe + 75 ppm)**
	FEED		**642.9**	**1,988**	**185.3**	**1.77**	**481.3**	**10.5**			
Comb #4	C.I.L. Tails	2	76.80	79.61	130.6	1.09	1.00	9.0	3.86	0.96	984 **(Fe + 75 ppm)**

* Calculated Total Cyanide

Table 3
Caro’s Acid Batch Treatment Results

			SOLUTION ASSAYS						REAGENT ADDITIONS			
TEST	**STREAM**	**RET’N TIME (hours)**	**CN_{WAD} (ppm)**	**$*CN_{TOT}$ (ppm)**	**Cu (ppm)**	**Ni (ppm)**	**Fe (ppm**	**pH**	**100% H_2O_2 (g / g CN_{WAD})**	**100% H_2SO_4 (g / g CN_{WAD})**	**$Ca(OH)_2$ (g / g CN_{WAD})**	**Cu^{2+} (ppm)**
	FEED		**631.50**	**1,511**	**72.30**	**1.66**	**313.5**	**10.5**				
Caro’s #1	C.I.L. Tails	0.5	193.00	278.0	56.50	0.15	30.42	9.0	1.31 (1.0 X Stoich)	7.55 (2.0 X Stoich)	3.69	-
Caro’s #2	C.I.L. Tails	0.5	71.50	157.0	47.10	0.12	30.58	9.1	2.62 (2.0 X Stoich)	15.1 (4.0 X Stoich)	7.56	-
Caro’s #3	C.I.L. Tails	0.5	40.00	143.5	35.50	0.10	37.04	9.1	3.92 (3.0 X Stoich)	22.6 (6.0 X Stoich)	14.88	-
Caro’s #4	C.I.L. Tails	0.5	28.50	129.2	29.65	0.09	36.04	9.0	4.57 (3.5 X Stoich)	26.4 (7.0 X Stoich)	22.19	-
Caro’s #5	C.I.L. Tails	0.5	23.70	131.6	20.93	0.06	30.11	9.0	5.23 (4.0 X Stoich)	30.2 (8.0 X Stoich)	24.33	-

* Calculated Total Cyanide

APPENDIX A

Direct Colorimetric Determination of Cyanide With Picric Acid

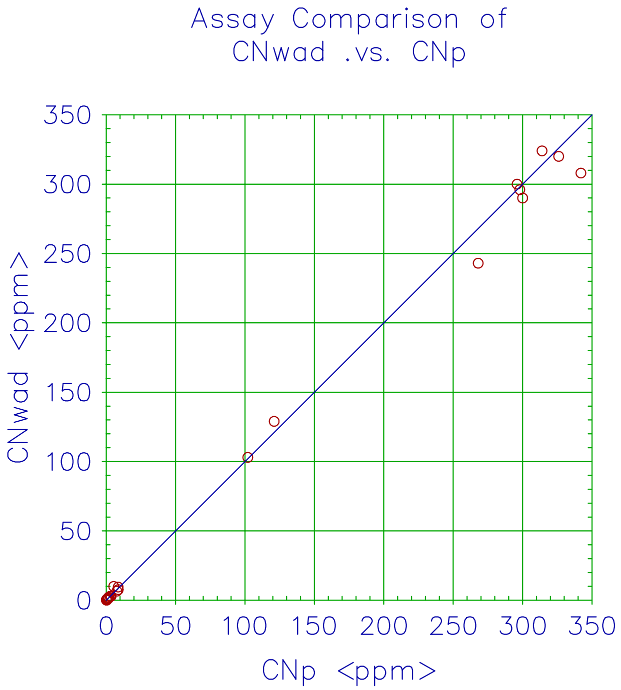
I Outline

Free cyanide and weak-acid dissociable cyanide reacts with the picric acid reagent to produce an orange colour, which can be measured colorimetrically at a wavelength of 520 nm. As with all colorimetric methods, standards must be prepared for comparison purposes.

The dissolved alkali metal picrate is converted by cyanide into the coloured salt of isopurpuric acid and its concentration is measured. For determination of cyanide below 0.1 ppm extractive preconcentration techniques can be used which are described in the original method. The presence of a small amount of nickel in the analyzed solutions has a positive effect on the overall performance of the method, but is not absolutely necessary.

II Application

The method is suitable for the determination of weak acid dissociable cyanide (CN_{WAD}) in effluents from flotation mills, gold cyanidation mills and electroplating shops. Since the detection limit for this procedure is 0.2 ppm CN_{WAD} it is especially useful for monitoring cyanide discharges to the environment. Below is a comparison of the results from the weak-acid dissociable cyanide distillation method (CN_{WAD}) and that obtained with the picric acid method (CN_P) described herein. It is apparent that CN_{WAD} is essentially the same as CN_P though it is useful to retain the distinction between the methods.



The reduction of picric acid is effected by free cyanide only. Cyanide tied up in copper, nickel, zinc or cadmium complexes is liberated by metathesis with:

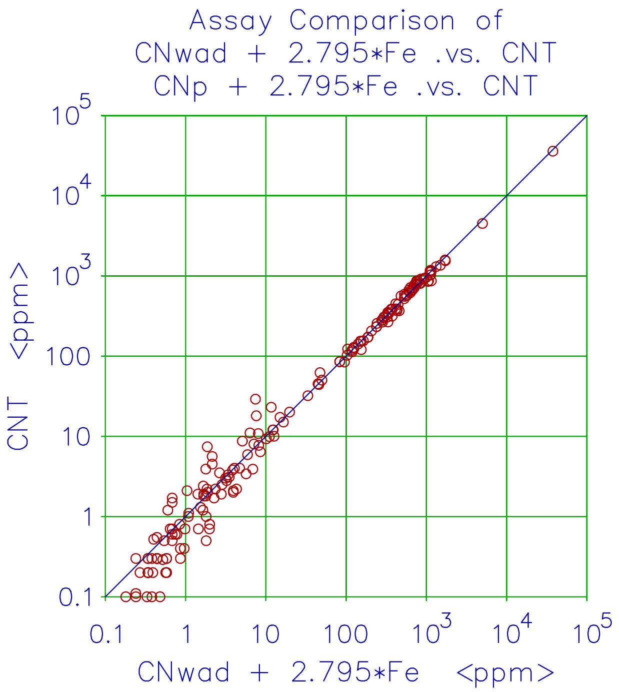
- diethylenetriaminepentaacetic acid (DTPA) or
- ethylenediaminetetraacetic acid (EDTA).

Iron-cyanide complexes, cobalt-cyanide complexes, gold-cyanide complexes, and silver-cyanide complexes do not react leaving their portion of cyanide undetermined. Usually only iron cyanide is present in any significant concentration so one can calculate total cyanide (CN_T) with one of the two formulae

$$CN_T = CN_P + 2.795 \text{ x Fe}$$

$$CN_T = CN_{WAD} + 2.795 \text{ x Fe}$$

As the concentrations of CN_P or CN_{WAD} and Fe approach zero, the formula becomes less exacting since a ligand other than cyanide might be present to keep the iron (Fe) in solution.



The direct colorimetric method allows for the accurate measurement of 10 - 200 μg CN^- in a sample aliquot of up to 50 mL. For samples containing greater than 1000 ppm CNp, dilute with distilled water. The table below should be used as a guide to determine the sample aliquot to be used for preparing the 100 ml mixture of the unknown.

Cyanide Concentration in Aliquot < ppm CN_P >	**Aliquot < mL >**
0.2 - 4	50
4 - 20	10
20 - 200	1
200 - 400	0.5
400 - 1000	0.2

III **Interferences**

Thiocyanate, cyanate and thiosulphate ions have no adverse effects and can be tolerated at levels normally occurring in gold mill effluents. Sulfide is a source of interference, 0.1 mg $S^{=}$ being equivalent to 0.025 mg CN^{-}. If present, sulfide ions can be readily removed by the addition of lead salts. However, it is unlikely that mill effluents would contain sulfide at levels large enough to significantly interfere in the cyanide determination. Sulfide particles which contact the picric acid reagent because of improper filtering of a gold bearing slurry, will also cause the $S^{=}$ interference.

The method requires a close control of pH since it affects the colour intensity produced by the cyanide-picric acid reaction. The most intense coloration results at pH 9.0 - 9.5. For maximum sensitivity and a good reproducibility of analytical results, the picric acid reagent solution should therefore be buffered. In the present procedure a mixture of sodium tetraborate and carbonate as well as DTPA itself serve this purpose. DTPA is preferred to EDTA due to more favourable values of acid ionization constants and stability constants of some metal chelates.

The method is highly recommended for monitoring the effluent of the Inco process since it is simple to do (once the picric acid reagent has been prepared) and any procedural errors will result in an assay biased high; whereas, any procedural errors in the distillation methods will bias the assay low. If the Inco Process has lost its catalytic activity, an orange colour may develop instantly upon addition of the picric acid reagent due to an $SO_3^{=}$ interference (unoxidized SO_2 in solution). The interference can be removed by adding $CaCl_2$ which will precipitate the $SO_3^{=}$ as $CaSO_3$. The precipitate must be filtered out prior to using the colorimeter. If the $SO_3^{=}$ is not precipitated out of solution the final result may be biased high.

IV Safety Precautions

Solutions of picric acid (trinitrophenol) are safe in ordinary laboratory use. However, in dry form the acid and especially some of its salts have explosive properties. This requires that all picric acid solutions be thoroughly washed down with water. Spills must be carefully wiped up. Picric acid has the tendency of staining the skin, and wearing protective hand gloves is therefore recommended. Glass stained by picric acid is best washed with methanol or acetone.

V Direct Colorimetry (10 - 200 μg CN^-)

Measure the absorbency of solutions more deeply coloured than the reagent blank at 520 nm using the reagent blank as the reference (Note 3).

VI Calibration and Sample Analysis

For the most accurate results, add only a portion of the distilled water (75 mL) called for in preparing the standards and unknowns. After the colour has been developed, add the contents to a 100 mL volumetric flask and wash out the conical flask with distilled water and add it to the volumetric flask until the 100 mL mark has been reached. Always measure absorbency against the respective reagent blank. Plot the absorbency readings vs. μg CN^- added in the aliquots of the standard cyanide solution, to construct the calibration graph. The plot should be a smooth gentle curve.

VII Calculation

Convert the absorbency reading of the aqueous solution or the extract into micrograms of cyanide using the calibration graph. If you are using the colorimeter in direct reading mode your reading is already in micrograms of cyanide and no graph is needed. The graphical method is by far the most accurate of the two and less prone to error. The colorimeter in direct reading mode uses a single point calibration and generates a linear response to absorbency changes whereas the actual response for a range of colour standards falls on a typical Beer's Law curve. By using the graphical method this linearization error can be avoided as well as the possible error due to the calibration of the colorimeter with older, contaminated standards.

Once the microgram of cyanide is known calculate the cyanide concentration in the original sample solution as follows :

$$ppm\ CN_P = \frac{mg\,CN^-}{L} = \frac{\mu g\ CN^-\ from\ the\ Calibration\ Graph}{Aliquot\ Volume\ in\ mLs}$$

VIII Notes

1. A white precipitate of calcium carbonate might separate from samples containing large quantities of calcium. This is dissolved by addition of 0.1-0.2 g of EDTA disodium salt.

2. When heating the picric solutions they should reach a temperature close to the boiling point but should not be allowed to boil for any length of time. Alternately, the analysis is carried out in 150 mL conical flasks, which are then immersed in a boiling water bath for a period of 30 minutes.

3. The absorbency of the reagent blank usually varies between 0.006 - 0.009 (520 nm, slit width 0.03 mm, 1-cm glass cell). By using the standard, which is darker than the sample the result will be biased slightly high. The converse is also true.

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SaniBrane®

Membrane Bioreactors for Wastewater Treatment Systems

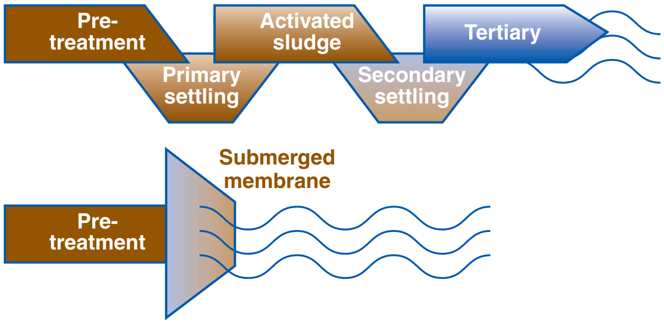
SANITHERM ENGINEERING LIMITED

Since 1946

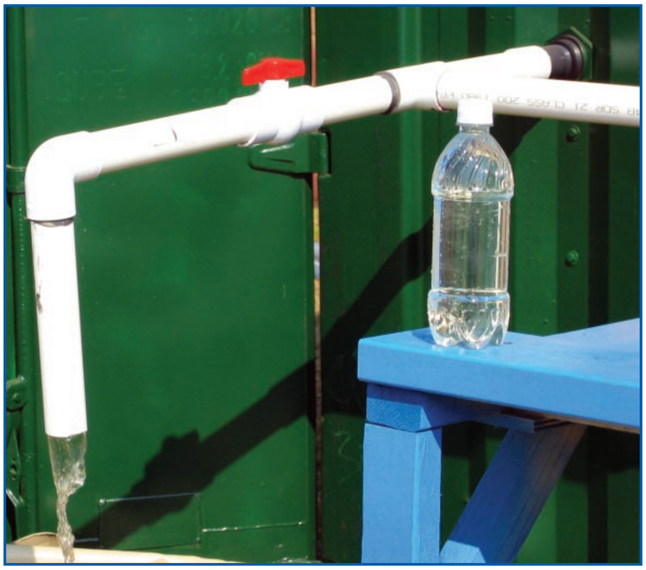
Membrane Bioreactor Treatment Technology: Revolutionizing Wastewater Treatment.

A membrane bioreactor (MBR) combines one of the oldest and most mature wastewater treatment technologies with the very newest. It is an activated sludge treatment plant combined with an extremely effective clarifier.

The basic operating theory behind membranes is conventional biological treatment combined with a semi-permeable barrier that precludes mixed liquor suspended solids (MLSS) from being discharged from the biological reactor. This semi-permeable barrier is generally an engineered plastic such as PVDF or PVC, perforated with innumerable tiny holes less than one micron in diameter – smaller than the size of the MLSS. Clear, treated liquid is drawn through the openings, either by gravity or by using a pump. Normally, such a semi-permeable barrier would plug immediately after being placed in the MLSS tank, but proper design prevents solids from accumulating on the membrane surface and “blinding” the holes.

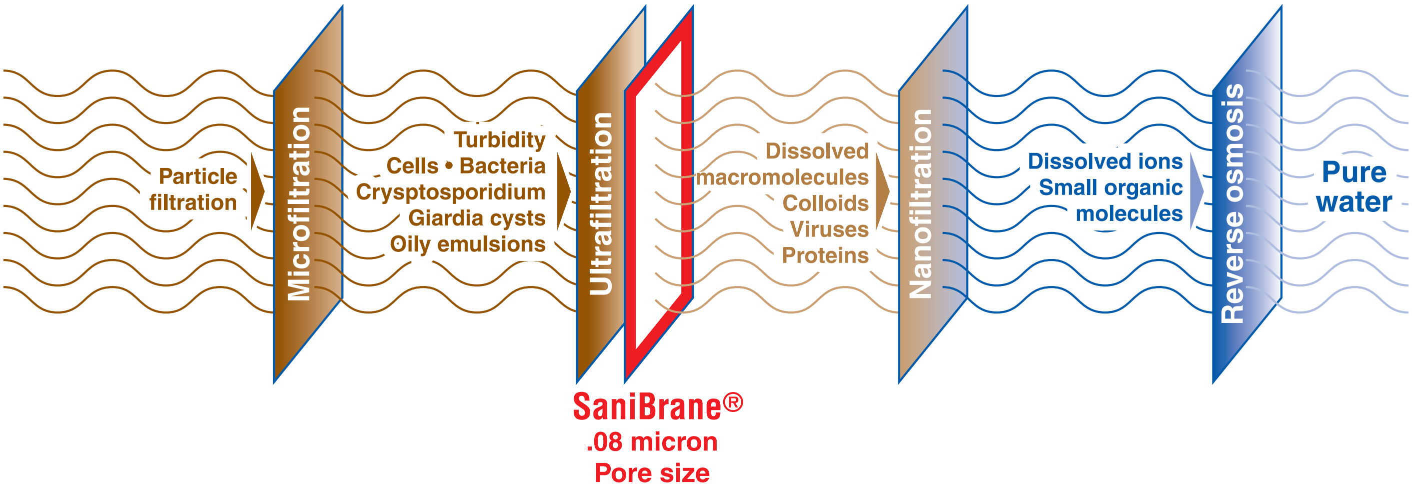


MBRs take fewer steps than conventional activated sludge plants to produce the required effluent. That means there is less room for operator error and equipment malfunctions – saving you money and time.



The SaniBrane® system results in effluent that is often well above the standard required.

Generally speaking, there are two wastewater membrane configurations. Hollow-fibre designs resemble spaghetti strands with hollow centres. Flat-plate designs consist of plates with membrane fabric on each side. SaniBrane® designs are strictly flat-plate, which allows optimum air-scouring to keep the membrane surfaces clean. This results in less maintenance: for example, no back pulsing.

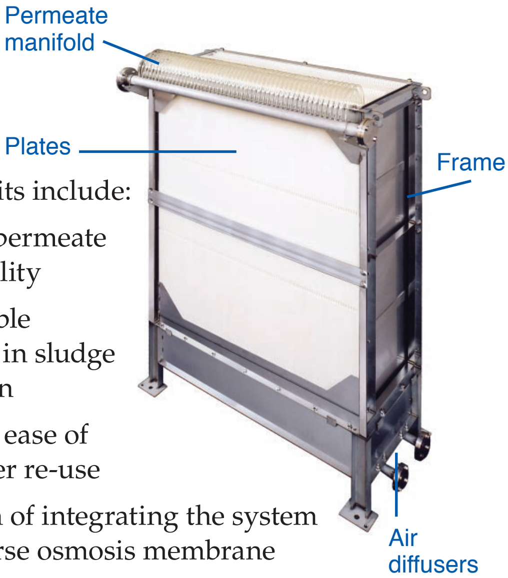


The SaniBrane® MBR: a Flat-Plate Design

The SaniBrane® flat-plate MBR design allows optimum air-scouring to keep the membrane surfaces clean. Use of PVDF for membrane surfaces results in the most consistent pore size and distribution.

The reliable air scouring and consistent, long-term flux rates make these membranes suitable for treating domestic sewage in both industrial and municipal environments.

SaniBrane® flat-plate unit being installed in a concrete tank.



Other benefits include:

- excellent permeate water quality
- considerable reduction in sludge production
- improved ease of wastewater re-use
- the option of integrating the system with reverse osmosis membrane
- two-year warranty on membrane life
- ability to operate with gravity flow (i.e., no pump required)
- significantly less operator intervention than is required with hollow-fibre membranes
- open-top flow-through design ensures effective scouring and MLSS mixing

TYPICAL APPLICATIONS

SaniBrane® Projects	Design Flow	Modules	MLSS	BOD	TSS	Fecal Coliform	Comments
Snap Lake NWT, Canada	5,283 gpd (20 m³/day)	1	12,000 – 18,000 *(Design Range)*	< 5 mg/L *(detection limit)*	< 2 mg/L	< 15 F.C./100 ml	Industrial Camp
Sooke BC, Canada	63,401 gpd (240 m³/day)	4	12,000 – 18,000 *(Design Range)*	< 5 mg/L *(detection limit)*	< 1 mg/L		Residential
Attawapiskat ONT, Canada	48,750 gpd (184.5 m³/day)	3	12,000 – 18,000 *(Design Range)*	10 mg/L	10 mg/L	100 F.C./100 ml	650 Man Industrial Camp
Attawapiskat ONT, Canada	17,250 gpd (65.3 m³/day)	1	12,000 – 18,000 *(Design Range)*	10 mg/L	10 mg/L	100 F.C./100 ml	230 Man Industrial Camp
Gahcho Kue NWT, Canada	7,000 gpd (26.5 m³/day)	1	12,000 – 18,000 *(Design Range)*	15 mg/L	15 mg/L	10 F.C./100 ml	Industrial Camp
Pemberton BC, Canada	3,963 gpd (15 m³/day)	1	12,000 – 18,000 *(Design Range)*	< 5 mg/L *(detection limit)*	< 3 mg/L	< 5 F.C./100 ml	Industrial Camp
Lake O' Hara Lodge BC, Canada	5,019 gpd (19 m³/day)	1		< 5 mg/L *(detection limit)*	< 1 mg/L		Ultraviolet treatment following SaniBrane®
Gulf Islands, BC, Canada	26,417 gpd (100 m³/day)	2	36,000	< 5 mg/L *(detection limit)*	< 1 mg/L	< 1 F.C./100 ml	Sludge thickening: activated sludge

Plants Custom-Designed to Meet Your Unique Requirements

SaniBrane® MBR technology is suitable for a wide variety of applications in both industrial and municipal environments. Sanitherm's range of configurations and housing systems will fit your needs perfectly, regardless of the remoteness of your location or the severity of the climate at your site.

Sanitherm's wastewater treatment plants are currently in use worldwide, in municipalities, rural gas stations, remote resorts, golf courses, schools, construction camps and oil and gas exploration camps. They are also suitable for cruise ships and offshore oil drilling facilities – anywhere needing reliable waste treatment with a small footprint.

Sanitherm's design team will work with you to determine the most suitable size and configuration for your project, based on population and environmental considerations. Then Sanitherm will build and install your system. Once in place, you will find it versatile and easy to operate.

SaniBrane® Container Systems

Sanitherm is at the forefront of addressing wastewater challenges in remote areas. The SaniBrane® Container System is suitable if you have limited land mass, a small population and need a complete, compact and self-contained wastewater treatment system.

The plant is built in a shipping container, which makes shipping easy to any location in the world. A 15 m³/d plant weighs approximately 15,000 pounds or 6,800 kg, which means that it's transportable with a heavy-lift helicopter. On-site, it has a small footprint.

Clients for this efficient plant include mines, oil fields, industrial camps, remote municipalities, resorts, rural rest stops and . . .

A SaniBrane® container system can be set-up and operating in just a few hours – no building required. All you need is the sewage inlet connection, the treated effluent connection and the power connection. The system is very low-maintenance and you will find that in most cases the effluent is of higher quality than required.

Several standard sizes are available, all complete with flow equalization, treatment tankage, heat, lights and controls. A long list of available options will ensure compatibility with your specific requirements. For example:

- Larger heaters (standard is 5kW)
- Effluent discharge pump chamber
- Inlet screens
- Air conditioning
- Effluent disinfection

Let Sanitherm custom-build a compact and cost-effective wastewater treatment solution for your site.

Standard sizes include:

- 4,000 gpd (15m³/d), built inside a 40-ft "hi-cube" container
- 8,000 gpd (30m³/d), inside a 48-ft container
- 12,000 gpd (45m³/d), inside two 40-ft "hi-cube" containers
- 16,000 gpd (60m³/d), inside two 48-ft containers
- Custom containers

If a helicopter can get there, so can a SaniBrane® Container System.

SaniBrane® Concrete Tank Systems

Customers with large volumes to treat may prefer the SaniBrane® Concrete Tank option. These permanent tanks are ideal for in-ground installations. They are space-saving, as you can build offices or equipment rooms above them. They can also be built in stages: pour the tanks now, install equipment as it is required.

Sanitherm can help you design an MBR to treat flows of 1 MGD (3800 m^3/d) and greater. Sanitherm's packages can include all of the ancillary equipment required, including aeration blowers, permeate pumps, mixers, supplemental aeration, and level controls. As well, you can incorporate process controls and starters using major manufacturers such as Sutorbilt, Gorman-Rupp, Flygt, Allen-Bradley or any other that you prefer. The plant controls can be simple or as comprehensive as you need.

A concrete tank is ideal for isolated municipalities.

Sanitherm also supplies miscellaneous fabricated components such as access stairways, grating and handrails.

Installing the MBR units.

Because of the modular design of the SaniBrane® membrane units, which do not require chemical dip tanks or back-pulse piping, plants are simple to build and expand. In-situ chemical cleaning reduces the long-term maintenance costs. Sanitherm has been designing plants since 1946 and troubleshooting sewage treatment plants in some of the most remote parts of the globe since the early 1990s. Sanitherm can offer your team real-world, practical experience.

SaniBrane® Pre-Fabricated Steel Plants

To minimize site labour, time and expense, a Sanitherm pre-engineered steel plant is the recommended solution. They handle large volumes, are portable, self-contained, and pre-piped. Sanitherm has built hundreds of pre-fabricated treatment plants utilizing professionally-engineered tankage, fabricated to ASME, CWB and AWS standards.

Standard plants are built within a 12-ft (3.66-m) width and height envelope. Shipping requirements are also considered during design. Transporting via cargo plane, container ship or helicopter is feasible. To ensure minimum delay when reassembling on site, external piping is factory-installed and then removed for transport.

Municipal application: at a residential resort.

Industrial application: at a diamond mine. *Right:* prefab plants are easy to ship.

SaniBrane® pre-fabricated steel plants can be installed on-grade, on concrete pads or compacted gravel bases or they can be buried, to suit your specific site conditions. Depending on the local climate, the plants can be totally free-standing or they can be housed within pre-engineered or site-built buildings.

Safe service access is assured with industrial-grade stairways, handrailing and grating over all tanks.

Typical installations include remote industrial sites as well as residential subdivisions. By reducing the installation time, the sites can be populated sooner and the subdivision lots can be sold more quickly.

SANITHERM ENGINEERING LIMITED

Since 1946

Sanitherm has earned a worldwide reputation for quality equipment and service and continues to acquire new and proven technologies capable of meeting the toughest of regulations.

Sanitherm's experienced team will work with you to create a custom design to suit your requirements. With Sanitherm, you are assured a wastewater treatment system that is operator-friendly, economical, reliable and effective.

Sanitherm has designed, manufactured and installed hundreds of SaniBrane® systems, giving Sanitherm the experience necessary to provide you:

- Standard systems that are pre-plumbed, pre-wired and tested
- Custom designs to suit your requirements
- Designs and systems that are operator-friendly and economical

Please call for details on how Sanitherm can design, build and install a wastewater treatment system that is tailored to your needs and budget.

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