BAFFINLAND IRON MINES CORPORATION

MARY RIVER PROJECT

FRESH WATER SUPPLY, SEWAGE AND WASTEWATER MANAGEMENT

FOR

PRE-DEVELOPMENT WORKS

ADDENDUM TO WASTEWATER MANAGEMENT PLAN

APPENDIX B.5

2011-09-02	A	Issue for Internal Review	R. Kapadia			
DATE	**REV.**	**STATUS**	**PREPARED BY**	**CHECKED BY**	**APPROVED BY**	**APPROVED BY**
HATCH						**CLIENT**

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Table of Contents

1. Introduction

This document is an addendum to the existing wastewater management plant (March 2010) and supports a submission being made to the Nunavut Impact Review Board (NIRB) regarding the execution and management of pre-development works (PDW). Specifically, this document focuses on freshwater supply and wastewater treatment and disposal at Milne Port, the Mine Site and Steensby Port.

2. Milne Site Supply of Fresh Water

2.1 Fresh Water at Milne Inlet

Fresh water is currently drawn from 32 km Lake water source using a small pump which then fills a water tank. The water tank delivers the water to storage tanks at the camp site where fresh water is drawn as needed. The maximum number of people at the site during the pre-development phase will be 150. The potable water demand for this population will be approximately 45 m^3/day (using a per capita consumption of 300 Lpd/capita – see potable design basis document H337697-4000-10-109-0001).

During the pre-development phase the current practice will continue. An additional truck may be required to deliver the water. The existing water supply tank supports a population of 60 people and as such a second tank will be added to the site to store the daily requirements for the extra 90 people. There will be no other significant fresh water requirement during the pre-development phase.

Existing water treatment consists of filtration followed by UV disinfection. The existing equipment will continue to be used. The current treatment scheme will be replicated for the additional personnel with new filtration and UV equipment.

2.2 Sewage Treatment at Milne Inlet

Currently sewage generated by the camp site is managed through an existing RBC type sewage treatment plant (Seprotech manufactured). Sludge is discharged to a dedicated waste pond. Treated effluent is stored in a small heated tank. The effluent is then withdrawn by a vacuum truck and if it meets discharge requirements it is discharged to the overland outfall which drains by gravity to the ocean. If the effluent doesn't meet the discharge requirements the vacuum truck delivers it to a local waste storage pond for additional treatment. During the winter, latrines are used and the waste collected is incinerated; any small quantities of grey water are discharged to a waste storage pond located adjacent to the camp.

For the pre-development phase the existing RBC shall continue to operate. The camp population will increase during pre-development by approximately 90 people. To accommodate the additional sewage waste generated a new RBC (may be a new or used model) sewage treatment system will be installed adjacent and in parallel to the existing unit. This new unit will be designed to meet the project sewage effluent discharge limits. The treated effluent will continue to be discharged using the same method as is currently practiced. Both systems will be fed from a common new equalization tank (EQ Tank). This EQ Tank will be sized to accept the sewage flow generated by the entire 150 person camp. The EQ Tank will come with two (2) suction pumps. One pump will deliver sewage to the existing sewage treatment system while the second will feed the new sewage treatment plant. It should be noted that the existing RBC is already equipped with an equalization tank. As such, the new equalization tank will feed into this existing one (in order to integrate into the existing infrastructure). The existing waste storage ponds shall not be modified.

During start-up the new RBC system will take between 2 weeks to 4 weeks to reach full capacity. Therefore the new system will be installed at least 2 weeks to 4 weeks before the camp reaches its full manpower.

Total sewage generated during the maximum occupancy of 150 personnel will be ~51.6 m^3/day (using a per capita sewage generation of 344 Lpd/capita – see sewage design basis document H337697-4000-10-109-0002).

A review of the laydown area indicates that there is ample space for the additional equipment required.

2.3 Oily Stormwater Treatment at Milne Inlet

There currently exists a wastewater treatment system to treat run-off from the fuel tank farm. There are no pre-development requirements to expand this farm and as such the current practices will continue without change.

3. Mine Site Supply of Fresh Water

3.1 Fresh Water at Mine Site

The water supply for the Mine Site is obtained using a submersible electric pump adjacent to the shoreline of Camp Lake. Water is pumped directly from the lake source to water storage tanks located at the camp. The average number of people at the site during the pre-development phase will be 120. The total camp watershed use for this source s estimated to range up to a maximum of 80 m^3/day.

Existing water treatment consists of filtration followed by UV disinfection. The existing equipment will continue to be used and is designed with sufficient capacity.

3.2 Sewage Treatment at Mine Site

Currently the Mine Site has a permitted rotating biological contactor (RBC) based sewage treatment system designed to accommodate 120 people. As such the existing equipment will continue to be used during the pre-development period. The current approvals and wastewater management plan also allow for treated sewage to be discharged from the PWSPs (Polishing Waste Stabilization Ponds) after further treatment as required. Refer to the current Wastewater Management Plan for details concerning design criteria, capacity, process review, operations and maintenance, pond treatment / discharge, sludge management, monitoring and reporting.

3.3 Oily Stormwater Treatment at Mine Site

Oily stormwater is generated within the existing bulk fuel and hazardous waste containment areas at the Mine Site. Oily water is currently treated by means of a mobile treatment trailer. The trailer comes complete with oil / water separation and water filtration equipment. The trailer is operated on an as needed basis. When needed, contaminated water is drawn from the contaminated water source and sent through the purification system. Treated water is discharged overland while collected oil is re-used where possible otherwise the oil is stored and shipped south to be recycled.

The current oily water treatment practice is permitted and will continue during the pre-development phase.

4. Steensby Site Supply of Fresh Water

4.1 Fresh Water at Steensby Port

Currently Steensby Inlet Camp potable water comes from 3 km lake approximately 3 km east of the camp. A collapsible water line was installed from 3 km lake water source to the Steensby Inlet Camp.

4.2 Sewage Treatment at Steensby Port

For the upcoming pre-development phase the camp personnel will be accommodated on a barge which is equipped with potable water and sewage treatment systems.

For land based activity personnel will use latrines. The sewage from these latrines will be collected in tanks and then sent to the barge where the waste will be treated.

These ship based systems will suffice for the pre-development phase and will handle fresh water and wastewater treatment requirements.

If deemed necessary latrines with waste incineration can be set up along the road between Steensby and the Mary River site to accommodate truck drivers delivering equipment to remote locations.

4.3 Oily Stormwater Treatment at Steensby Port

During the pre-development phase of the project oily water may be generated at various locations. There will be run-off from a fuel farm where diesel and some jet fuel will be stored. Another source will be run-off from a landfarm and contaminated snow dump areas.

These sources will be managed using a mobile treatment trailer similar to the one described in Section 3.3 for the Mine Site. The trailer will withdraw impacted water as needed and then treat the water to remove oil and other contaminants. The purified water will be discharged overland. Separated oil will be collected and re-used where possible, otherwise the oil will be shipped south for recycle.

There will also be a small maintenance shop where some equipment washing will occur. The collected wash water from this facility may contain oil contaminants.

An oily water storage tank will be located within the maintenance facility where the oily wastewater will be stored.

The oily water storage tank will be equipped with an oil / water separator. The separated oil will be stored in tanks and disposed of as described above. The cleaned water will be re-used as wash water.

5. Regulations, Standards, and Codes

As a minimum standard of acceptability, all actions undertaken will be compliant with appropriate sections of both Federal and Provincial legislation as indicated in the table below:

Table 5-1: Applicable Regulations, Standards and Codes

Number / Acronym	Title
AWWA	*American Water Works Association*
IBC	*International Building Codes*
NSF	*National Sanitation Foundation*
GCWQ	*Guidelines for Canadian Drinking Water Quality*
NWT Reg 108-2009	*Northwest Territories Water Supply System Regulations*
Ontario Reg 170/03	*Safe Drinking Water Act, 2002*
Nunavut Waters and Nunavut Surface Rights Tribunal Act, SC 2002, c 10	
Northwest Territories Water Act	
Northwest Territories Water Regulations (SOR/93-303)	
Ontario Drinking Water Quality Standards	
Canadian Fisheries Act	
Canadian Environmental Protection Act (1999)	
CCME Water Quality Guidelines for the Protection of Aquatic Life	
Ontario Guidelines for Sewage Works 2008	
CCME Guidelines for Compost Quality	
NSF/ANSI Standard 61	Drinking Water System Components
AWWA Standard B100	Filtering Material
AWWA Standard B604	Granular Activated Carbon
OSHA	*Occupational Safety and Health Administration*

5.1 Roles and Responsibilities

The responsibilities for implementing this plan are divided among the various entities as follows:

Owner: Shall have overall responsibility for making sure that the plan is implemented as outlined and in accordance with the commitments provided in the Environmental Impact Statement, and shall undertake monitoring, review and auditing of the activities of the EPCM contractor.

EPCM Contractor: Shall provide onsite direction of all water supply and wastewater treatment activities.

Contractors: Shall be responsible for the supply of potable water in their working areas in accordance with this document. Contractors will be responsible for the offsite transportation and final disposal of all hazardous waste generated as a result of their activities.

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

WASTEWATER MANAGEMENT PLAN

Rev. No.	Revision	Date	Approved
0	Issued in Final	September 15, 2007	DC
1	Issued in Final	March 31, 2009	JM
2	Issued in Final	March 31, 2010	JM

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This Wastewater Management Plan has been prepared by Baffinland Iron Mines Corporation with the technical assistance, support, and review services of various consulting engineers and scientists. The consulting companies involved, and the specific areas of technical expertise provided, are listed below:

Seprotech Systems Inc. (Seprotech) of Ottawa, ON - Wastewater Treatment Plant Design Development, Installation, Maintenance, Technical Support, and Operator Training.

Genivar Consultants PL (Genivar) of Timmins, ON - Polishing Waste Stabilization Ponds (PWSPs) and Piping/Outfall Design, Construction QA/QC and As-Built Drawings, Author of September 15, 2007, Version of the Wastewater Management Plan.

AMEC Earth & Environment (AMEC) of Waterloo, ON - Treatment Plant Design Review, 2010 Sludge Management Plan, PWSP Effluent Discharge Plan, and general review.

Knight Piésold Ltd. (KPL) of North Bay, Ontario, and North/South Consultants (NSC) Inc. of Winnipeg, Manitoba - Receiving Environment Baseline Data Compilation, Mass Balance Modeling, Effects Prediction and Assessment, and Toxicity Assessment.

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

WASTEWATER MANAGEMENT PLAN

TABLE OF CONTENTS

PAGE

LIST OF FIGURES & DRAWINGS

LIST OF APPENDICES

BAFFINLAND IRON MINES CORPORATION
MARY RIVER PROJECT

WASTEWATER MANAGEMENT PLAN

SECTION 1.0 - INTRODUCTION

Genivar Consultants PL (Genivar) was retained by Baffinland Iron Mines Corporation (BIM) in 2007 to design the sewage works for the Mary River Project (the Project), specifically for Mary River and Milne Inlet Camps on Baffin Island, Nunavut, to support the Bulk Sampling Program. As a requirement under BIM's Water Licence 2BB-MRY0710 issued by the Nunavut Water Board (NWB) on July 27, 2007, and in accordance with Part D, item 13, BIM was required to submit a Wastewater Management Plan (WWMP) as follows:

> *"The Licensee shall submit to the Board for approval, within thirty (30) days following the commissioning of the Waste Water Treatment Facilities, a Waste Water Management Plan which includes provision for Operation and Maintenance in accordance with the "Guidelines for the Preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in the Northwest Territories, 1996". The plan shall include options for treatment and disposal of sludge."*

On September 15, 2007, BIM submitted a Wastewater Management Plan (WWMP) to the NWB that addressed the following key elements related to sewage works and management at their Mary River and Milne Inlet Camps (refer to Figure 1 for location map):

- Process design,
- Construction and commissioning,
- Operation and maintenance, and
- Effluent discharge to receiving environment.

The September 2007 WWMP was subsequently revised in March 2009 (Revision 1) and submitted to the NWB as an Appendix to the 2008 NWB Annual Report and approved in August 2009. Revision 1 of the WWMP was revised to include the following items:

- Changes to sewage infrastructure including the construction and commissioning of two additional Polishing/Waste Stabilization Ponds (PWSPs) at the Mary River Camp.
- Revisions to operating manual documentation, maintenance, and monitoring practices to reflect enhancements that have been implemented since start-up of the waste water treatment facilities (WWTFs).
- Review and revision of the design basis of the sewage treatment systems in consideration of actual monitoring/operational/performance data.
- Presentation of a provisional option to add RBC media to the Mary River Camp sewage treatment system to address current and unexpected throughput limitations resulting from higher than anticipated average nitrogen loading.

- Proposed management and disposal technical strategy for the effluent currently residing in three (3) PWSPs at Mary River and one (1) PWSP at Milne Inlet.
- Proposed management and disposal technical strategy for sludge currently stored in the PWSPs.
- Review and validation of the prediction for no adverse impacts to the receiving environment associated with the discharge of treated sewage effluent and in consideration of the planned 2009 discharges from the PWSPs.

The WWMP (Revision 2), herein, is a revised version of the March 2009 document. Minor revisions have been made throughout the document but the key revisions include the following:

- Section 6.0 and Appendix F.1 (PWSP Effluent Discharge Work Plan) has been updated to reflect practical experience gained during the 2009 season.
- Section 7.0 and the addition of a new Appendix F.2 (Sludge Management and Work Plan) has been updated to reflect the current plans regarding the sludge management plan and the 2010 work plan.
- Section 10.0 and Appendix G has been updated to incorporate recent PWSP discharge and aquatics data as well as to provide an assessment of the effects of the treated sewage discharge.

An overview and chronology of the sewage works at the Mary River and Milne Inlet Camps are provided in Sections 1.1 and 1.2, below. A location plan showing the two camps is provided as Figure 1.

1.1 MARY RIVER CAMP WWTF OVERVIEW

The existing camp at Mary River currently has a potential capacity for 200 persons. This capacity consists of a 100 person seasonal camp, originally set up and used for the exploration work prior to 2007, plus an adjacent all-season camp with a nominal design capacity of 100 people that was constructed in late 2007 and early 2008. The all-season camp consists of predominantly Weatherhaven™ tents, two steel Quonset huts as maintenance facilities, and numerous small wooden outbuildings, situated approximately 200 meters from the shores of Camp Lake (refer to Figure 2 and Drawing 002).

A pre-engineered mechanical sewage treatment plant (referred to as the 'Tanks-a-Lot system') was commissioned in November 2007 and was operated until February 2008, when a new mechanical WWTF was commissioned. The new WWTF, consisting of a Rotating Biological Contactor (RBC) and ultra-violet light (UV) disinfection (manufactured and installed by Seprotech), was designed to achieve tertiary levels of treatment with the potential for piped, year-round, discharge to Sheardown Lake. The existing Tanks-a-Lot system was substantially decommissioned in 2008 following commissioning of the new WWTF.

With the design basis that was adopted, the new RBC WWTF was sized for a nominal occupancy of 150 persons. Since, October 2008, the camp occupancy at Mary River has declined from previous levels with very low numbers (less than 10 personnel) during the off-season period (October to April) and increased numbers (50-100 personnel) during the field season to support exploration drilling and site reclamation programs. During the upcoming 2010 field season the occupancy numbers in camp are currently expected to be around 100 persons to support a three drill exploration program.

In 2008, BIM conducted a review of the design basis for the wastewater treatment facility, its standard operating procedures for operations and maintenance, and monitoring requirements, with the aim of consistently meeting discharge requirements thereby reducing the dependency on the use of the PWSPs. Since the implementation of the recommendations from this review, water licence effluent requirements have largely been met (since December 2008).

Although effluent produced from the Mary River RBC WWTF has been compliant for most effluent parameters, there have been problems with the WWTF consistently meeting the total phosphorous criterion. Because of this inconsistency in achieving the target total phosphorus concentration in the WWTF effluent, BIM has recognized the need for a conservative approach and has discharged all treated effluent to the PWSPs for further testing and treatment, as required, prior to final discharge to Sheardown Lake. During 2009, an appropriate polishing treatment, discharge, and monitoring plan for partially treated sewage effluent stored in the PWSPs was developed and implemented at the Mary River site. The treated 2,858 m^3 of effluent that was discharged to Sheardown Lake during this program met or exceeded applicable effluent criteria, including total phosphorus, and was not acutely toxic.

In response to operating experience in 2008 and 2009, Baffinland continues to review the Mary River WWTF design and operation with the aim of consistently meeting discharge requirements for all parameters, thereby reducing or eliminating the need for additional polishing treatment within the PWSPs prior to discharge. Baffinland recognizes that an appropriate discharge and monitoring plan for partially treated effluent was effectively developed and executed during 2009, and continuation of this plan may be an appropriate and protective method for ongoing treatment and discharge of treated effluent at the Mary River camp.

During 2010, Baffinland will continue to work to reduce total phosphorus concentrations in treated effluent from the WWTF with the intention of direct discharging to Sheardown Lake. However, if testing results remain inconsistent for total phosphorus concentrations, our intention will be to continue to utilize the PWSPs for treated effluent storage. Due to the discharge of treated effluent from the PWSPs during 2009, there is now sufficient projected storage capacity for 2010 and winter 2011.

1.2 MILNE INLET CAMP WWTF OVERVIEW

The Milne Inlet site is the shipping point for materials and supplies to and from the Mary River Operations (refer to Figure 3 and Drawing 003). An all-season trailer camp was installed in 2007 to support the annual re-supply and Bulk Sample Program operations. The camp facilities at Milne consist of a Shanco™ accommodation complex with a RBC WWTF (complete with UV disinfection). The Milne facilities and WWTF are sized for a nominal capacity of 60 workers to support peak periods of activity, primarily during the initial mobilization and final ore shipment stages of the Bulk Sample Program. Since the completion of the Bulk Sample Program in October 2008, the Milne

Inlet Camp population has declined to two persons and the RBC was shut down and winterized. Currently there are no plans to operate the RBC to support camp occupancy during 2010 since it is anticipated the total number of persons will remain very low. Toilet wastes at Milne Inlet are being managed through use of latrines and the incineration of latrine waste. Small quantities of grey water are discharged to a leach pit located adjacent to the camp.

The RBC WWTF was commissioned in October 2007. During the start-up period, effluent and sludge were disposed of in a PWSP, constructed on site for that purpose. Treated effluent from this facility first met the water license discharge requirements in January 2008 and was directed to the approved receiving ditch upstream of Milne Inlet. Compliance with water license criteria enabled direct discharge to the receiving environment for the majority of 2008, with intermittent periods where effluent not meeting discharge criteria was directed to the PWSP. The effluent volume in the Milne PWSP was substantially reduced in June of 2009. Approximately 331 m^3 of treated effluent stored in the PWSP at Milne Inlet camp was discharged to a ditch that drains directly into Milne Inlet during the month of June. Pre-treatment prior to discharge was not required since stored effluent met effluent requirements and was acutely non-toxic.

SECTION 2.0 - WASTEWATER REGULATORY BACKGROUND AND CHRONOLOGY

2.1 WASTEWATER MANAGEMENT CHRONOLOGY

This section presents, in the following Table 2-1, a chronological listing of key regulatory submissions/approvals and key activity/milestones related to wastewater treatment and management from September 2007 to March 2010. Also included in this section are regulatory/government comments that were received in response to the September 2007 submission of the original WWMP, comments arising from other regulatory submissions since that time (e.g., Modification request for additional PWSPs at Mary River and Milne Inlet Camps), and comments and responses arising from the March 2009 submission of Revision 1 of the WWMP.

2.2 COMMENTS FROM REGULATORY/GOVERNMENT AGENCIES

Since the submittal of the WWMP in September 2007, there have been three rounds of comments received from regulatory and government agencies regarding wastewater management for the Project. Comments were received from INAC regarding the September 2007 submittal of the WWMP. BIM responded to these comments in a letter to the NWB, dated December 9, 2007. This letter and attachments are provided for reference in Appendix A.1 of this document.

The second round of comments on wastewater management was received from Environment Canada and INAC Water Resources Division in April 2008 regarding BIM's Request for Modification to Waste Disposal Facilities. The third round of comments was received from Environment Canada in response to BIM's Annual Water Licence Report submission. The above correspondence from Environment Canada and INAC are also provided for reference in Appendix A.2, along with a tabulated summary of the comments and BIM's response/action for each (refer to Table A.2, Appendix A).

Baffinland responded to comments from the NWB, Environment Canada, and the Nunavut Department of Environment regarding its March 2009 WWMP (rev. 1) submission. A response letter was provided in July 2009. This letter and attachments are provided in Appendix A.3. The approval letter for the WWMP (rev. 1) is also provided.

Wastewater Management Chronology

Date	**Activity/Milestones and Regulatory Submissions/Approvals**
September 2007	Submission of Wastewater Management Plan
October 2007	Commissioning of Milne Inlet Rotating Biological Contactor (RBC) and Polishing / Waste Stabilization Pond (PWSP)
November 2007	Commissioning of 'Tanks-a- Lot' Wastewater Treatment Facility (WWTF) at Mary River
January 2008	As-Built submission for Milne Inlet RBC Facility
January 2008	As-Built submission for the Mary River 'Tanks-A-Lot' sewage system
January 2008	Treated effluent from Milne RBC meets Water Licence criteria and is discharged to the Milne Inlet
February 2008	Installation of all-season tent camp at Mary River
February 2008	Construction completion and commissioning of Mary River RBC facility
March 2008	Submission of Water Licence Annual Report (2007)
April 2008	Submission of Waste Disposal Facilities Modification Request for PWSP No. 2 and No. 3 at Mary River and an additional PWSP at Milne Inlet
May 2008	Construction completion and commissioning of Mary River PWSP No. 2
May 2008	Water License Modification granted - Waste Disposal Facilities
July 2008	As-built submission for Mary River RBC and PWSP No. 1 and No. 2
August 2008	Milne effluent tested for acute toxicity and passes
October 2008	Shut-down of Milne Inlet RBC due to low population numbers in camp
November 2008	Submission of Annual Geotechnical Inspection Report
December 2008	Construction completion and commissioning of Mary River PWSP No. 3
December 2008	Effluent from Mary River RBC starts meeting Water Licence Criteria
March 2009	Submission of revised WWMP (rev. 1)
March 2009	As-built submission for Mary River PWSP No. 3
June 2009	Discharge of Milne PWSP (no pre-treatment required)
June 2009	Submission of schedule of activities for Summer 2009 as related to treatment and discharge of the PWSPs
July 2009	Submission of response to reviewer's comments on the WWTP
August 2009	Approval received for WWMP (Rev. 1)
August 2009	Treatment and discharge of effluent from PWSP Nos. 2 and 3.
November 2009	Submission of Annual Geotechnical Inspection Report
March 2010	Submission of revised WWMP (Rev. 2)

SECTION 3.0 - DESIGN CRITERIA, CAPACITY, AND PROCESS REVIEW

This section presents the original design basis for the Mary River and Milne Inlet RBC WWTFs and presents the results of a process design review that was performed that focused on the Mary River RBC system in particular. This review was undertaken due to the longer-than-anticipated time that it has taken to achieve water licence criteria for treated effluent. The objective of the review was to provide recommendations on the actual treatment capacity of the Mary River sewage treatment system. As a follow-up to this review work, a provisional option to install additional RBC media in the Mary River WWTF is provided as a means of eliminated nitrogen removal as a current limitation on the ability of the facility to meet its original design throughput.

Through 2009, the Mary River RBC system was considered to be generally performing within its expected operational limits and successfully treating the wastewater for all parameters, with the notable exception of phosphorus. During 2010, Baffinland will continue to work to reduce total phosphorus concentrations in treated effluent from the Mary River WWTF with the intention of direct discharging to Sheardown Lake.

The treated effluent from the Milne Inlet RBC first met the water licence discharge requirements in January 2008 and, since then, there was direct discharge to the receiving environment for the majority of 2008, with intermittent short periods where effluent not meeting discharge criteria was directed to the PWSP. These periods resulted from minor upset conditions in the RBC related to mechanical or process maintenance, and intermittent spikes in camp occupancy that resulted in higher than design loadings. Based on operational experience over 2008, the Milne RBC treatment system is considered to be generally performing within its expected operational parameters.

3.1 DESIGN BASIS

Prior to construction of the Milne and Mary River camps the per capita sewage flows and strengths were originally estimated based on the typical values found in Tables 10.3, 10.4 and 13.1 of the 1996 “Cold Regions Utilities Monograph, Third Edition”, a publication highly respected and used in Canada and USA for the design of infrastructure in the arctic regions. Copies of these Tables are included in Appendix B to this report.

The characteristics of sewage in remote/cold regions, depend on the type of work being performed, work schedules, facilities provided, and the type and capacity of the water supply. These factors directly affect the flow rates and the amount of dilution seen in the wastewater.

For design of the freeze protection of the forcemain, the minimum ambient temperature was assumed to be -45 degrees C and wind speed was assumed to be 40.3 kph. The heat tracing on the forcemain was designed to keep the pipe contents at 5 degrees C.

The sewage at both camps was expected to be a ‘moderately diluted wastewater’ as defined in Table 10.4 in Appendix B. The average BOD5/TSS concentrations for this type of wastewater were expected to be 460 mg/L BOD5 and 490 mg/L TSS. In addition, a loading of 65 mg/L TKN and

10 mg/L phosphorus was assumed by Seprotech, the manufacturer of the RBC units, derived from their experience with similar operating facilities.

Average flow rates for similar camps have been recorded in the range of 132 to 220 litres per capita per day (Lpcd). For design purposes, sewage generation was conservatively assumed to be 225 Lpcd, with a maximum loading of 460 mg/L BOD5, 490 mg/L TSS, 65 mg/L TKN and 10 mg/L Phosphorus.

The following tables 3-1 and 3-2 below provide a summary of the original design sewage flows and strengths, the discharge requirements of the water licence, and the original design basis of the pre-engineered RBC units. The original design briefs and loading calculations completed by Seprotech are provided in Appendix C to this report.

Table 3-1 Design Sewage Flows and Strengths

Facility Type	Water/Sewage Quantity (Lpcd)	BOD_5/TSS (Avg. - mg/L)	No. of Persons (Capita)	Total Daily Flow (L/d)	Total Flow 400 days (m^3)
Drilling Camp	83 to 227	460/490	-	-	
Average Work Camp	170	460/490			
Average Construction Camp	220		-	-	
Design Criteria for Mary River Camp	**225**	**460/490**	**150**	**33,750**	**13,500**
Design Criteria for Milne Inlet Camp	**225**	**460/490**	**60**	**13,500**	**5,400**

Table 3-2 Water License Discharge Requirements and the Original Design Basis

Parameter	Water License Requirements Maximum Average Concentration		Wastewater Treatment Plant Design Effluent Concentrations	
Location	Milne Inlet WWTF	Mary River WWTF	Milne Inlet WWTF	Mary River WWTF
BOD_5	100 mg/L	30 mg/L	20	10
TSS	120 mg/L	35 mg/L	20	10
Faecal Coliform	1,000 CFU/100mL	10,000 CFU/100mL	Less than 200 Counts per 100 mL	Less than 200 Counts per 100 mL
Oil and Grease	No visible sheen	No visible sheen	Removed by grease traps	Removed by grease traps
pH	Between 6.0 and 9.5	Between 6.0 and 9.5	Between 6.0 and 9.5	Between 6.0 and 9.5
Toxicity	Final effluent not acutely toxic	Final effluent not acutely toxic	Not acutely toxic due to nitrification	Not acutely toxic due to nitrification
Ammonia	N/A	N/A	2 mg/L NH3-N	2 mg/L NH3-N
Total Phosphorus	N/A	N/A	N/A	0.5 mg/L target level**

** Note: The 0.5 mg/L phosphorus target level is considered to be conservative based on anticipated overall phosphorus loadings to Sheardown Lake and modeling results that are presented in Section 10 of this document. It also needs to be recognized that because these target levels are very close to what is technically achievable, that levels may on occasion may range between 0.5 to 1.0 mg/L, especially as related to discharge from the PWSPs. The modeling takes this 0.5 to 1.0 mg/L range into consideration when calculating loadings for discharge from the PWSPs.

3.2 MARY RIVER RBC DESIGN PROCESS EVALUATION

Due to the poorer than expected performance of the Mary River RBC sewage treatment system, a review was performed by AMEC Geomatrix Limited (AMEC). The AMEC review compared the original design basis to actual 2008 operating conditions with the aim of identifying the actual treatment capacity of the system. The treatment capacity recommendation is based on an independent review of the design parameters, the estimated original design capacity, and the actual loading data recorded during the 2008 operating season. AMEC's technical memorandum, Mary River RBC Design Process Evaluation, provided in Appendix D to this report, contains the technical details of the evaluation. A summary of this work including key results is provided below.

For general background, it is important to understand that RBC design is based on hydraulic and organic loading rates across a surface area and that increases or decreases in surface area increase the fundamental treatment capacity of the system. The variability in surface area is provided by the configuration of the media (spacing and diameter of the RBC discs) and promotes biofilm growth on the rotating discs. The biofilm is responsible for removal of organic and nutrient constituents. Once the sludge reaches a certain thickness it sloughs off of the media for removal. AMEC conducted an independent review of the design parameters used by Seprotech against accepted published values. Based on the results of this review, in terms of the design flowrates and the organic loading capacity of the system, it was concluded that the system has been designed to be within published loading criteria, however, little flexibility or safety factor has been designed into the system. It is possible that small changes in wastewater characteristics would have a significant impact on treatment efficiency.

AMEC also compared the actual 2008 measured wastewater loading data with the design basis for the system. The results of this comparison was that the actual flowrates were lower than the design basis (26 m^3/day actual compared with 33.75 m^3/day in the design basis). It is suspected that the daily habits of camp crews have impacted the overall flowrates to the wastewater treatment system in that some flows of dilute wastewater have not been entering the system. The higher concentration material has continued to enter the system which has resulted in overall wastewater concentrations that are higher (particularly nitrogen measured as TKN) than in the original design basis. The resulting mass loading rates were similar to design mass loading rates although BOD5 and TSS loadings were less than estimated while TKN loading was higher than original estimates.

It has been identified that TKN is the limiting design parameter for the RBC system currently operating at Mary River. The treatment system was designed with a maximum TKN loading of 2194 grams of nitrogen per day (g N/day). To produce effluent consistently meeting the water license criteria in the current configuration (one shaft, four stages) the number of staff on-site at any one time would be limited to 123 people based on the per capita loading rates of 16.9 g of nitrogen per person per day observed in 2008 in order to provide sufficient surface area for nitrification.

The key tables summarizing these results are provided in AMEC's technical memorandum found in Appendix D to this report.

3.3 PROVISIONAL OPTION - ADDITIONAL RBC MEDIA

A treatment option has been developed to enable the Mary River RBC to treat sewage at the originally designed hydraulic throughput. By adding additional growth media to the RBC, the sewage system will be capable of treating the higher than expected nitrogen levels while preserving the design hydraulic throughput.

In late 2008, anticipating a potential treatment bottleneck, Baffinland purchased from Seprotech a stand-alone RBC media unit. This unit has not been installed, but consists of a tank assembly complete with 3,038 m^2 of high density packaged media designed specifically for nitrification. Seprotech has provided a design basis for this system and design brief which is provided in Appendix D to this report. AMEC conducted a review of the provisional system including development of a conceptual process flow diagram for the proposed configuration (also provided in Appendix D).

The suggested layout would consist of adding the new media in series with the existing four (4) stages of media contained within the existing RBC facility. By adding an additional four (4) stages of media, the surface area available for treatment would increase to 5,382 m^2. Connecting the existing 4- stage Shaft #1 in series with the new 4 stage shaft Shaft #2 would provide a total of two (2) shafts and eight (8) stages.

In the proposed configuration, the first four media stages would be used for BOD removal and the remaining 4 stages would be used for nitrification. Although the additional media will not increase the existing hydraulic capacity, it will allow the existing system to operate at the original design capacity instead of the current "TKN limited" capacity. The maximum hydraulic loading would be limited by the system hydraulic loading of 33.75 m^3/day. The additional shaft and discs would increase the existing treatment capacity and result in a more robust system capable of treating wastewater from a maximum of 236 people at 143 L/person/day. The tanks, pumps, alum system and filter systems will not need to be upgraded as the hydraulic capacity will not change.

For the purposes of determining a maximum number of staff that the Mary River facility can support the sizing calculations were based on calculated mass loading and available surface area. This analysis and results are presented in the AMEC TM in Appendix D.

SECTION 4.0 - SEWAGE TREATMENT AND DISCHARGE

4.1 TREATMENT

Treatment of sewage at the Mary River Site is by a ROTORDISK®; N-70 packaged RBC System by Seprotech Systems Inc. Effluent from the sewage treatment system has the potential to be transmitted directly to the submerged outlet at Sheardown Lake via an insulated 75 mm forcemain. Since start-up in February 2008, treated effluent has been discharged to the three PWSPs constructed for that purpose.

The fully contained RBC system is comprised of a primary settlement tank, a Rotating Biological Contact (RBC) tank, and a secondary settling tank. Raw sewage is pumped into the primary settlement tank, whereby, heavy solids are retained through gravity settling and thickening. Supernatant from the primary settlement tank enters the RBC tank through an inlet slot located at the front section of the RBC tank. The RBC tank is made up of four stages, or disk banks. The four separate disk banks are mounted on a common rotating shaft. As the disk banks are partially submerged, the rotation serves to provide continual aeration for the fixed film biological growth and filtering process (which occurs on the disk banks).

The first disc bank represents 40% of the total RBC surface area and is responsible for the most significant reduction in BOD. Subsequently, the accumulation of biological growth will be the greatest on the first disc bank and gradually decrease through subsequent sections. The growth will be generally thick and often filamentous on the 1st disk bank, becoming thinner and more compact on stages 2 through 4. Under certain operating conditions, nitrifying bacteria may become dominant in the 3rd and 4th disc banks. The 4th disc bank has a circulation device that allows well-treated liquid to be recycled to the primary settling tank. Treated water from the RBC enters the secondary settlement tank, whereby biomass sloughed from the disks and other suspended solids settle through gravity.

The existing RBC system uses aluminum sulphate (commonly called “alum”) to precipitate dissolved phosphorus and form insoluble aluminum phosphate. This insoluble aluminum phosphate settles in the RBC tankage and is periodically removed along with the accumulated biological solids sloughed off from the rotating media. Thus, phosphorus removal is a 2-stage process whereby the dissolved phosphorus is first precipitated to form a solid, and secondly those solids are then removed from the treated water. For systems that experience occasionally high suspended solids concentrations in the effluent, meeting low phosphorus concentrations can be problematic. To ensure the Mary River WWTF is able to consistently meet a 0.5 mg/L phosphorus discharge target concentration, the existing alum addition program can be combined with effluent filtration.

The dimensions and sizes of the system can be seen in the Seprotech drawings provided in Appendix C.

Treatment of sewage at Milne Inlet is by a ROTORDISK®; B-30 packaged RBC System by Seprotech Systems Inc. This system is similar to the N-70 unit. In order to meet the requirement of the water license for a non-acutely toxic effluent, this unit was modified as part of its original installation to promote nitrification. The B-30 system operation is similar to the N-70 as discussed above.

4.2 MARY RIVER DISCHARGE

Since start-up, all effluents have been directed to the PWSPs. The location of the three PWSPs relative to the RBC system is shown in Figure 2 and Drawing 002.

The as-built report for the sewage treatment system including the RBC, PWSP No. 1 and No. 2, and associated piping and outfall was submitted to the NWB in July 2008. The as-built report for PWSP No. 3 was submitted to the NWB in March 2008. These reports contain detailed design and as-constructed survey information. Drawings Nos. 002, 004, 005, and 006 provide as-built plans and profiles for the Mary River Camp sewage treatment infrastructure including piping, outfall, and PWSPs. In general, the designs of the PWSPs consist of cells lined with a 1.0mm (40 mil) HDPE liner. The slopes of the PWSPs designed to be a minimum of 2H: 1V with allowance for 0.3m of sludge, 1.5 m of water, and 0.6m of free board. The total operating volume for the combined volume of the three PWSPs at Mary River is approximately 9,400 m^3.

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Freeze protection has been designed by Urecon Limited. The 75 mm DR 26 HDPE pipe is fitted with 50 mm of polyurethane insulation and a PVC jacket. Inside the insulation, an integral conduit houses a Thermocable C13-240-COJ heating cable with an output of 13 watts/meter controlled by an electronic thermostat set at 5 degrees C with a high limit of 65 degrees C for protection of the HDPE pipe. Operating experience has shown that due to the harsh climate and irregular topography along the pipeline route that it is risky and difficult to keep the line from freezing during winter conditions because the pipe is not self draining. Therefore, during the winter it is recommended that all discharge be directed to PWSP No. 3, rather than attempting to utilize the effluent discharge pipeline all the way to Sheardown Lake.

Since December 2008, the treated effluent from the Mary River RBC system has met effluent requirements with the exception of total phosphorus. During the open water season in 2009, the partially treated effluent contents of PWSP No. 2 and 3 were further treated and discharged to the receiving environment based on the strategy as presented in Revision 1 of the WWMP and in accordance with water licence requirements. Since the discharge event in August 2009, the effluent criteria from the RBC has been mainly within discharge criteria (including total phosphorus). Therefore, it is anticipated that the stored effluent in PWSP No. 3 will be tested in May or early June 2010 and, if all regulatory criteria are met and the effluent is non-acutely toxic, then the pond can be direct discharged to the receiving environment without further treatment via the existing pipeline and outfall.

4.3 MILNE INLET DISCHARGE

During the RBC start-up at Milne Inlet (from November 2007 to January 2008), treated effluent from the plant was transported to the PWSP via vacuum truck. The location of the PWSP relative to the RBC and other camp infrastructure is shown on Figure 3 and Drawing 003. Commencing in

January 2008, treated effluent was discharged to the receiving environment with the exception of short periods when water licence criteria were not or not likely being met. During normal operation, treated effluent is transported regularly from the RBC via vacuum or tanker truck to local drainage ditch (non-fish bearing) where the effluent is released to the ditch that flows to the receiving environment. The dimensions of the ditch are as follows: average width of the drainage ditch is 15 m, average depth relative to surrounding land is 1.9 m and approximate length of the ditch 275 m. The ditch discharges to Milne Inlet.

The Milne Inlet RBC was shut down and winterized in October 2008 and not operated during 2009. The RBC will not be operated during 2010 due to the projected low camp occupancy. Based on an occupancy level of less than five (5) persons, latrines are to be used and the collected waste incinerated.

The as-built drawings for the Milne RBC and PWSP was submitted to the NWB in December 2007. The PWSP consists of a cell lined with a 1.0mm (40 mil) HDPE liner. The slopes of the PWSP are 2H: 1V with allowance for 0.3m of sludge, 1.5 m of water, and 0.6m of free board. Total operating volume of the PWSP at Milne Inlet is approximately 575 m^3. Detailed as-constructed drawings and profiles of the PWSP at Milne is presented in Drawings 003 and 007.

The effluent from the RBC System is transferred to a holding tank with a capacity of two days of average flow. The effluent holding tank is housed adjacent to the RBC System to protect the tank from freezing. Inside temperature is normally kept at a minimum of 10 degrees C. The holding tank itself is sized to hold twice the average daily sewage volume generated.

The discharge location along the drainage ditch is protected by means of an energy dissipater to prevent erosion. Silt fences have been maintained downstream from the discharge location as an additional protective measure.

In June 2009, the PWSP at Milne was partially discharged (without pre-treatment) as the effluent met water licence effluent requirements and was acutely non-toxic. Similar to 2009, the residual effluent remaining in the PWSP will be retested in May 2010 and further discharged if criteria are met.

SECTION 5.0 - OPERATIONS AND MAINTENANCE (O&M)

Both routine and non-routine O&M procedures are described in detail in the Installation, Operation, and Maintenance Manuals provided in Appendix E. They are briefly summarized in the subsections below.

5.1 TRAINING

The manufacturer of the RBC WWTFs (Seprotech) provides training to BIM managers and RBC facility operators during routine periodic visits to the Project site, as well as providing a training program at their Ottawa offices. Seprotech have provided the level of training to BIM supervisors and operators that it recommends to clients of their equipment. To enhance management capabilities and enable continuity of operation, BIM designates specific contract operators for its WWTFs. These operators have undergone on-site training by the manufacturer, Seprotech, as described above. Seprotech is also available to provide on-call expert advice, as required. BIM is currently developing in-house training capabilities for its WWTF operators.

5.2 ROUTINE O&M

BIM have developed a checklist for routine inspections that occur on a daily basis. A copy of the checklist that is used is provided in Appendix E.1. When the checklist is completed, it is provided to the BIM Camp Manager where the results of the inspection are reviewed and any actions taken as required. The record is safely stored in a record filing system developed for the purpose. In addition to reviewing the daily checklists for upset conditions that might require action, the treatment plant operators are instructed to immediately notify the Camp Manager as soon as an atypical condition is observed.

The following procedures associated with operation and maintenance of the sewage facilities are performed on a scheduled basis while the Mary River and Milne Inlet Camp RBCs are in operation:

- Visual inspection of the RBC unit to detect any leaks, malfunctions, discoloration, foul odours (refer to checklist for complete list)
- Monitoring for indicator parameters such as pH and temperature
- Visual inspection of camp kitchen grease traps to ensure proper operation
- Visual inspection of effluent pipeline and heat trace checks along the pipeline to detect any leaks, damage or malfunction of the heat tracing system
- Visual Inspection of the pump station at the camp to verify the liquid levels, and detect any system blockages
- Visual inspection of the discharge outfall to ensure continuous discharge and detect any leaks in the embankment

Prior to inspecting the RBC unit, the operator must ensure that the unit is well ventilated and appropriate personal protective gear is worn, including disposable gloves. During routine visual inspection of the RBC unit, attention will be paid to the nature of the biological growth on the disk media. The colour of the growth will typically be dark brown to black on the 1st disk stage. The growth on disks 2-4 will typically range between medium brown to tan on the final section. Unusual discoloration/texture of the disk media growth or strong sour odours could be indicative of process malfunction. Full details of the routine inspections and troubleshooting guidelines are provided in the Seprotech O&M Manual. These conditions are also noted on the daily checklists.

5.3 NON-ROUTINE O&M

Non-routine O&M procedures will be preformed associated with the following system needs:

- Sewage sludge management (discussed in Section 6 of this report)
- Unit Start up
- Unit Shutdown
- Special start-up procedures must be followed if the RBC unit has been out of operation. These procedures are outlined in detail in Appendices E.2 and E.3, and are briefly summarized below:
    - Support bearings on shaft and coupling re-lubricated;
    - Primary settling tank should be filled with fresh water;
    - While the RBC is rotating, introduce wastewater at design or less than design loading rates; and
    - Unit start-up normally requires 2 ½ to 3 weeks, with 50% BOD removal often occurring after one week
    - Shut down procedures are necessary if the treatment unit is to be taken out of operation for any significant period of time. These procedures are briefly summarized below:
    - Remove all accumulated sewage sludge from settlement chambers;
    - Clean disk media and flush unit clean; and
    - Drain tanks and pipes and disconnect pipes.

SECTION 6.0 - PWSP EFFLUENT RELEASE WORK PLAN

In 2009, BIM retained AMEC to prepare a technical strategy for the management, treatment, and disposal of the wastewater and sludge solids stored in the polishing/waste stabilization ponds (PWSPs) at Milne Inlet and the Mary River facilities. The technical strategy was successfully implemented during the 2009 open water season. A large portion of the PWSP effluent at Milne was discharged (without pre-treatment) to Milne Inlet. At Mary River, the contents of PWSP Nos. 2 and 3 were treated and discharged to Sheardown Lake. The 2009 technical strategy also provided guidance regarding the future steps required to manage sewage sludge. This section summarizes the current PWSP release work plan, which is built on the success of the 2009 field program. Section 7.0 provides an update on the sludge management strategy, also building on the data collection and test work completed during the 2009 field season.

This PWSP effluent release work plan was originally developed using information gathered from a number of sources including analytical monitoring/sampling data for the RBC and PWSPs, the Mary River RBC process design evaluation (Section 3.2), and environmental discharge criteria established based on water licence requirements and considering potential impacts to the receiving environment. The plan was developed iteratively and in cooperation with Knight Piésold (KP), North/South Consultants (NSC), and BIM, to quantify the projected discharge limits that are required to meet this objective (refer to Section 10). It is critical that discharge water from the PWSPs meet the Water Licence criteria that were detailed in Section 3.1 of this report and are specified in Part D, Items 10 and 11 of Water Licence 2BB-MRY0710. The target level for phosphorus has been established at 0.5 to 1.0 mg/L in consideration of anticipated overall phosphorus loadings to Sheardown Lake and modeling results that were presented in Section 10 of the 2009 WWMP (rev. 1) document. Ammonia concentrations are required to be acutely non-toxic. Most importantly, the PWSP effluent release work plan has been based on the practical experience and data that were collected during the 2009 open water season.

The PWSP effluent release work plan for discharging the accumulated water from the PWSPs is presented in a technical memorandum prepared by AMEC and presented in Appendix F.1. It involves two options.

Option no. 1 will be implemented if the PWSP melt water samples collected in May 2010 are in compliance with effluent regulatory criteria. If effluent is compliant, then discharge will commence. Once discharge has commenced, Baffinland will implement a field testing program that will provide early warning that effluent is approaching regulatory criteria limits. Since there is no treatment required for this option, this activity is a permitted activity under the currently approved WWMP (rev. 1) and the water licence.

Option no. 2 will be implemented if the PWSP water quality does not meet the effluent discharge criteria. In this case, the effluent would be treated using the polishing pond treatment system (as was used during the 2009 open water season). The various components, processes, monitoring program, and operating criteria for the system are presented in the AMEC technical memorandum provided in Appendix F.1.

It should be noted that at the present time, it is not planned to implement Option No. 2 during 2010 due to the storage capacity available in the Mary River PWSPs and the requirement for resources to be committed elsewhere during 2010. Option 1 will be implemented assuming effluent criteria are met. Based on the letter received from the NWB on August 10, 2010 (refer to Appendix A.4) providing approval for the WWMP (rev. 2), the NWB has advised Baffinland to submit an application to amend the water licence in the event that PWSP polishing treatment is required in 2010. Therefore, in the event Option 2 is adopted during 2010, this request would need to be appropriately addressed.

SECTION 7.0 - ROUTINE SLUDGE MANAGEMENT AND LONG TERM TECHNICAL STRATEGY AND WORK PLAN

7.1 ROUTINE SLUDGE MANAGEMENT

At the design capacity of the RBC System at Mary River, the sludge accumulates at a rate of approximately 13.5 kg per day in the Primary Settling Tank. During periods of camp occupancy at design capacity, this sludge is removed to PWSP No 1 as required based on sludge depth measurements within the RBC. Sludge is not discharged to PWSP Nos. 2 or 3, since these two ponds are to be used for future polishing treatment efforts. The accumulation of sludge in the WWTF can be indirectly monitored by visually observing the thickness of the scum blanket on the surface of the primary settlement tank and sludge depth measurements taken by means of a Sludge Judge sampling pole. The quantification of sludge volumes is difficult and depends on density and amount of effluent removed with the sludge.

At the design capacity of the RBC System at Milne Inlet, sludge accumulates at a rate of approximately 12.9 kg per day in the Primary Settling Tank. No sludge has been generated at Milne Inlet since shutdown of the RBC in October 2008.

7.2 2009 SLUDGE TESTING PROGRAM

The 2009 sludge management program involved the quantification and characterization of sludge within each of the PWSPs resulting in a solids inventories and bench scale test work. The solids inventories are presented in Tables 1 to 3 of the technical memorandum prepared by AMEC and presented in Appendix F.2. The volume of sludge measured in the Mary River PWSPs Nos. 1 and 2 totals approximately 542 m^3. There is a minimal, non-measureable, volume of sludge in PWSP No. 3. The estimated volume of sludge in the Milne PWSP is <200 m^3. Sludge thickness varies from 0.15 to 0.45 m.

The physical characteristics for the settled sludge at the Mary River site are of relatively light density for primary sewage solids and as a result, the concentration is estimated to be approximately 10,000 mg/L. The lighter weight solids cause the intermediate water depths to have relatively high concentrations of suspended solids which have been measured between 700 to 1000 mg/L TSS throughout in the majority of the water column.

During 2009, bench scale testing was conducted to simulate two passive sludge dewatering methods. These include:

- Geotextile dewatering bags (Geotube brand geosynthetic dewatering material), and,
- Freeze/thaw sludge dewatering trials.

The detailed results of the test work are presented in Appendix F.2.

7.3 SLUDGE MANAGEMENT AND TECHNICAL STRATEGIES – 2010 WORK PLAN

The sludge management work plan for 2010 will build on the results from 2009. The following strategies will be reviewed and assessed in 2010.

- Shorter term (1-2 yrs) dewatering and disposal strategy. This strategy would be implemented in the event there is a requirement to rapidly reclaim and close the site. Specifically, containerized geotubes and mechanical dewatering will be assessed.
- Longer term (3-5 yrs) management and disposal strategy. This strategy would be implemented in the event there is longer time frame to reclaim and close the site. The technologies to be assessed include sludge drying beds and geotubes.

Disposal of sludge solids will require that specific criteria are met. The suggested criteria at this time include: passing the slump test for physical consistency, passing the TLCP test for landfill disposal, and easy material handling of the dewatered sludge utilizing existing equipment at the site. More details concerning these criteria are presented in Appendix F.2.

To develop, a successful and sustainable sludge handling, treatment, and disposal process for the project requires additional site specific information and testing to increase the confidence level of the proposed technologies. The proposed 2010 work plan is presented in Appendix F.2.

SECTION 8.0 - CONTINGENCY MEASURES

Design criteria for the Mary River Camp WWTF have been reviewed and revised to provide additional safety factor. The average occupancy level for Mary River has now been established at 123 persons, revised downward from the original 150 persons. In the event that the Mary River Camp occupancy expands to greater numbers, a provisional contingency involving the installation of additional RBC media can be implemented (refer to Section 3.3). There is currently acceptable safety factor built into the Milne Camp WWTF. The WWTF's and PWSP effluent discharge strategy and work plan are designed to be protective of the receiving environment and meet or exceed the requirements of the water license. Baffinland has incorporated the temporary storage ponds to be used during periods of start-up, shut-down or during periods of system upset.

The RBC units and the PWSPs are located sufficiently remote from surface water bodies. The RBC is a fully enclosed unit and the PWSPs are designed with an impermeable liner. In the event of a spill of untreated or partially treated sewage from these facilities, Baffinland will follow the procedures in its spill response plan. Sewage spills are treated the same as more immediately hazardous hydrocarbon based spills.

SECTION 9.0 - SAMPLING, MONITORING, AND REPORTING

Monitoring and reporting under the water license is described in the updated Site Water Management Plan. Generally, sampling and monitoring of the wastewater treatment systems will include the following:

- Regular sampling of sewage discharge at both WWTFs and PWSPs in accordance with water licence requirements.
- More frequent internal process sampling (minimum once per week) and monitoring (daily) to identify potential upset conditions early that could lead to non-compliance.
- Record of volumes of sewage effluent discharged and sludge generated in accordance with water licence requirements.
- Completion of daily checklists related to the O&M requirements for the facilities and the reporting of any upset conditions that require action.
- Aquatic effects monitoring program to confirm/validate environmental predictions.

The monitoring program will identify upset conditions related to the WWTF and PWSPs which will be immediately reported to the Camp Manager for corrective action.

SECTION 10.0 - EFFLUENT EFFECT ON RECEIVING WATERS

Knight Piésold Ltd. (KPL) and North/South Consultants (NSC) were retained by BIM in 2007 to assess potential effects on the receiving waters from the WWTF and confirm that facility designs were appropriate given the projected operating schedule, and projected discharge concentrations and loadings. Based on available receiving environment data and process design considerations, the final effluent from the facilities was expected to be non-acutely toxic. The potential for eutrophication of the fresh water receiving environment (Sheardown Lake) was also evaluated by means of a mass balance modelling approach that used conservative assumptions. The model results indicated that fully mixed concentrations of TSS, ammonia, and nitrate would be within CCME guidelines for the protection of aquatic life, and that total phosphorus increases would remain within triggers specified in the CCME guidance framework for the management of phosphorus. Localized and short-term effects to biota were predicted to occur in the vicinity of the outfall, including localized DO depletion and chronic effects related to TSS, ammonia, and nitrate. The conclusions of the 2007 assessment were that that overall sites and facilities were designed to limit the impact of the treated sewage effluent on the receiving environments

The 2009 WWMP (rev. 1) updated the 2007 modeling results and assessment based on operational plans for 2009 which included the PWSP discharge scenario. A revised and updated technical memorandum update was prepared by NSC and is presented in Appendix G of this document. The purpose of the memorandum was to provide:

- An update to include additional baseline water quality data collected in Sheardown Lake prior to PWSP effluent discharge;
- A description of the results of the water quality monitoring conducted in Sheardown Lake immediately after PWSP sewage effluent release; and,
- An overall assessment of the effects of the PWSP sewage discharge event on water quality in Sheardown Lake, including mass balance modeling based on the effluent discharge data.

10.1 EFFLUENT TOXICITY

Environment Canada recommended toxicity testing of the treated effluent during review of BIM's application to amend its water license in 2007, and the Nunavut Water Board incorporated this requirement into the amended water license. The WWTFs have been designed accordingly.

Environment Canada developed a guideline with respect to ammonia in wastewater effluent discharges (Canada Gazette, 2004). This guideline recommends weekly testing of ammonia and pH in wastewater effluent to establish if the effluent is acutely toxic, based on the following relationship established between ammonia concentration and pH:

$y = 306132466.34 \times (2.7183(-2.0437 \times pH))$

This relationship between ammonia concentration, pH and acute toxicity is shown on the attached Figure 4, extracted from the Environment Canada guideline (Canada Gazette, 2004).

The acute toxicity of ammonia increases with increasing with pH. Knight Piésold measured pH in the marine waters of Milne Inlet on two occasions in August 2007 and recorded pH measurements of 8.05 and 8.15. During water quality monitoring of on-ice drilling in May and June 2007, a pH of 8.27 was recorded. Based on the higher of these two summer-time pH measurements (pH= 8.15), the threshold at which ammonia is acutely toxic in the receiving waters of Milne Inlet is 17.9 mg/L. Based on a pH of 8.0 in Sheardown Lake, ammonia is acutely toxic in that receiving water at 24.3 mg/L.

The RBC treatment facilities include nitrification such that ammonia-nitrogen concentrations in the final effluent will be less than 2 mg/L, which is non-acutely toxic according to the Environment Canada guideline. The final effluent from the RBCs is therefore expected to be acceptable for direct discharge to the final receiving waters of Sheardown Lake and Milne Inlet before mixing. The final effluent discharged from the PWSPs will be non-acutely toxic as demonstrated by water quality and toxicity sampling/analyses that will be conducted prior to and during discharge using applicable and approved methods.

Testing completed on the Mary River and Milne RBC and PWSP effluent have indicated that effluent samples collected were not acutely toxic to the test organisms (Daphnia magna and rainbow trout) and no mortalities of either test organism occurred over the duration of the toxicity tests.

10.2 EFFECTS OF SEWAGE EFFLUENT DISCHARGES TO SHEARDOWN LAKE

The following provides a summary of the effects assessment to Sheardown Lake from the PWSP discharge event. Please refer to the technical memorandum in Appendix G.

Approach

Baseline data provided the foundation for assessing effects of effluent discharge on water quality in the receiving environment. Specifically, the monitoring results were examined for:

- Differences relative to baseline water quality conditions measured in the open-water seasons of 2007 and 2008;
- Spatial differences in water quality conditions across Sheardown Lake, in relation to distance from the effluent outfall; and
- Comparison to the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life (PAL).

Sewage effluent quality, discharge rates, and acute toxicity were monitored during discharge to Sheardown Lake in August 2009. As an additional screening tool, effluent quality was also compared to CCME PAL water quality guidelines. As CCME guidelines are representative of “chronic” conditions, this comparison to effluent quality is highly conservative. However, where parameters are shown to meet CCME guidelines at the end-of-pipe, there is high certainty that the effluent would not lead to in-lake chronic toxicity.

Lastly, to provide an additional measure of potential effects of the discharge of treated sewage effluents on water quality in Sheardown Lake, a mass balance modelling approach was applied using the measured effluent discharge volume and effluent quality for the discharge period in August 2009. Methodology and assumptions for this modeling are provided in Appendix G.

Baseline Water Quality and Limnology of Sheardown Lake

Detailed descriptions of water quality in Sheardown Lake were provided in the 2009 WWMP (rev. 1) and included information collected up to the fall of 2008. The updated memo provides an overview of the baseline (i.e., pre-discharge) water quality and limnology of Sheardown Lake that includes in situ water quality data collected under ice in April and May 2009. Figure 5 presents the bathymetry of the northwest basin of Sheardown Lake ("Sheardown Lake NW") and Figure 6 presents the locations of the sampling sites.

Lower DO concentrations at depth have been observed at several sites in winter and concentrations were below the CCME PAL guidelines at one site in 2007 and numerous sites in winter 2009.

In general, Sheardown Lake NW is a relatively clear lake (low turbidity and high Secchi Disk depth), is alkaline in the open-water season (pH > 7) and near neutral in the winter (Mean pH of 7.03 in May 2007), soft (hardness typically at or below 60 mg/L), and contains a relatively low concentration of dissolved solids (mean of 71 mg/L in the open-water season and 102 mg/L in winter). Like other lakes in the area, Sheardown Lake NW is nutrient-poor and contains low levels of total phosphorus (TP) and inorganic forms of nitrogen. TP was generally near or below the analytical detection limit (0.003 mg/L) over the period of baseline studies. Lake-wide mean TP concentrations were somewhat higher in the open-water season of 2008 than 2007. Similarly, nitrate, nitrite, and ammonia concentrations are low and were generally not detected over the baseline studies.

According to the CCME phosphorus guidance framework, Sheardown Lake would be classified as "ultra-oligotrophic" and "oligotrophic" on the basis of TP concentrations measured in 2007 and 2008 Similarly, on the basis of chlorophyll a concentrations measured in the open-water seasons of 2007 and 2008, Sheardown Lake would be categorized as ultra-oligotrophic or oligotrophic.

Effluent Discharge and Effluent Quality

PWSP treated sewage effluent discharge was monitored for toxicity and compared to CCME PAL guidelines (CCME 1999; updated to 2010) to assess chronic toxicity of undiluted effluent. All measurements of pH and ammonia were within or below CCME PAL guidelines. There was one exceedance of aluminum measured in a single sample which likely reflects an upset associated with the use of aluminum in the sewage treatment process. Aluminum was below the CCME PAL guideline in Sheardown Lake including the site nearest the effluent outfall.

Ambient Water Quality Monitoring

Water quality monitoring was conducted just after PWSP discharge using two approaches: effluent plume monitoring, and core water quality monitoring. The plume monitoring used field parameters to detect and characterize the plume in the vicinity of the outfall. The core water quality monitoring was conducted at five sites and analyzed for a broad range of parameters.

The plume monitoring results indicated that there was no evidence of an effluent plume at the time of monitoring. Most routine water quality variables measured across four sampling sites in Sheardown Lake were similar to lake-wide means obtained in 2007 and 2008 indicating that effluent discharge had no notable effect on water quality in the lake. Spatially, most routine water quality variables were similar across sites sampled in Sheardown Lake and there was no clear gradient from the effluent outfall to more distant sampling sites. The primary exception occurred for chlorophyll a, which was higher at the two sites nearest the outfall in August 2009. All measurements of routine water quality variables (nitrate, ammonia, pH, dissolved oxygen, and total suspended solids) were within CCME PAL guidelines in August 2009 and feacal coliform bacteria were not detected in the lake. A comparison of mean concentrations of total and dissolved metals for the open-water seasons of 2007 and 2008 and the August 2009 monitoring results indicates that conditions were relatively similar across years. The key exceptions were notably higher concentrations of total aluminum and sodium measured near the effluent outfall relative to other more distant sites. Although aluminum was within the range observed in Sheardown Lake NW in 2008, sodium was elevated relative to baseline studies.

Mass Balance Modelling

A whole-lake mass balance model was used to estimate the cumulative effects of treated sewage effluent discharged to Sheardown Lake NW in August 2009. The mass balance model indicates that if all effluents were instantaneously mixed in the lake (with no losses of water quality constituents), that the effects of the effluent on whole-lake pH, ammonia, TKN, TSS, TP, BOD, and faecal coliform bacteria would not be detectable. Detailed modeling results are presented in Appendix G.

Summary and Conclusions

Overall, the available water quality monitoring results indicate that discharge of treated sewage effluent did not result in notable changes in water quality in Sheardown Lake in August 2009, with the possible exceptions of slight elevations in total sodium and aluminum and chlorophyll a near the outfall. Effluent discharge does not appear to have caused or contributed to exceedances of CCME PAL water quality guidelines.

Mass-balance modeling indicated that the effects of discharge of the PWSP effluent to Sheardown Lake in August 2009 would not have been expected to cause a detectable change in routine water quality lake-wide.

10.3 EFFECTS OF SEWAGE EFFLUENT DISCHARGES AT MILNE INLET

Receiving Drainage Ditch

The receiving environment for the treated sewage effluent at Milne Inlet is a large, wide ditch, several hundred metres in length, which reports to Milne Inlet. This drainage ditch has a small associated catchment of approximately 0.25 km^2.

Milne Inlet - Final Receiving Water

Available bathymetry for Milne Inlet is shown on Figure 3. The measurements shown on Figure 3 have not been corrected for tidal variations so are considered approximate. Near-shore water depths have not been collected but water depths ranging from 1.5 m to 2.8 m was measured in excess of 60 m from shore, after which water depth quickly increases to 10 to 15 m. The assumed average water depth from the shoreline to 60 m from shore is 1.0 m. Milne Inlet has semi-diurnal tides with the lowest tide typically ranging from 0.1 to 0.3 m and the highest tide typically ranging from 2.2 to 2.4 m (Department of Fisheries and Oceans, 2006). Current velocity within the Eclipse Sound area generally ranges from 15-35 cm/s (Buckley et al. 1987; Dickens et al. 1990).

Data collected in Ragged Channel, located at Cape Hatt near the northern end of Milne Inlet, indicated that temperature and salinity characteristics at that site were typical of the region (Buckley et al. 1987). In the ice-free season, freshwater inputs from snow melt and rain run off establish a strong surface layer characterized by lower salinity and higher water temperature, which ultimately is mixed with underlying cooler and more saline water by wind and currents. As the open water season progresses and freshwater inputs are reduced, the strength of the surface layer is reduced and thermal and saline stratification is reduced.

At Ragged Channel, water temperature during ice covered conditions (June, 1980) was 1.5ºC throughout the water column. During open water conditions in August, 1980, at the same location, water temperature was approximately 4ºC at the surface and declined to -1ºC by about 70 m depth (Buckley et al .1987). Similarly, salinity was uniform at ~32 ppt through the water column during June, but was stratified during August. At that time, surface salinity was about 24 ppt, and increased through the upper 10 m or so of the water column to about 30 ppt (Buckley et al. 1987). Recent salinity measurements at surface where the drainage ditch reports to Milne Inlet measured 22.9 ppt (Knight Piésold, unpublished data).

In-situ water quality measurements were recorded by Knight Piésold on three occasions at the shore where the ditch discharges in August 2007, and water temperatures ranged from 4.4ºC to 9.2ºC, pH ranged from 8.05 to 8.15, and dissolved oxygen ranged from 10.75 to 11.30 mg/L (Knight Piésold, unpublished data).

Discharge Conditions

Discharge conditions will vary with the season. In early summer (i.e. July), the active layer thaws and sea ice deteriorates and pulls away from shore. July has the largest monthly runoff and is also the month subject to break-up. For example, in early July 2007 and 2008, most of the sea ice at the lower portion of the inlet had melted, whereas sea ice in the upper half of the inlet towards the mouth was still intact. Phillips Creek would appear to have a meaningful influence on the deterioration of ice at the head of the inlet. Freeze up begins in late September or early October. Open water is present roughly from July through September.

The effluent is trucked to a dedicated location where it is released to the ditch (refer to Figure 3) Some infiltration of the effluent into the active layer is expected to occur as the effluent flows towards Milne Inlet, depending upon the progress of ground thaw. During regular RBC operations, it is expected that at the low rate of discharge to the ditch that very little to none of the treated effluent will report directly to Milne Inlet.

During winter operations, effluent discharged to the drainage ditch freezes. The maximum volume of effluent that could be discharged to the ditch during this 8-month period (measured as water and not ice) is roughly 3,240 m^3 based on the peak design capacity of the WWTF. Actual volumes will be less. Due to low temperatures, the effluent will freeze within the ditch. During the spring thaw, the frozen treated effluent will melt and flow to the thawing ice or marine waters of Milne Inlet. It is estimated that the ice pack will melt over an approximate four week period from approximately mid-June to mid-July. Since the final effluent will be non-toxic, no meaningful environmental effects are anticipated under this discharge scenario. The winter storage, melting, and subsequent mixing in the final receiving waters of Milne Inlet provide some contingency if the final effluent does not achieve the expected treatment levels. A mixing zone in Milne Inlet has not been calculated on the basis that the effluent already meets discharge and acute toxicity requirements. Mixing zones are commonly incorporated into the design of sewage management facilities.

The decanting of the Milne PWSP during June 2009 involved the discharge of approximately 200 m^3 of effluent over a one week. The small volume of discharged effluent was not acutely toxic based on testing results and was unlikely to have had an adverse effect on the receiving environment of Milne Inlet due to mixing due to tidal current action.

Baffinland Iron Mines Corporation

SECTION 11.0 - REFERENCES

1. B.H. MARTIN CONSULTANTS LTD. 2007. Waste Water Management Plan for Mary River and Milne Inlet Camp Sites, Nunavut, Canada. Prepared for Baffinland Iron Mines Corporation, Mary River Project. September 2007.

2. BAFFINLAND IRON MINES LICENSE 2BB-MRY0710, Nunavut Water Board.

3. BUCKLEY, J.R., B.R. DE LANGE BOOM AND E.M. REIMER. The physical oceanography of the Cape Hatt region, Eclipse Sound, N.W.T. Arctic 40 (1987): 20-33.

4. CANADA GAZETTE. 2004. Guideline for the release of ammonia dissolved in water found in wastewater effluents, pursuant to Subsection 54(1) of the Canadian Environmental Protection Act, 1999. Environment Canada. Canada Gazette: Part I, Volume 138, No. 49, December 4, 2004.

5. CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT. (CCME). 1999. Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg. Updated to 2008.

6. D.W. SMITH, 1996, Cold Regions Utilities Monograph, Third Edition, 10.1 to 10.7, Wastewater treatment.

7. DUONG AND KENT, 1996, Guidelines for the preparation of an Operation and Maintenance Manual for Sewage and Solid Waste Disposal Facilities in Northwest Territories.

8. KNIGHT PIESOLD, 2006 AND 2007, Unpublished documents pertaining to Mary River Project.

9. KNIGHT PIESOLD, 2006, Environmental Screening Document, submitted to NIRB on behalf of Baffinland Iron Mines Corporation.

10. NORTH/SOUTH CONSULTANTS INC. (NSC). 2008a. Freshwater aquatic environment baseline report: Lake limnology and lower trophic levels. Prepared for Knight Piésold Consulting, Baffinland Iron Mines Corporation, Mary River Project. Draft March 2008.

11. NORTH/SOUTH CONSULTANTS INC. (NSC). 2008b. Freshwater aquatic environment baseline report: Fish and fish habitat. Prepared for Knight Piésold Consulting, Baffinland Iron Mines Corporation, Mary River Project. Draft April 2008.

12. SEPROTECH, 2007, RBC system data and manuals, unpublished.

FIGURES AND DRAWINGS

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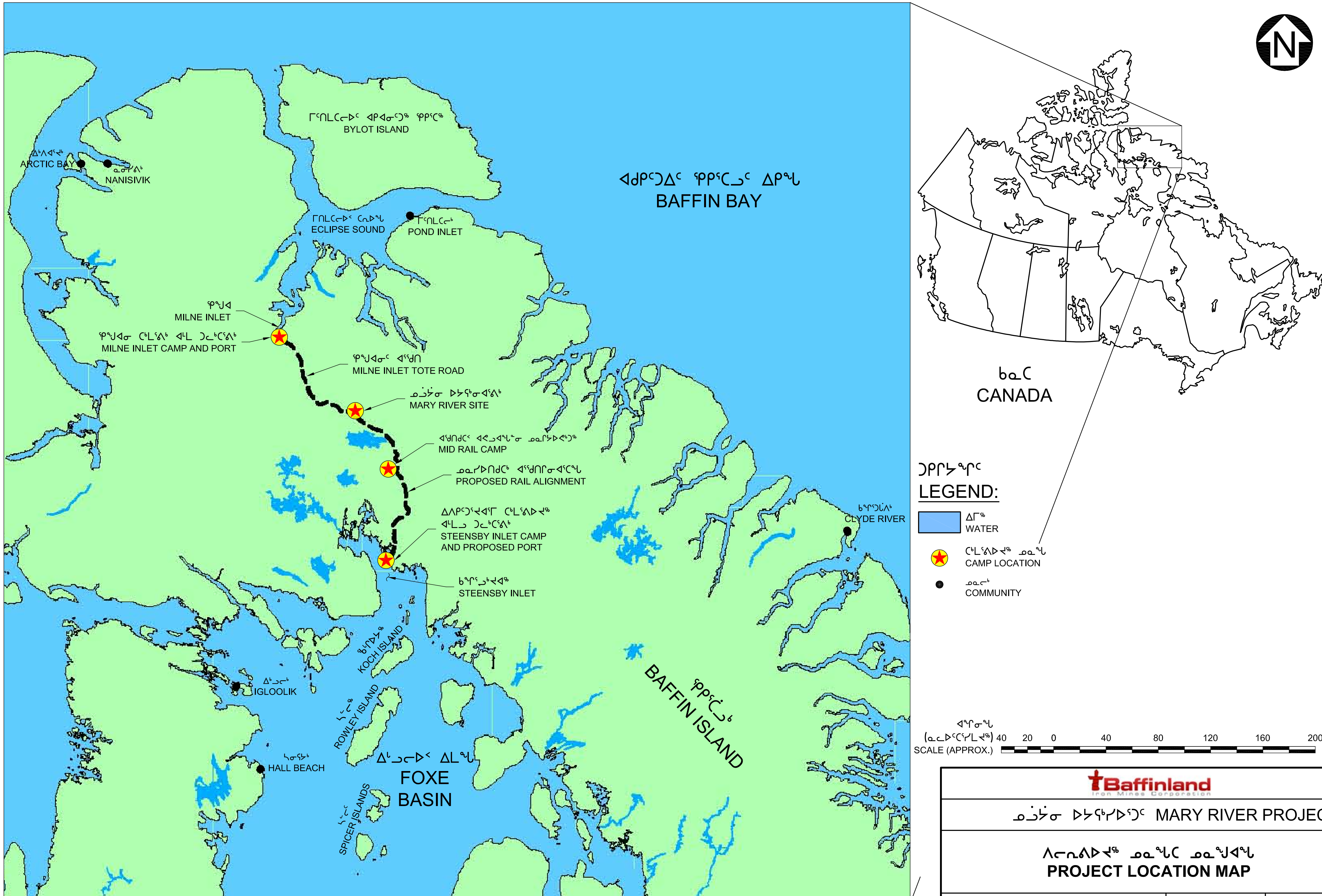


Baffinland
Iron Mines Corporation

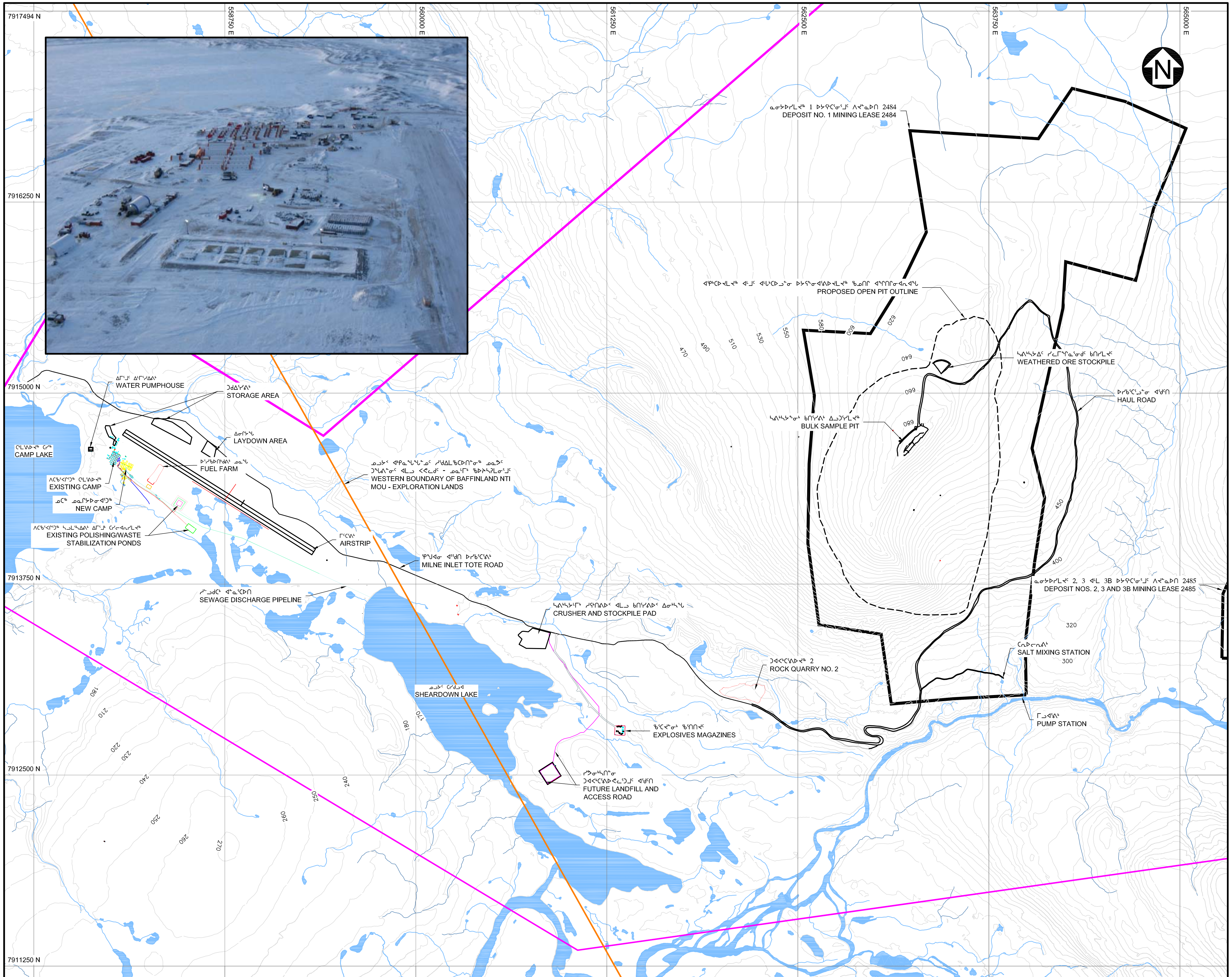
MARY RIVER PROJECT

PROJECT LOCATION MAP

P/A NO.	REF.	REV.
NB102-181/15	NB09-00214	0

FIGURE 1

NORTH BAY ON. SAVED: I:\102-00181-15\Assignment\Acad\Figs\A04, 3/13/2009 8:57:10 AM PRINTED: 3/13/2009 9:49:30 AM, A_Landscape, Bpark



LEGEND:

- WATER
- RIVER/STREAM/DRAINAGE
- BAFFINLAND'S COMMERCIAL LEASE ON INUIT OWNED LAND
- MINING LEASE BOUNDARY
- WESTERN BOUNDARY OF BAFFINLAND NTI MOU - EXPLORATION LANDS

NOTE(S):

1. COORDINATE GRID IS UTM (NAD83) ZONE 17 AND IS IN METRES.
2. CONTOUR INTERVAL IS 10 METRES.
3. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
4. MINE SITE INFORMATION PROVIDED BY GENIVAR DECEMBER 9, 2008.
5. REFER TO PHOTO SHEETS FOR ADDITIONAL DETAIL OF CAMP AREA.

SCALE 250 125 0 250 500 750 1000 1250 m

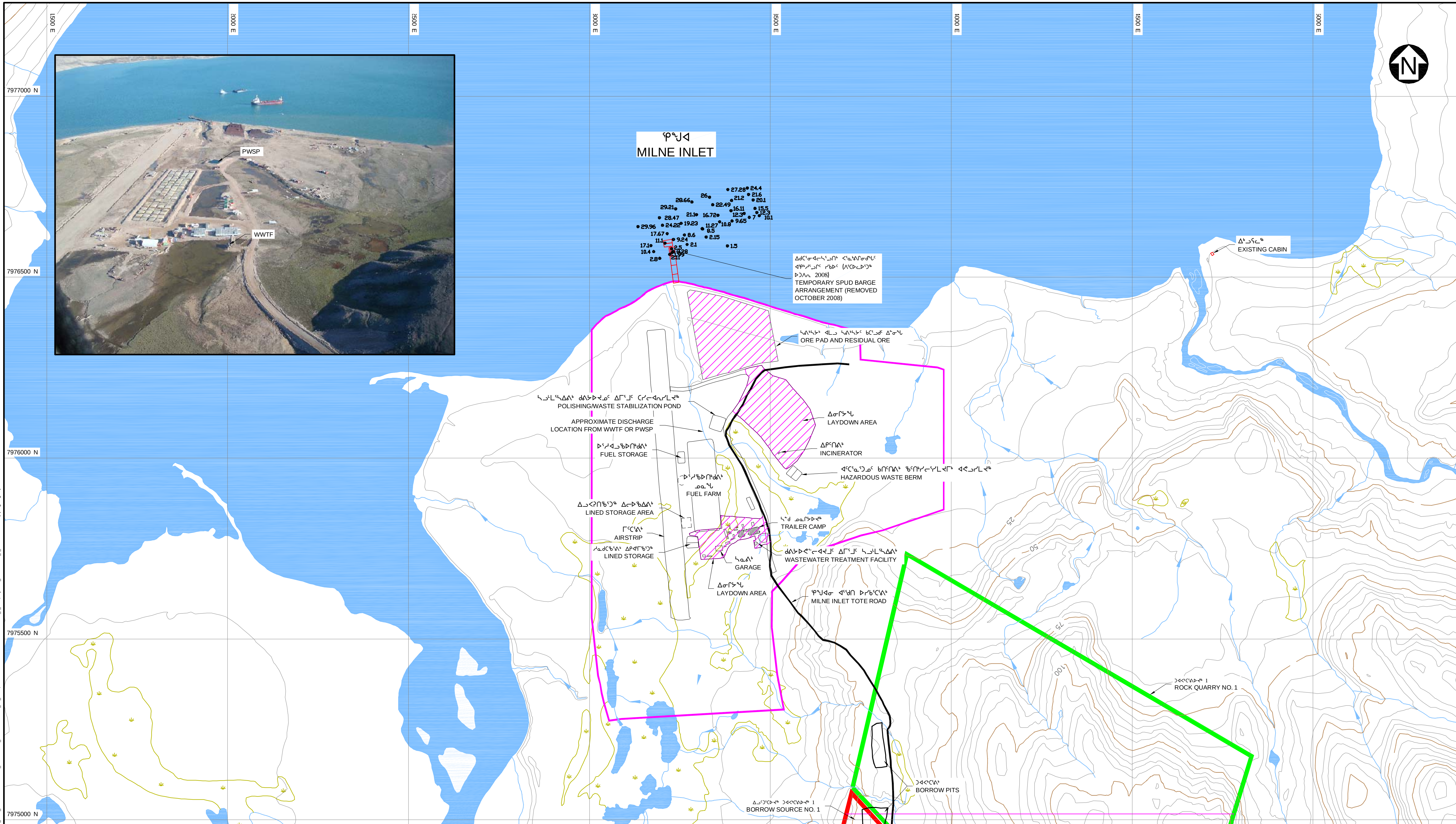
Baffinland Iron Mines Corporation

MARY RIVER PROJECT

EXISTING SITE LAYOUT AT MARY RIVER

P/A NO.	REF.	REV.
NB102-181/15	NB09-00214	0

FIGURE: 2



LEGEND:

- WATER
- WETLAND
- LAYDOWN AREA
- BAFFINLAND'S COMMERCIAL LEASE ON INUIT OWNED LAND
- RIVER/STREAM/DRAINAGE
- DIRECTION OF SURFACE WATER RUNOFF
- MILNE INLET TOTE ROAD
- ROAD
- EXISTING ROCK QUARRY (IOL COMMERCIAL LEASE)
- EXISTING BORROW AREA (IOL COMMERCIAL LEASE)

1. EAGLE MAPPING (2005)
2. UTM (NAD83) ZONE 17
3.

NOTE(S):

1. TOPOGRAPHY PROVIDED BY EAGLE MAPPING (2005).
2. COORDINATE GRID IS SHOWN IN UTM (NAD83) ZONE 17 AND IS IN METRES.
3. CONTOURS ARE IN METRES. CONTOUR INTERVAL IS 5 METRES.

SCALE 100 50 0 100 200 300 400 500 m

Baffinland Iron Mines Corporation

MARY RIVER PROJECT

EXISTING SITE LAYOUT AT MILNE INLET

P/A NO.	REF.	REV.
NB102-181/15	NB09-00214	0

FIGURE 3

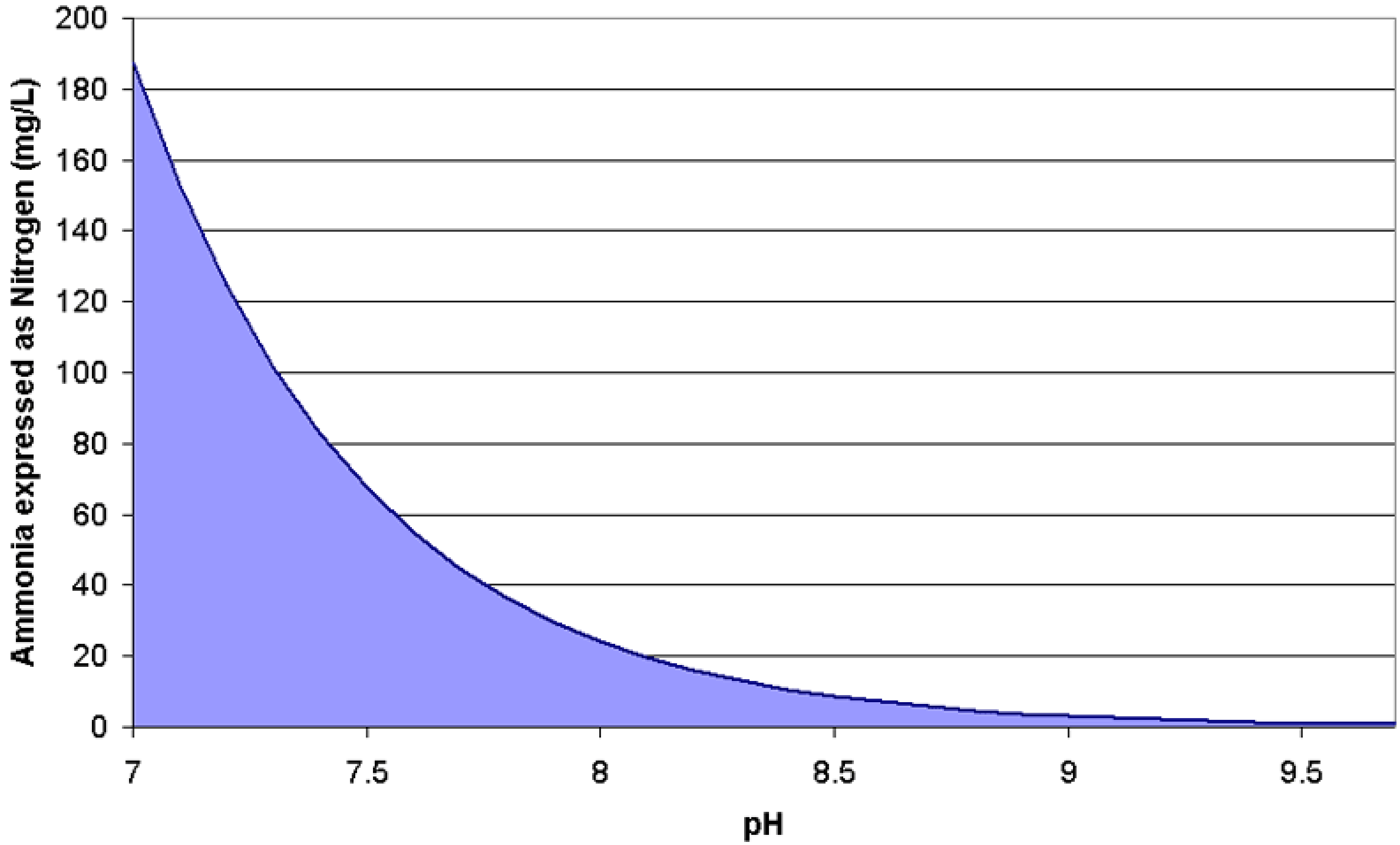


Figure 4. Acute Toxicity of Ammonia with pH.

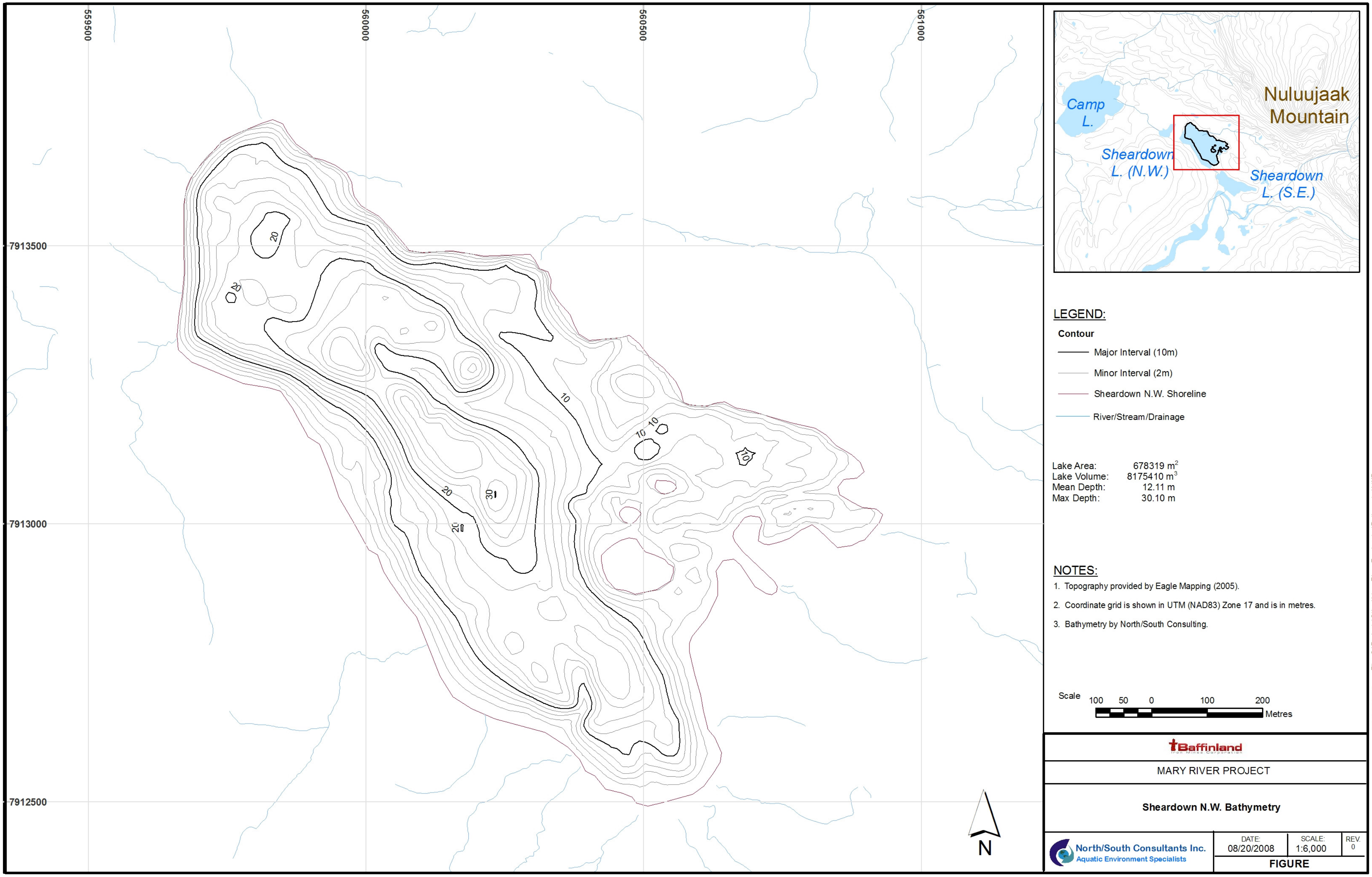


Figure 5: Sheardown Lake NW Bathymetry

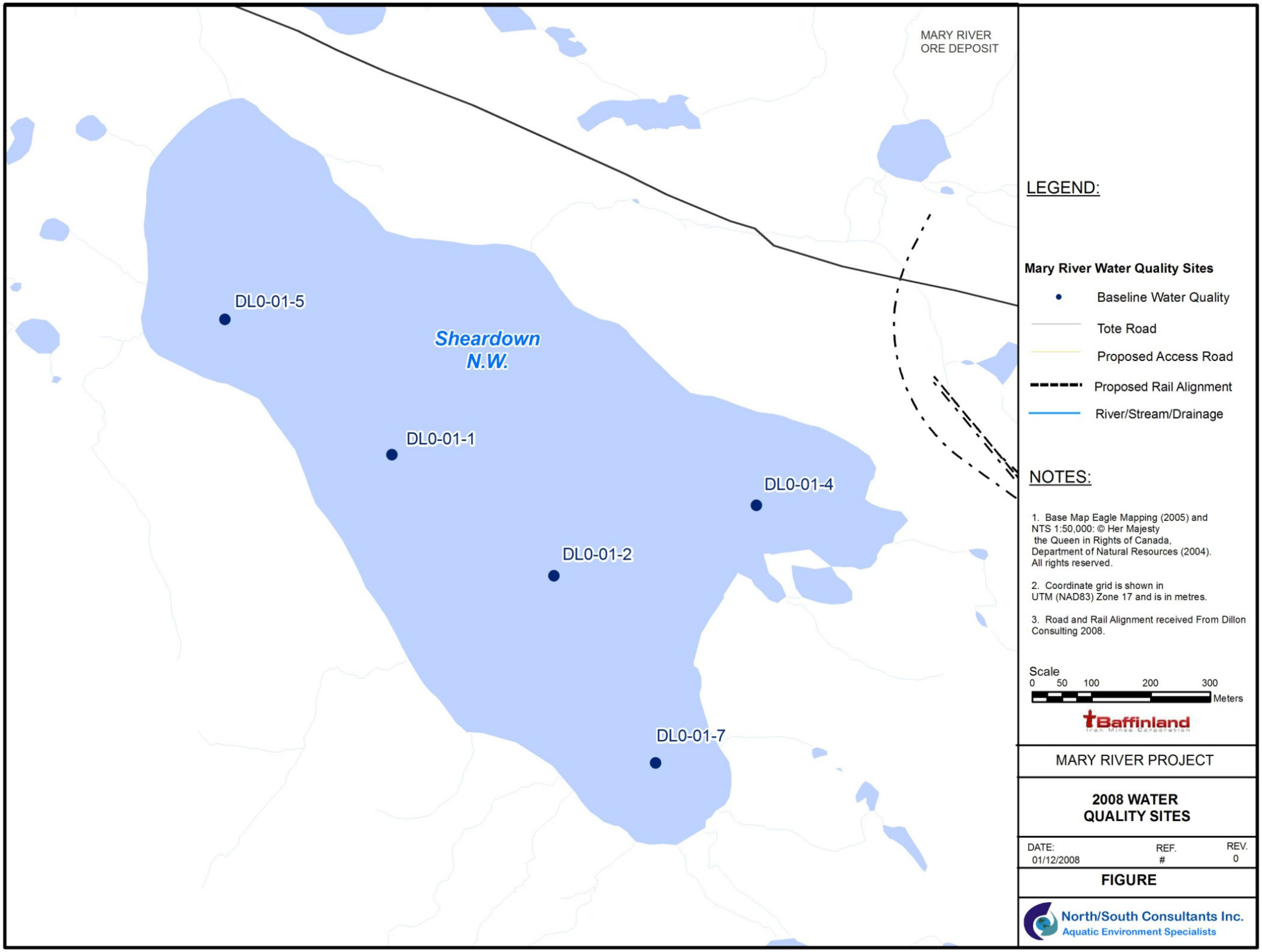
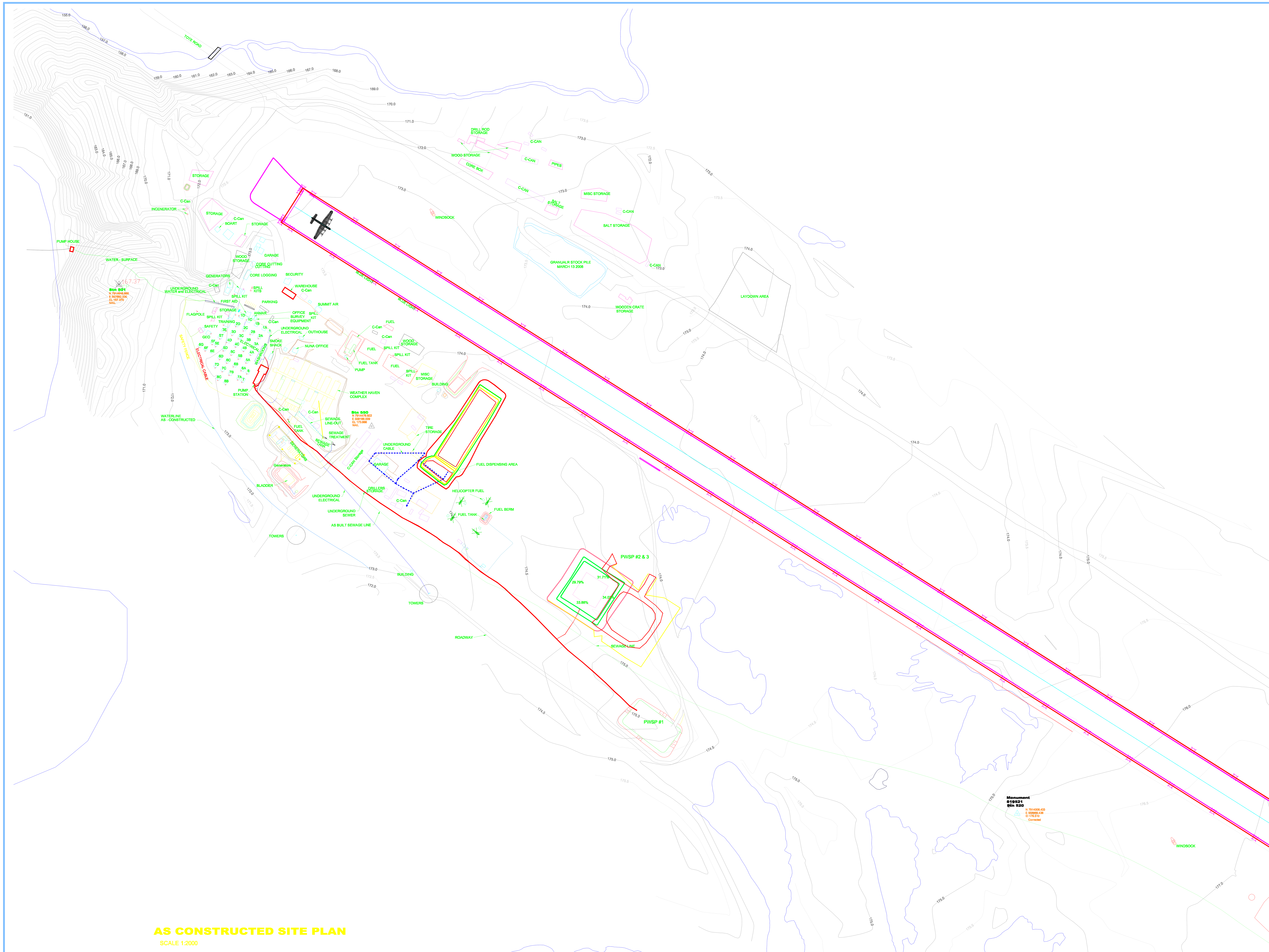


Figure 6: Sheardown Lake NW Water Quality Sites



AS CONSTRUCTED SITE PLAN

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AS CONSTRUCTED MARY RIVER SITE PLAN

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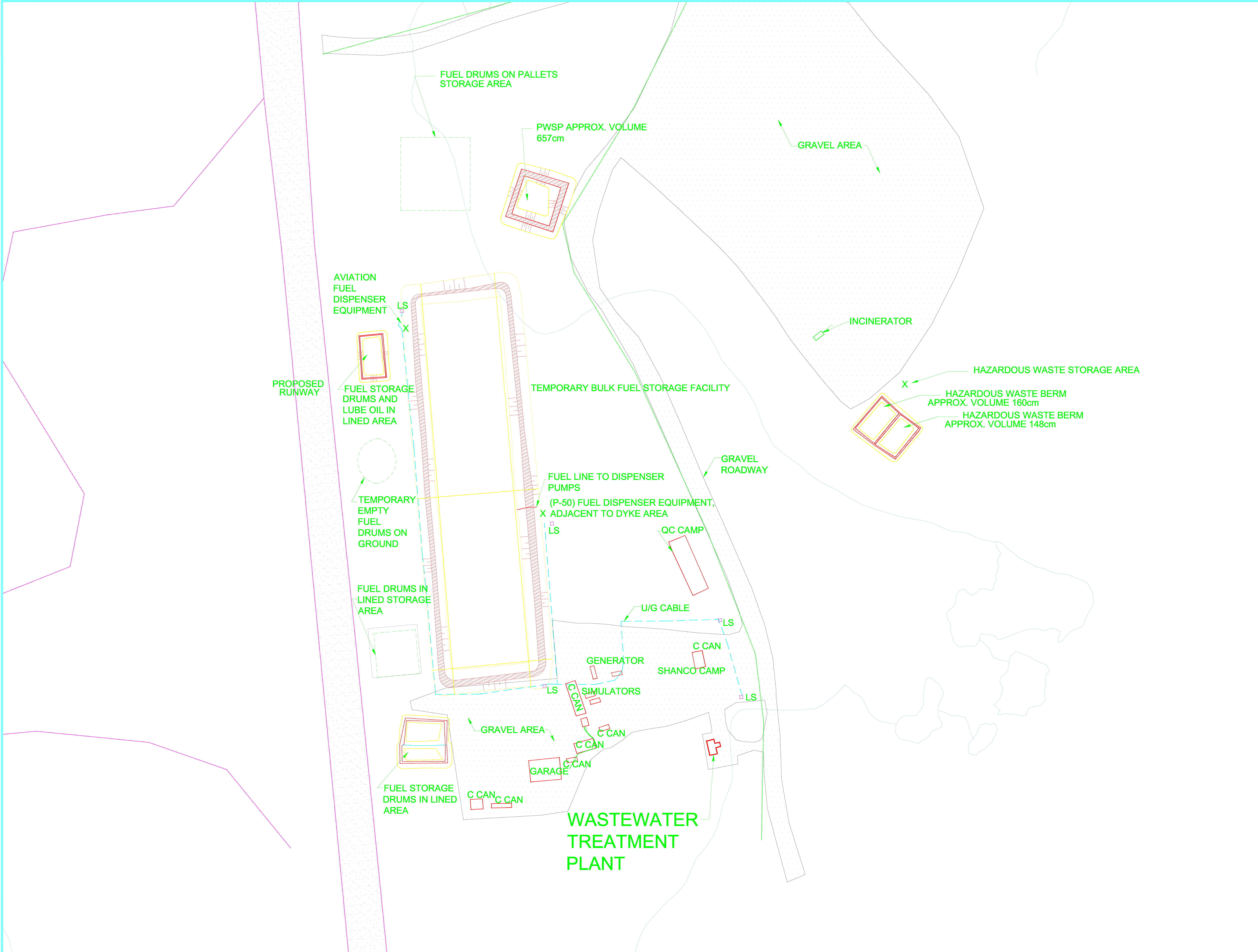

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Drawing
MILNE INLET
AS CONSTRUCTED
SITE PLAN

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Checked	Drawing Number: 003
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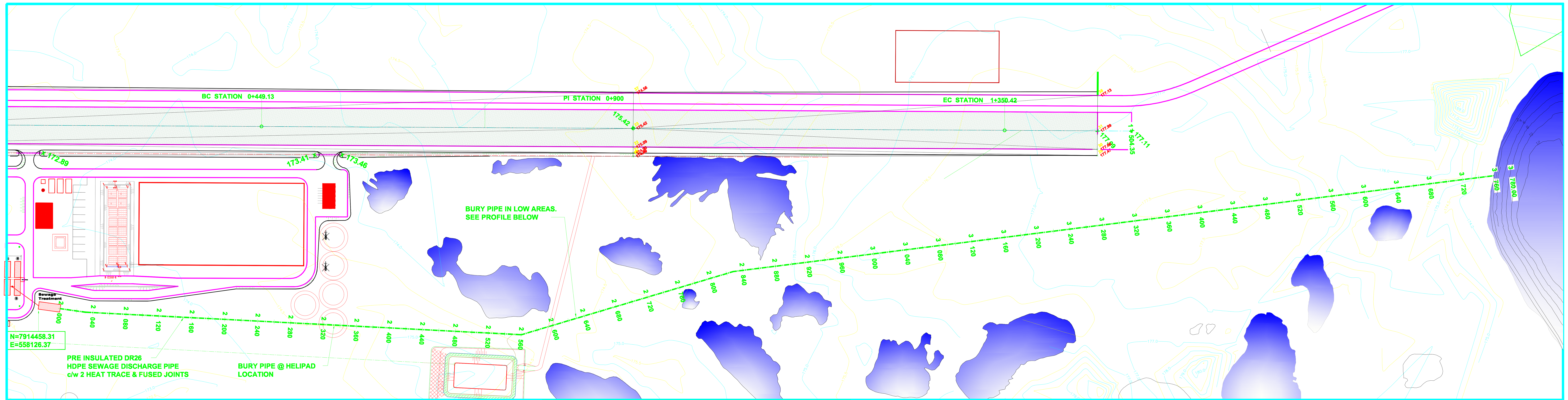
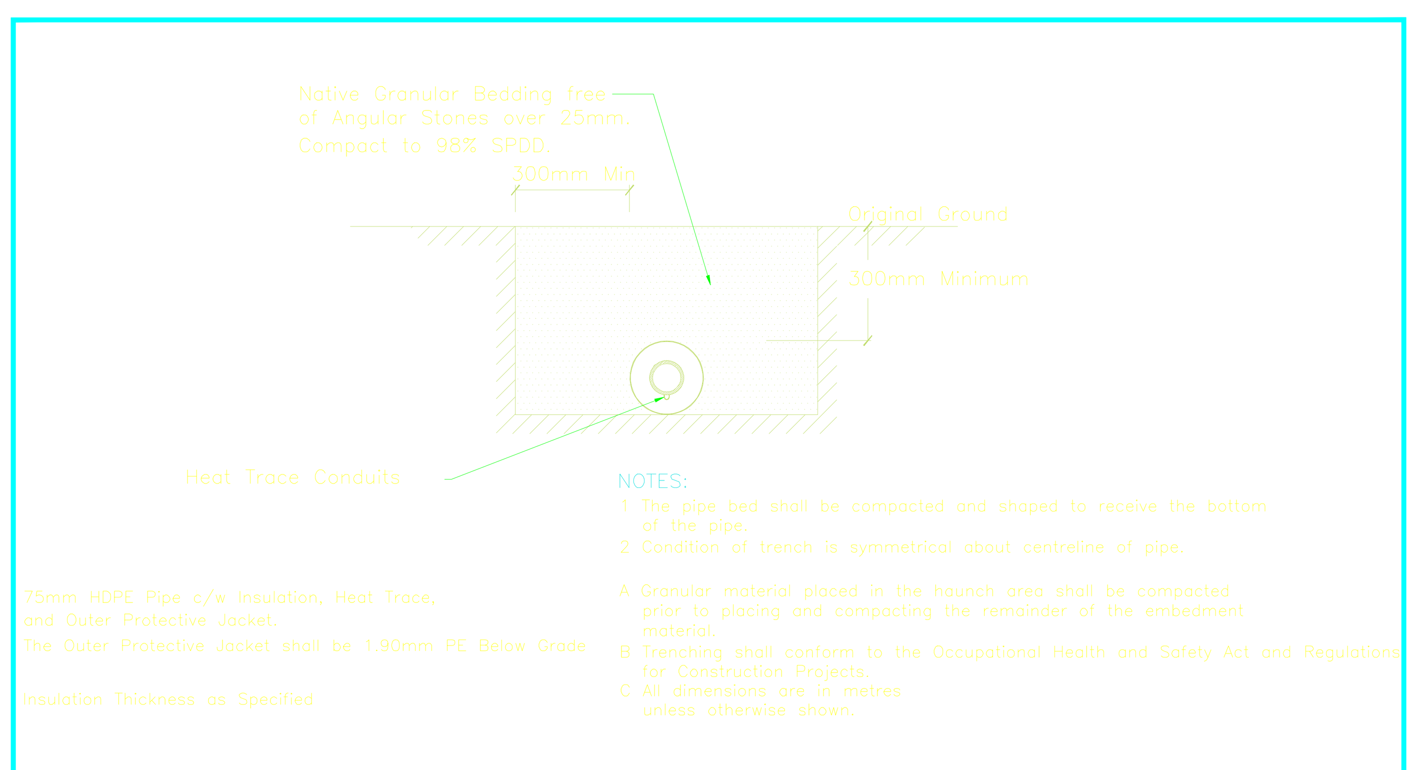


SITE PLAN

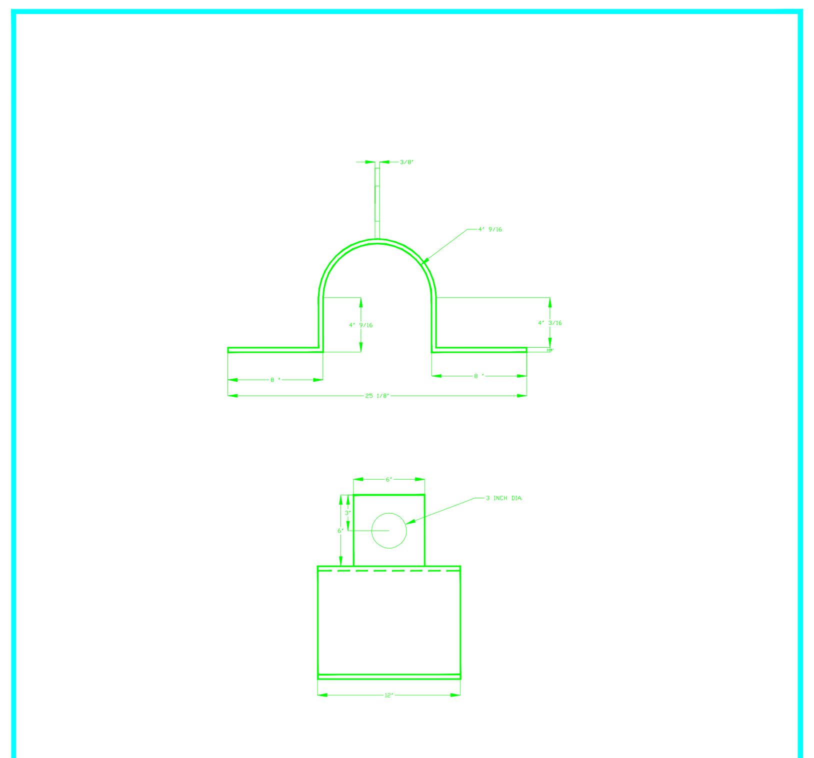
SCALE 1:2500

PROFILE THRU SEWAGE DISCHARGE PIPE

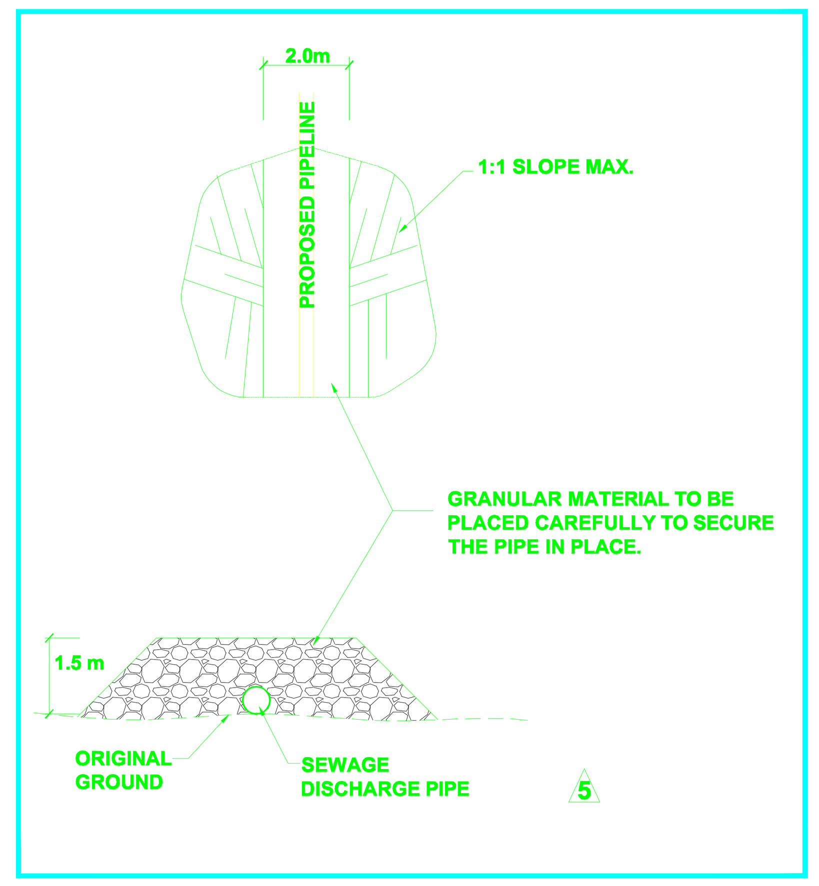
SCALE 1:2500 HORIZONTAL
SCALE 1:200 VERTICAL

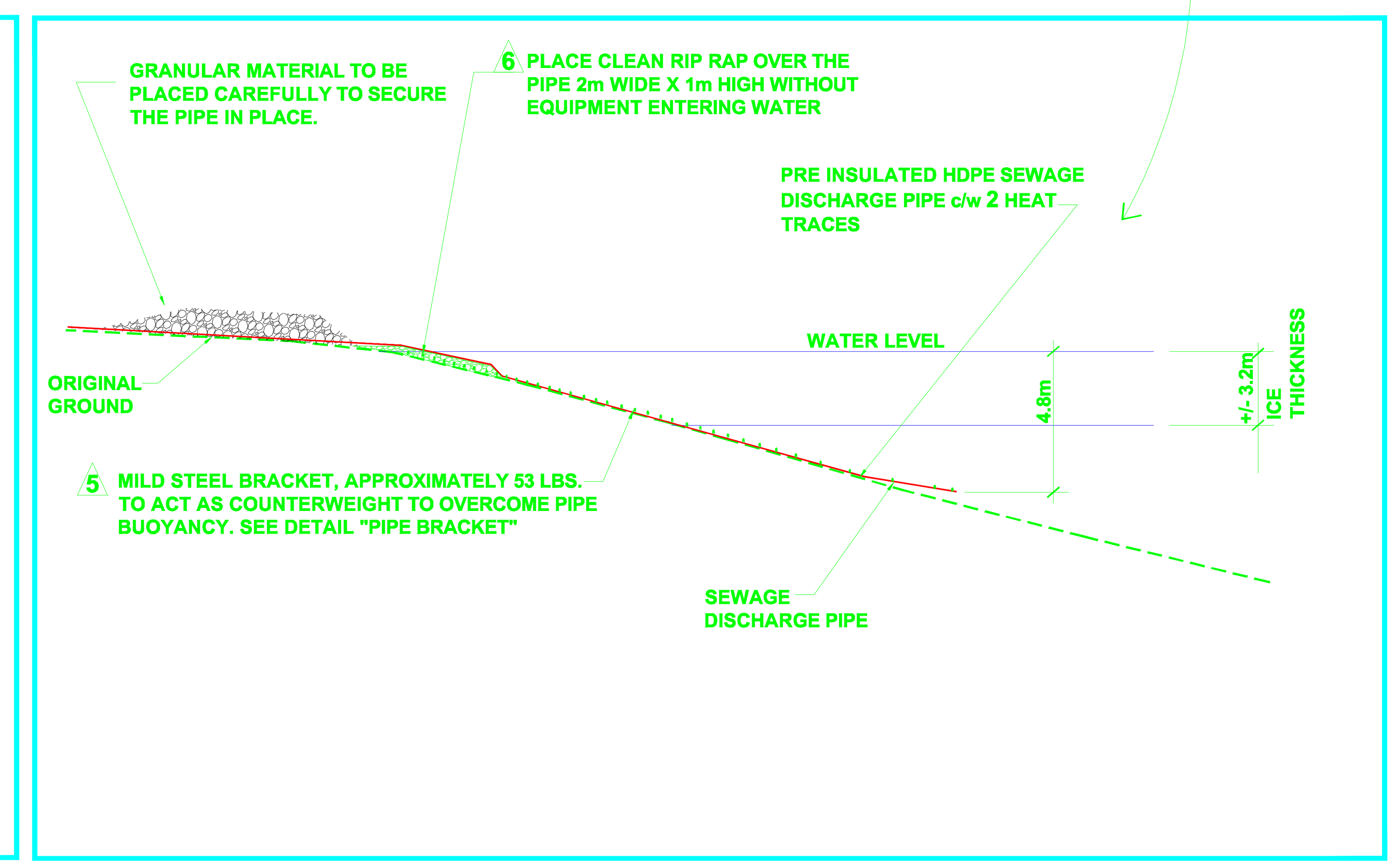


EFFLUENT OUTFALL PIPE DETAIL



PIPE BRACKET





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RIP RAP REMOVED AND BRACKET ADDED	Jul. 29/08	5
NEW DETAIL	Oct. 29/07	4
REVISED PIPE INSTALLATION	Oct. 9/07	3
ISSUED FOR CONSTRUCTION	July 03,2007	1
ISSUED FOR TENDER/REVIEW	May 24,2007	0

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MINES. CORP
BAFFIN ISLAND, NUNAVUT

Drawing
MARY RIVER CAMP
SEWAGE DISCHARGE
PLAN/PROFILE & DETAILS

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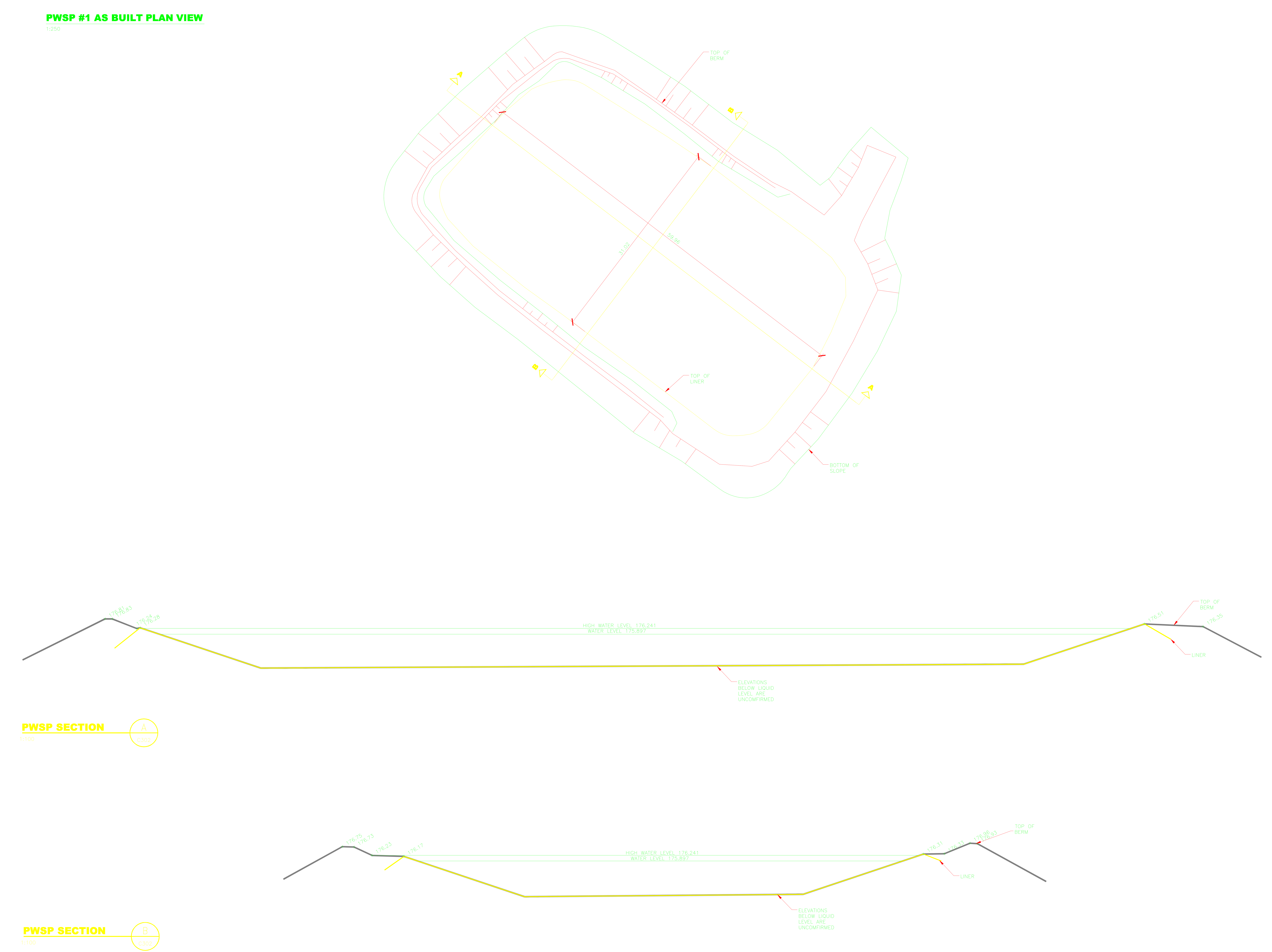

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MARY RIVER PROJECT
BAFFINLAND IRON MINES CORPORATION

BAFFIN ISLAND NUNAVUT

Drawing

AS CONSTRUCTED
MARY RIVER PWSP 1
PLAN AND SECTIONS

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BAFFINLAND IRON MINES CORPORATION
BAFFIN ISLAND — NUNAVUT

Drawing
AS CONSTRUCTED
MARY RIVER PWSP2 & PWSP3
PLAN AND SECTIONS

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Approved: M.K	

PWSP PLAN VIEW

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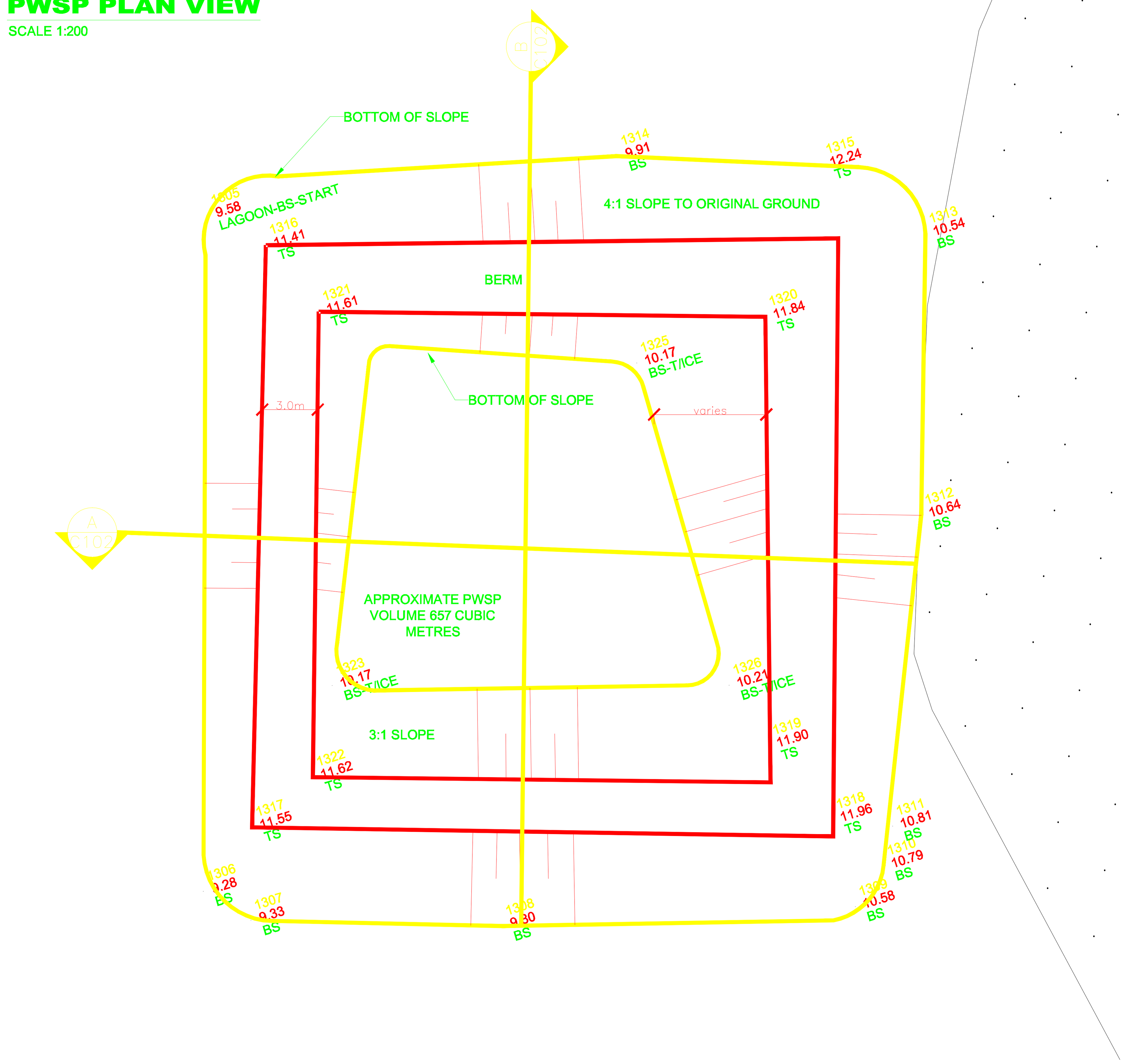
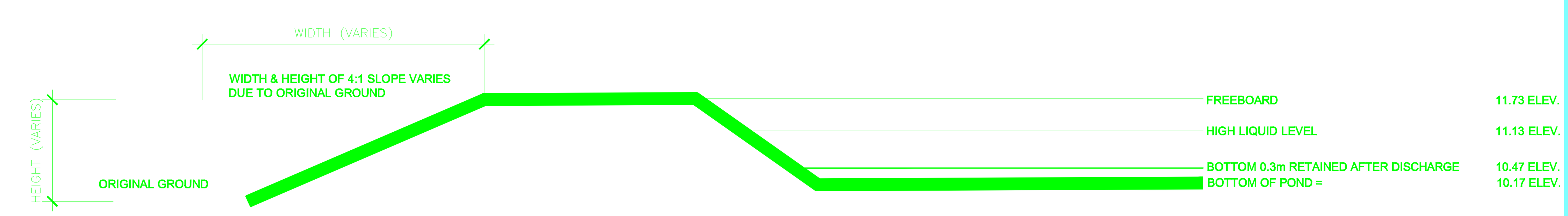


TYPICAL BERM

SCALE 1:75



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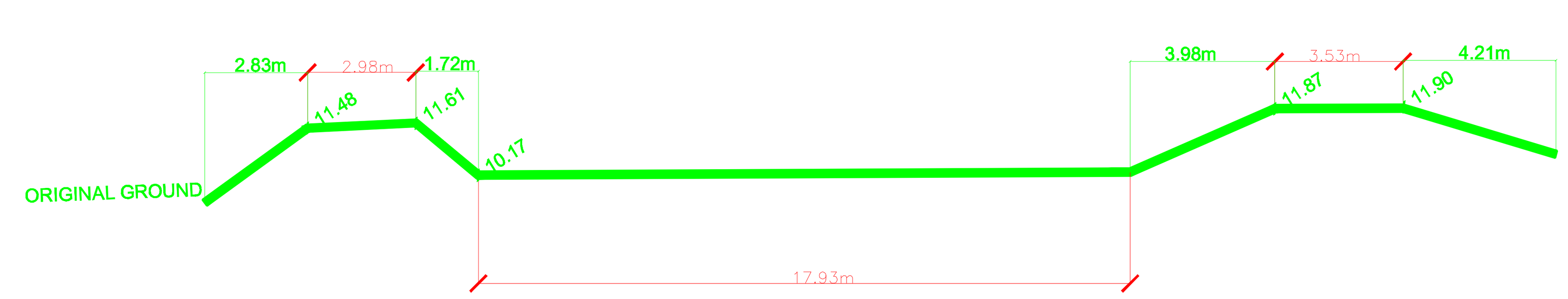

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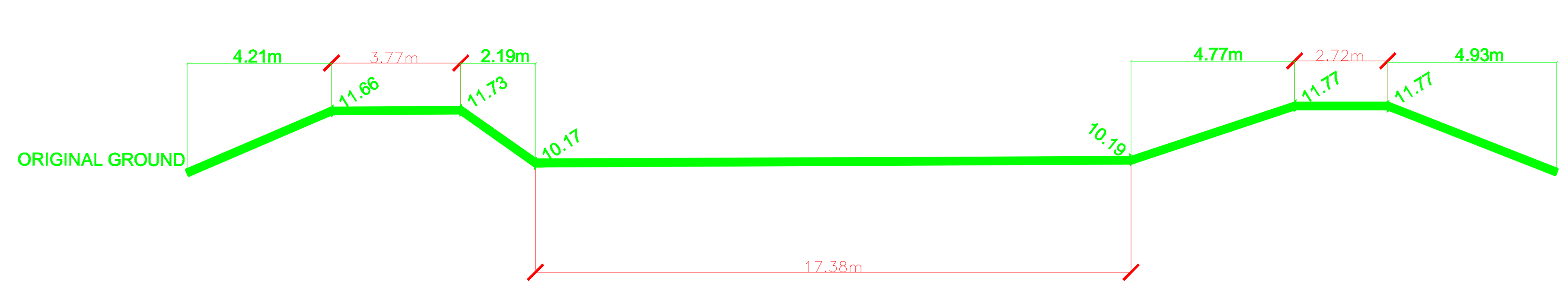

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MILNE INLET PWSP
PLAN AND PROFILES

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APPENDIX B

TABLES FROM COLD REGIONS UTILITIES MONOGRAPH

APPENDIX “B”

- **Tables 10.1 to 10.4 from “Cold Regions Utilities Monograph, 3rd Edition**

TABLE 10-3 TYPICAL QUANTITITES OF SEWAGE FLOW

Source		Quantity L/(p•d)
1. Communities and Permanent Military Bases		
a. 1,000 population with conventional piped water and sewage		
Thule Air Force Base, Greenland		303
College, AK		265
Fairbanks, AK		303
Ski resorts in Colorado and Montana		345
	Average	300
b. 1,000 population with conventional piped water and sewage		
Bethel, AK		265
DEW Line, Greenland		208
	Average	240
c. with truck-haul systems, conventional internal plumbing	Average	140
d. with truck-haul systems, low-flush toilets	Average	90
e. no household plumbing, water tanks and honey-bucket toilet	Average	1.5
f. same as (e) above but with central bathhouse and laundry	Average	15
2. Construction Camps		
North Slope, Ak (1971)		189
"Typical" Canadian		227
Alaska Pipeline (1976)		258
	Average	220
3. Remote Military with Limited Availability of Water		
McMurdo, Antarctica		151
Barrow, AK (DES Sta)		114
"Typical" Army Field Camp		129
	Average	130

wastes and extra amounts of garbage and grease from institutional kitchens.

10.3.1 Quantity. The resulting quantities of sewage flow depend on the type of installation and its permanence. Table 10-3 summarizes typical sewage flows for various cold-regions situations.

Separate facilities such as schools, laundries, restaurants, and hotels with conventional plumbing tend to have loadings similar to those in conventional temperate zone practice.

Projected data for the community should be used to establish a design value for per-person flow. The average values given in Table 10-3 may be used to

TABLE 10-4 CHARACTERISTICS OF BASIC WASTEWATER CATEGORIES

Parameter	Units	Undiluted (Heinke, 1973)	Moderately Diluted (Eggener & Tomlinson, 1978)	Conventional Diluted (Metcalf & Eddy Inc., 1979)	Greatly Diluted (Bethell, 1981)	Greywater (Hrudey & Raniga, 1981)
BOD_5	mg/L	–	460 280 to 700	220 110 to 400	55 40 to 60	–
COD	mg/L	110,400 80,800 to 134,800	1,000 700 to 1,300	500 250 to 1,000	–	(TOC) 210 40 to 900
Suspended solids (NFR)	mg/L	78,200 66,000 to 85,000	490 370 to 820	220 100 to 350	50 20 to 150	290 40 to 2,000
Total nitrogen	mg/L as N	8,100 7,300 to 9,500	–	40 20 to 90	(NH_3) 10 6 to 30	(NH_3/N) 1.4 8
Phosphorus	mg/L as P	1,200 1,100 to 1,400	–	8 4 to 15	3 2 to 6	9 4 to 20
Calculated flow*	L/(p•d)	1.2 1.1 to 1.4	170 110 to 290	360 200 to 730	1,500 1,300 to 2,000	310 50 to 2,300

All values rounded off from published data.

* Calculated based on 80 g BOD_5 per person per day and 90 g suspended solids (SS) per person per day (where applicable), modified activated sludge, and septic tanks. In some instances, lagoon treatment is followed by land disposal.

TABLE 13-1 WATER DEMAND VALUES FOR VARIOUS CAMPS

Camp Type	Population	Water Demand Range*	Water Demand Average*
Drilling camp		83 to 227	132
Base camp (Trink, 1981)		121 to 348	200
Exploration base (Murphy et al., 1977)	40 to 100 w/o bleeding		250
	40 to 100 with bleeding		445
Alaska pipeline construction (Eggener and Tomlinson, 1978)	200 to 1,300		265
Alaska pipeline construction (Murphy et al., 1977)	200 to 400		257
Alaska drilling camp (Alaskan Dept. of Health & Welfare, 1969)			212
Correctional camp (Grainge et al., 1973)	44		
Hydro generation construction camp (Belanger and Bodineau, 1977)	4,000 summer 2,000 winter		340**
Artificial island (Heuchert, 1974)			108**
U.S. military camps (Lufkin and Tobiasson, 1969)			
Main base	3,000 to 6,000	442 to 514	514
Ice research camp	25		79
Other camp with snow melt for water supply	96 to 227		121
Other camp with steam to melt snow for water supply	85 to 200		189
Alaska drilling rig camps (North Slope) (Tilsworth and Damron, 1973)			313
Value most frequently quoted	44	227 to 681	149**

* flow rate (L/(p•d))
** wastewater flow rate (L/(p•d))

vary from 1.4 to 1.77 (Lufkin and Tobiasson, 1969; Murphy et al., 1977; Given, 1978). These values do not represent a drastic change from those found for the households in small communities.

In addition to life support, water requirements specific to the work camp activity, for example, equipment washdown, pressure testing, and fire protection must be included in the estimate of total camp water supply.

An evaluation of water usage of various facilities at an Alaskan drilling camp and base camp is shown in Tables 13-2 and 13-3. The percentage of water

APPENDIX C

SEPROTECH DESIGN BRIEFS FOR MODELS N70 (MARY RIVER CAMP) AND N30 (MILNE INLET CAMP) RBC UNITS

APPENDIX C.1

MODEL N70 – MARY RIVER CAMP RBC

DESIGN BRIEF

BAFFINLAND - N70

May 25 2007

1. HYDRAULIC DESIGN: (AVERAGE DAILY FLOW)

1 unit at	34	**m3/day =**	34	**m3/day = Q**
Peak Flow (to EQ tank)	101			
design based on a	24	hour day.		

2. INFLUENT PARAMETERS:

BOD (biochemical oxygen demand) =	519	mg/l
SS (suspended solids) =	519	mg/l
TKN =	65	mg/l
Phosphorus =	10	mg/l

Ontario Application?	n	y/n
Designated Model?	y	y/n
What Model?	N	70

3. TREATED EFFLUENT QUALITY:

BOD (biochemical oxygen demand) =	10	mg/l
SS (suspended solids) =	10	mg/l
NH3-N =	2	mg/l
Phosphorus =	0.5	mg/l

4. R.B.C. SURFACE AREA REQUIRED (AO):

a) Removal in Primary Settling Tank (P.S.T.)

Primary BOD Removal =	10%			(Ref.1)
Primary Tank. Eff. BOD =	519	mg/l x	90%	
to RBC =	467.1	mg/l		

b) RBC BOD Loading.

Applied Load =	467.1	mg/l	**34**	**m3/day**
	15.76	kg BOD/day		

c) Area required to reduce BOD to 10 mg/l (AO)

Applied Load =	15.76	kg BOD/day	**15.76**	**kg BOD/ day**
For	10	mg/l* use	1.93	kg/day/100m2
	817	m2		

(*in a nitrification application, reduce BOD to 30 mg/l, the nitrification

d) NH3-N to be removed

(Assume Organic Nitrogen is converted to Ammonia NH3)

Removed to	5	mg/l	=	65	less	5	times	**33,750**	**litres/day**
=	2.03	kg/day	=	**4.46**	**lb/day**				
Area Required to reduce NH3-N to	5	mg/l							
=	2.03	kg/day	over	0.147	kg NH3-N/day/100 m2	**(Ref. 12)**			
=	1378	m2	=						
Residual NH3-N to be removed below 5 mg/l =	5	mg/l	less	2	mg/l times	**33,750**	**litres/day**		
=	0.101	kg/day							
Area Required to reduce NH3-N to	2								
=	0.101	kg/day	over	0.068	kg NH3-N/day/100 m2				
=	149	m2	=						
Total Nitrification Area Required =	1526	m2	=						

e) Total Surface Media Required

Total Surface Media Required = 2343 m2

f) Staging

Hydraulic Loading	0.15	L/d/m2
B.O.D.post primary	15.76	kg BOD/day
Media req'd(B.O.D)	817	m2
Media req'd(nitrfct'n)	1,526	m2
Total req'd	2,343	m2
Min req'd to prevent 1st st. overload	509	m2
Min req'd to prevent 2nd st. overload	509	m2

	ACTUAL AREA (m2)
First Stage	495
Second Stage	205
Third Stage	822
Fourth Stage	822
TOTAL	2,344

	ACTUAL AREA (ft2)	
First Stage	5,328	21%
Second Stage	2,207	9%
Third Stage	8,848	35%
Fourth Sytage	8,848	35%
TOTAL	25,230	

Minimum First Stage Media Area

Maximum loading to prevent first stage overload =	3.1	kg/day/100 m2
=	15.76	kg of post primary BOD/day divided by max. loading times 100 m2
=	509	m2

=

BOD remaining for 2nd Stage =	15.76	kg/day
Minimum Media 2nd Stage =	508.54	m2

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5. PRIMARY SETTLING TANK (P.S.T.) (per RBC unit):

a) Primary Settling Tank Influent Flows (per RBC unit)

Average Daily Flow =	**33,750**	**litres/day**			
Recycle at	203%	%	=	68584	litres/day
Total Average Flow =	102,334	litres/day			
Peak Daily Flow =	101,250	litres/day			
Peak Flow including Recycle =	169,834	litres/day			

b) Loading Rates

Average Overflow Rate =	16,000	Litres/day/m2	max from	(Ref.5)
Peak Overflow Rate =	24,000	Litres/day/m2 (rounded)		(Ref.7)
Detention Time =	4	hours	use 4 hrs	(Ref.6)

c) Surface Area Required

i) by Average Overflow Rate = Total Average Flow divided by Average Overflow Rate
= 6.40 m2
ii) by Peak Flow Rate = Peak Flow divided by Peak Overflow Rate
= 7.08 m2
Therefore, use 7.08 m2 to compare with actual area of P.S.T.

P. S. T. Surface Area for Model N 6.25 m x 3.35 m = 20.9 m2

Safety factor of: 2.96 times supplied.
Therefore **Surface Area Acceptable**

d) Volume Required = Q x Detention Time / 24 hrs / day
= 5.6 m3
P.S.T. Tank Capacity for this N is 44 m3
(after allowance for sludge) 7.7 **safety factor**
Therefore **Volume Acceptable**

6. FINAL SETTLING TANK (F.S.T.):

a) Loading Rates

Average Overflow Rate =	24000	Litres/day/m2	[Ref. 10]
Peak Overflow Rate =	44822	Litres/day/m2	[Ref. 10]
Detention Time =	3	hours	

b) Surface Area Required

i) by Average Overflow Rate = Average Flow divided by Average Overflow Rate
= 1.41 m2
ii) by Peak Flow Rate = Peak Flow divided by Peak Overflow Rate
= 2.26 m2
Therefore, use 2.26 m2 to compare with actual area of F.S.T.

F. S. T. Surface Area for Model N 3.35 m x 3.0 m = **10** m2

Safety factor of 4.41 times supplied.
Therefore **Surface Area Acceptable**

c) Volume Required = Q x Detention Time / 1000 / 24 hrs / day
= 4.2 m3 =
F.S.T. Tank Capacity for this N is 10.9 m3
(after allowance for sludge) **2.6** safety factor
Therefore **Volume Acceptable**

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7. ALUM DOSING CALCULATIONS:

Alum Dosing

$Al_2(SO_4)_3 + 2\ PO_4^{3-} = 2\ AlPO_4 + 3\ SO_4^{2-}$

Assumptions

Conc. Al_2O_3 in comm. alum sol.:	8.1	%
Density comm. alum sol.:	1.328	kg/l

Data specific to site

Conc. P PST:	10	mg/l
Conc. P Out:	0.5	mg/l
Required P removal:	9.5	mg/l
	95	%
Black and Veach suggested Al:P molar ratio:	2.3	
ADF	33,750	l/day
Required tank autonomy:	28 days = 4	weeks

Dosing Calculations

Conc. Al_2O_3 needed =	37.8	mg/l
Conc. comm. alum sol. needed =	467.1	mg/l
Relative volume comm. alum sol. Needed =	0.000351765	l comm. alum/l wat.
Daily comm. alum consumption =	**11.9**	**l/day**
(dosing pump sizing):	**0.49**	**l/h**
Volume tank required =	**332**	**l**
	73	**imp. gal.**
	88	**US gal.**

Molecular Weights

Al	27	g/mol
P	31	g/mol
$AlPO_4$	122	g/mol
Al_2O_3	102	g/mol
$Al(OH)_3$	78	g/mol
$Al_2(SO_4)_3$	342	g/mol
$Al_2(SO_4)_3 \cdot 14H$	594	g/mol

mol Al per mol Al_2O_3:	2
mol AlPO4 per mol P:	1
mol Al per mol P in $AlPO_4$:	1
mol Al per mol $Al(OH)_3$:	1
mol Al per mol $AlPO_4$:	1

Black and Veach (with interpolations)			
P Reduction	Mole Ratio	Weight Ratio	Weight Ratio
Required (%)	Al:P	Al:P	Alum:P
75	1.38	1.2	13
76	1.41	1.23	13.3
77	1.45	1.26	13.6
78	1.48	1.29	13.9
79	1.52	1.32	14.2
80	1.55	1.35	14.5
81	1.58	1.38	14.8
82	1.62	1.41	15.1
83	1.65	1.44	15.4
84	1.69	1.47	15.7
85	1.72	1.5	16
86	1.78	1.55	16.6
87	1.84	1.6	17.2
88	1.89	1.65	17.8
89	1.95	1.7	18.4
90	2	1.75	19
91	2.05	1.79	19.5
92	2.1	1.83	19.9
93	2.17	1.89	20.6
94	2.24	1.94	21.3
95	2.3	2	22
96	2.38	2.05	22.6
97	2.45	2.1	23.2
98	2.47	2.15	23.8
99.7	2.57	2.235	24.82

7. SLUDGE CALCULATIONS:

Assumptions Used for Calculation of Sludge Accumulation

1. Inlet TSS:	519	mg/l
2. Outlet TSS:	10	mg/l
3. Inlet BOD5:	519	mg/l
4. Outlet BOD5:	10	mg/l
5. Average Daily Flow:	34	m3/day
6. Proportion of inlet BOD5 soluble:	70%	
7. Total incoming solids	17.52	kg/d
8. Inert portion of solids (30%)	5.25	kg/d
9. Remaining organic solids (70%)	12.26	kg/d
11. Assuming Aerobic digester removal efficiency 50%.	6.13	kg/d
12. BOD removed in secondary treatment	15.09	kg/d
13. Sludge produce due to BOD removal	4.53	kg/d
15. Aerobic digester removal efficiency 50%.	2.26	kg/d
16. Total sludge produced per day	13.65	kg/d

Information Pertaining to the ROTORDISK Used in Calculation of Sludge Accumulation

1. All sludge accumulates in the PST (sludge settled in the FST is pumped back to the PST).

2. PST Surface Area:	20.9	m2
3. PST Volume:	43.6	m3
4. PST Sludge Storage Capacity:	21.8	m3
TOTAL Mass of sludge produced that accumulates in the PST:	**13.6**	**kg/day**
Volume of Wet Sludge produced Daily:	0.2730	m3/day
Depth of Wet Sludge produced Daily:	0.0130	m/day
Frequency of Pump-Outs:	80	days

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SUMMARY OF REFERENCES

Ref.1
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 475, which states, " Sedimentation with coagulation may remove 60 to 90% of the TSS, 40 to 70% of BOD5, 30 to 60% of COD, 70 to 90% of the Phosphorus, and 80 to 90% of the bacteria loadings. In comparison, sedimentation without coagulation, may remove only 40 to 70% of the TSS, 25 to 40% of the BOD5, 5 to 10% of the Phosphorus loadings, and 50 to 60% of the bacteria loadings."

Ref.2
excerpt from "Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems, Ontario Regulation 374/81 under part VII of the Environmental Protection Act", May 1982, ISBN 0-7743-7303-2, section 12.7.1, which states, "if it is a system operating on the rotating biological disc or similar principle involving contact of the biomass with air, provide a disc area so that the daily loading of sewage will not be in excess of 1.25 kg of BOD5 per 100 sq.m. of disc area, or a hydraulic loading in excess of 45 l/sq.m. of disc area".

Ref.3
excerpt from "Pilot Plant Studies of Rotating Biological Contactors treating municipal Wastewater", by: K.L. Murphy and R.W. Wilson, International Environmental Consultants Ltd., Toronto Ontario, prepared for Central Mortgage and Housing Corporation, Ottawa, Ontario.

Ref.4
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 776, which states, "...whenever the first stage loading limit exceeded 3.1 kg BOD5/100 sq.m.day(6.4 lbs. BOD5/d/1000 sq.ft.), the system was associated with the presence of sulfur-oxidizing organisms".

Ref.5
excerpt from "EPA Process Design Manual, On-site Wastewater Treatment and Disposal Systems", Oct 1980, EPA 625/1-80-012, section 6.4.2.4.e., p.149, which states, "...average flow design values normally range from 200 to 400 gpd/sq.ft.(8 to 16 cu.m./d/sq.m.)".

Ref.6
excerpt from " O&M of Trickling Filters, RBC's, and Related Processes, Manual of Practice OM-10, 1988, Water Pollution Control Federation, p. 105, which states, " Weir overflow rates typically range from 125 to 250 cu.m./m.d (10,000 to 20,000 USgpd/ft.)...The wastewater detention time in a settling basin is normally between 1 to 3 hours, but has been as high as 10 hours with excellent results". [use 4 hours]

Ref.7
excerpt from "EPA Process Design Manual, Wastewater Treatment Facilities for Sewered Small Communities", Oct 1977, EPA-625/1-77-009, section 6.4.2., which states, " the peak overflow rate may be 2,500 to 3,000 USgpd/sq.ft. (100 to 120 cu.m./sq.m.d) for primary clarifiers followed by biological treatment processess".
" Clarifiers handling chemical flocs, such as aluminum or iron coagulants, should be designed for peak overflow rates no longer than 600 and 800 USgpd/sq.ft.(24 and 32 cu.m./sq.m.d)".

Ref.8
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 484, which states, " TSS removal efficiencies in primary sedimentation tanks usually range between 50 and 65%. Many designers assume a removal efficiency of 60% for estimation purposes".

Ref.9
excerpt from "Wastewater Engineering Treatment, Disposal, and Reuse", 3rd ed., Metcalf and Eddy Inc., revised by George Tchobanoglous and Franklin L. Burton, p.808, table 12-14, which shows,"...typical concentrations of thickened sludge for a rotating biological contactor is 2 to 5%".

Ref.10
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-106, section 2.10, which states, " Murphy and Wilson recommend surface overflow rates less than 600 gpd/sq.ft. to maximize solids removal... DeCarlo recommends that peak hydraulic rates be limited to 1000 to 1200 gpd/sq.ft.".

Ref.11
excerpt from "EPA Process Design Manual, Wastewater Treatment Facilities for Sewered Small Communities", Oct 1977, EPA-625/1-77-009, section 9.2.4.6, p.9-43, which states, " Sludge produced by the RBC unit is similar to humus sludge from a trickling filter. The amount of sludge produced will depend on waste characteristics and loading rates. An RBC unit designed for 80% BOD5 removal would produce about 0.7 lb. of sludge per lb. of BOD5 removed; 95% percent removal would produce about 0.3 lb. of sludge."

Ref.12
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-106, section 5.5.2.2, which states, "Figure 5-19 represents data for one day for a given stage...The zero-order removal rate above bulk liquid ammonia nitrogen concentrations of 5 mg/l in Figure 5-19 is projected at 0.3 lb. NH3-N/day/1000 sq.ft., same as the Autotrol design". (Figure 5-19 attached)

Ref.13
excerpt from Ministry of Environment and Energy - Ahlberg & Kwong Report - "Winter Operation"
No process or operating problems were experienced throughout the winter. The minimum temperature encountered in the unit, with a raw sewage feed rate of 320 gpd, was 4 oC. Process performance remained good during the winter even under conditions of intermittent operation.

Ref.14
excerpt from the Forgie study
For the RBC unit and wastewater tested, the effect of temperature on removal efficiency over the 15 oC to 5 oC range was relatively low (theta = 1.001 to 1.02)

Ref.15
excerpt from Trinh - Environment Canada "Exploration Camp Wastewater Characterization and Treatment Plant Assessment"
It [the RBC] also operated at a low liquid temperature of 4 oC during one week without the effluent quality deteriorating.

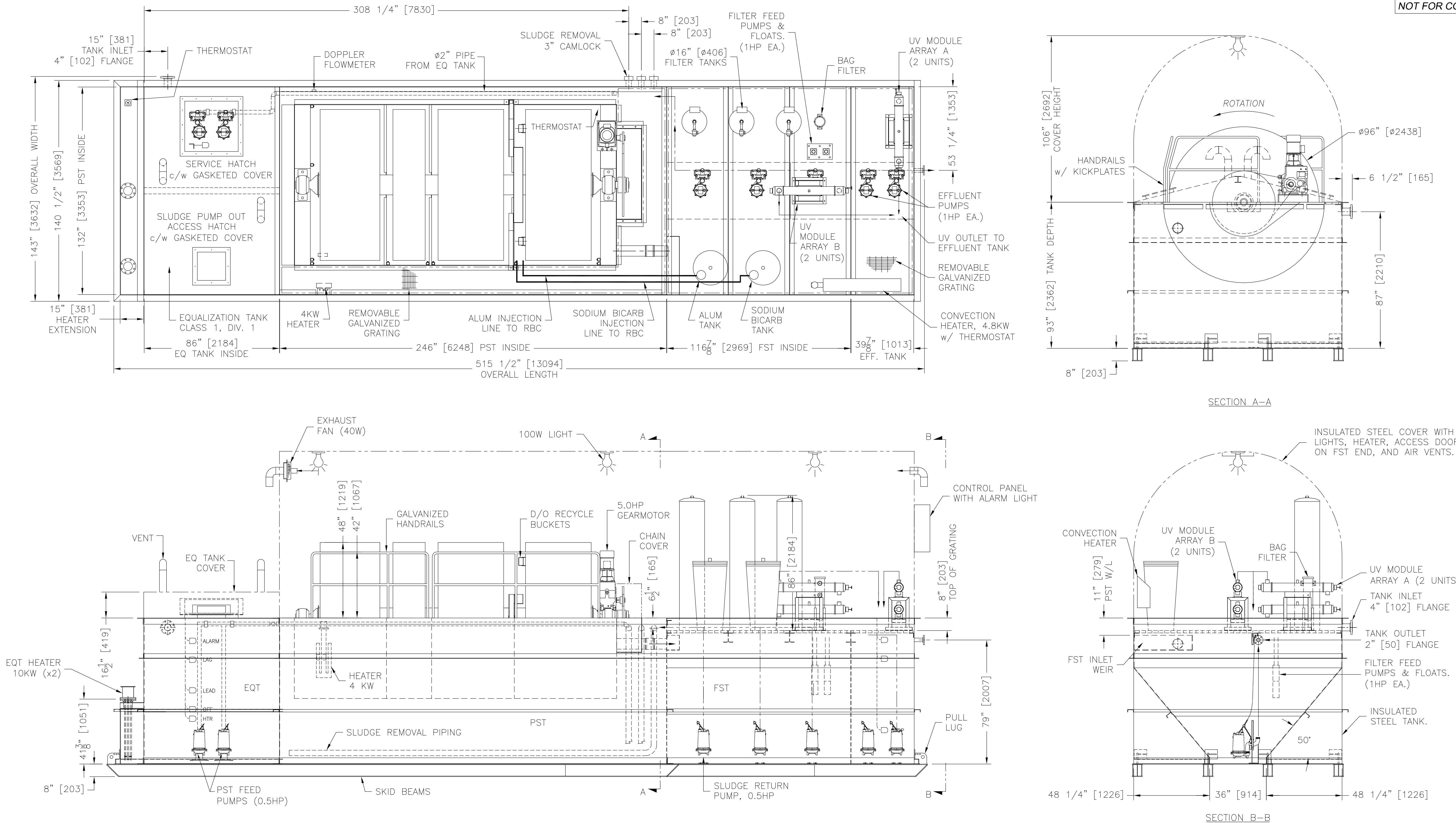
Ref.15
WEF MOPNo. 8, p913 Oxygen recovery is 2.86 mg O2/mg NO3-N reduced."

Ref.16
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-106,
section 2.9.3, which states, " The observed denitrification rate at 550F was approximately 0.85 lb NO3-N /day/1000sq. ft.."

Ref.17
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-106,
section 2.9.2, which states, " The commonly used design value for the required methanol dosage is 3 mg/mg NO3-N reduced."

Ref.18
WEF MOPNo. 8, p913 states that "Oxygen recovery is 2.86 mg O2/mg NO3-N reduced." and that Heterotrophic biomass production is approximately 0.4 mg VSS/mg COD removed"

PRELIMINARY
NOT FOR CONSTRUCTION



NOTES:
1. UNIT TO BE PLACED LEVEL ON CONCRETE OR WELL COMPACTED GRAVEL. (PAD DESIGN BY OTHERS)
2. ALL DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.
3. TANKS, RBC TROUGH, & SHAFT SANDBLASTED AND PAINTED WITH DEVTAR 5A FINISH.
4. INLET/OUTLET ARE STD. 150# ANSI B16.5 RAISED FACE FLANGES.

NOTES:
5. WEIGHT SHOWN IS DRY WEIGHT ONLY.
6. TANKS ARE EQUIPPED WITH DRAIN PORTS FOR SHIPPING PURPOSES ONLY.
7. THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION WITHOUT PRIOR APPROVAL OF SEPROTECH SYSTEMS INC.

REV	DESCRIPTION	YY/MM/DD	BY
1	AS BUILT CONFIGURATION	09/03/06	XX

PROJECT:
BAFFINLAND IRON MINES
MARY RIVER, NUNAVUT

ALL TOLERANCES ARE +/- 1/32" UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE IN INCHES.

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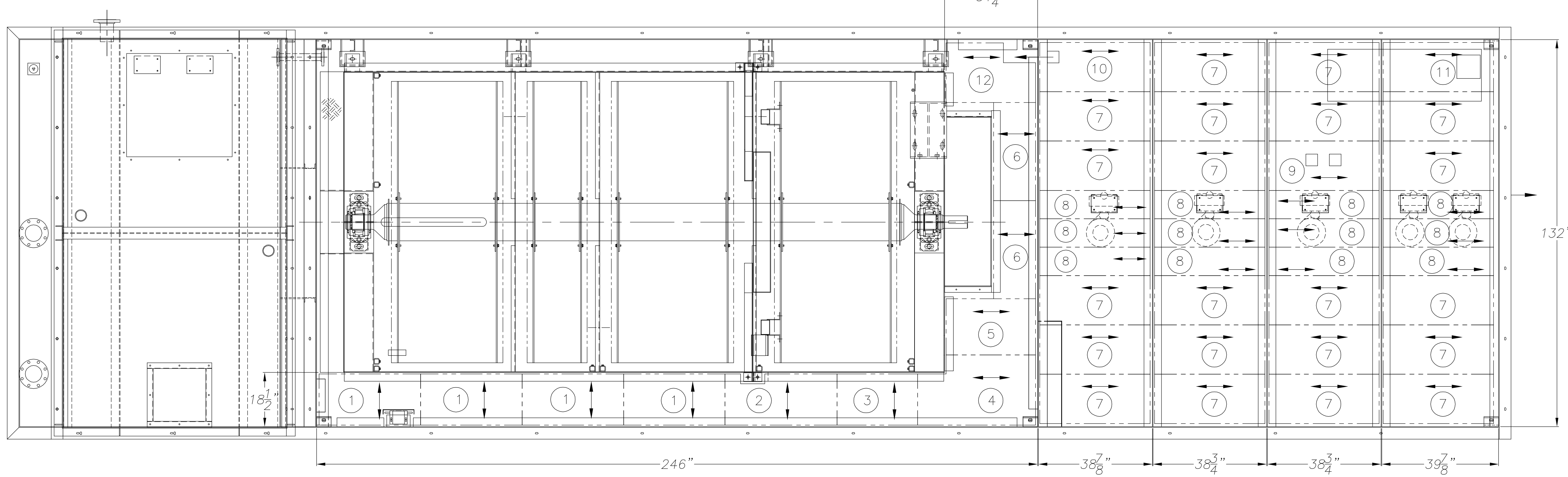
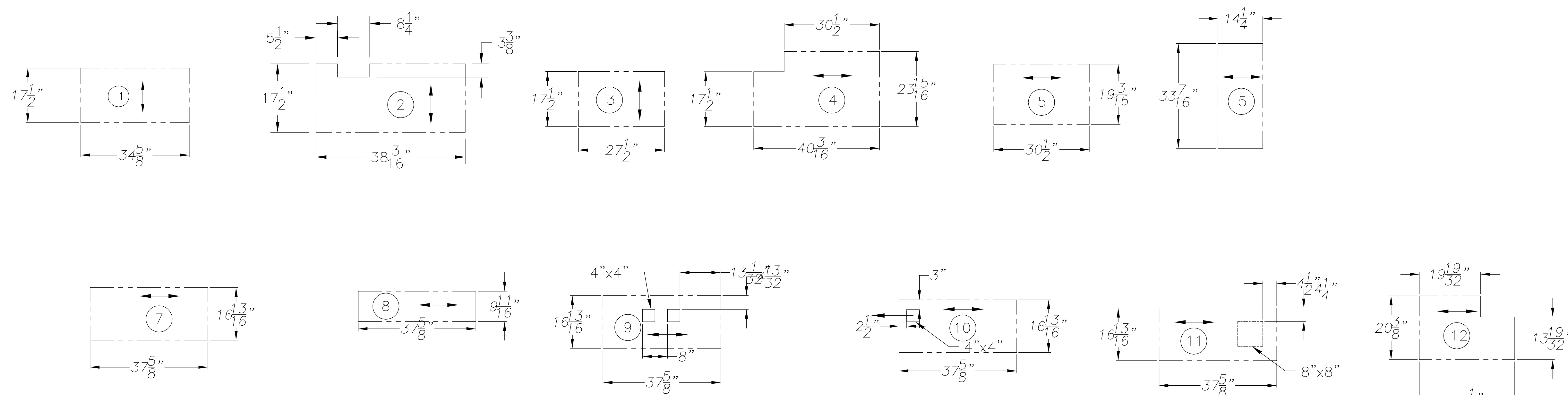
SEPROTECH SYSTEMS INC.
2378 HOLLY LANE OTTAWA, ONTARIO, CANADA K1V 7P1
TEL: (613) 523-1641 FAX: (613) 731-0851
Email: contact@seprotech.com Web: http://www.seprotech.com

DESCRIPTION
MODEL N70, GENERAL ARRANGEMENT
FULL STEEL, w/ FILTERS, EQT & EFFLUENT TANK

DRAWN	CHECKED						
AH							
DATE	SIZE	SCALE	WEIGHT	SHEET		DWG NO.	REV
28–MAY–2007	B	1:60	50000 LB.	1 OF 1		60052–L01	1





PANEL DETAILS
SCALE = 1:32

BANDED GALVANIZED GRATING

GRATINGS 1 - 6 & 12 = W/B-6
1 1/4" X 3/16" (8.9 LB/SQ FT)

GRATING 7 - 11 = W/B-8
1 1/2" X 3/16" (10.6 LB/SQ FT)

SADDLE CLIPS INCLUDED.
2 PER PANEL. 94 TOTAL.

GRATING	QTY
1	4
2	1
3	1
4	1
5	1
6	2
7	21
8	12
9	1
10	1
11	1
12	1

NOTES:
1. SADDLE CLIPS INCLUDED, 2 PER PANEL.

NOTES:

REV	DESCRIPTION	YY/MM/DD	BY
XX	XXXXX	YY/MM/DD	XX

ALL TOLERANCES ARE +/- 1/32" UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE IN INCHES.

PROPRIETARY INFORMATION MAY NOT BE REPRODUCED OR DIVULGED WITHOUT PRIOR WRITTEN CONSENT OF SEPROTECH SYSTEMS INC. DO NOT SCALE. IF IN DOUBT, ASK

Seprotech Water. Pure and Simple
SEPROTECH SYSTEMS INC.
2378 HOLLY LANE OTTAWA, ONTARIO, CANADA K1V 7P1
TEL: (613) 523-1641 FAX: (613) 731-0851
Email: contact@seprotech.com Web: http://www.seprotech.com

DESCRIPTION
GRATING, N70 - SPECIAL
E70S/F70 w/ FILTERS & EFF. TANK

DRAWN	CHECKED						
SA							
DATE	SIZE	SCALE	WEIGHT	SHEET	DWG NO.	REV	
30-MAY-2007	B	1:40	1980 LB.	1 OF 1	60052-S03	0	

APPENDIX C.2

MODEL N30 – MILNE INLET CAMP RBC

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DESIGN BRIEF
SHANCO NUNAVUT - RETRO-FIT

*Note that since this is a retro-fit that has not been tested in the field, effluent values are target values.

1. HYDRAULIC DESIGN: (AVERAGE DAILY FLOW)

1 unit at	14	**m3/day =**	14	**m3/day = Q**	
Peak Flow	41				
design based on a	24	hour day.			

2. INFLUENT PARAMETERS:

BOD (biochemical oxygen demand) =	491	mg/l
SS (suspended solids) =	491	mg/l
TKN =	70	mg/l
Phosphorus =	n/a	mg/l

Ontario Application?	n	y/n
Designated Model?	y	y/n
What Model?	B30	**MODIFIED with extra media**
In concrete tank?	Full Steel	

3. TREATED EFFLUENT QUALITY:

BOD (biochemical oxygen demand) =	20	mg/l	
SS (suspended solids) =	20	mg/l	
NH3-N =	2	mg/l	this effluent concentration is expected after the retro-fit
Phosphorus =	n/a	mg/l	

4. R.B.C. SURFACE AREA REQUIRED (AO):

a) Removal in Primary Settling Tank (P.S.T.)

Primary BOD Removal =	10%			(Ref.1)
Primary Tank. Eff. BOD =	490.9090909	mg/l x	90%	
to RBC =	441.8181818	mg/l		

b) RBC BOD Loading.

Applied Load =	441.8181818	mg/l	**14**	**m3/day**
	5.96	kg BOD/day		

c) Area required to reduce BOD to 20 mg/l (AO)

Applied Load =	5.96	kg BOD/day		**5.96**	**kg BOD/ day**
For	20	mg/l*	use	1.95	kg/day/100 m2
	306	m2			

(*in a nitrification application, reduce BOD to 30 mg/l, the nitrification process completes the BOD reduction)

TABLE #1
BOD REMOVAL RATES
Seprotech Curve

Req. effl.	lbs/day/1000 ft2	kg/day/100 m2
5	1.25	0.61
10	2.65	1.29
15	2.00	0.98
20	2.65	1.29
25	3.35	1.64
30	4.00	1.95
35	4.60	2.25
40	5.15	2.52
50	6.00	2.92
60	7.15	3.52
70	8.28	4.05
80	9.40	4.59
90	10.53	5.13
	USE	1.95

* For effluent strengths less than 20 mg/l, filtration is required. Filtration removes the sloughed biomass 50% of which is BOD. Therefore, to obtain effluent strengths of 5 and 10 mg/l BOD use the loading rates for 10 and 20 mg/l respectively with filtration.

No temperature correction required Refs. 13,14,&15

d) NH3-N to be removed

(Assume Organic Nitrogen is converted to Ammonia NH3)

Removed to	5	mg/l	=		70	less	5	times	13,500	**litres/day**
=	0.88	kg/day	=		**1.93**	**lb/day**				
Area Required to reduce NH3-N to	5	mg/l								
=	0.88	kg/day		over	0.147	kg NH3-N/day/100 m2		**(Ref. 12)**		
=	597	m2	=							
Residual NH3-N to be removed below 5 mg/l =	5	mg/l		less	2	mg/l	times	13,500	**litres/day**	
=	0.041	kg/day								
Area Required to reduce NH3-N to	0									
=	0.041	kg/day		over	0.089	kg NH3-N/day/100 m2		**(Ref. 12)**		
=	46	m2	=							
Total Nitrification Area Required =	642	m2	=			**(Ref. 12)**				

TABLE # 2 - Brenner

Req'd NH3-N concentration (mg/l)	Removal Rate (kg/day/ 100m2)
1	0.037
1.5	0.061
2	0.089
2.5	0.110
3	0.123
3.5	0.135
4	0.147
4.5	0.147
5	0.147

No temperature correction required Refs. 13,14,&15

e) Total Surface Media Required

Total Surface Media Required = 948 m2

f) Staging

Hydraulic Loading	0.13	L/d/m2
B.O.D.post primary	5.96	kg BOD/day
Media req'd(B.O.D)	306	m2
Media req'd(nitrfct'n)	642	m2
Total req'd	948	m2
Min req'd to prevent 1st st. overload	192	m2
Min req'd to prevent 2nd st. overload	71	m2

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Media Distribution After Retro-fit

	ACTUAL AREA (m2)
First Stage	205
Second Stage	140
Third Stage	784
Fourth Stage	0
TOTAL	1,129

Minimum First Stage Media Area
Maximum loading to prevent first stage overload = 3.1 kg/day/100 m2
= 5.96 kg of post primary BOD/day divided by max. loading times 100 m2
= 192 m2

BOD remaining for 2nd Stage = 2.21 kg/day
Minimum Media 2nd Stage = 71.38 m2

5. PRIMARY SETTLING TANK (P.S.T.) (per RBC unit):

a) Primary Settling Tank Influent Flows (per RBC unit)
Average Daily Flow = **13,500** **litres/day**
Recycle at 507% % = 68472 litres/day
Total Average Flow = 81,972 litres/day
Peak Daily Flow = 40,500 litres/day
Peak Flow including Recycle = 108,972 litres/day

The actual volume per bucket may change in the field depending on how much wastewater each bucket picks up

b) Loading Rates
Average Overflow Rate = 16,000 Litres/day/m2 max from (Ref.5)
Peak Overflow Rate = 24,000 Litres/day/m2 (rounded) (Ref.7)
Detention Time = 4 hours use 4 hrs (Ref.6)

c) Surface Area Required
i) by Average Overflow Rate = Total Average Flow divided by Average Overflow Rate
= 5.12 m2
ii) by Peak Flow Rate = Peak Flow divided by Peak Overflow Rate
= 4.54 m2
Therefore, use 5.12 m2 to compare with actual area of P.S.T.

P. S. T. Surface Area for Model B30 3.35 m x 4.19 m = 14.0 m2

Safety factor of: 2.74 times supplied.
Therefore **Surface Area Acceptable**

d) Volume Required = Q x Detention Time / 24 hrs / day
= 2.3 m3
P.S.T. Tank Capacity for this B30 is 27 m3
(after allowance for sludge) 12.0 **safety factor**
Therefore **Volume Acceptable**

6. FINAL SETTLING TANK (F.S.T.):

a) Loading Rates
Average Overflow Rate = 24000 Litres/day/m2 [Ref. 10]
Peak Overflow Rate = 44822 Litres/day/m2 [Ref. 10]
Detention Time = 3 hours

b) Surface Area Required
i) by Average Overflow Rate = Average Flow divided by Average Overflow Rate
= 0.56 m2
ii) by Peak Flow Rate = Peak Flow divided by Peak Overflow Rate
= 0.30 m2
Therefore, use 0.56 m2 to compare with actual area of F.S.T.

F. S. T. Surface Area for Model B30 3.35 m x 1.0 m = **3** m2

Safety factor of 5.75 times supplied.
Therefore **Surface Area Acceptable**

c) Volume Required = Q x Detention Time / 1000 / 24 hrs / day
= 1.7 m3 =
F.S.T. Tank Capacity for this B30 is 4.0 m3
(after allowance for sludge) **2.4** safety factor
Therefore **Volume Acceptable**

7. SLUDGE CALCULATIONS:

Assumptions Used for Calculation of Sludge Accumulation

1. Inlet TSS:	491	mg/l
2. Outlet TSS:	20	mg/l
3. Inlet BOD5:	491	mg/l
4. Outlet BOD5:	20	mg/l
5. Average Daily Flow:	34	m3/day
6. Proportion of inlet BOD5 soluble:	70%	
7. Total incoming solids	16.57	kg/d
8. Inert portion of solids (30%)	4.97	kg/d
9. Assuming Aerobic digester removal efficiency, 50%.	5.80	kg/d
10. BOD removed in secondary treatment	14.24	kg/d
11. Sludge produce due to BOD removal	4.27	kg/d
12. Aerobic digester removal efficiency 50%.	2.14	kg/d
13. Total sludge produced per day	12.90	kg/d

Information Pertaining to the ROTORDISK Used in Calculation of Sludge Accumulation

1. All sludge accumulates in the PST (sludge settled in the FST is pumped back to the PST).		
2. PST Surface Area:	14.0	m2
3. PST Volume:	27.0	m3
4. PST Sludge Storage Capacity:	13.5	m3
TOTAL Mass of sludge produced that accumulates in the PST:	**12.9**	**kg/day**
Volume of Wet Sludge produced Daily:	0.2581	m3/day
Depth of Wet Sludge produced Daily:	0.0184	m/day
Frequency of Pump-Outs:	52	days

SUMMARY OF REFERENCES

Ref.1
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 475, which states, " Sedimentation with coagulation may remove 60 to 90% of the TSS, 40 to 70% of BOD5, 30 to 60% of COD, 70 to 90% of the Phosphorus, and 80 to 90% of the bacteria loadings. In comparison, sedimentation without coagulation, may remove only 40 to 70% of the TSS, 25 to 40% of the BOD5, 5 to 10% of the Phosphorus loadings, and 50 to 60% of the bacteria loadings."

Ref.2
excerpt from "Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems, Ontario Regulation 374/81 under part VII of the Environmental Protection Act", May 1982, ISBN 0-7743-7303-2, section 12.7.1, which states, "if it is a system operating on the rotating biological disc or similar principle involving contact of the biomass with air, provide a disc area so that the daily loading of sewage will not be in excess of 1.25 kg of BOD5 per 100 sq.m. of disc area, or a hydraulic loading in excess of 45 l/sq.m. of disc area".

Ref.3
excerpt from "Pilot Plant Studies of Rotating Biological Contactors treating municipal Wastewater", by: K.L. Murphy and R.W. Wilson, International Environmental Consultants Ltd., Toronto Ontario, prepared for Central Mortgage and Housing Corporation, Ottawa, Ontario.

Ref.4
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 776, which states, "...whenever the first stage loading limit exceeded 3.1 kg BOD5/100 sq.m.day(6.4 lbs. BOD5/d/1000 sq.ft.), the system was associated with the presence of sulfur-oxidizing organisms".

Ref.5
excerpt from "EPA Process Design Manual, On-site Wastewater Treatment and Disposal Systems", Oct 1980, EPA 625/1-80-012, section 6.4.2.4.e., p.149, which states, "...average flow design values normally range from 200 to 400 gpd/sq.ft.(8 to 16 cu.m./d/sq.m.)".

Ref.6
excerpt from " O&M of Trickling Filters, RBC's, and Related Processes, Manual of Practice OM-10, 1988, Water Pollution Control Federation, p. 105, which states, " Weir overflow rates typically range from 125 to 250 cu.m./m.d (10,000 to 20,000 USgpd/ft.)...The wastewater detention time in a settling basin is normally between 1 to 3 hours, but has been as high as 10 hours with excellent results". [use 4 hours]

Ref.7
excerpt from "EPA Process Design Manual, Wastewater Treatment Facilities for Sewered Small Communities", Oct 1977, EPA-625/1-77-009, section 6.4.2., which states, " the peak overflow rate may be 2,500 to 3,000 USgpd/sq.ft. (100 to 120 cu.m./sq.m.d) for primary clarifiers followed by biological treatment processess".
" Clarifiers handling chemical flocs, such as aluminum or iron coagulants, should be designed for peak overflow rates no longer than 600 and 800 USgpd/sq.ft.(24 and 32 cu.m./sq.m.d)".

Ref.8
excerpt from "Design of Municipal Wastewater Treatment Plants Volume 1", Chapters 1-12, WEF Manual of Practice No. 8, ASCE Manual and Report on Engineering Practice No. 76, p. 484, which states, " TSS removal efficiencies in primary sedimentation tanks usually range between 50 and 65%. Many designers assume a removal efficiency of 60% for

estimation purposes".

Ref.9
excerpt from "Wastewater Engineering Treatment, Disposal, and Reuse", 3rd ed., Metcalf and Eddy Inc., revised by George Tchobanoglous and Franklin L. Burton, p.808, table 12-14, which shows,"...typical concentrations of thickened sludge for a rotating biological contactor is 2 to 5%".

Ref.10
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-106, section 2.10, which states, " Murphy and Wilson recommend surface overflow rates less than 600 gpd/sq.ft. to maximize solids removal... DeCarlo recommends that peak hydraulic rates be limited to 1000 to 1200 gpd/sq.ft.".

Ref.11
excerpt from "EPA Process Design Manual, Wastewater Treatment Facilities for Sewered Small Communities", Oct 1977, EPA-625/1-77-009, section 9.2.4.6, p.9-43, which states, " Sludge produced by the RBC unit is similar to humus sludge from a trickling filter. The amount of sludge produced will depend on waste characteristics and loading rates. An RBC unit designed for 80% BOD5 removal would produce about 0.7 lb. of sludge per lb. of BOD5 removed; 95% percent removal would produce about 0.3 lb. of sludge."

Ref.12
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-106, section 5.5.2.2, which states, "Figure 5-19 represents data for one day for a given stage...The zero-order removal rate above bulk liquid ammonia nitrogen concentrations of 5 mg/l in Figure 5-19 is projected at 0.3 lb. NH3-N/day/1000 sq.ft., same as the Autotrol design". (Figure 5-19 attached)

Ref.13
excerpt from Ministry of Environment and Energy - Ahlberg & Kwong Report - "Winter Operation"
No process or operating problems were experienced throughout the winter. The minimum temperature encountered in the unit, with a raw sewage feed rate of 320 gpd, was 4 oC. Process performance remained good during the winter even under conditions of intermittent operation.

Ref.14
excerpt from the Forgie study
For the RBC unit and wastewater tested, the effect of temperature on removal efficiency over the 15 oC to 5 oC range was relatively low (theta = 1.001 to 1.02)

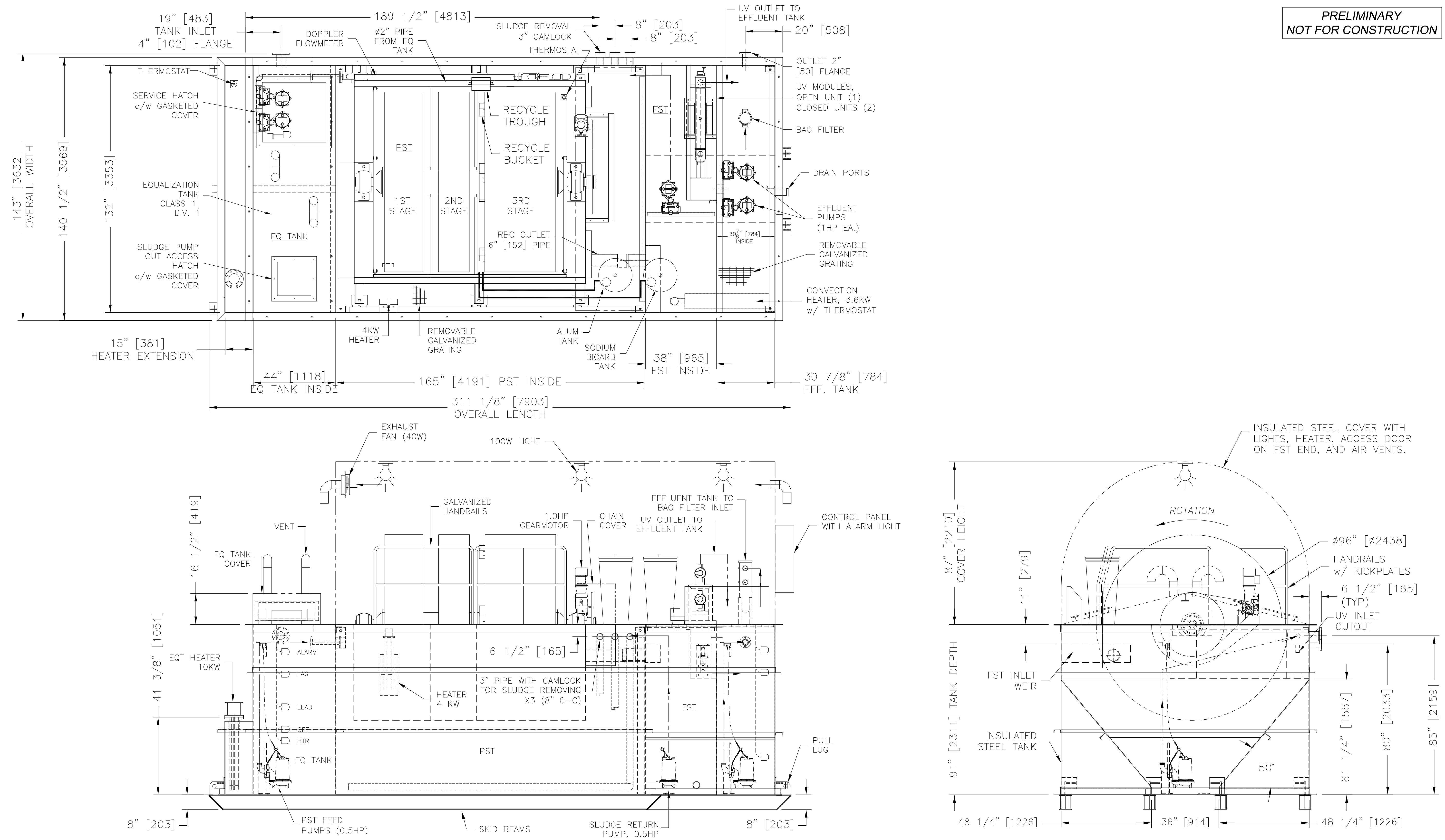
Ref.15
excerpt from Trinh - Environment Canada "Exploration Camp Wastewater Characterization and Treatment Plant Assessment"
It [the RBC] also operated at a low liquid temperature of 4 oC during one week without the effluent quality deteriorating.

Ref.15
WEF MOPNo. 8, p913
Oxygen recovery is 2.86 mg O2/mg NO3-N reduced."

Ref.16
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-106, section 2.9.3, which states, " The observed denitrification rate at 550F was approximately 0.85 lb NO3-N /day/1000sq. ft.."

Ref.17
excerpt from "Design Information on Rotating Biological Contactors", by Richard C. Brenner, EPA-600/2-84-106, section 2.9.2, which states, " The commonly used design value for the required methanol dosage is 3 mg/mg NO3-N reduced."

Ref.18
WEF MOPNo. 8, p913 states that "Oxygen recovery is 2.86 mg O2/mg NO3-N reduced." and that
Heterotrophic biomass production is approximately 0.4 mg VSS/mg COD removed"



NOTES:
1. UNIT TO BE PLACED LEVEL ON CONCRETE OR WELL COMPACTED GRAVEL. (PAD DESIGN BY OTHERS)
2. ALL DIMENSIONS IN BRACKETS ARE IN MILLIMETERS.
3. TANKS, RBC TROUGH, & SHAFT SANDBLASTED AND PAINTED WITH DEVTAR 5A FINISH.
4. INLET/OUTLET ARE STD. 150# ANSI B16.5 RAISED FACE FLANGES.

NOTES:
5. WEIGHT SHOWN IS DRY WEIGHT ONLY.
6. TANKS ARE EQUIPPED WITH DRAIN PORTS FOR SHIPPING PURPOSES ONLY.
7. THIS DRAWING IS NOT TO BE USED FOR CONSTRUCTION WITHOUT PRIOR APPROVAL OF SEPROTECH SYSTEMS INC.

REV	DESCRIPTION	YY/MM/DD	BY
2	AS BUILT CONFIGURATION	09/03/06	DC
1	RETROFIT FROM B30 TO N30, RECYCLE SYSTEM CHANGED	07/11/21	AH

ALL TOLERANCES ARE +/- 1/32" UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE IN INCHES.

Seprotech Water. Pure and Simple

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DESCRIPTION
GENERAL ARRANGEMENT, N30 – SPECIAL E15/N30/F30 w/o FILTERS – SHANCO NUNAVUT

DRAWN	CHECKED		
SA	AH		

DATE	SIZE	SCALE	WEIGHT	SHEET	DWG NO.	REV
29-MAY-2007	B	1:24	34200 LB.	1 OF 1	60069-L00	2

APPENDIX D

MARY RIVER RBC DESIGN PROCESS EVALUATION

Technical Memorandum

To: Jim Millard
Environmental Superintendent
Baffinland Iron Mines Corporation

Project: W01391.001

From: Dave Ellis, P.Eng., AMEC Geomatrix Limited
Jered Munro, AMEC Geomatrix Limited

Date: March 27, 2009

Subject: Mary River RBC Process Design Evaluation

AMEC Geomatrix Limited (AMEC) has completed a third party review of the Mary River sewage treatment plant for Baffinland Iron Mines Corporation (BIM) and has summarized the findings of the review in this technical memorandum.

The memo discusses the original design basis provided from Seprotech Systems Inc. (Seprotech), actual 2008 operating conditions, and provides a recommendation on the treatment capacity of the installed system at Mary River. The treatment capacity recommendation is based on the estimated original design capacity and the actual loading data recorded during the 2008 operating season. AMEC has also prepared a process flow diagrams (attached) which provides information on proposed enhancements to the existing system for provisional future improvements in site treatment capacity.

Recommendations

Using the hydraulic and ammonia loading rates generated during 2008 at Mary River, AMEC recommends that BIM limit the maximum on-site staff at Mary River to 123 people for the existing treatment system. This recommendation is based on the assumption that the daily per capita hydraulic and organic loadings remain the same as the 2008 operating season and is conservative.

If in the future, BIM requires more than 123 employees on site, it is recommended that the additional media provided by Seprotech (Shaft #2) be installed in series with the existing Shaft #1 (current RBC unit). This will increase the nitrification capacity of the system to allow for up to 236 people. The increased capacity, however, does not allow for increased hydraulic loadings, i.e, the total water usage cannot be increased above current maximum average daily design flowrate.

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Wastewater Treatment System Review Assumptions

This wastewater treatment system review is based on the following general assumptions.

- We have assumed that 100% of the organic nitrogen measured in the total Kjeldahl nitrogen (TKN) test hydrolyzes to form ammonia-nitrogen (NH_3-N).
- A 10% removal across the primary clarifier section is assumed.
- The minimum wastewater system operating temperature of 15 deg C is maintained in the treatment sections throughout the operating season
- The specific BOD removal rates used by Seprotech in the design calculations are valid for their systems based on their experience with arctic installations..

Biological System Design Basis

The design basis for the Mary River wastewater treatment system was developed by Seprotech in 2007. The subsequent system design was required to produce treated effluent that would meet the regulated requirements established by the Nunavut Water Board (NWB). A summary of regulatory requirements specified in Baffinland's NWB Licence No. 2BB-MRY0710 are listed in Table 1.

Table 1: NWB Sewage Discharge Requirements

Parameter	Units	Maximum Average Concentration
BOD_5	mg/L	30
Total Suspended Solids (TSS)	mg/L	35
Faecal Coliform	CFU/100mL	1000
pH	-	6.5-9.0
Oil and Grease	-	No visible sheen
Acute Toxicity	-	Non acutely toxic*

* Acute lethality to Rainbow Trout, Oncorhynchus mykiss (as per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/13); and Acute lethality to Daphnia magna (as per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/14).

Although the limits do not specifically identify the effluent ammonia concentration, the requirement for acute toxicity testing provides an inherent effluent ammonia limit. Work completed by Knight Piesold and North/South Consultants Inc. in 2007 (Wastewater Management Plan) and confirmed in recent study (Section 10 of the revised Wastewater Management Plan herein), showed that effluent toxicity is generally expected to occur at ammonia-nitrogen concentrations above 15 mg/L.

A rotating biological contactor (RBC) was selected for treatment of the Mary River domestic wastewater and was commissioned in January 2008. During 2008, effluent quality did not consistently meet the criteria identified in Table 1, and hence did not permit discharge of treated effluent to the receiving environment.

AMEC Geomatrix completed a review of the original design basis used by Seprotech for the BIM system. The estimated hydraulic and organic loading rates are identified in Table 2.

Table 2: Mary River RBC Design Basis

Parameter	Units	MR Design Basis
BOD_5	mg/L	519[1]
TSS	mg/L	519[1]
TKN	mg/L	65[1]
People in camp	-	150[2]
Water Consumption	L/person/day	225[3]
Daily Average Flow	m^3	33.75

1. Estimated by Seprotech using Table 10-4: Characteristics of Basic Wastewater Categories "Cold Regions Utilities Monograph" Third Edition,1996 assuming "moderately diluted wastewater"
2. Estimation provided by BIM in July 2008.
3. Estimated by Seprotech using Table 10-3: Typical Quantities of Sewage Flow , Item 2 "Construction camps", "Cold Regions Utilities Monograph", Third Edition 1996

Using the data from Table 2, the resulting mass loadings were calculated and are summarized in Table 3.

Table 3: Mary River RBC Design Basis Mass Loading

Parameter	Mass Loading Rates (mg/L)	Mass Loading Rates (g/day)
BOD_5	519	17,517
TSS	519	17,517
TKN	65	2,194

This loading data was used by Seprotech to design and develop the system as installed at the Mary River Camp. From a review of *Wastewater Management Plan for Mary River and Milne Inlet Camp Sites* (September 2007), Seprotech used typical published RBC design parameters to determine the size of the system. For general background, it is important to understand that RBC design is based on hydraulic and organic loading rates across a surface area and that increases or decreases in surface area increase the fundamental treatment capacity of the system. The variability in surface area is provided by the configuration of the media (spacing and diameter) and promotes biofilm growth. The biofilm is responsible for removal of organic and nutrient constituents. Once the sludge reaches a certain thickness it sloughs off of the media for removal.

AMEC has reviewed the design parameters used by Seprotech against accepted published values and have summarized this review in Table 4.

Table 4: Comparison of Typical Design Parameters

		Design Information on Rotating Biological Contactors, EPA Design Manual No. 600[1]		Metcalf and Eddy, Wastewater Treatment and Design, 4th Edition[2]		Mary River Design by Seprotech
		Minimum	Maximum	Minimum	Maximum	Design
Hydraulic Loading	m^3/m^2*d	0.01	0.04	0.03	0.08	0.014
Organic Loading	g $sBOD_5/m^2*d$ g $tBOD_5/m^2*d$		 17	2.5 5	8 16	9.4 19.3
Maximum 1st Stage Organic Loading	g $sBOD_5/m^2*d$ g $tBOD_5/m^2*d$	5 10	17 31	12 24	15 30	16 32
NH_3 Loading	g N/m^2*d	0.75	1.5	0.75	1.5	1.45
Hydraulic Retention	Hours	1.5	4	1.5	4	4
Effluent tBOD5 Effluent NH4-N	mg/L mg/L	7 <2	15 <2	7 <2	15 <2	10 <2

Review of published design data suggests that the hydraulic capacity of the Mary River RBC is conservative (0.014 m^3/m^2/day used for design compared with published values of 0.01 to 0.08 m^3/m^2/day), however a recycle stream of 200% or 68 m^3/day is employed to re-oxygenate the influent water which results in a total hydraulic loading of approximately 0.042 m^3/m^2. This is still in the mid-range of published values. Since the primary treatment tank has been designed to accommodate the internal recycle flow of 68 m^3/day it is expected that the system will perform as intended at the maximum average daily design flowrate of 33.75 m^3/day.

The organic loading capacity of the system was designed using 19.3 g $tBOD_5/m^2$/day The maximum 1st stage loading rate was calculated using a rate of 31 g $tBOD_5/m^2$/day which agrees with the maximum value published in Metcalf and Eddy of 30 g/m^2/day. The design calculations identify that 509 m^2 of media are required to prevent first stage overloading and it is suspected that the 495m^2 installed in the first stage may have been due to physical equipment constraints. If treatment issues arise due to overloading of the first stage, installation of a small bypass to the second stage will reduce the loading to be within acceptable ranges. An overloaded first stage, where loading rates are consistently at or above design rates, may experience reduced treatment efficiency during peak loading which would likely result in increased effluent concentrations.

The total nitrification area available is 1527 m^2. The design ammonia loading rate is below the maximum published removal rates of 1.5 g/m^2/day and the calculated surface area required to produce an effluent ammonia concentration of 2 mg/L is 1509 m^2.

Efficient nitrification requires removal of BOD_5 to 30mg/l in order for nitrifying bacteria to thrive. At maximum loading rates, any reduction in BOD_5 removal efficiency will limit the surface area available for nitrification and could result in increased ammonia concentrations in the effluent.

A summary of the installed design is summarized in Table 5

Table 5: Mary River Design

	Units	Design
Daily per capita consumption	L/person/day	225
Mary River Staff on-site	people	150
Flowrate	m^3/day	33.75
BOD_5 Concentration	mg/L	519
BOD_5 after primary clarifier (10% removal)	mg/L	467
Total Organic Removal Area Required	m^2	817
Total Organic Removal Area Actual	m^2	817
1st Stage Area Required	m^2	508.5
1st Stage Area Actual	m^2	495
Nitrogen (TKN) Concentration	mg/L	65
Total Nitrification Area Req'd	m^2	1526
Total Nitrification Area Actual	m^2	1527
Total Surface Required	m^2	2343
Total Surface Area Actual	m^2	2344

In summary, although the system has been designed to operate within published loading criteria, little flexibility or safety factor has been designed into the system. It is possible that small changes in wastewater characteristics will have a significant impact on treatment efficiency, particularly the ability of the system to nitrify ammonia.

2008 Operating Treatment Capacity

Two independent sets of data were gathered during the 2008 operating season. One set of data was gathered by BIM staff while another was collected by Seprotech during a review of the treatment system during late spring 2008

Analytical wastewater treatment data, staffing records and monthly sewage effluent quantities gathered from BIM record data have been summarized to develop an “MR 2008 Average” data set consisting of annual averages, although data from January 2008 was not included in the average due to unrepresentative start-up conditions. The August 2008 data was also not included in the average, because of sludge removal activities that occurred near the time of the sampling event. The data generally shows that the nitrogen influent concentrations in wastewater were double what was expected but other parameters were generally consistent with the original design basis.

Lab analysis data from the Seprotech 2008 review provided representative average wastewater concentrations measured during the course of their late spring 2008 sampling program. The average data presented in the Seprotech report has been identified as the "2008 Seprotech data set for the purposes of this technical memorandum. The data collected by Seprotech between May 5 and June 8 2008 was during a period with an increased average number of staff on-site (182 compared with 150 as used for the design basis).

AMEC's review indicates that the 2008 Seprotech data is an accurate representation of the loadings on-site. This is due in large part to the sampling intensity during Seprotech's spring 2008 monitoring program and the larger-than-usual number of samples that were collected during that time.

Table 5: Actual 2008 Measured Wastewater Loading Data

Parameter	Units	Design Basis (Table 2)	2008 Seprotech Data,	MR 2008 Average[1] Data, Baffinland
BOD_5	mg/L	519[1]	664	520
TSS	mg/L	519[1]	500	225
TKN	mg/L	65[1]	125	135
People in camp	-	150	182	160
Water Consumption	L/person/day	225[3]	143	138
Daily Average Flow	m^3/day	33.75	26	26

[1]Average for 2008 operating period excluding Jan 2008 (start-up) and August 2009 (sludge removal event) data

A review of the average values from the two data sets against the design basis data identifies significantly lower flowrates than estimated in the design basis (26 m^3/day compared with 33.75 m^3/day in design basis). It is suspected that the daily habits of camp crews have impacted the overall flowrates to the wastewater treatment system in that some flows of dilute wastewater have not been entering the system. The higher concentration material has continued to enter the system which has resulted in overall wastewater concentrations that are higher (particularly nitrogen) than in the original design basis.

The resulting mass loading rates as outlined in Table 6 were similar to design mass loading rates although TKN loading was higher than original estimates.

Table 6: 2008 Actual Mass Loading

Parameter	Units	Mary River Average Loading	
		Design Basis	Actual 2008 Operating Data Seprotech
People	-	150	182
Water Consumption	L/person	225	143
Daily Flow	m^3/day	33.8	26.0
BOD	mg/L	519	664
	g/day/person	116.8	95.0
	g/day	17,516	17,281
TSS	mg/L	519	500
	g/day/person	116.8	71.5
	g/day	17,516	13,013
TKN	mg/L	65.0	125.0
	g/day/person	14.6	17.9
	g/day	2194	3253

The analytical data from the sampling program conducted by Seprotech in 2008 has been used to determine the maximum operating capacity of the installed treatment system based on the number of employee's on-site.

Maximum Operating Capacity of Current System

It has been identified that TKN is the limiting design parameter for the current RBC system currently operating at Mary River. The treatment system was designed with a maximum ammonia loading of 2194 g/day. To produce effluent meeting the water licence criteria in the current RBC configuration (1 shaft, 4 stages) the recommended average number of staff on-site is 123 people based on per capita loading rates of 16.9 g of nitrogen/person/day that would provide sufficient surface area for nitrification. The operational parameters are summarized below.

Table 7: Revised Capacity and Operating Scenario

	Units	TKN Limited
Daily per capita consumption	L/person/day	143
Mary River Staff on-site	people	123
Flowrate	m^3/day	17.6
BOD_5 Concentration	mg/L	664
BOD_5 after primary (10% removal)	mg/L	598
BOD_5 loading	g/day	10525
Total Organic Removal Area Required	m^2	545[1]
Total Organic Removal Area Actual	m^2	817
1st Stage Area Required[2]	m^2	386.2
1st Stage Area Actual	m^2	495
Nitrogen (TKN)	mg/L	125
Nitrogen loading	g/day	2200
Total Nitrification Area Required[3]	m^2	1517
Total Nitrification Area Actual	m^2	1527
Total Surface Required	m^2	2137
Total Surface Area Actual	m^2	2344

[1] based on 19,3 gBOD/m^2/day
[2] based on 30 gBOD/m^2/day
[3] based on 1.45 gN/m^2/day

Provisional Treatment Capacity

BIM has an additional RBC component system available at the Mary River site that was purchased from Seprotech in 2008. The component system, which has not yet been installed, includes a complete, high density packaged unit designed specifically for nitrification with a total treatment surface area of 3038 m^2.

Specifically, the components consist of a four stage, single shaft RBC system with an effluent break tank. The unit is not equipped with any other tankage or treatment equipment and as a result will not increase the hydraulic capacity of the existing system. The unit, however, is well suited for increasing the nitrification capacity of the current RBC system.

A review of the additional component system indicates that the plates, or media, spacing in the first stage is much closer than in the existing system. The spacing of the media is important to the treatment capacity of the system since bridging of the biofilm can result in reduced treatment efficiency. For this reason in particular, the new unit is not suitable for installation in parallel with the existing unit and can only be installed in series.

The suggested system layout would consist of connecting the existing 4-stage Shaft #1 in series with the 4-stage shaft Shaft #2 for a total of two shafts and eight stages. A summary of the physical layout is listed below and conceptual process flow diagrams are attached..

Table 8: Provisional treatment configuration

Shaft	Stage	Actual Area (m^2)
1	Stage One	495
1	Stage Two	205
1	Stage Three	822
1	Stage Four	822
2	Stage Five	736
2	Stage Six	736
2	Stage Seven	783
2	Stage Eight	783
	Total Surface Area	5382 m^2

As part of the retrofit, AMEC suggests removing the baffle between Stages One and Two on Shaft #1 in order to provide sufficient first stage surface area to prevent organic overload.

In the proposed configuration, the first four stages of Shaft #1 would be used for BOD removal and the remaining 4 stages on Shaft #2 would be used for nitrification. Although the additional RBC will not increase the existing hydraulic capacity it will allow the existing system to operate at maximum capacity instead of the current "TKN limited" hydraulic capacity. The maximum hydraulic loading would be limited by the current system hydraulic loading of 33.75 m^3/day. The additional shaft would increase the existing treatment capacity and result in a more robust system capable of treating a maximum of 236 people at 143 L/person/day. The tanks, pumps, alum system and filter systems will not need to be upgraded as the hydraulic capacity will not change.

The treatment capacity calculations are summarized in Table 9. For the purposes of determining a maximum number of staff that the Mary River facility can support the sizing calculations were performed based on the "Actual 2008" data presented in Table 6 and available surface area A surplus of 1119 m3 of treatment capacity is expected to be available under these conditions.

Seprotech provided a design basis for the provisional system with peak loadings that were observed during their sampling program. The loading rates were calculated using a single data set captured during the 2008 sampling program that were approximately double the average rates observed during the course of the sampling program and have been included in the final column of the table as “Maximum Loading”. This scenario was provided to be representative of potential changes in the wastewater characteristics due to future changes in work activities on-site. As demonstrated the provisional system has sufficient capacity to accommodate process variations.

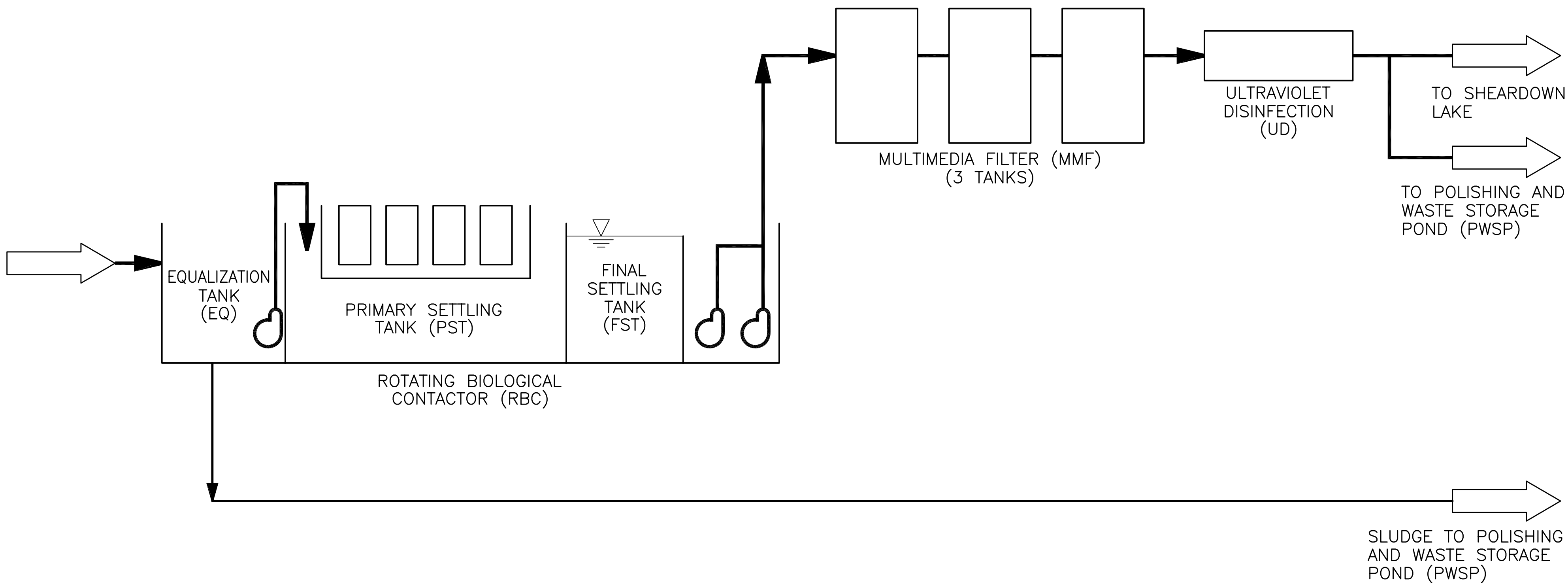
Table 9: Provisional Treatment Capacity

	Units	Actual Observed Loading (2008)	Maximum Observed Loading (2008)
Daily per capita consumption	L/person/day	143	143
Mary River Staff on-site	people	236	234
Flowrate	m^3/day	33.75	33.5
BOD_5 concentration	mg/L	664	1204
BOD_5 after primary (10% removal)	mg/L	598	1083
BOD_5 loading	g/day	20183	36281
Total Organic Removal Area Required[1]	m^2	1046	2035
Total Organic Removal Area Actual	m^2	2344	2344
1st Stage Area Required[2]	m^2	672	1209
1st Stage Area Actual	m^2	700	1522
Nitrogen (TKN)	mg/L	125	152
Nitrogen loading	g/day	4219	5092
Total Nitrification Area Req'd[3]	m^2	2910	3500
Total Nitrification Area Actual	m^2	3038	3038
Total Surface Required	m^2	4183	5382
Total Surface Area	m^2	5382	5382

[1] based on 19.3 gBOD/m^2/day
[2] based on 30 gBOD/m^2/day
[3] based on 1.45 gN/m^2/day

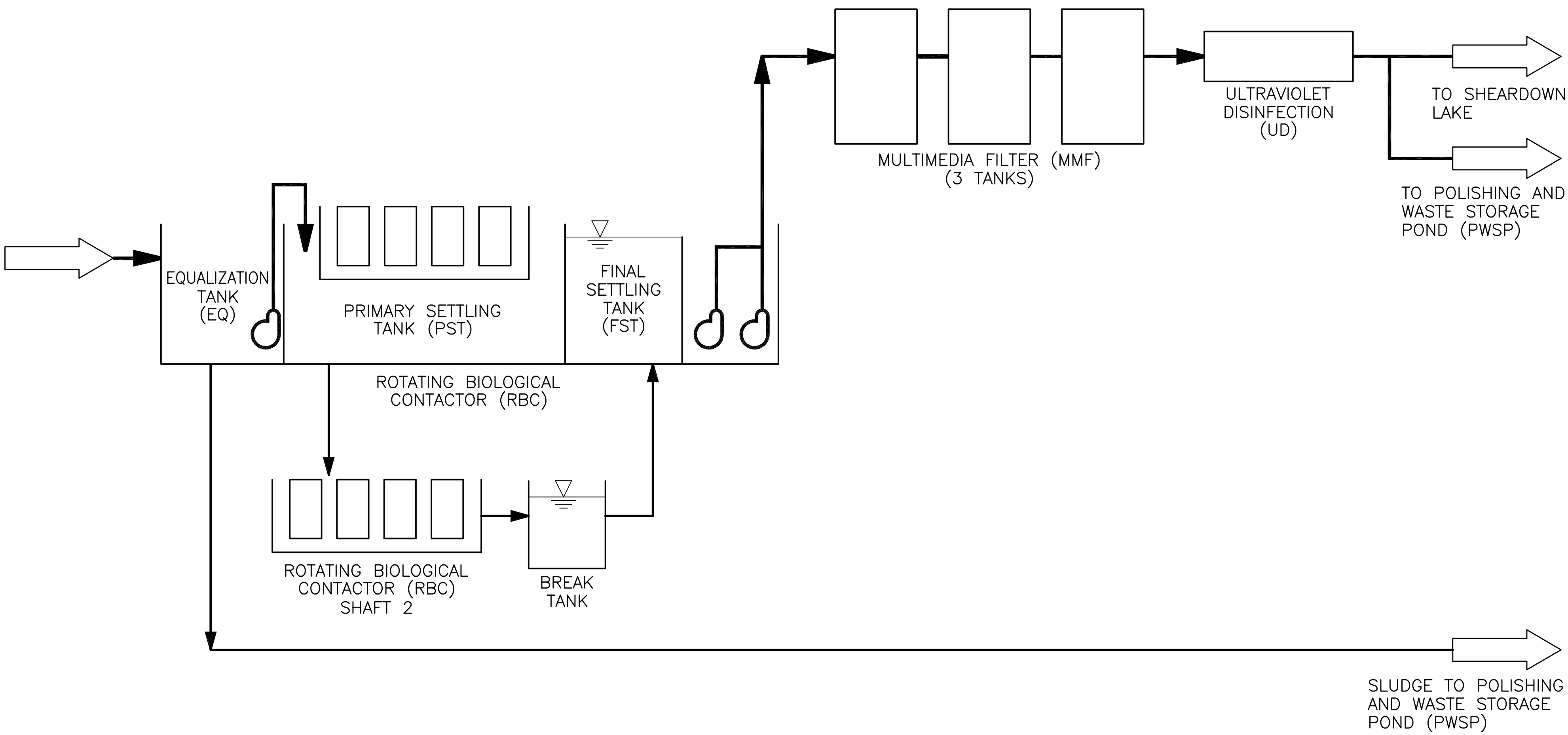
It should be noted that to avoid first stage overload using the “maximum loading” condition, provisions would be required to remove sufficient baffles in order to avoid first stage organic overload. The physical arrangement of the plate spacing would also need to be reviewed. It is possible that plates would need to be removed in stage three and four on the first shaft to accommodate biofilm growth associated with organic removal in these stages.

If the per capita water usage on-site increases, a resulting reduction in staff will be required to avoid exceeding the daily effluent volume of 33.75 m^3/day. If the provisional system were to be installed an increase in sludge removal frequency would also be required.



March 17, 2009–4:48pm

AMEC Geomatrix AMEC Geomatrix Limited 420 Weber Street, North, Unit G Waterloo, Ontario N2L 4E7 (519) 886-7500	PROCESS FLOW DIAGRAM MARY RIVER WWTP BAFFINLAND IRON MINES BAFFIN ISLAND, NUNAVUT TERRITORY	DATE MARCH 2009	PROJ. NO. W01391.001
		FILE NO. W01391–PFD	DWG. NO. PFD-01



March 17, 2009–4:48pm

AMEC Geomatrix AMEC Geomatrix Limited 420 Weber Street, North, Unit G Waterloo, Ontario N2L 4E7 (519) 886-7500	PROCESS FLOW DIAGRAM MARY RIVER WWTP ADDITIONAL CAPACITY RETROFIT BAFFINLAND IRON MINES BAFFIN ISLAND, NUNAVUT TERRITORY	DATE MARCH 2009	PROJ. NO. W01391.001
		FILE NO. W01391–PFD	DWG. NO. PFD-01a

DESIGN BRIEF

DATE: **July 8, 2008**
PROJECT NAME: **Mary River**

1. HYDRAULIC DESIGN: (AVERAGE DAILY FLOW)

1 units each at 29 m3/day = 29 m3/day = Q
design based on a 24 hour day.

2. INFLUENT PARAMETERS:

BOD (biochemical oxygen demand) =	1204	mg/l
SS (suspended solids) =	N/A	mg/l
TKN =	152	mg/l
Phosphorus =	N/A	mg/l

3. TREATED EFFLUENT QUALITY:

BOD (biochemical oxygen demand) =	20	mg/l
SS (suspended solids) =	N/A	mg/l
NH3-N =	2	mg/l
Phosphorus =	N/A	mg/l

4. R.B.C. SURFACE AREA REQUIRED (AO):

a) Removal in Primary Settling Tank (P.S.T.)

Primary BOD Removal = 10% (Ref.1)
Primary Tank. Eff. BOD = 1204 mg/l x 90%
to RBC = 1083,6 mg/l

b) RBC BOD Loading.

Applied Load = 1083,6 mg/l 29 m3/day
30,88 kg BOD/day

c) Area required to reduce BOD to 20 mg/l (AO)

Applied Load = 30,88 kg BOD/day 30,88 kg BOD/ day
For 20 mg/l* use 1,29 kg/day/100 m2
2394 m2

(*in a nitrification application, reduce BOD to 30 mg/l, the nitrification

d) NH3-N to be removed

(Assume Organic Nitrogen is converted to Ammonia NH3)

Removed to 5 mg/l = 152 less 5 times **28 500** **litres/day**
= 4,19 kg/day = **9,22** **lb/day**
Area Required to reduce NH3-N to 5 mg/l
= 4,19 kg/day over 0,147 kg NH3-N/day/100 m2 **(Ref. 12)**
= 2850 m2 =
Residual NH3-N to be removed
below 5 mg/l = 5 mg/l less 2 mg/l times **28 500** **litres/day**
= 0,086 kg/day
Area Required to reduce NH3-N to 2
= 0,086 kg/day over 0,089 kg NH3-N/day/100 m2 **(Ref. 12)**
= 96 m2 =
Total Nitrification Area Required = 2946 m2 =

(Ref. 12)
TABLE # 2 - Brenner

Req'd NH3-N concentration (mg/l)	Removal Rate (kg/day/ 100m2)
1	0,037
1,5	0,061
2	0,089
2,5	0,110
3	0,123
3,5	0,135
4	0,147
4,5	0,147
5	0,147

No temperature correction required
Refs. 13,14,&15

e) Total Surface Media Required

Total Surface Media Required = 5340 m2

f) Staging

Hydraulic Loading	5,30	L/d/m2
B.O.D.post primary	30,88	kg BOD/day
Media req'd(B.O.D)	2 394	m2
Media req'd(nitrfct'n)	2 946	m2
Total req'd	5 340	m2
Min req'd to prevent 1st st. overload	996	m2
Min req'd to prevent 2nd st. overload	582	m2

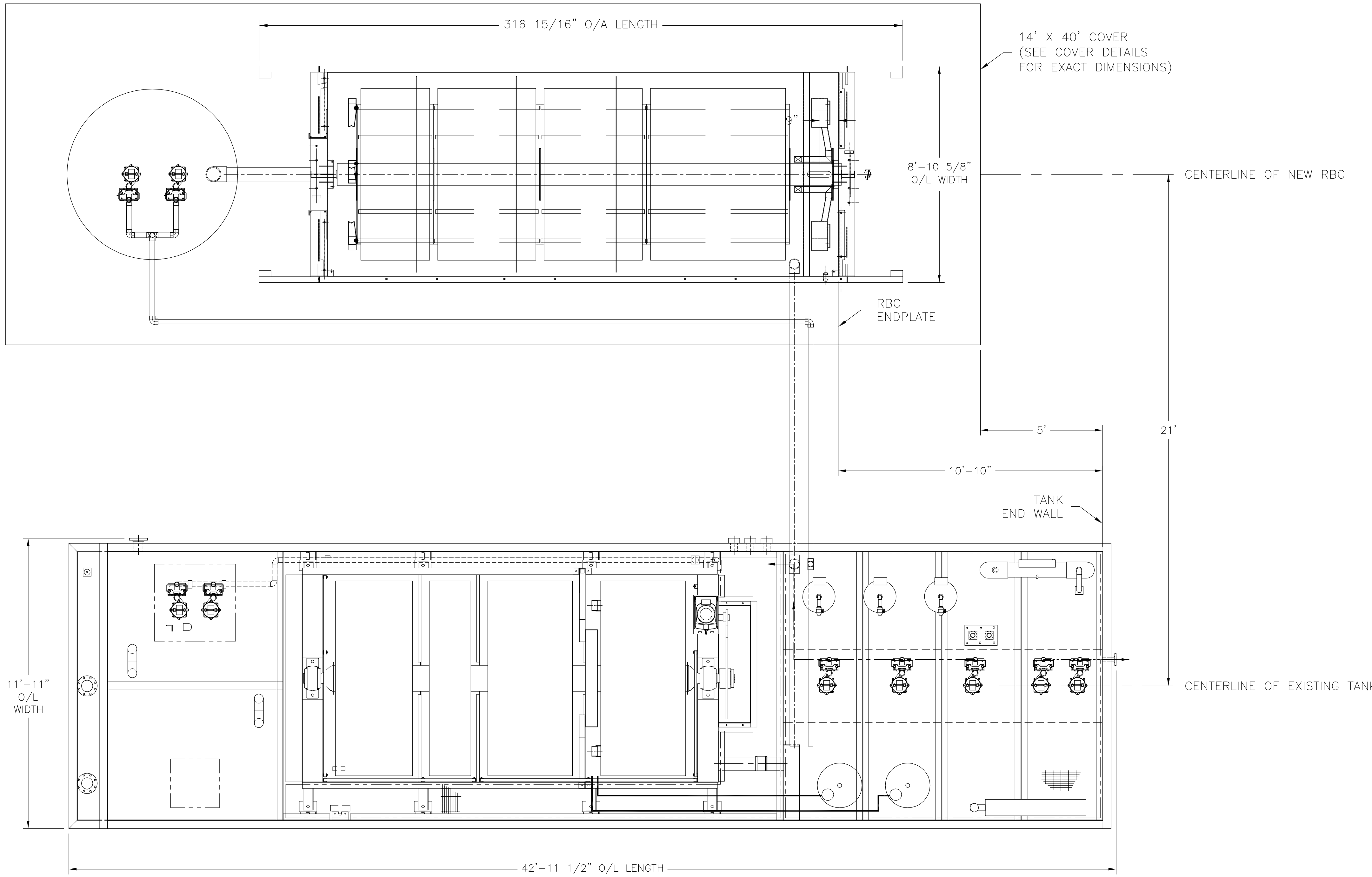
	ACTUAL AREA (m2)
First Bank	495
Second Bank	205
Third Bank	822
Fourth Bank	822
Fifth Bank	736
Sixth Bank	736
Seventh Bank	783
Eighth Bank	783
TOTAL	**5 382**

Minimum First Stage Media Area
Maximum loading to prevent first stage overload = 3,1 kg/day/100 m2
= 30,88 kg of post primary BOD/day divided by max. loading times 100 m2
= 996 m2

BOD remaining for 2nd Stage = 18,03 kg/day
Minimum Media 2nd Stage = 582 m2

OPR.	DESCRIPTION

ITEM	PART #	DESCRIPTION	QTY



NOTES:

1. XXXXX

NOTES:

REV	DESCRIPTION	YY/MM/DD	BY
XX	XXXX XXXXX	YY/MM/DD	XX

ALL TOLERANCES ARE +/- 1/32" UNLESS OTHERWISE SPECIFIED. DIMENSIONS ARE IN INCHES.

Seprotech
Water. Pure and Simple
SEPROTECH SYSTEMS INC.
2378 HOLLY LANE OTTAWA, ONTARIO, CANADA K1V 7P1
TEL: (613) 523-1641 FAX: (613) 731-0851
Email: contact@seprotech.com Web: http://www.seprotech.com

DESCRIPTION
GENERAL ARRANGEMENT, N70 – SPECIAL BAFFINLAND ADDITION

DRAWN	CHECKED
DC	

DATE	SIZE	SCALE	WEIGHT	SHEET	DWG NO.	REV
15-OCT-2008	B	1:60	50000 LB.	1 OF 1	60052-L04	0

APPENDIX E

SEPROTECH RBC INSTALLATION, OPERATION, AND MAINTENANCE MANUALS

Appendix E.1

RBC Wastewater Treatment Inspection Logs

Baffinland Iron Mines Corporation

DATE: ____________

MARY RIVER N70 RBC WASTEWATER TREATMENT INSPECTION LOG

Submit daily the completed log to Baffinland Camp Manager

System Performance Checks

	Yes	No	N/A	Corrective Action Taken
Are there any alarms?	☐	☐	☐	
Are ice and other obstructions removed from doorway?	☐	☐	☐	
Are ice and other obstructions removed from ventilation ports?	☐	☐	☐	
Are influent, effluent & RBC vent heat trace warm?	☐	☐	☐	
Are the floats clear of debris?	☐	☐	☐	
Are the UV lights operating?	☐	☐	☐	
Are all the pumps set in auto?	☐	☐	☐	
Is there more than 2" of foam on PST? (Skim it clean)	☐	☐	☐	
Wipe grease off of bearings?	☐	☐	☐	
Lube oil level at top of chain?	☐	☐	☐	
Is bacteria growing on walls of FST & lift station	☐	☐	☐	

UV Lamps: Intensity: ______ Sheaths require cleaning?: Yes ☐ No ☐ Intensity after cleaning: ______

Sodium Hypochlorite: Pump stroke: _____ Stroke percent: _____ Volume remaining: _____ Batch Mixed? _____

Alum: Pump stroke: _____ Stroke percent: _____ Volume remaining: _____ Batch Mixed? _____

Process Performance Checks

	Value	Unit	Acceptable Range	Corrective Action Taken
pH		None	Minimum 7.6	
24 hour Total Flow Rate		Litres	Maximum 33,750 L	
Temperature		°C	Minimum 17°C	
PST sludge level		Feet	Maximum depth = 2'	PST sludge pumped ☐
Odour		Smell	Musty	
Colour on primary disk		Colour	Medium brown	
Colour on secondary disk		Colour	Medium brown	
Colour on final disk		Colour	Medium brown	
Effluent Clarity Test		Solids	Clear – No solids	

Adjustments/Corrective Action/Comments (Document if instructions provided by 3rd party): ____________

Chemical Performance Checks: **Monday Operator Analysis Completed** ☐ **UV light Cleaned** ☐

Influent	Value	Unit	Maximum Limit	*Effluent*	Value	Unit	Acceptable Range
pH		None		pH		None	6.0 to 9.5
Temperature		°C		Temperature		°C	N/A
COD		mg/L		COD		mg/L	N/A
TSS		mg/L	490	TSS		mg/L	Maximum 35 mg/L
TKN		mg/L	65	TKN		mg/L	N/A
TP		mg/L	10	TP		mg/L	N/A

Monthly Lab Sample Taken by Technician: Check box to indicate sample taken ☐

Weekly Ops PM checklist complete on Monday ☐ **Monthly Ops PM checklist complete 1st day of the month** ☐

Adjustments/Corrective Action/Comments (Document if instructions provided by 3rd party): ____________

OPERATOR (please print): ____________ SIGN OFF: ____________

Baffinland Iron Mines Corporation

DATE: ____________

MARY RIVER N30 RBC WASTEWATER TREATMENT INSPECTION LOG

Submit daily the completed log to Baffinland Camp Manager

System Performance Checks

	Yes	No	N/A	Corrective Action Taken
Are there any alarms?	☐	☐	☐	
Are ice and other obstructions removed from doorway?	☐	☐	☐	
Are ice and other obstructions removed from ventilation ports?	☐	☐	☐	
Are influent, effluent & RBC vent heat trace warm?	☐	☐	☐	
Are the floats clear of debris?	☐	☐	☐	
Are the UV lights operating?	☐	☐	☐	
Are all the pumps set in auto?	☐	☐	☐	
Is there more than 2" of foam on PST? (Skim it clean)	☐	☐	☐	
Wipe grease off of bearings?	☐	☐	☐	
Lube oil level at top of chain?	☐	☐	☐	
Is bacteria growing on walls of FST & lift station	☐	☐	☐	

UV Lamps: Intensity: ______ Sheaths require cleaning?: Yes ☐ No ☐ Intensity after cleaning: ______

Sodium Hypochlorite: Pump stroke: ______ Stroke percent: ______ Volume remaining: ______ Batch Mixed? ______

Alum: Pump stroke: ______ Stroke percent: ______ Volume remaining: ______ Batch Mixed? ______

Process Performance Checks

	Value	**Unit**	**Acceptable Range**	**Corrective Action Taken**
pH		None	Minimum 7.6	
24 hour Total Flow Rate		Litres	Maximum 33,750 L	
Temperature		°C	Minimum 17°C	
PST sludge level		Feet	Maximum depth = 2'	PST sludge pumped ☐
Odour		Smell	Musty	
Colour on primary disk		Colour	Medium brown	
Colour on secondary disk		Colour	Medium brown	
Colour on final disk		Colour	Medium brown	
Effluent Clarity Test		Solids	Clear – No solids	

Adjustments/Corrective Action/Comments (Document if instructions provided by 3rd party): ______

Chemical Performance Checks: **Monday Operator Analysis Completed** ☐ **UV light Cleaned** ☐

Influent	Value	Unit	Maximum Limit	*Effluent*	Value	Unit	Acceptable Range
pH		None		pH		None	6.0 to 9.5
Temperature		°C		Temperature		°C	N/A
COD		mg/L		COD		mg/L	N/A
TSS		mg/L	490	TSS		mg/L	Maximum 35 mg/L
TKN		mg/L	65	TKN		mg/L	N/A
TP		mg/L	10	TP		mg/L	N/A

Monthly Lab Sample Taken by Technician: Check box to indicate sample taken ☐

Weekly Ops PM checklist complete on Monday ☐ **Monthly Ops PM checklist complete 1st day of the month** ☐

Adjustments/Corrective Action/Comments (Document if instructions provided by 3rd party): ______

OPERATOR (please print): ____________ SIGN OFF: ____________

Appendix E.2

Model N70 – Mary River Camp

ROTORDISK®
Aerobic Wastewater
Treatment Plant

Model N70

BAFFINLAND
Project #60052

ROTORDISK®
Aerobic Wastewater Treatment Plant
Model N70

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

BAFFINLAND
Project #: 60052

Seprotech
Water. Pure and Simple

ROTORDISK®

Wastewater Treatment Plant
Model N70

INSTALLATION, OPERATION & MAINTENANCE MANUAL

AUGUST 2007

SEPROTECH SYSTEMS INC.
2378 HOLLY LANE
OTTAWA, ONTARIO
K1V 7P1
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Tel: (613)-523-1641
Fax: (613)-731-0851

Seprotech Systems Incorporated
2378 Holly Lane, K1V 7P1
Ottawa, Ontario, Canada
Telephone (613) 523-1641
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INSTALLATION, OPERATION AND MAINTENANCE

MANUAL

TABLE OF CONTENTS

IMPORTANT: READ THIS INSTALLATION PROCEDURE PRIOR TO START-UP.

1.0 SITE INSTALLATION OF ROTORDISK® SEWAGE TREATMENT PLANTS:

1.1 (applies to Steel Tankage only)

When there is a complete ROTORDISK® unit supplied, site preparation is as follows:

A level concrete or well-compacted gravel base is to be supplied by Customer/Contractor.

Unit to be lifted only at lifting points by use of hooks and spreader bars.

All anchoring and levelling of ROTORDISK® on site to be done by customer/contractor. Check alignment of shaft and sprockets and clearances of couplings where applicable prior to start-up, failure to do so may void manufacturer's warranty. Refer to this ROTORDISK® manual for details. If required, the contractor must perform levelling.

All hydraulic piping, to and from the unit, is to be supplied and installed by customer/contractor.

All input electric and hydro hook-ups to be done by customer/contractor to local governing regulations and a signed approval sent to SEPROTECH SYSTEMS INCORPORATED. Under no circumstances must electrical connections, junction boxes or equipment pertaining to the electrical function of the unit be installed in the ROTORDISK® tank.

SEPROTECH SYSTEMS INCORPORATED GROUP INC. will supply a man on-site to assist customer/contractor at a specified rate and at customer/contractor discretion.

If unit is not shipped completely assembled assembly instructions and drawings will be supplied.

IMPORTANT: READ THIS INSTALLATION PROCEDURE PRIOR TO START-UP.

1.2 - (applies to Concrete Tankage for ROTORDISK® only)

If the ROTORDISK® unit supplied is to be encased in concrete tankage, the site preparation is as follows:

The unit is lowered into the concrete tankage, the pipe at the end of the unit is placed into the opening of the intermediate wall between the primary and final settlement chambers and lowered onto the anchor bolts (contractors supply).

Unit to be lifted only at lifting points by use of hooks and spreader bars.

All anchor bolts (contractors supply) should be correctly located in concrete in a vertical position. In addition, all bolts should include a levelling nut.

All anchoring and levelling of ROTORDISK® on site to be done by customer/contractor. When the unit is set onto the anchor bolts in the concrete tank, it must be levelled to a slope of no more than 3/4" in 20' along the length. The unit is then centred in the tank and completely bolted down.

After the unit has been bolted down, check alignment of shaft and sprockets and clearances of couplings where applicable prior to start-up, failure to do so may void manufacturer's warranty. Refer to this ROTORDISK® manual for details. If required, the contractor must perform levelling.

All hydraulic piping, to and from the unit, is to be supplied and installed by customer/contractor.

All input electric and hydro hook-ups to be done by customer/contractor to local governing regulations and a signed approval sent to SEPROTECH SYSTEMS INCORPORATED. Under no circumstances must electrical connections, junction boxes or equipment pertaining to the electrical function of the unit be installed in the ROTORDISK® tank.

SEPROTECH SYSTEMS INCORPORATED will supply a man on-site to assist customer/contractor at a specified rate and at customer/contractor discretion.

If unit is not shipped completely assembled assembly instructions and drawings will be supplied. (As shown)

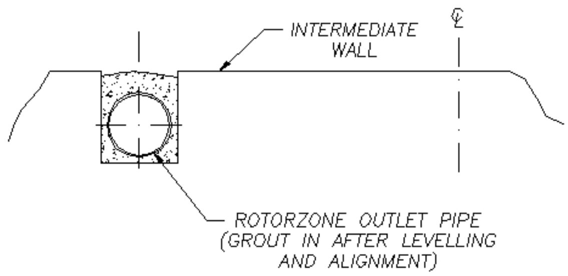


Figure a - **ROTORDISK®** tank outlet through intermediate wall between settlement tank chambers.

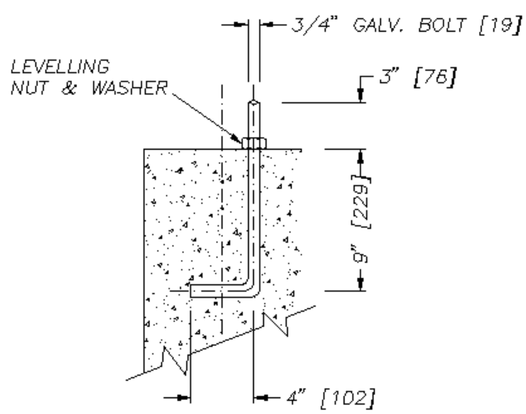
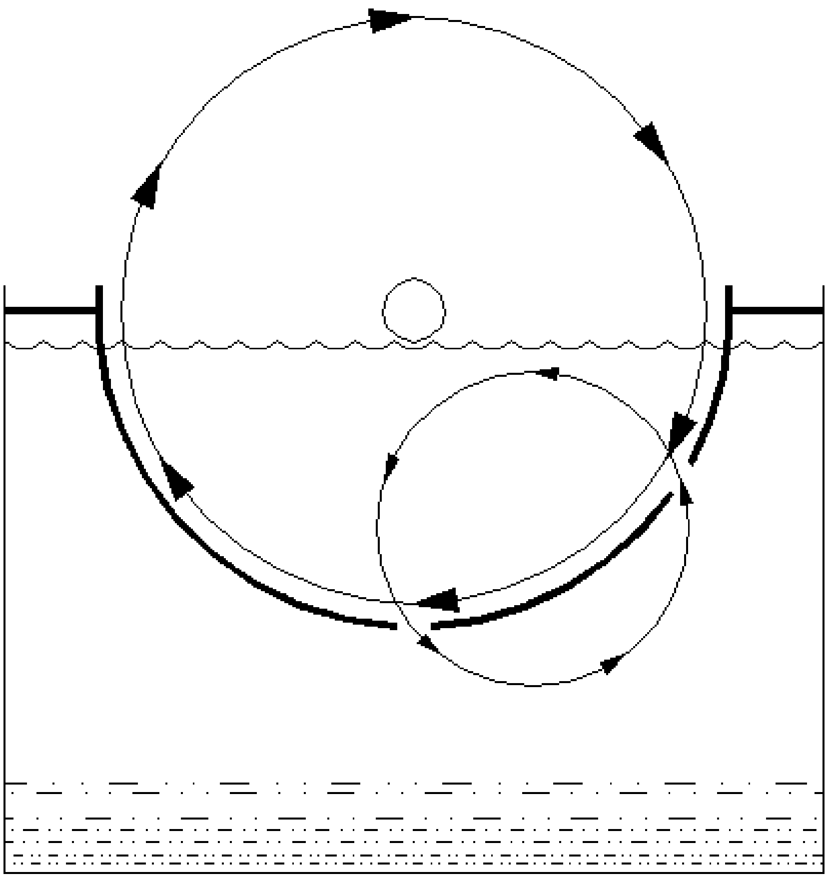


Figure b - anchor bolt detail for **ROTORDISK®** tank.

1.3 - DIRECTION OF SHAFT ROTATION



The direction of shaft rotation should be such that disks mounted on shaft will enter water on the side where inlet to "Rotorzone" is located. The electric motor driving the shaft should be wired accordingly.

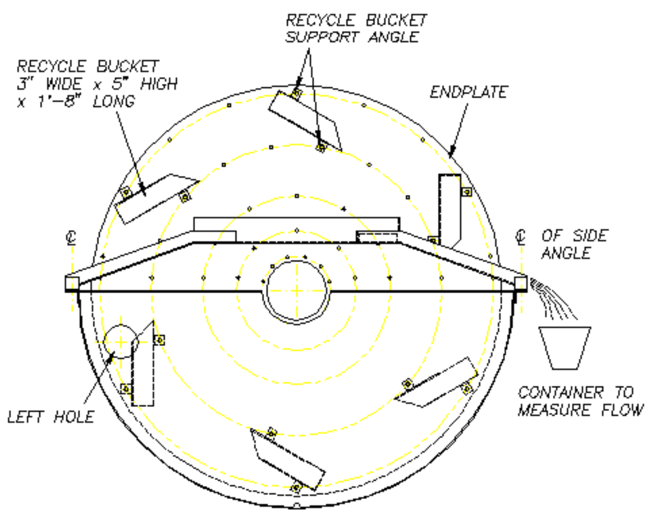
1.4 - DISSOLVED OXYGEN (D.O.) RECYCLE for ROTORDISK®

1.4.1 Recycle buckets are mounted on the last stage of the ROTORDISK®. These buckets rotate at the same speed as the disks. See the attached elevation view of the recycle buckets and trough on the Rotorzone tank.

1.4.2 As the disks rotate, the buckets scoop-up treated wastewater. As this wastewater falls into the recycle trough, it is exposed to the atmosphere, where it absorbs fresh oxygen. The wastewater then cascades on one side of the trough through a narrow steel channel and mixes back with the contents of the Primary Clarifier, thereby introducing fresh dissolved oxygen in the Primary Clarifier. See the section of diskbank assembly showing buckets and recycle trough.

1.4.3 The set-up described above is comprised of the recycle buckets and recycle trough, is what we term as our D.O. re-circulation device. This is especially advantageous to preventing septic conditions from occurring in the Primary Clarifier in small flow or low flow situations.

1.4.4 It is **important** to measure the **actual recycle rate** on the **ROTORDISK®**. This data is compared to our theoretical recycle rate designed. This is advantageous prior to connecting and setting-up for service. Using a container (5 gallon bucket is ideal) and a stopwatch, record the water flowing out of the effluent channel of the recycle trough. Make 3-5 readings, and report this data to SEPROTECH SYSTEMS INCORPORATED for future reference.



SECTION OF DISKBANK ASSEMBLY
SHOWING 6 BUCKETS
AND RECYCLE TROUGH

1.5 - SUMMARY OF OPERATION

(ROTORDISK® systems designed for BOD/SS/Ammonia/Nitrate removal)

A). The sewage plant (as supplied by SEPROTECH SYSTEMS INCORPORATED) is comprised of five (5) main components: the primary settling tank, the RBC tank, the denitrification tank, the secondary settling tank and the multi-media filters.

B). The RBC tank is the aerobic section of the treatment plant divided into four (4) stages.

Raw sewage is pumped and/or gravity flows into the primary settling tank (PST). When the sewage is pumped into the plant, pumping must simulate conditions encountered in gravity fed systems. Indeed, over a 24-hour period, the plant is designed to handle a flow rate corresponding to the Average Daily Flow (ADF) and can accommodate for two Peak Daily Flow (PDF) periods of two (2) hours per day. Each PDF event can be at a maximum of three times ADF.

In the PST, sedimentation separates heavy solids from the bulk of the liquid and the supernatant enters the aerobic section through the inlet slot located at the front section of the RBC tank.

The aerobic section is made up of four stages. The 1st stage is mounted on one common shaft. This 1st stage is comprised of one (1) to three (3) disk banks. The normal colour of the bacteria in the 1st stage is dark brown. This is the stage where most of the BOD removal by biological oxidation occurs. The succeeding 2nd, 3rd, and 4th stages are mounted on the rest of the shaft or another common shaft. Each stage has one (1) to three (3) disk banks. It is in the 2nd stage that further BOD is removed, and nitrifying bacteria (those which convert ammonia (NH_3) in the form of ammonium ions (NH_4^+) into nitrite (NO_2^-) and, ultimately, nitrate (NO_3^-)) start to predominate in the 3rd and 4th stages. The 4th and last aerobic stage has recycle buckets that introduce both fresh dissolved oxygen into the primary settling tank and nitrifying bacteria present in the recycled water.

The rotation of the disks in and out of the water provides a mean of air and heat transfer from the ambient air to the water. The transfer of air to the water is important for aerobic bacteria to remove BOD and ammonia. The transfer of heat to the water is important to maintain the water at an optimum temperature of 15 °C and above such that BOD and ammonia removal rates by the bacteria are maximised (removal rates are a function of the water temperature). Because maintaining a temperature that provides acceptable removal rates is important to the process, RBC's are installed indoors and ambient air is maintained at 15 °C and above.

C). The media in the denitrification section is completely submerged since denitrifying bacteria convert nitrate (NO_3^-) to nitrogen gas (N_2) in an anoxic (i.e., in the absence of dissolved oxygen (DO)) environment.

(Text missing pending completion of patent application process.)

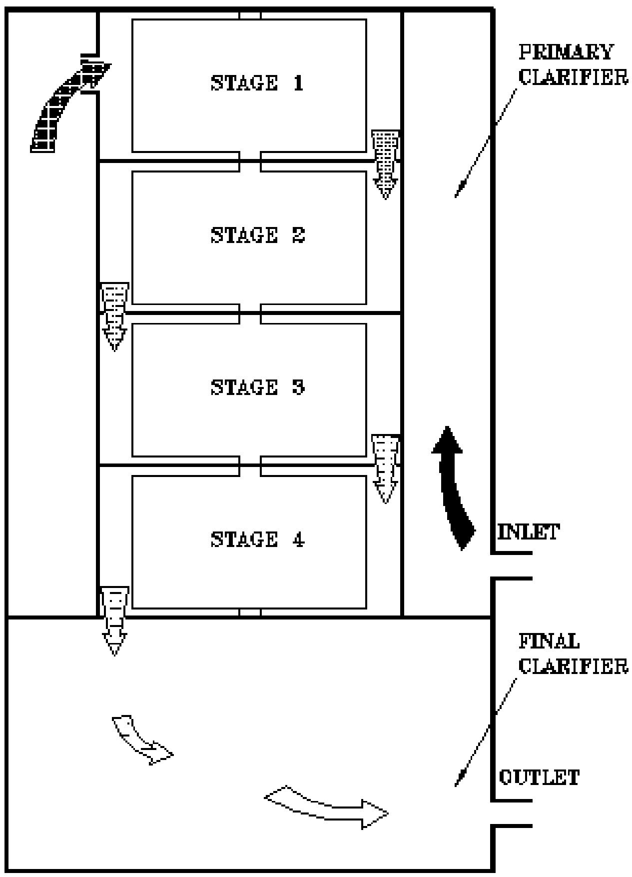
The denitrification section is comprised of two stages separated by a baffle. An equal amount of media is provided in both stages.

D). Partially treated water from the denitrification section then enters the secondary settling tank. Sloughed off biomass from the disks and media bundles and other suspended solids is further settled in this chamber.

E). The partially treated water is then fed to three (3) multi-media filters using one of two (2) submerged pumps. The purpose of these filters is to further reduce the concentration of suspended solids in the final effluent.

2.0 - ROUTINE VISUAL CHECKS ON PHYSICAL AND BIOLOGICAL FUNCTIONING OF ROTORDISK® & DESCRIPTION OF TREATMENT PROCESS

ROTORDISK® sewage treatment plants have three major steps in the purification process. In the primary settling tank, gross solids separate from the flow by either sinking or floating. In the Rotorzone, dissolved pollutants are broken down to simple, non-pollutant compounds by the bacteria ("biomass") which grows on the rotating disks. The final settling tank permits gravity separation of spent biological growth, which continually sloughs off the disks in the Rotorzone preceding it.



2.1 - PRIMARY SETTLING TANK (PST OR PRIMARY "CLARIFIER")

The accumulation of floating scum on the surface of the primary clarifier is normal. It is proportional to the accumulation of settle-able solids at the bottom of the tank. Periodic (9-12 months) removal of sludge at the bottom of the tank is required for proper operation of the Unit.

If no sludge measuring device is available, the accumulation of 9"-12" depth of scum on the surface is a good indication that it is time to remove the accumulated deposits of sludge from the bottom of the tank(s).

2.2 - ROTORZONE

The Rotorzone is subdivided into four sections, with disk banks in each. The wastewater first enters the Rotorzone in the section marked "1" in the sketch (furthest away from the inlet to the plant). The flow then proceeds through sections 2, 3, and 4 before entering the denitrification zone.

The accumulation of biological growth will be greatest in section 1, and gradually decrease through subsequent sections. Generally, the growth will be thick, and often filamentous ("stringy"), in section 1, becoming thinner and more compact through sections 2-4.

The colour of the growth will typically be dark brown to black in Section 1. Some grey growth may also be noticed, depending on the relative load and type of wastewater being treated. Growth in sections 2-4 will typically vary from medium brown to a light brown or tan growth in section 4.

In a well-functioning unit with the appropriate feed of wastewater, there will be an earthy, humus-like ("musty") smell inside the unit. A substantial sour, "sewage" smell may be an indication of sub-optimal conditions in the treatment process.

2.2.1 - 'BATHTUB RING'

The wastewater flows by gravity within a ROTORDISK® Plant thus the water level is relatively constant. Changes in water level of 1" to 2" are not unusual due to surge flows entering the unit. The evidence of this is a 'bathtub ring' 1" - 2" above the normal level. A 'bathtub ring' higher than this suggests that partial or complete flooding of the unit has occurred since the last check. If so, the (gravity or pump) discharge system should be checked for blockages or mechanical malfunction. Another condition which can lead to the level of water rising to greater levels than 1" – 2" is if the plant is fed by pumps that exceed the design limits of the plant (i.e., ADF over a period of 24 hours including a maximum of two (2) PDF events no longer than 2 hours each).

2.3 – ACETIC ACID INJECTION SYSTEM

One of the most important building blocks of life is carbon. The bacteria responsible for denitrification need carbon in an organic form to grow and thus convert nitrate to nitrogen gas. Most soluble organic carbon (often measured in terms of Biochemical Oxygen Demand or BOD) has been consumed in the aerobic section of the wastewater treatment plant and there is thus very little left for the denitrifiers by the time the wastewater reaches the denitrification section of the plant. It is for this reason that acetic acid (vinegar), an easily biodegradable organic carbon source, is injected at the inlet of the denitrification zone.

The system provided consists in a 125 imp. gal. storage tank (ϕ=30", H=49") equipped with a mixer and of a dosing pump of maximum capacity 12.3 l/h mounted on a skid.

The dosing pump can be controlled in either of two ways: by a 4-20 mA signal coming from the flowmeter located on the effluent outlet pipe (the system is programmed to be operated that way by default) or by a dry contact (by others) located outside SEPROTECH SYSTEMS INCORPORATED's main control panel. For example, that dry contact (by others) could be closed when the pumps (by others) feeding the wastewater treatment plant are running and opened when they are not.

The target dose of pure acetic acid (CH_3COOH) in the water is: 175 mg/litre. Assuming that commercial acetic acid is at a concentration of 12% by weight, this means that the target dose of commercial acetic acid at the inlet of the denitrification section would be 1460 mg of commercial acetic acid per liter of water. At ADF (i.e., 49,000 litres per day), this corresponds to a dosing rate of 2.9 litres of commercial acetic acid per hour. If the 4-20 mA signal from the flowmeter is used to control the dosing pump (again, this is the default mode), then the actual dosing rate will be $3 \times 2.9 = 8.7$ litres of commercial acetic acid per hour one third of the time since the flow exiting the plant (via the flowmeter) is pumped from the FST to the multi-media filters at a rate of $3 \times$ ADF = PDF (i.e., 147,000 litres per day).

The average daily quantity of commercial acetic acid necessary has been estimated at 70 l/day (15.4 imp. gal per day) based on an ADF of 49,000 litres/day.

2.4 – DENITRIFICATION ZONE

(Text missing pending completion of patent application process.)

In the denitrification zone, the media is completely submerged such that anoxic conditions (i.e., the absence of Dissolved Oxygen (DO) in the water) prevail and thus the denitrification process (i.e., the conversion of nitrate (NO_3^-) to nitrogen gas (N_2)) can take place. The denitrification zone includes two (2) stages that are separated by a baffle.

2.5 – FINAL SETTLING TANK (FST OR FINAL "CLARIFIER")

The effluent near the outlet at the backside of the final clarifier should be relatively clear and colourless and relatively free of suspended matter. Clarity can best be judged by scooping a small volume of the final effluent into a clear glass container. This is particularly true of larger units where the depth and dark colour of the tank walls may make clarity hard to determine. (Note: Although the risk of infection is very small, the wearing of rubber gloves is a rational safety precaution when hand-scooping the effluent for a clarity check. This is particularly true if there are open cuts on the hands.)

Although the final effluent itself should be relatively clear, some floating matter may accumulate on the surface of the final clarifier. This is normal, and will typically be much less than the accumulation of floating scum in the primary clarifier.

2.6 – FILTERS FEED PUMPS LOGIC AND LEVELS IN THE FST

The level in the FST is controlled in the following manner:

- Level Switch Low (LSL or float #1): both filter feed pumps (each of capacity = 3 × ADF) stop when this level is reached;
- Level Switch High (LSH or float #2): lead filter feed pump starts when this level is reached;
- Level Switch High High (LSHH or float #3): lag filter feed pump starts (lead filter feed pump is maintained in operation) and an alarm goes off when this level is reached (i.e., the alarm light is activated);
- Overflow: the FST is equipped with an outlet that can be connected directly to the storm sewer in the exceptional case that the plant is overflowed (piping between this outlet and the storm sewer is out of SEPROTECH SYSTEMS INCORPORATED' scope of supply).

2.7 – POST FILTRATION SYSTEM

The clarified water is pumped from the FST to three multi-media filters operating in parallel. The purpose of these multi-media filters is to reduce further the concentration of suspended solids in the treated wastewater.

The three filters operated in parallel are designed to treat peak low rates (PDF) of 3 times the design average daily flow (ADF) and are fed at this flow rate since each filter feed pump also has a capacity of PDF.

Each of the three filters is filled with anthracite, sand and garnet with gravel underbedding. The water is filtered from top to bottom of each filter with the coarser filtration media placed on top and the finer on the bottom of the filter. Each vessel is made of fibreglass. In normal operation (i.e., when all 3 filters operate in parallel), the filtration velocity is about 10 m/h on each filter.

A backwash of one of the three filters is performed approximately every 4 hours. The filters are backwashed alternately, i.e., filter no. 2 gets backwashed approximately 4 hour (exactly 4 hours + the time it takes to backwash and rinse a filter) after filter no. 1 gets backwashed and filter no. 3 gets backwashed approximately 4 hour after filter no. 2 gets backwashed. These operating parameters are adjustable on the plant's main control panel (see Section 2.9). When a backwash occurs, the water pumped at PDF from the FST is fed to two of the filters and the filtrate from these is used to backwash the third filter from bottom to top (inverse direction than in filtration mode). The two filters used to produce the filtrate operate at velocities of approximately 15 m/h while the third filter gets backwashed at a velocity of approximately 30 m/h.

The filtration system is controlled by the main control panel for the plant. The automatic diaphragm valves installed on the filtration unit are pneumatic and are thus opened and closed using compressed air. A compressor is provided with the plant. The compressed air transits through a filters solenoid valves panel.

2.8 – MONITORING OF DISCHARGE FLOW RATE

The plant is equipped with a magnetic flow meter located on the clean effluent's discharge pipe. This instrument is equipped with a counter that allows tracking of the total volume of clean effluent discharged by the plant. As mentioned in paragraph 2.3, the flow meter is also used to control the injection rate of acetic acid. A thermal chart recorder was also provided in order to produce hardcopies of the flow measurements taken by the flowmeter.

2.9 – OPERATING PARAMETERS ADJUSTABLE ON THE CONTROL PANEL

The following operating parameters were set as default in the Programmable Logic Control (PLC) panel provided with the plant but are adjustable within the ranges shown below. Making changes and adjustments to the default plant's operating parameters requires a good understanding of the wastewater treatment process and should therefore only be performed by qualified and trained staff. Please contact SEPROTECH SYSTEMS INCORPORATED if assistance is needed to optimise the operation of the plant.

	T1 Time between backwashes	T2 Time for a backwash	T3 Time for rinse	T4 Time between sludge pumping	T5 Time for sludge pumping
Factory Setting	4 h	10 min	5 min	1.0 h	0.25 min
Minimum	1 h	5 min	2 min	0.5 h	0.10 min
Maximum	18 h	30 min	30 min	12.0 h	1.00 min

2.10 - FREQUENCY OF INSPECTION

Visual checks every week should be sufficient. However, for better preventative maintenance of the wastewater treatment plant and thus the capital investment, a daily walk through is often the preferred frequency of visit. Many owners prefer the visual and audible (look and listen) walk through. A standard operator checklist should be prepared and used by the person responsible for periodic maintenance of the plant at every visit. SEPROTECH SYSTEMS INCORPORATED can assist in preparing such checklist upon request.

The acetic acid storage tank should be topped off every time the plant is being visited.

The pressure loss on every filter should also be controlled. Two pressure gauges were provided for this purpose, one on the inlet pipe and one on the outlet pipe of each filter. The pressure drop across a filter shouldn't exceed 15 PSI. If it does even after a filter has been backwashed, the frequency and/or duration of backwashes should be increased.

3.0 - STANDARD RECOMMENDATIONS AND PROCEDURES FOR SLUDGE REMOVAL

3.1 - STORAGE CAPACITIES

A design feature of ROTORDISK®, which contributes greatly to overall simplicity of the process, is the sizing of clarifiers to accommodate static internal sludge storage for extended periods. Depending on such factors as raw wastewater solids concentrations, and design organic loading in a given application, maximum sludge storage levels will typically be reached in 6-9 months of operation.

This period is based on calculated rates of initial decomposition of raw and biological solids, and, upon operating experience, indicating the degree of auto-digestion/compacting, which proceeds during the storage period. The 6-9 month period will be shortened to the extent that design hydraulic and waste loads are exceeded. It will be lengthened to the extent that flows and waste load are less than those designed for.

3.2 - DETERMINATION OF ACCUMULATED SLUDGE VOLUMES

The accumulation of maximum storage capacities can be indirectly monitored through visual observation of the thickness of the scum blanket on the surface of the primary clarifier. When the scum blanket has matured to a height of approximately 7"-10", this is a good indication that sludge accumulations at the bottom of both clarifiers are at or near maximum levels, and that sludge withdrawal is indicated.

A more accurate procedure of determining sludge levels is to directly measure actual accumulations, and compare these to the maximum storage capacities listed on the "Details" section of the general arrangement drawing for the ROTORDISK® model in question.

A variety of sludge measuring devices is commercially available. The two most common are the weighted hollow tube type, and, the (electronic) turbidity-change detector type. The former is less costly, relatively easy to use, and more appropriate because of the low frequency with which measurements need to be made in a ROTORDISK® unit.

Whatever means of measuring the sludge may be selected, it must be kept in mind that the sludge is <u>not</u> a firm solids substance. Domestic wastewater sludge is mostly trapped water and other liquids. Only to determine sludge levels by "feeling" for a solid layer with a stick or pole. The settled sludge is far more liquid than the surface scum, which is perhaps 30-40% solids by volume.

Irrespective of the type of device used, sludge levels should be measured at several locations in each settlement tank to ensure a reasonably accurate calculation of accumulated volumes. This is required since sludge accumulation levels are not uniform; being highest at the inlet ends of both clarifiers, and, below the slot at the bottom of the first section of the Rotorzone trough.

Once an average sludge height has been determined, multiply by the surface area of the clarifier in question to determine the existing volume of stored sludge. Compare to maximum design capacity listed on the general arrangement drawing. If the accumulated levels equal or exceed design values, it is time to remove the sludge from the unit.

3.3 - SLUDGE REMOVAL

A pump-out truck of the same type that pumps out septic tanks normally does the sludge removal. For smaller ROTORDISK® units, the entire liquid contents of the treatment plant can be withdrawn. For larger installations, the haulage contractor should be instructed to get the suction hose directly to the bottom of the tanks and withdraw the sludge only, while taking as little of the supernatant as possible. Once the primary sludge is withdrawn from the primary settlement tank, the supernatant of the secondary clarifier can be transferred to the primary settlement tank to expose the secondary sludge. The suction hose should be placed down at a multiple number of points to help ensure complete removal of accumulated sludge deposits. Floating surface scum should also be removed. Haulage contractors should be given a brief description of the unit and its operation if they are not already familiar with it. A particular point to emphasise is that the biological growth on the disks should <u>not</u> be washed off, but should be left in place. The exception to this is if the disks have accumulated excess biomass due to sludge pump out being delayed past the indicated intervals.

Sludge removed from the unit is normally hauled away by the pumping truck and disposed of at municipal facilities, or, by controlled spreading on farmland. On-site disposal in shallow trenches and/or some form of on-site volume reduction (prior to export) may be feasible or desirable depending on the specific opportunities and limitations afforded by the site of a given installation.

3.4 - POTENTIAL CONSEQUENCES OF OPERATING ROTORDISK® UNITS PAST DESIGNATED MAXIMUM SLUDGE STORAGE LEVELS

Sludge accumulations should be removed once they reach indicated maximum storage levels, because failure to do so could result in lowered treatment efficiency, and possibly cause serious damage to the structure of the Rotating Assembly and drive unit. The potential for problems is as described below and depicted in the attached sketches.

Figure (c) shows a unit operating with sludge build-ups at or near maximum storage levels. This will cause no problem since the storage heights are designated so that flows through the primary clarifier will not disturb the sludge layer. Characteristics of wastewater reaching the Rotorzone at this time (and since start-up) will be in the range of 180-200 mg BOD/1 and 50-250 mg SS/1. The supporting structure of the rotating assembly is over designed for the amount of biological build-up which will occur on the disks under this operating condition, and the shear force of the rotation through the trough water will limit the thickness of growth.

However, if sludge is allowed to accumulate past designated storage heights, flow through the primary clarifier will begin to disturb the sludge blanket, and thus carry loads of solids and dissolved organic matter into the Rotorzone which are not anticipated in the design of the unit (Figure d). The pollutant load reaching the biomass on the first stage of disks will overload that biomass (in terms of F:M ratio), and force a change in its activity and growth. The biomass becomes more gelatinous, and does not shear off as well with disk rotation. Additionally, the biomass will readily adsorb and entrap the extra solids with the sum effect being an increase in weight on the rotating assembly that considerably exceeds that which its design is based on.

This tendency reaches its extreme if sludge is allowed to accumulate to the point where it will be disturbed by-, and caught up in -, the re-circulation pattern created by the two slots in the trough on the first section of the Rotorzone (see Figure e).

The sludge will have characteristics in the order of 20,000 mg TSS/1 and 10,000 mg BOD/1, so it is obvious that even a minor amount of this material caught up in the re-circulation flow will significantly increase the concentration of the waste stream entering the Rotorzone. If, for example, the sludge was caught up in the recycle flow at a ratio of as little as 1:10 or 1:15, the resulting concentration would be sufficient to produce a considerable first-stage overload on an amount of disk area selected based on normal concentrations.

The resulting build-up of poorly-shearing gelatinous biomass and trapped solids would pose a serious potential for strain on the drive unit, and for structural damage to disk bank assemblies and shaft, in spite of them being considerably over designed for loads anticipated in normal operation.

Clearly, these potential problems should be avoided by the removal of sludge once it reaches the level specified as maximum for the ROTORDISK® unit in question.

3.5 - FRONT VIEW SCHEMATIC OF ROTORDISK®

UNIT OPERATING AT-, AND ABOVE-,
RECOMMENDED MAXIMUM SLUDGE STORAGE LEVELS

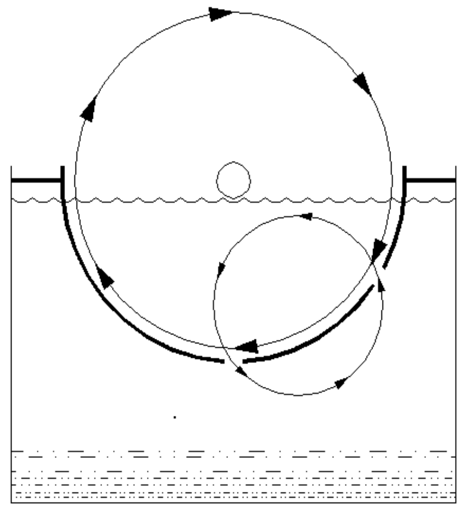


Figure c-unit operating at maximum sludge storage levels. Neither influent flows, nor re-circulating flows, disturb sludge blanket.

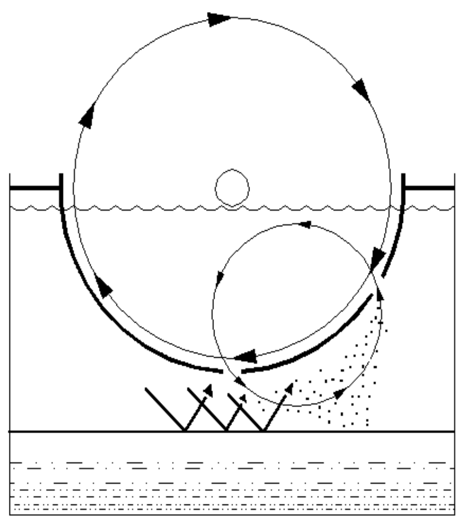


Figure d- unit operating with excess accumulations. Influent flows may disturb sludge blanket and increase BOD and solids loads to Rotorzone to levels above treatment design.

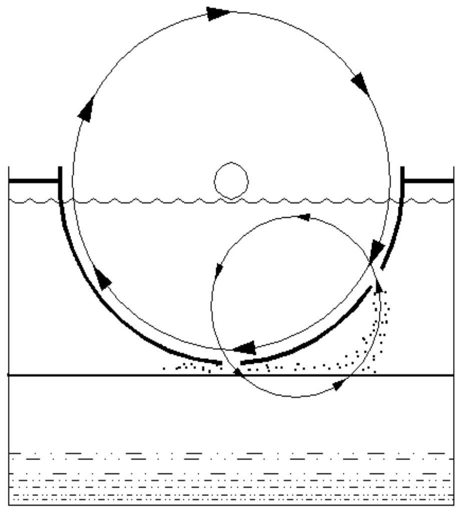


Figure e-Unit operating with excess sludge accumulated to base of Rotorzone. Both influent flows and re-circulation flows will disturb and carry sludge solids. Increase in BOD and solids loads entering Rotorzone will be substantially above design treatment levels, increase accumulated masses on rotating assembly, produce potential for damage to structure and drive unit.

3.6 - PUMPOUT PROCEDURES FOR ROTORDISK® TREATMENT SYSTEMS (summary)

Using suction hose, floating or surface scum should be removed first. Place the suction hose directly to the bottom of the tank and withdraw sludge only, while taking as little as possible of the volume of waste liquid above the sludge blanket (supernatant).

Move the hose at multiple number of points along the bottom of the settlement tanks. Do not wash off biological growth (biomass) on the disks. The exception to this is excess accumulated biomass on the disks due to an overdue sludge pump-out. Excess accumulated biomass is when a disk bank is 100% fully covered with biomass and the colour is grey with a slight odour.

Keep a record of all pump-outs to arrive at an actual normal operating interval for sludge pump-outs. For systems with several flow meters, it is also beneficial to note the total flow generated between pump-outs.

3.7 - START-UP PROCEDURES OF ROTORDISK®

WARNING: A VALVE LOCATED AT THE BOTTOM OF THE DENITRIFICATION TANK AND EQUIPPED WITH A REMOTE ACTUATION MECHANISM WAS PROVIDED WITH YOUR UNIT. THIS VALVE:

- Needs to be OPEN: when the plant is first filled with water, during draining if the plant ever requires such operation and during subsequent refilling operations. FAILURE TO OPEN THIS VALVE DURING FILLING AND DRAINING WILL RESULT IN SERIOUS DAMAGE TO THE PLANT. This is because, during a filling operation, the water rising in the PST would push the denitrification tank upwards while it is empty (this tank wouldn't have had a chance to fill with water until the water level reaches the inlet slot between the PST and the aerobic ROTORDISK®. Th open valves provide a mean of filling the PST and the through (denitrification tank included) at the same time.

- Needs to be CLOSED: during normal operation of the plant. Indeed, the denitrification section contains water already partly treatment thus this water and that contained in the PST shouldn't mix. FAILURE TO CLOSING THIS VALVE DURING NORMAL OPERATION OF THE PLANT WILL RESULT IN A POOR QUALITY EFFLUENT.

The ROTORDISK® sewage treatment plant is based on a fixed film treatment process referred to as the Rotating Biological Contactor (RBC). In this process, micro-organisms or bugs are attached and grown on the surface of a media, the quantity of bugs being directly proportional to the amount of food in the wastewater. When starting up a new system, it will normally take about two weeks to get organic removal from the wastewater and three to four weeks to establish the nitrification process at normal domestic sewage temperatures. The method of and effluent discharge during system start-up should be discussed and thoroughly communicated with the environmental authority. The primary sedimentation tank and RBC of the system should, preferably, be filled with fresh water before admitting wastewater to the system. A flow less than design is not a problem. The biomass will develop themselves on the media. If there is a small flow only a portion of the disk will have biomass. As the flow increases the amount of biomass will increase.

Seeding a ROTORDISK® with activated sludge, although not required, can be accomplished. The activated sludge should be at the same temperature as the influent. Sudden changes in wastewater temperature cause biomass sloughing. In most cases, the use of domestic waste as a seed culture has provided the required biomass for continuous operation. When seeding the ROTORDISK® with activated sludge is decided, the primary sedimentation tank and RBC of the system should first be filled with fresh water (preferably) and the activated sludge added to the RBC. The RBC should be rotating at all times. The wastewater introduced to the tank needs to have only 20% of the disks covered with waste. This can already provide the needed wetting and still provide some time to reach normal operating levels when source flow is introduced. The final clarifier does not need to be filled with anything.

Alternately, seeding can be accomplished using dry bacteria and a source of organic carbon such as raw molasses or sugar. This can be done, for example, in situations where wastewater or activated sludge are not available and the plant needs to be ready to treat wastewater very shortly after it begins receiving it. By simulating the conditions encountered in wastewater (where large amounts of organic carbon and bacteria are present), biomass will establish on the ROTORDISK® and the plant can thus be prepared to work under actual conditions before these are actually encountered. SEPROTECH SYSTEMS INCORPORATED can help find appropriate supplies of both dry bacteria and raw molasses.

The preferred start up is the introduction of source wastewater at design or less than design loading. The disks need to be rotating at all times. When the disks are rotating and wastewater is introduced the biomass will develop and the pollutants will be removed.

The practice of starting up a sewage plant with a charge of septage or activated sludge may be appropriate for suspended growth systems where sludge return is an essential and necessary part of the process. However, start-up with septage is <u>not</u> an appropriate practice for fixed film systems such as the Rotating Biological Contactor process and is <u>not</u> recommended. This is especially true of the ROTORDISK® process and its static, internal storage of sludge.

Studies have shown that the natural start-up time for a ROTORDISK® is 2 1/2 – 3 weeks (normal temperatures and BOD reduction only), and that it has already developed sufficient biomass for 50% removals in only 1 week. These are time frames significantly shorter than respective ones for suspended growth systems. Thus there is little rationale for "pre-starting" a ROTORDISK® unit with septage.

Further, septage contains solids that are already well digested, and therefore not subject to further digestion-compaction in the storage zones. This contrasts to the fresh solids, which will undergo considerable digestion-compaction in the 6 – 9 months after initial settlement. Therefore, a charge of septage would contribute disproportionately to the accumulation of sludge levels, and necessitate a shorter interval to the first pump-out of the unit.

The ROTORDISK® concept of static sludge storage contributes greatly to its overall operation and maintenance simplicity. Following the above guidelines and recommendations will help ensure that the trouble-free simplicity of ROTORDISK® is maintained.

4.0 - STORAGE OF **ROTORDISK®** SEWAGE TREATMENT EQUIPMENT

If the unit is not to be operated for an extended period, then the motor-reducer assembly (drive unit) should be removed from its mound and stored at room temperature in a reasonably dry area (unless the whole unit is being stored in such an area).

Additionally:

1. Reducer: The input shaft should be given several turns once a month to re-lubricate the upper bearings.

NOTE: Some reducers are shipped to site filled with synthetic lubrication. Otherwise, fill the reducer with the lubricant (see reducer section of installation & maintenance instructions).

2. Motor: The motor has a tendency to take on moisture when not in operation. It requires no attention during storage, but before it goes into operation the insulation should be measured using a Meger. It should be at least 1.0 mega-ohm. If below 1.0 mega-ohm, it has taken on excessive condensation, and must be dried out before being operated. (Note: any electrical contractor or repair shop commonly understands these terms and procedures).

3. Support bearings on main ROTORDISK® shaft(s) should be re-lubricated prior to start-up.

4. The system should not be installed and operated in water. In the absence of sewage inputs and normal biological activity, freezing and consequent mechanical damage would be a distinct possibility. Water level in the primary settlement tank to be dropped to below the bottom of the Rotorzone tank level, if freezing of the tank contents is possible.

5.0 - ASSEMBLY PROCEDURE OF ROTORDISK® COMPONENTS SUPPLIED BY SEPROTECH SYSTEMS INCORPORATED

1. Upon receipt of mechanical components:

   a. Check packing list for any missing items on delivery.

   b. Motor/Reducer is shipped loose, for assembly on the reducer flange. The reducer is shipped completely filled with synthetic lubricant.

   c. Bearing components are shipped as a set. Open only when ready for assembly, to avoid moisture contamination.

   d. Chain and sprockets are shipped as a set. Check for the following:

   -Large sprocket bushing (O.D.) fits into the large sprocket bore.
   -Large sprocket bushing bore (I.D.) fits the Rotordisk® shaft drive end.
   -Small sprocket bore (I.D.) fits on the reducer output shaft.
   -Cottered chain fits or matches the teeth on the sprockets.

   e. Coupling (applicable only to split-shaft ROTORDISK® is shipped as a set. Check the coupling hubs if they fit the center stub ends of the ROTORDISK®shafts.

   f. Disk banks are shipped pre-assembled on the shaft by SEPROTECH SYSTEMS INCORPORATED and are shipped on A-frames. Handle with care, as the Fiberglass of the disk banks is brittle.

   g. Hardware (bolts, nuts, washers) for mounting the following items are provided:

   -Bearings
   -Reducer
   -Recycle trough

2. If, for any reason, the diskbanks must be removed from the shaft, the procedure for remounting them is as follows:

If disk banks are 5 ft. in diameter or larger (supplied in semicircular sections)

Mount them on shaft(s) as shown on Dwg.# GL-28D, with 1/2-20NFX1-1/2 Bolts. Connect two half sections with two connecting plates (see sketch of typical mounting details) Remove outer nuts on required tie rods, fit connecting plate on tie rods over the end plates, then fasten them together with nuts and washers.

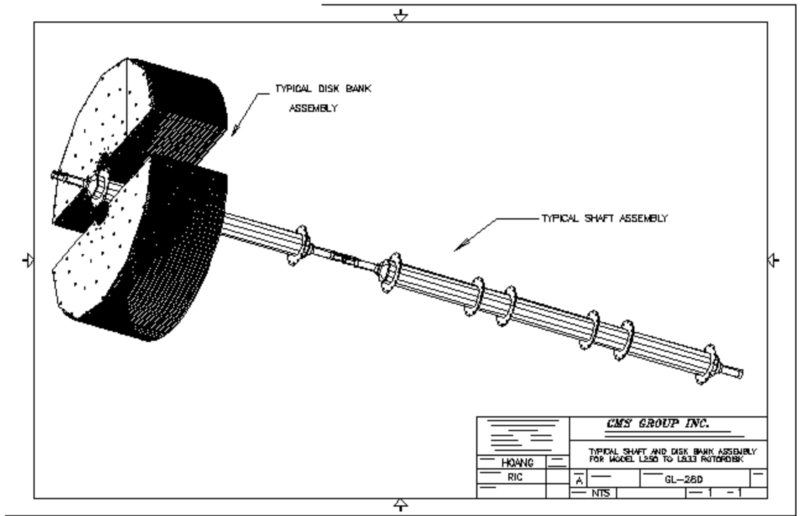


Figure f - typical mounting of disk banks on the shaft(s).

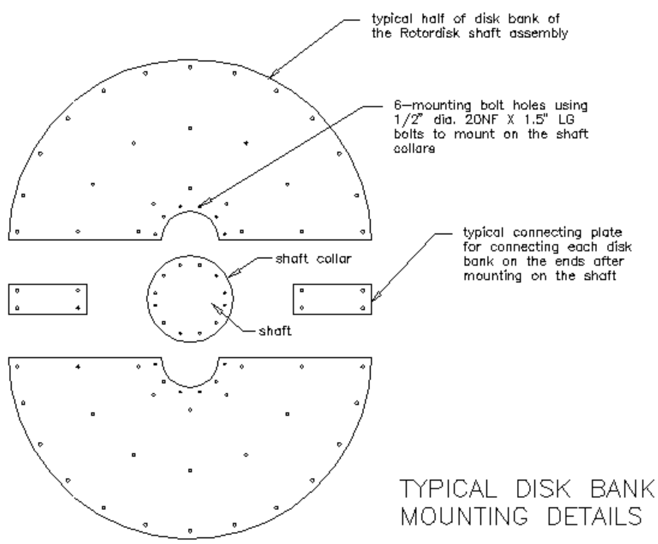


Figure g - exploded view of disk bank mounting parts.

3. Mount Bearings on Shaft(s).

   a) Bearing should be mounted at the centre of stub end. Follow bearing manufacturer's installation instructions.
   b) Use of the bearing fixing rings: one bearing of each pair is "fixed", the other "floating". Install the fixed bearing on the drive end of the shaft and the floating bearing on the non-drive end.

FOR 'L'Rotordisk® models ONLY: On the shaft where the large sprocket will be mounted, fix the bearing into its housing closest to the sprocket. On the other shaft fix the bearing into its housing closest to the coupling (i.e. one bearing should be fixed on every shaft).

NOTE: All bearings mounted on tapered sleeves have to be driven up the taper to the tolerances given in the manual, using a bearing locking tool or equal. See installation, operation and maintenance instructions section of this manual regarding bearings.

4. Mount coupling hubs on their respective shafts (if applicable) so that hub face is flush with the end of its shaft (for direct drive and 'L' models). See installation, operation and maintenance instructions section of this manual regarding couplings.

5. Install shaft(s) in ROTORDISK® tank.

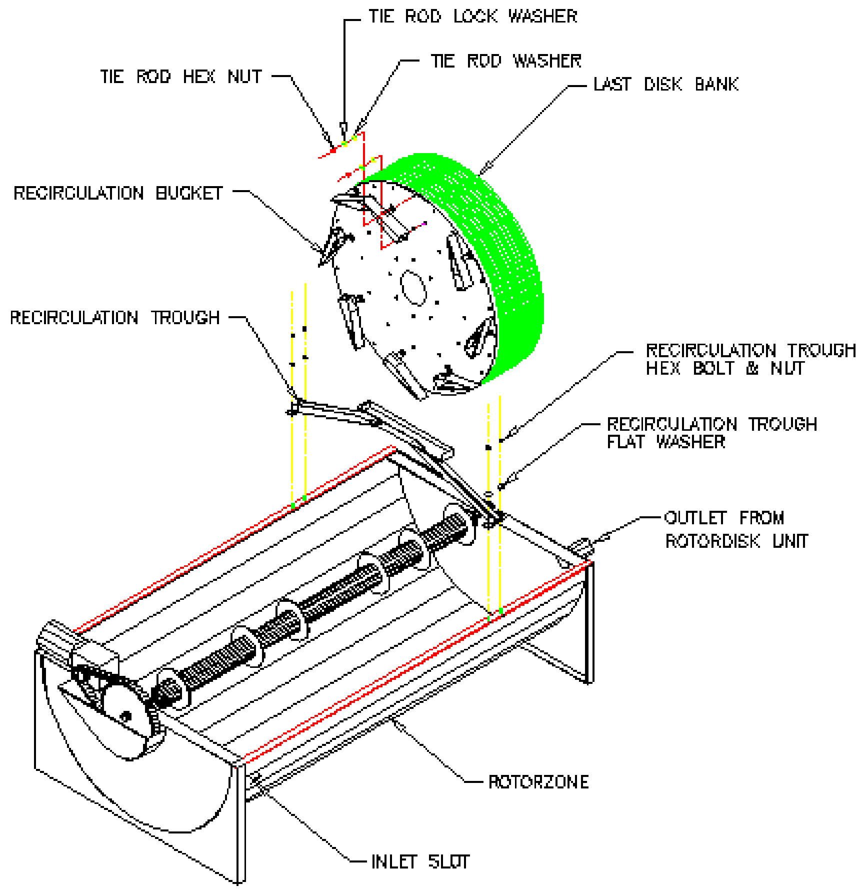
6. Mount small sprocket/coupling hubs on reducer output shaft (whichever is applicable).

7. Install Reducer-Motor Assembly in place. The reducer comes completely filled with synthetic lubricant. Ensure that the breather plug (mounted on top of one of the reducer oil intake ports) is installed on the reducer, after it is mounted on the ROTORDISK®. It is recommended that the motor be mounted into the reducer prior to assembly into the ROTORDISK® tank. Allow for some play in the reducer mounting bolt tightness so the chain tightness can be adjusted later.

8. Connect sprockets with chain. Check the axial alignment of the sprockets while tightening the chain. Tighten the previously loosened reducer mounting bolts after the sprockets are aligned and set in place. See installation, operation and maintenance instructions section of this manual regarding roller chain drives.

9. Connect two coupling hubs, grease, and fit coupling cover (if applicable). Before mounting, check bore on both hubs to match the shaft diameter. See installation, operation and maintenance instructions section of this manual regarding couplings.

10. Mount the stainless steel recycle trough on the ROTORDISK® tank with the bucket opening points to the proper rotation of the shaft.



<u>NOTES:</u>

1. Follow manufacturers instructions in the "Installation & Maintenance Manuals" included by SEPROTECH SYSTEMS INCORPORATED for mounting bearings, couplings (if applicable), reducer, sprockets and chain (if applicable).

2. Make sure all setscrews on sprockets and coupling hubs; bolts on reducer and bearings, are all well tightened before machine goes into operation.

6.0 - ROUTINE MECHANICAL MAINTENANCE OF **ROTORDISK®** SEWAGE TREATMENT PLANTS

6.1 - MOTOR:

If motor is equipped with grease fittings and relief plugs, it should be re-lubricated using a low-pressure gun once a year with Shell Alvenia R2" grease (DO NOT OVER-LUBRICATE). There is no lubrication required for motors without grease fittings and relief plugs

6.2 - REDUCER:

Reduction gear on ROTORDISK® units is filled with synthetic long life lubricant. No inspection or maintenance outside of periodic visual inspection is normally required. If there are no evidence of oil leaks on the seals, the synthetic lubricant must be changed every five (5) years for ROTORDISK® units running 24 hours a day.

Reduction Gear on medium and large ROTORDISK® size units are filled with Shell Tivela 75 oil and does not require oil changes (permanent lubrication). Periodic visual inspection is required. Check oil level and top up to required level with same oil, if necessary.

6.3 - BEARINGS:

Lubricant will deteriorate in time and rate of deterioration is a function of the operating conditions encountered. Lubrication cycle can be determined by analysing the samples taken near the bearing. See bearing manufacturer's maintenance instructions.

6.4 - SPROCKETS AND CHAIN:

(Applicable to non-direct drive ROTORDISK® units)

Chain drive should be inspected every six- (6) months for following points:
- If Chain is covered with grit or chips, it should be cleaned in kerosene and re-lubricated.
- Inspect oil for contamination, such as chips, dirt or grit. Replace oil if necessary (Oil with viscosity of SAE30 at ambient temperature 40^o to 100^o F is recommended).
- Milky white colour of the oil is indicative of flooding. Replace oil and determine the cause of the flood.
-Check Chain tension and adjust if required.

6.5 - COUPLING:

(Applicable for direct drive ROTORDISK® units and 'L' models)

Coupling should be checked for lubricant level. Lubricant is to be added if required. Re-lubrication with NLGI#2 or LTG Grease once a year is usually adequate.

7.0 - TROUBLE SHOOTING

7.1 - MECHANICAL HARDWARE

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
Noisy chain	1. Loose chain 2. Faulty lubrication 3. Misalignment 4. Worn Parts 5. Moving parts rubbing stationary parts	1. Tighten chain 2. Lubricate properly 3. Correct sprocket alignment 4. Replace worn chain 5. Align & tighten chain to clear oil bath
Rapid wear on chain	1. Faulty lubrication 2. Loose or misalign parts	1. Lubricate properly 2. Align & tighten entire drive
Chain climbing sprockets	1. Worn out chain and sprockets 2. Loose chain	1. Replace worn out parts 2. Tighten chain
Stiff chain	1. Misalignment 2. Worn out chain or sprockets 3. Faulty lubrication 4. Rust corrosion	1. Correct alignment 2. Replace worn out parts 3. Lubricate properly 4. Clean and lubricate
Noisy Bearing	Rollers or bearings damaged	Replace bearing cartridge
Bearing grease discoloured or mixed with water	Insufficient grease in the bearings	Purge bearing with grease and increase lubrication interval
Hot bearing	1. Improper lubrication 2. Rollers or bearing race damaged	1. Purge bearing with grease and decrease lubrication interval 2. Replace bearing cartridge
Reducer temperature rises above 200 degrees Fahrenheit.	Oil level too high or too low	Maintain proper oil level
Oil leakage from reducer	1. Oil seals need to be replaced 2. Ventilators/breather plugged causing pressure build-up inside the reducer. 3. Oil level too high	1. Replace oil seals 2. Clean Ventilators 3. Correct oil level
Noisy reducer	1. Bearing failure 2. Misalignment in worm gear inside 3. Coupling between motor and reducer worn out and misalign	1. Check bearings and replace if necessary 2. Align worm gear shafts. 3. Replace coupling between motor and reducer. Align coupling hub vertically
Noisy Motor	Bearing damage	Replace damaged bearings
Motor overheating	1. Reducer overheating 2. Cooling fins on motor are clogged 3. Overload 4. Rotor rubbing on stator 5. Over greasing or lubrication	1. Check reducer 2. Clean fins 3. Check for excess friction or imbalance 4. Replace bearings 5. Avoid packing grease too tightly
Motor won't start	1. Power trouble 2. Single phasing at station 3. Fuse blown	1. Check source of power supply 2. Do not try to make it go and "fry" motor. Check starter windings 3. Replace fuse
Knocking/rumbling on motor bearings	1. Bearing worn due to lack of lubrication or excessive mechanical overload 2. bearings slack in housing	1. Replace bearing and put new grease of recommended grade. 2. Fir new end shields
Rotordisk® shaft doesn't turn	1. Power failure 2. Motor failure 3. Reducer failure 4. chain drive failure	1. Check power supply 2. Check and replace motor and bearings. 3. Check teeth worn gears and bearings. Replace necessary parts 4. Replace chain

7.2 - ROTORDISK® PROCESS

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
1. Slime on media appears shaggy with a brown colour	PROPER OPERATION	NO PROBLEM NORMAL CONDITION
2. Black slime growing on disks	Solids and/or BOD overloading	**a.** Pre-aerate RBC influent **b.** For severe organic overloads, increase recycle rate **c.** De-sludge unit **d.** Place another RBC unit in parallel
3. Rotten egg or other obnoxious odors	Solids or BOD overloading	See Problem 2, solutions a, b, c and d, above
4. Development of odors and white biomass over most of the media surface	1. Septic influent wastewater or high hydrogen sulfide or sulfate concentration	**e.** Determine the cause of the problem and correct it at source. For example, aerate equalization tank **f.** Pre-aerate influent wastewater **g.** Determine the cause of the problem, possibly with the addition of chlorine or hydrogen peroxide; potassium permanganate has also been used
	2. Overload first stage	**a.** Check dissolved oxygen levels to confirm overload problem **b.** Increase number of recycle buckets
5. White slime	1. Bacteria that feed on sulfur compounds. Also, industrial discharges containing sulfur compounds may cause an overload	▪ See Problem 2, solutions a and b above
	2. Grease on the disks	**a.** Remove grease at source **b.** Install grease traps
6. Sloughing or loss of slime (biomass)	1. Toxic or inhibitory substances in influent, including abrupt pH changes	**a.** Eliminate source of toxic or inhibitory substances **b.** Reduce peaks of toxic or inhibitory substances by carefully regulating inflow to plant **c.** Dilute influent using plant effluent or any other source of water **d.** See Problem 7.4
	2. Variation in flow or organic loading	**a.** - During low flow or loading periods, pump from secondary clarifier or 4th stage RBC unit effluent to recycle water with food and dissolved oxygen through the RBC unit **b.** - During high flow or loading conditions, attempt to throttle plant inflow during peak periods **c.** - For severe organic under loads, add a cheap source of soluble carbon in the PST such as molasses

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
7. Decrease in process efficiency	1. Reduced wastewater temperature	**a.** Decrease air opening in RBC building **b.** Heat air inside RBC unit cover or building
	2. Unusual variations in flow or organic loading	▪ See Problem 6, cause 2, solutions a and b above
	3. Sustained flows or loads above design levels	▪ Install additional treatment units
	4. High or low pH values	▪ Adjust pH to near neutral
	5. Improper rotation of media	▪ Inspect chain tension and adjust
8. Accumulation of solids and clogging in the RBC system	Solids removal in pre-treatment steps is not adequate	**a.** Improve pre-treatment efficiencies **b.** Provide supplemental aeration to help prevent solids from settling **c.** De-sludge primary tank
9. Floating or rising sludge in the secondary clarifier	Removal of sludge from the clarifier is inadequate	**a.** Increase the duration of pumping sludge from the clarifier **b.** Remove sludge from the clarifier more often
10. Excess shaft weight or biomass thickness	1. Organic loading too high	▪ Decrease organic loading
	2. Stage loading too high	**a.** Increase number of recycle buckets
	3. Inorganic solids accumulation because of inadequate pre-treatment	▪ Check primary treatment and grit removal equipment for proper operation
	4. Accumulation of minerals	▪ Use chemical pre-treatment to eliminate minerals
	5. Digester supernatant adding excessive BOD or sulfides	▪ Modify supernatant pumping frequency
11. Shaft rotation non-uniform or "jerky"	1. Normal variations in balance	▪ Time rotation by quarters. A difference of less than 3 seconds in quarter rotation time is normal
	2. Uneven biomass weight due to power outage	**a.** If severe, shut unit down and wash down disks **b.** Turn off the unit temporarily and rotate manually to uniformly wet biomass growth before restarting **c.** Decrease or stop flow of wastewater to affected units **d.** contact manufacturer for assistance

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
12. Effluent quality apparently below requirements	1. Organic loading too high	**a.** Add additional operating RBCs **b.** Identify cause of additional loading and eliminate at source **c.** Add supplemental air to RBC trough
	2. Sampling or testing procedures inaccurate	**a.** If nitrification is occurring, analyze for carbon BOD only by using nitrification inhibitor **b.** Check for contaminated dilution water, sampler lines, or improper sampling storage
	3. Inadequate secondary clarifier operation	**a.** Clean and de-sludge clarifier **b.** Modify sludge removal procedures to eliminate BOD kickback **c.** Install filters after clarifier **d.** Increase alum dose to enhance flocculation
	4. Anaerobic solids in the RBC tanks producing BOD kickback	▪ Flush or drain tanks
13. Snails or other nuisance organisms in RBC tanks	Nutritional and conducive environment for reproduction of hard-bodied shell snails ($^1/_8$" - $^1/_2$" in size)	**a.** Addition of controlled dosages of chlorine. Physical removal may be required with taking units out of service temporarily **b.** Contact manufacturer

Contact SEPROTECH SYSTEMS INCORPORATED for advice on how to resolve problems related to the process before making changes to the process or equipment.

Adapted from Water Pollution Control Federation "Manual of Practice OM-10", 1988.

8.0 - MAINTENANCE PROGRAM – Do’s and Don’ts

DO'S

1. Do use biodegradable soap if at all possible. The system will however handle a certain amount of normal soap. When laundering clothes, please follow manufacturer's instructions regarding quantity of detergent. Excessive use of detergent can cause odour in the system.

2. Do put large amounts of grease in a container and dump in garbage. The system will handle a certain amount of fat and grease. If a tile bed is used and if fats and grease get into it, they may plug the pores of the soil and seal up the bed. Never put large amounts of grease (i.e. old grease from deep fryer) into the sewer lines.

3. Have your system pumped out a minimum of once a year to remove sludge and scum to maintain top operating treatment in your system and filter bed.

4. For small systems equipped with a service hatch, keep the service hatch above the ground. Do not let run-off water enter system, as this will cause hydraulic overload.

5. If a tile bed is used, do keep traffic such as cars, snowmobiles, etc., away from the system bed areas as they will break pipes and seal the soil over the bed.

6. If a tile bed is used, do leave the raised filter in place without disturbing it. The filter is specifically designed to provide maximum dispersal of the water. Altering it by adding fill, covering it up or changing in any way may destroy its water dispersal characteristics and result in bed failure.

7. If a tile bed is used, do encourage a growth of ground cover over the filter bed as it helps disperse water by evaporation and transpiration.

DON'Ts

1. Do not put non-biodegradable materials downs the drain, put them in the garbage, these include any plastics, rubber, disposable diapers, sanitary napkins, rubber goods, cigarettes, children's toys, cellophane, etc. They will plug the system, and a pump out will be needed.

2. Do not put harsh chemicals down the drain. They will kill the bacteria necessary for efficient treatment. These include acid or caustic cleaners, gasoline, oil, turpentine, photographic chemicals, etc. Disinfectant and chlorine bleaches should be kept to domestic uses.

3. Do not leave taps running or faulty toilets. The excess water may overload the system and, if used, tile field causing breakout and poor treatment.

4. If you do not have access to workers with appropriate training, do not attempt to fix the mechanical parts yourself. Your dealer is trained to repair your plant and work safely with electrical and mechanical components. Call him if you have a problem or concerns.

5. Do not connect any other electrical load to the fuse or breaker feeding the plant as it will cause damage to the controls.

6. Never put large amounts of grease (i.e. old grease from deep fryer) into the sewer lines.

YOUR CO-OPERATION WITH RESPECT TO THE ABOVE POINTS SHOULD ENSURE TROUBLE-FREE OPERATION OF YOUR TREATMENT PLANT AND WILL BE GREATLY APPRECIATED.

9.0 - INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS FOR VARIOUS MECHANICAL PARTS OF THE **ROTORDISK®** AND OTHER EQUIPMENT SUPPLIED

9.1 INSTALLATION & MAINTENANCE DETAILS FOR ROLLER CHAIN DRIVES

CHAIN TENSIONING:

The proper fit of a chain may be obtained by adjusting the sprocket centres. When a chain is correctly tensioned, the total mid-span movement (double amplitude) in the slack span should be 4-6% of the span length for normal drives.

Where there is no adjustment means, adjustment may be made by removing links to compensate for elongation due to wear (Drives with fixed centres). Proper lubrication and proper drive maintenance may minimize chain wear.

LUBRICATION:

Although many slow speed drives operate successfully with little or no lubrication beyond the initial factory lubrication, proper lubrication will greatly extend the useful life of every chain drive.

A good grade of clean petroleum oil without additives, free from flowing at the prevailing temperatures should be used.

Chain drives should be protected from abrasive and corrosive conditions, and the oil supply kept free of contamination. Periodic oil change is desirable. The lubricant viscosity recommended for ambient temperature 40^o - 100^oF is SAE 30.

OIL BATH:

With bath lubrication, the lower strand of chain runs through a sump of oil in the drive housing. The oil level should reach the pitch line of the chain at its lowest point while operating. Only a short length of chain should run through oil.

INSTALLATION RECOMMENDATIONS:

Shafting, bearings and foundations should be supported rigidly to maintain the initial alignment. Roller chain should be free of grit and dirt. Wash chain in kerosene when required. Re-lubricate!

Misalignment results in uneven loading across the width of the chain and may cause roller link-plate and sprocket tooth wear. Drive alignment involves two things:

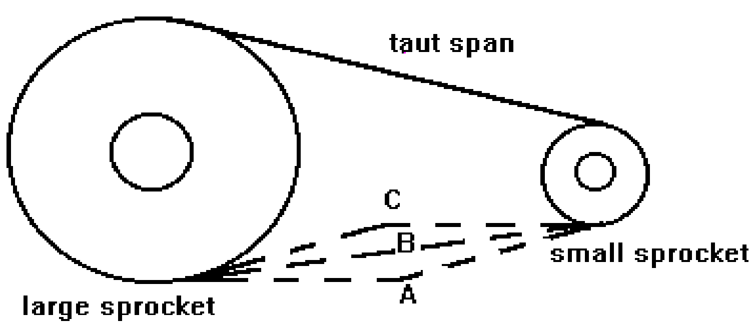
a) Parallel shaft alignment: Shafts should be parallel and level.
b) Axial sprocket alignment: Sprocket axial alignment can be checked with a straight edge, which will extend across the finished sides of the two sprockets.

Normally, it is good practice to align sprockets as close to the shaft bearings as possible.

Installing the Chain: Recheck all preceding adjustments for alignment and make sure all setscrews, bolts and nuts are tight. Fit chain around both sprockets and bring free ends together around one sprocket for connection.

Chain Tension: Check chain tension to be sure that the slack span has 4-6% mid-span movement in horizontal drives.

Recommended Possible Mid-Span Movement AC									
Drive	Tangent Length Between Sprockets								
Center-Line									
	5”	10”	15”	20”	30”	40”	60”	80”	100”
Horizontal to 45	.25”	.5”	.75”	1”	1.5”	2”	3”	4”	5”
Vertical to 45	.12”	.25”	.38”	.5”	.75”	1”	1.5”	2”	2.5”



AC = Total Possible Mid-Span Movement
Depth of Free Sag = .866 AB, approximately

MAINTENANCE RECOMMENDATIONS:

Regular maintenance schedules should be followed for all chain drives. Each drive should be inspected every six months. At each inspection period the following points should be checked:

a) Check Lubrication: If chain is covered with grit or chips, it should be cleaned in kerosene and re-lubricated before reinstalling. With bath lubrication, oil should be maintained at the proper level, as shown in lubrication instructions. Add oil if necessary. At each inspection, oil should be checked for contamination, such as chips, dirt or grit.

b) Check sprocket alignment: If the chain is properly aligned, no wear will show on the inner surfaces of the chain roller link-plates. If wear is apparent, this is evidence that sprockets are misalign and should be realigned as outlined in the installation instructions to prevent further chain and sprocket wear.

c) Check sprocket tooth wear: If sprocket shows evidence of wear high on the sprocket teeth, this is evidence of excessive wear in the chain, the chain should be replaced. If the sprocket teeth are severely worn, the sprocket should be replaced. Do not run new chain on worn sprockets.

d) Check chain tension: At each inspection period, the chain tension should be adjusted. If excessive slack has accumulated which cannot be removed by available shaft centre adjustment (i.e. by moving reducer away from large sprocket using chain tensioning bolts), two or more pitches of chain should be removed and chain reconnected.

9.2 PROCEDURE FOR ASSEMBLING BEARINGS AND PILLOW BLOCKS

Shaft Preparation
Clean shaft and remove any burrs or sharp edges. Check the shaft diameter to given specifications.

Seal Installation
Place seal, which consists of: Double lip 'G' type seal

MOUNTING OF BEARING ON SHAFT

Adapter Sleeve Mounting
Position adapter sleeve on the shaft to correct location with respect to required bearing centerline. A smear of lubricating oil (SAE 10 or 20) applied to the sleeve outside diameter surface results in easier bearing mounting and removal. (For pillow blocks mounted close to a pulley hub or similar obstruction, mount the adapter sleeve with threads inboard for easy removal. Remember to slide lock-nut, lock-washer and bearing onto the shaft before positioning the sleeve.)

NOTE: All bearings mounted on tapered sleeves have to be driven up the taper to the tolerances given in SKF tables, to ensure correct fits. Spherical roller bearings can be measured between the unloaded rollers and the outer ring sphere surface.

Un-mounted Clearance, Spherical Roller Bearings
Measure the un-mounted internal clearance in the bearing by inserting and sliding progressively larger feeler blades the full length of the roller between the most vertical unloaded rollers and the outer ring sphere. Never run the rollers over the feeler blade, as the wrong value will be obtained. Record the measurement of the largest size blade that will slide through. This is the un-mounted internal clearance.

Bearing
Mount the bearing hand tight on the adapter sleeve. Be sure the large end of the bore of the inner ring matches the taper of the adapter. To avoid damage to the bearing it is most important during this and subsequent operation that the shaft is blocked up so the bearing is unloaded. Do not apply lock-washer. Drive up procedure may damage it.

Bearing Drive Up, Spherical Roller Bearings
Lubricate the face and thread of the lock nut and apply to sleeve with chamfered face toward the bearing. Tighten the lock nut. Do not attempt to tighten the lock nut with a hammer and drift (use proper wrenches), the lock nut can be damaged and chips can enter the bearing. Further tighten the lock nut and measure the internal clearance until the internal clearance is less than the un-mounted clearance figure by the amount shown in the attached table (see last page). Finally, remove lock nut, position lock washer with outer tangs facing away from the bearing, and inner tang properly seated in the slot provided in the adapter. Replace lock nut and tighten until firmly seated.

PREPARATION OF PILLOW BLOCK HOUSING

Check to be sure all pillow block parts are free of burrs and are completely clean. Internal surfaces should be removed. Apply a thin coat of grease to the bearing seat in the base. Fit the bearing and seal inserts into the pillow block base, being careful not to damage to O-rings. For assembling larger sizes where hoists must be used, it may be convenient to seat both bearings into their housing bases simultaneously.

<u>FIXING RINGS</u>

On each shaft one bearing is generally "Held" and other bearings are "Free", to permit shaft expansion. For "Held" bearing housings, use two fixing rings. Place one on each side of bearing.

<u>CAPPING THE PILLOW BLOCK</u>

Place the cap on the base so that the dowel pins in the base align with the holes in the cap, being careful not to damage the O-rings. Caps and bases are <u>not</u> manufactured for interchangeable assembly. They must be kept together. Install cap-bolts with lock washers and tighten securely.

<u>GREASE LUBRICATED BLOCKS</u>

Lubrication Notes

<u>Grease Lubrication</u>

If grease is used as a lubricant, it should be smeared between the rolling elements and worked in. The lower half of the housing should be packaged $^1/_2$ to $^3/_4$ full.

PROCEDURE FOR APPLYING LUBRICANT TO BEARINGS AND PILLOW BLOCKS

Pack each bearing as completely full of the specified grease as possible by swiveling the outer ring open and rotating it as necessary to inject the grease. Then, swivel the outer ring closed being careful not to use force in the event a roller end catch the corner of the outer ring sphere.

B) Before assembling the pillow block cap to the base, and after completing bearing and base assembly, fill $^1/_2$ to $^3/_4$ of the pillow block <u>base</u> with the same lubricant that was used to pack the bearing.

LUBRICATION PROCEDURE TO BE USED AT START-UP

A) All pillow block assemblies that have not been prepared for stage are ready for use, assuming the installation procedures have been correctly followed.

B) While shaft is rotating, lubricate each seal through the outside lubricant fittings until grease is seen emerging from the labyrinth areas. Make sure the outside of the lubricant fitting is clean before applying grease.

RE LUBRICATION

Lubricants deteriorate in time, and the rate of deterioration is a function of the lubricant used at the operating conditions encountered. Determining the re-lubrication cycle depends on sampling the grease and analysis of the samples. Provisions must be made to adequately evaluate the contamination by solids. Samples for grease evaluation should be taken from near the bearing, and evaluation of the samples should dictate the re-lubrication cycle.

Remove caps once a year and re-apply new grease.

Each seal assembly should be lubricated once a month, while the bearing is rotating, with the same grease that is used in the bearing.

GREASE CLASSIFICATION

		Oil Viscosity Saybolt Second (approx. SSU)		
Class	Type of Base (1)	@ 100 F	@ 210 F	NLGI (2) Grade
A	Lithium or Equal	200 - 500	48 – 55	0
B	Lithium or Equal	400 - 600	58 – 68	1
C	Lithium or Equal	800 - 1,000	75 – 82	1
D	Lithium only	800 - 1,000	75 – 82	2

	Grease requirement from above			
Operating temperature of bearing (4)	Low (5)	Medium	High	Suggested Re-lube cycle
0 – 70	A or B			6 – 12 months
70 – 120	B or C			6 – 12 months
120 – 160	B or C	C or D (6)	D (7)	2 - 3 weeks
160 – 200	C	C or D (6)	D (7)	1 - 4 weeks

1) Calcium Complex Greases NOT recommended for spherical roller bearings.

2) National Lubricating Grease Institute Consistency Code.

3) Definition of speed categories:
Low: up to 1/4 of catalog speed limit for static oil lubrication.
Medium: 1/4 to 1/2 catalog speed limit for static oil lubrication.
High: 1/2 to full catalog speed limit for static oil lubrication.

4) Consult SKF Engineering if temperature is below 0^o or above 200^oF.

5) Extremely slow speed will require special consideration if loads are high.

* Under all conditions, application should be checked using the SKF lubricant film parameter found in the Engineer Data Catalog.

6) Use type "C" where load is heavy, 15,000 hours-rating life or less and/or speed are less than RPM.

7) Consult SKF Engineering - Grease lube not normally recommended under this combination of operating conditions.

8) Dry clean applications only. For moderate conditions of dirt and/or moisture, use cycle of 1 to 2 months. For extreme conditions of dirt and/or moisture, use cycle of 1 week. Vertical applications normally require shorter than normal re-lube cycle.

9) Never mix greases with unlike bases.

10) Remove old grease at least once a year.

10 - LIMITED WARRANTY

SEPROTECH SYSTEMS INCORPORATED warrants the parts in each treatment plant to be free from defects in material and workmanship; for a period of 15 months from shipment or 12 months from start-up, whichever occurs first, in the treatment of domestic wastewater. Sole obligation under this warranty is as follows:

SEPROTECH SYSTEMS INCORPORATED shall fulfil this warranty by repairing or exchanging any component part, F.O.B. our factory, that in SEPROTECH SYSTEMS' judgement, shows evidence of defects, provided said component part has been paid for and is returned through an authorized dealer, transportation prepaid. The warranty must also specify the nature of the defect to the manufacturer. New placed parts are under warranty for one year.

The warranty does not cover treatment plants that have been flooded, by external means, or that have been disassembled by unauthorized persons, improperly installed, subjected to external damage or damage due to altered or improper wiring or overload protection.

This warranty applies only to the treatment plant and does not include any other electrical wiring, plumbing, drainage, or disposal system. SEPROTECH SYSTEMS INCORPORATED is not responsible for any delay or damages caused by defective components or material, or for loss incurred because of interruption of service, or for any other special or consequential damages or incidental expenses arising from the manufacture, sale, or use of this plant.

SEPROTECH SYSTEMS INCORPORATED reserves the right to revise, change, or modify the construction and design of the treatment plant for domestic wastewater or any component part or parts thereof without incurring any obligation to make such changes for modifications in previously sold equipment. SEPROTECH SYSTEMS INCORPORATED also reserves the right, in making replacements of component parts under this warranty, to furnish a component part, which, in its judgement is equivalent to the Company part replaced.

Under no circumstance will SEPROTECH SYSTEMS INCORPORATED, be responsible to the warrantee for any other direct or consequential damages. Including but not limited to; lost profits, lost income, labour charges, delays in production, and/or idle production, which damages are caused by a defect in material and/or workmanship in its parts.

This warranty is expressly in lieu of any other expressed or implied warranty, excluding any warranty of merchantability or fitness, and of any other obligation on the part of SEPROTECH SYSTEMS INCORPORATED.

Appendix E.3

Model N30 – Milne Inlet Camp

ROTORDISK®
Aerobic Wastewater
Treatment Plant

Model B30
Shanco Baffinland
Project #60069

ROTORDISK®
Aerobic Wastewater Treatment Plant
Model B30

INSTALLATION, OPERATION AND MAINTENANCE MANUAL

Shanco Baffinland
Project #60069

Seprotech
Water. Pure and Simple

ROTORDISK®

Wastewater Treatment Plant
Model B30

INSTALLATION, OPERATION & MAINTENANCE MANUAL

August 2007

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INSTALLATION, OPERATION AND MAINTENANCE

MANUAL

TABLE OF CONTENTS

IMPORTANT: READ THIS INSTALLATION PROCEDURE PRIOR TO START-UP.

1.0 SITE INSTALLATION OF ROTORDISK® SEWAGE TREATMENT PLANTS:

1.1 (applies to Steel Tankage only)

When there is a complete ROTORDISK® unit supplied, site preparation is as follows:

A level concrete or well-compacted gravel base is to be supplied by Customer/Contractor.

Unit to be lifted only at lifting points by use of hooks and spreader bars.

All anchoring and levelling of ROTORDISK® on site to be done by customer/contractor. Check alignment of shaft and sprockets and clearances of couplings where applicable prior to start-up, failure to do so may void manufacturer's warranty. Refer to this ROTORDISK® manual for details. If required, the contractor must perform levelling.

All hydraulic piping, to and from the unit, is to be supplied and installed by customer/contractor.

All input electric and hydro hook-ups to be done by customer/contractor to local governing regulations and a signed approval sent to SEPROTECH SYSTEMS INCORPORATED. Under no circumstances must electrical connections, junction boxes or equipment pertaining to the electrical function of the unit be installed in the ROTORDISK® tank.

SEPROTECH SYSTEMS INCORPORATED GROUP INC. will supply a man on-site to assist customer/contractor at a specified rate and at customer/contractor discretion.

If unit is not shipped completely assembled assembly instructions and drawings will be supplied.

IMPORTANT: READ THIS INSTALLATION PROCEDURE PRIOR TO START-UP.

1.2 - (applies to Concrete Tankage for ROTORDISK® only)

If the ROTORDISK® unit supplied is to be encased in concrete tankage, the site preparation is as follows:

The unit is lowered into the concrete tankage, the pipe at the end of the unit is placed into the opening of the intermediate wall between the primary and final settlement chambers and lowered onto the anchor bolts (contractors supply).

Unit to be lifted only at lifting points by use of hooks and spreader bars.

All anchor bolts (contractors supply) should be correctly located in concrete in a vertical position. In addition, all bolts should include a levelling nut.

All anchoring and levelling of ROTORDISK® on site to be done by customer/contractor. When the unit is set onto the anchor bolts in the concrete tank, it must be levelled to a slope of no more than 3/4" in 20' along the length. The unit is then centred in the tank and completely bolted down.

After the unit has been bolted down, check alignment of shaft and sprockets and clearances of couplings where applicable prior to start-up, failure to do so may void manufacturer's warranty. Refer to this ROTORDISK® manual for details. If required, the contractor must perform levelling.

All hydraulic piping, to and from the unit, is to be supplied and installed by customer/contractor.

All input electric and hydro hook-ups to be done by customer/contractor to local governing regulations and a signed approval sent to SEPROTECH SYSTEMS INCORPORATED. Under no circumstances must electrical connections, junction boxes or equipment pertaining to the electrical function of the unit be installed in the ROTORDISK® tank.

SEPROTECH SYSTEMS INCORPORATED will supply a man on-site to assist customer/contractor at a specified rate and at customer/contractor discretion.

If unit is not shipped completely assembled assembly instructions and drawings will be supplied. (As shown)

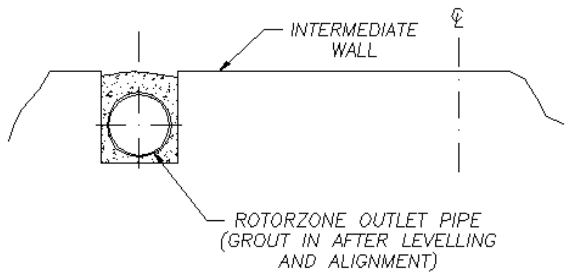


Figure a - **ROTORDISK®** tank outlet through intermediate wall between settlement tank chambers.

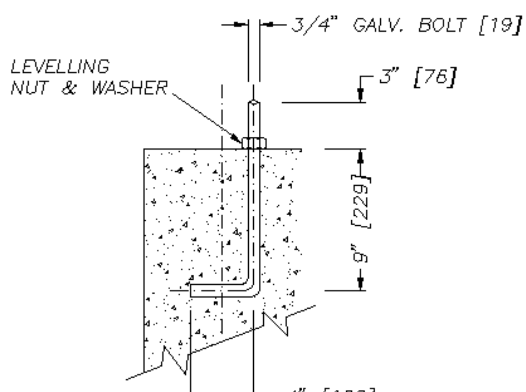
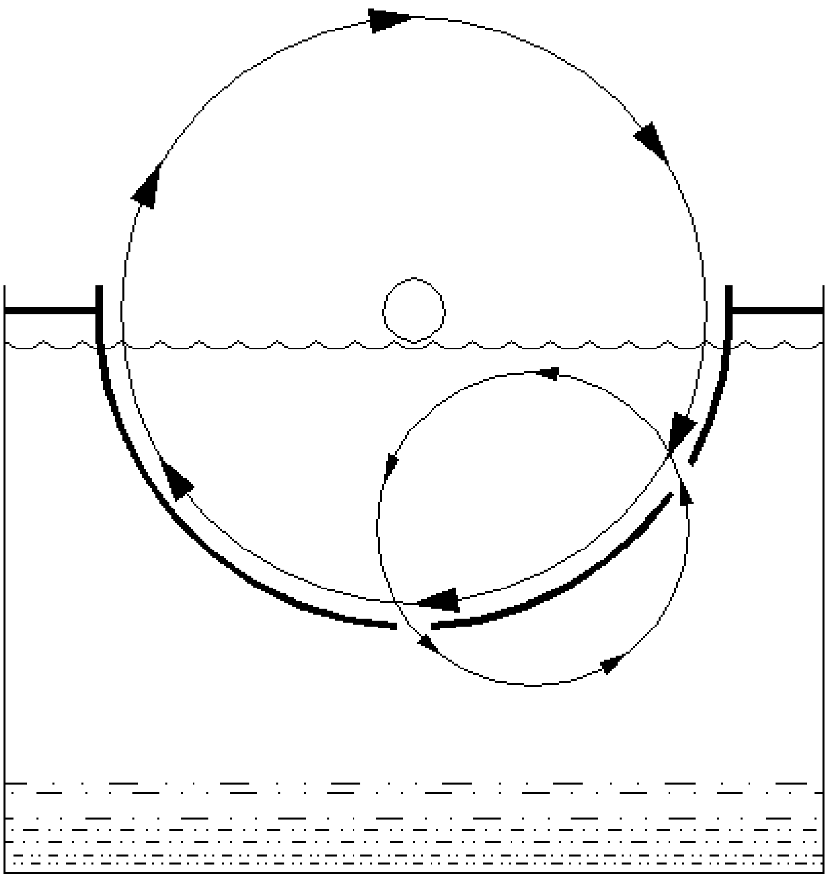


Figure b - anchor bolt detail for **ROTORDISK®** tank.

1.3 - DIRECTION OF SHAFT ROTATION



The direction of shaft rotation should be such that disks mounted on shaft will enter water on the side where inlet to "Rotorzone" is located. The electric motor driving the shaft should be wired accordingly.

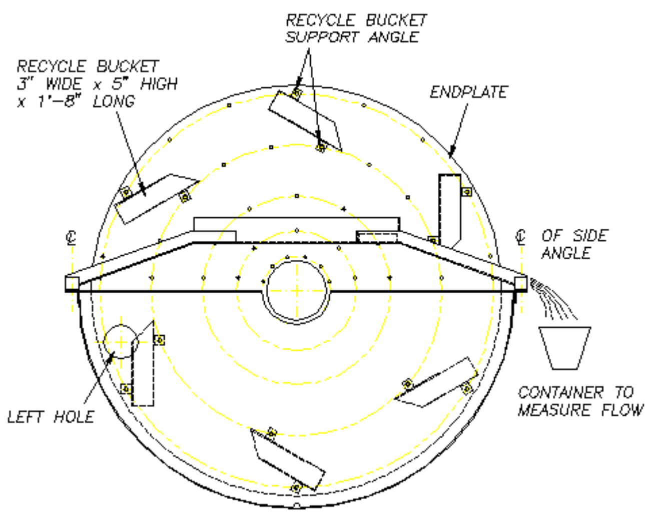
1.4 - DISSOLVED OXYGEN (D.O.) RECYCLE for ROTORDISK®

1.4.1 Recycle buckets are mounted on the last stage of the ROTORDISK®. These buckets rotate at the same speed as the disks. See the attached elevation view of the recycle buckets and trough on the Rotorzone tank.

1.4.2 As the disks rotate, the buckets scoop-up treated wastewater. As this wastewater falls into the recycle trough, it is exposed to the atmosphere, where it absorbs fresh oxygen. The wastewater then cascades on one side of the trough through a narrow steel channel and mixes back with the contents of the Primary Clarifier, thereby introducing fresh dissolved oxygen in the Primary Clarifier. See the section of diskbank assembly showing buckets and recycle trough.

1.4.3 The set-up described above is comprised of the recycle buckets and recycle trough, is what we term as our D.O. re-circulation device. This is especially advantageous to preventing septic conditions from occurring in the Primary Clarifier in small flow or low flow situations.

1.4.4 It is **important** to measure the **actual recycle rate** on the **ROTORDISK®**. This data is compared to our theoretical recycle rate designed. This is advantageous prior to connecting and setting-up for service. Using a container (5 gallon bucket is ideal) and a stopwatch, record the water flowing out of the effluent channel of the recycle trough. Make 3-5 readings, and report this data to SEPROTECH SYSTEMS INCORPORATED for future reference.



SECTION OF DISKBANK ASSEMBLY
SHOWING 6 BUCKETS
AND RECYCLE TROUGH

1.5 - SUMMARY OF OPERATION

(ROTORDISK® systems designed for BOD/SS/Ammonia/Nitrate removal)

A). The sewage plant (as supplied by SEPROTECH SYSTEMS INCORPORATED) is comprised of five (5) main components: the primary settling tank, the RBC tank, the denitrification tank, the secondary settling tank and the multi-media filters.

B). The RBC tank is the aerobic section of the treatment plant divided into four (4) stages.

Raw sewage is pumped and/or gravity flows into the primary settling tank (PST). When the sewage is pumped into the plant, pumping must simulate conditions encountered in gravity fed systems. Indeed, over a 24-hour period, the plant is designed to handle a flow rate corresponding to the Average Daily Flow (ADF) and can accommodate for two Peak Daily Flow (PDF) periods of two (2) hours per day. Each PDF event can be at a maximum of three times ADF.

In the PST, sedimentation separates heavy solids from the bulk of the liquid and the supernatant enters the aerobic section through the inlet slot located at the front section of the RBC tank.

The aerobic section is made up of four stages. The 1st stage is mounted on one common shaft. This 1st stage is comprised of one (1) to three (3) disk banks. The normal colour of the bacteria in the 1st stage is dark brown. This is the stage where most of the BOD removal by biological oxidation occurs. The succeeding 2nd, 3rd, and 4th stages are mounted on the rest of the shaft or another common shaft. Each stage has one (1) to three (3) disk banks. It is in the 2nd stage that further BOD is removed, and nitrifying bacteria (those which convert ammonia (NH_3) in the form of ammonium ions (NH_4^+) into nitrite (NO_2^-) and, ultimately, nitrate (NO_3^-)) start to predominate in the 3rd and 4th stages. The 4th and last aerobic stage has recycle buckets that introduce both fresh dissolved oxygen into the primary settling tank and nitrifying bacteria present in the recycled water.

The rotation of the disks in and out of the water provides a mean of air and heat transfer from the ambient air to the water. The transfer of air to the water is important for aerobic bacteria to remove BOD and ammonia. The transfer of heat to the water is important to maintain the water at an optimum temperature of 15 °C and above such that BOD and ammonia removal rates by the bacteria are maximised (removal rates are a function of the water temperature). Because maintaining a temperature that provides acceptable removal rates is important to the process, RBC's are installed indoors and ambient air is maintained at 15 °C and above.

C). The media in the denitrification section is completely submerged since denitrifying bacteria convert nitrate (NO_3^-) to nitrogen gas (N_2) in an anoxic (i.e., in the absence of dissolved oxygen (DO)) environment.

(Text missing pending completion of patent application process.)

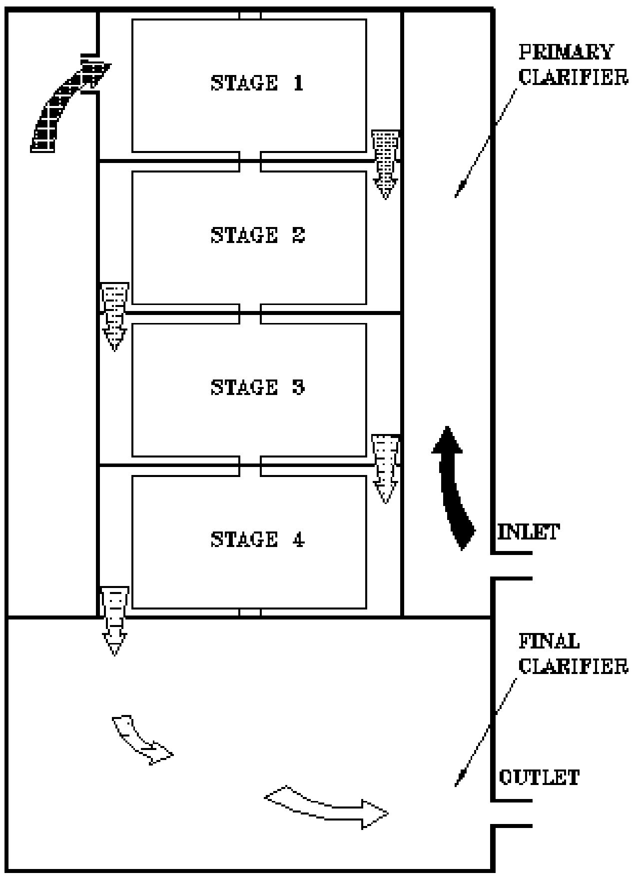
The denitrification section is comprised of two stages separated by a baffle. An equal amount of media is provided in both stages.

D). Partially treated water from the denitrification section then enters the secondary settling tank. Sloughed off biomass from the disks and media bundles and other suspended solids is further settled in this chamber.

E). The partially treated water is then fed to three (3) multi-media filters using one of two (2) submerged pumps. The purpose of these filters is to further reduce the concentration of suspended solids in the final effluent.

2.0 - ROUTINE VISUAL CHECKS ON PHYSICAL AND BIOLOGICAL FUNCTIONING OF ROTORDISK® & DESCRIPTION OF TREATMENT PROCESS

ROTORDISK® sewage treatment plants have three major steps in the purification process. In the primary settling tank, gross solids separate from the flow by either sinking or floating. In the Rotorzone, dissolved pollutants are broken down to simple, non-pollutant compounds by the bacteria ("biomass") which grows on the rotating disks. The final settling tank permits gravity separation of spent biological growth, which continually sloughs off the disks in the Rotorzone preceding it.



2.1 - PRIMARY SETTLING TANK (PST OR PRIMARY "CLARIFIER")

The accumulation of floating scum on the surface of the primary clarifier is normal. It is proportional to the accumulation of settle-able solids at the bottom of the tank. Periodic (9-12 months) removal of sludge at the bottom of the tank is required for proper operation of the Unit.

If no sludge measuring device is available, the accumulation of 9"-12" depth of scum on the surface is a good indication that it is time to remove the accumulated deposits of sludge from the bottom of the tank(s).

2.2 - ROTORZONE

The Rotorzone is subdivided into four sections, with disk banks in each. The wastewater first enters the Rotorzone in the section marked "1" in the sketch (furthest away from the inlet to the plant). The flow then proceeds through sections 2, 3, and 4 before entering the denitrification zone.

The accumulation of biological growth will be greatest in section 1, and gradually decrease through subsequent sections. Generally, the growth will be thick, and often filamentous ("stringy"), in section 1, becoming thinner and more compact through sections 2-4.

The colour of the growth will typically be dark brown to black in Section 1. Some grey growth may also be noticed, depending on the relative load and type of wastewater being treated. Growth in sections 2-4 will typically vary from medium brown to a light brown or tan growth in section 4.

In a well-functioning unit with the appropriate feed of wastewater, there will be an earthy, humus-like ("musty") smell inside the unit. A substantial sour, "sewage" smell may be an indication of sub-optimal conditions in the treatment process.

2.2.1 - 'BATHTUB RING'

The wastewater flows by gravity within a ROTORDISK® Plant thus the water level is relatively constant. Changes in water level of 1" to 2" are not unusual due to surge flows entering the unit. The evidence of this is a 'bathtub ring' 1" - 2" above the normal level. A 'bathtub ring' higher than this suggests that partial or complete flooding of the unit has occurred since the last check. If so, the (gravity or pump) discharge system should be checked for blockages or mechanical malfunction. Another condition which can lead to the level of water rising to greater levels than 1" – 2" is if the plant is fed by pumps that exceed the design limits of the plant (i.e., ADF over a period of 24 hours including a maximum of two (2) PDF events no longer than 2 hours each).

2.3 – ACETIC ACID INJECTION SYSTEM

One of the most important building blocks of life is carbon. The bacteria responsible for denitrification need carbon in an organic form to grow and thus convert nitrate to nitrogen gas. Most soluble organic carbon (often measured in terms of Biochemical Oxygen Demand or BOD) has been consumed in the aerobic section of the wastewater treatment plant and there is thus very little left for the denitrifiers by the time the wastewater reaches the denitrification section of the plant. It is for this reason that acetic acid (vinegar), an easily biodegradable organic carbon source, is injected at the inlet of the denitrification zone.

The system provided consists in a 125 imp. gal. storage tank (ϕ=30", H=49") equipped with a mixer and of a dosing pump of maximum capacity 12.3 l/h mounted on a skid.

The dosing pump can be controlled in either of two ways: by a 4-20 mA signal coming from the flowmeter located on the effluent outlet pipe (the system is programmed to be operated that way by default) or by a dry contact (by others) located outside SEPROTECH SYSTEMS INCORPORATED's main control panel. For example, that dry contact (by others) could be closed when the pumps (by others) feeding the wastewater treatment plant are running and opened when they are not.

The target dose of pure acetic acid (CH_3COOH) in the water is: 175 mg/litre. Assuming that commercial acetic acid is at a concentration of 12% by weight, this means that the target dose of commercial acetic acid at the inlet of the denitrification section would be 1460 mg of commercial acetic acid per liter of water. At ADF (i.e., 49,000 litres per day), this corresponds to a dosing rate of 2.9 litres of commercial acetic acid per hour. If the 4-20 mA signal from the flowmeter is used to control the dosing pump (again, this is the default mode), then the actual dosing rate will be $3 \times 2.9 = 8.7$ litres of commercial acetic acid per hour one third of the time since the flow exiting the plant (via the flowmeter) is pumped from the FST to the multi-media filters at a rate of $3 \times \text{ADF} = \text{PDF}$ (i.e., 147,000 litres per day).

The average daily quantity of commercial acetic acid necessary has been estimated at 70 l/day (15.4 imp. gal per day) based on an ADF of 49,000 litres/day.

2.4 – DENITRIFICATION ZONE

(Text missing pending completion of patent application process.)

In the denitrification zone, the media is completely submerged such that anoxic conditions (i.e., the absence of Dissolved Oxygen (DO) in the water) prevail and thus the denitrification process (i.e., the conversion of nitrate (NO_3^-) to nitrogen gas (N_2)) can take place. The denitrification zone includes two (2) stages that are separated by a baffle.

2.5 – FINAL SETTLING TANK (FST OR FINAL "CLARIFIER")

The effluent near the outlet at the backside of the final clarifier should be relatively clear and colourless and relatively free of suspended matter. Clarity can best be judged by scooping a small volume of the final effluent into a clear glass container. This is particularly true of larger units where the depth and dark colour of the tank walls may make clarity hard to determine. (Note: Although the risk of infection is very small, the wearing of rubber gloves is a rational safety precaution when hand-scooping the effluent for a clarity check. This is particularly true if there are open cuts on the hands.)

Although the final effluent itself should be relatively clear, some floating matter may accumulate on the surface of the final clarifier. This is normal, and will typically be much less than the accumulation of floating scum in the primary clarifier.

2.6 – FILTERS FEED PUMPS LOGIC AND LEVELS IN THE FST

The level in the FST is controlled in the following manner:

- Level Switch Low (LSL or float #1): both filter feed pumps (each of capacity = 3 × ADF) stop when this level is reached;
- Level Switch High (LSH or float #2): lead filter feed pump starts when this level is reached;
- Level Switch High High (LSHH or float #3): lag filter feed pump starts (lead filter feed pump is maintained in operation) and an alarm goes off when this level is reached (i.e., the alarm light is activated);
- Overflow: the FST is equipped with an outlet that can be connected directly to the storm sewer in the exceptional case that the plant is overflowed (piping between this outlet and the storm sewer is out of SEPROTECH SYSTEMS INCORPORATED' scope of supply).

2.7 – POST FILTRATION SYSTEM

The clarified water is pumped from the FST to three multi-media filters operating in parallel. The purpose of these multi-media filters is to reduce further the concentration of suspended solids in the treated wastewater.

The three filters operated in parallel are designed to treat peak low rates (PDF) of 3 times the design average daily flow (ADF) and are fed at this flow rate since each filter feed pump also has a capacity of PDF.

Each of the three filters is filled with anthracite, sand and garnet with gravel underbedding. The water is filtered from top to bottom of each filter with the coarser filtration media placed on top and the finer on the bottom of the filter. Each vessel is made of fibreglass. In normal operation (i.e., when all 3 filters operate in parallel), the filtration velocity is about 10 m/h on each filter.

A backwash of one of the three filters is performed approximately every 4 hours. The filters are backwashed alternately, i.e., filter no. 2 gets backwashed approximately 4 hour (exactly 4 hours + the time it takes to backwash and rinse a filter) after filter no. 1 gets backwashed and filter no. 3 gets backwashed approximately 4 hour after filter no. 2 gets backwashed. These operating parameters are adjustable on the plant's main control panel (see Section 2.9). When a backwash occurs, the water pumped at PDF from the FST is fed to two of the filters and the filtrate from these is used to backwash the third filter from bottom to top (inverse direction than in filtration mode). The two filters used to produce the filtrate operate at velocities of approximately 15 m/h while the third filter gets backwashed at a velocity of approximately 30 m/h.

The filtration system is controlled by the main control panel for the plant. The automatic diaphragm valves installed on the filtration unit are pneumatic and are thus opened and closed using compressed air. A compressor is provided with the plant. The compressed air transits through a filters solenoid valves panel.

2.8 – MONITORING OF DISCHARGE FLOW RATE

The plant is equipped with a magnetic flow meter located on the clean effluent's discharge pipe. This instrument is equipped with a counter that allows tracking of the total volume of clean effluent discharged by the plant. As mentioned in paragraph 2.3, the flow meter is also used to control the injection rate of acetic acid. A thermal chart recorder was also provided in order to produce hardcopies of the flow measurements taken by the flowmeter.

2.9 – OPERATING PARAMETERS ADJUSTABLE ON THE CONTROL PANEL

The following operating parameters were set as default in the Programmable Logic Control (PLC) panel provided with the plant but are adjustable within the ranges shown below. Making changes and adjustments to the default plant's operating parameters requires a good understanding of the wastewater treatment process and should therefore only be performed by qualified and trained staff. Please contact SEPROTECH SYSTEMS INCORPORATED if assistance is needed to optimise the operation of the plant.

	T1 Time between backwashes	T2 Time for a backwash	T3 Time for rinse	T4 Time between sludge pumping	T5 Time for sludge pumping
Factory Setting	4 h	10 min	5 min	1.0 h	0.25 min
Minimum	1 h	5 min	2 min	0.5 h	0.10 min
Maximum	18 h	30 min	30 min	12.0 h	1.00 min

2.10 - FREQUENCY OF INSPECTION

Visual checks every week should be sufficient. However, for better preventative maintenance of the wastewater treatment plant and thus the capital investment, a daily walk through is often the preferred frequency of visit. Many owners prefer the visual and audible (look and listen) walk through. A standard operator checklist should be prepared and used by the person responsible for periodic maintenance of the plant at every visit. SEPROTECH SYSTEMS INCORPORATED can assist in preparing such checklist upon request.

The acetic acid storage tank should be topped off every time the plant is being visited.

The pressure loss on every filter should also be controlled. Two pressure gauges were provided for this purpose, one on the inlet pipe and one on the outlet pipe of each filter. The pressure drop across a filter shouldn't exceed 15 PSI. If it does even after a filter has been backwashed, the frequency and/or duration of backwashes should be increased.

3.0 - STANDARD RECOMMENDATIONS AND PROCEDURES FOR SLUDGE REMOVAL

3.1 - STORAGE CAPACITIES

A design feature of ROTORDISK®, which contributes greatly to overall simplicity of the process, is the sizing of clarifiers to accommodate static internal sludge storage for extended periods. Depending on such factors as raw wastewater solids concentrations, and design organic loading in a given application, maximum sludge storage levels will typically be reached in 6-9 months of operation.

This period is based on calculated rates of initial decomposition of raw and biological solids, and, upon operating experience, indicating the degree of auto-digestion/compacting, which proceeds during the storage period. The 6-9 month period will be shortened to the extent that design hydraulic and waste loads are exceeded. It will be lengthened to the extent that flows and waste load are less than those designed for.

3.2 - DETERMINATION OF ACCUMULATED SLUDGE VOLUMES

The accumulation of maximum storage capacities can be indirectly monitored through visual observation of the thickness of the scum blanket on the surface of the primary clarifier. When the scum blanket has matured to a height of approximately 7"-10", this is a good indication that sludge accumulations at the bottom of both clarifiers are at or near maximum levels, and that sludge withdrawal is indicated.

A more accurate procedure of determining sludge levels is to directly measure actual accumulations, and compare these to the maximum storage capacities listed on the "Details" section of the general arrangement drawing for the ROTORDISK® model in question.

A variety of sludge measuring devices is commercially available. The two most common are the weighted hollow tube type, and, the (electronic) turbidity-change detector type. The former is less costly, relatively easy to use, and more appropriate because of the low frequency with which measurements need to be made in a ROTORDISK® unit.

Whatever means of measuring the sludge may be selected, it must be kept in mind that the sludge is <u>not</u> a firm solids substance. Domestic wastewater sludge is mostly trapped water and other liquids. Only to determine sludge levels by "feeling" for a solid layer with a stick or pole. The settled sludge is far more liquid than the surface scum, which is perhaps 30-40% solids by volume.

Irrespective of the type of device used, sludge levels should be measured at several locations in each settlement tank to ensure a reasonably accurate calculation of accumulated volumes. This is required since sludge accumulation levels are not uniform; being highest at the inlet ends of both clarifiers, and, below the slot at the bottom of the first section of the Rotorzone trough.

Once an average sludge height has been determined, multiply by the surface area of the clarifier in question to determine the existing volume of stored sludge. Compare to maximum design capacity listed on the general arrangement drawing. If the accumulated levels equal or exceed design values, it is time to remove the sludge from the unit.

3.3 - SLUDGE REMOVAL

A pump-out truck of the same type that pumps out septic tanks normally does the sludge removal. For smaller ROTORDISK® units, the entire liquid contents of the treatment plant can be withdrawn. For larger installations, the haulage contractor should be instructed to get the suction hose directly to the bottom of the tanks and withdraw the sludge only, while taking as little of the supernatant as possible. Once the primary sludge is withdrawn from the primary settlement tank, the supernatant of the secondary clarifier can be transferred to the primary settlement tank to expose the secondary sludge. The suction hose should be placed down at a multiple number of points to help ensure complete removal of accumulated sludge deposits. Floating surface scum should also be removed. Haulage contractors should be given a brief description of the unit and its operation if they are not already familiar with it. A particular point to emphasise is that the biological growth on the disks should not be washed off, but should be left in place. The exception to this is if the disks have accumulated excess biomass due to sludge pump out being delayed past the indicated intervals.

Sludge removed from the unit is normally hauled away by the pumping truck and disposed of at municipal facilities, or, by controlled spreading on farmland. On-site disposal in shallow trenches and/or some form of on-site volume reduction (prior to export) may be feasible or desirable depending on the specific opportunities and limitations afforded by the site of a given installation.

3.4 - POTENTIAL CONSEQUENCES OF OPERATING ROTORDISK® UNITS PAST DESIGNATED MAXIMUM SLUDGE STORAGE LEVELS

Sludge accumulations should be removed once they reach indicated maximum storage levels, because failure to do so could result in lowered treatment efficiency, and possibly cause serious damage to the structure of the Rotating Assembly and drive unit. The potential for problems is as described below and depicted in the attached sketches.

Figure (c) shows a unit operating with sludge build-ups at or near maximum storage levels. This will cause no problem since the storage heights are designated so that flows through the primary clarifier will not disturb the sludge layer. Characteristics of wastewater reaching the Rotorzone at this time (and since start-up) will be in the range of 180-200 mg BOD/1 and 50-250 mg SS/1. The supporting structure of the rotating assembly is over designed for the amount of biological build-up which will occur on the disks under this operating condition, and the shear force of the rotation through the trough water will limit the thickness of growth.

However, if sludge is allowed to accumulate past designated storage heights, flow through the primary clarifier will begin to disturb the sludge blanket, and thus carry loads of solids and dissolved organic matter into the Rotorzone which are not anticipated in the design of the unit (Figure d). The pollutant load reaching the biomass on the first stage of disks will overload that biomass (in terms of F:M ratio), and force a change in its activity and growth. The biomass becomes more gelatinous, and does not shear off as well with disk rotation. Additionally, the biomass will readily adsorb and entrap the extra solids with the sum effect being an increase in weight on the rotating assembly that considerably exceeds that which its design is based on.

This tendency reaches its extreme if sludge is allowed to accumulate to the point where it will be disturbed by-, and caught up in -, the re-circulation pattern created by the two slots in the trough on the first section of the Rotorzone (see Figure e).

The sludge will have characteristics in the order of 20,000 mg TSS/1 and 10,000 mg BOD/1, so it is obvious that even a minor amount of this material caught up in the re-circulation flow will significantly increase the concentration of the waste stream entering the Rotorzone. If, for example, the sludge was caught up in the recycle flow at a ratio of as little as 1:10 or 1:15, the resulting concentration would be sufficient to produce a considerable first-stage overload on an amount of disk area selected based on normal concentrations.

The resulting build-up of poorly-shearing gelatinous biomass and trapped solids would pose a serious potential for strain on the drive unit, and for structural damage to disk bank assemblies and shaft, in spite of them being considerably over designed for loads anticipated in normal operation.

Clearly, these potential problems should be avoided by the removal of sludge once it reaches the level specified as maximum for the ROTORDISK® unit in question.

3.5 - FRONT VIEW SCHEMATIC OF ROTORDISK®

UNIT OPERATING AT-, AND ABOVE-,
RECOMMENDED MAXIMUM SLUDGE STORAGE LEVELS

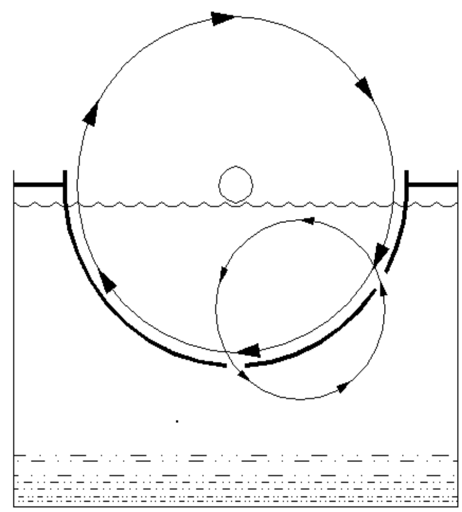


Figure c-unit operating at maximum sludge storage levels. Neither influent flows, nor re-circulating flows, disturb sludge blanket.

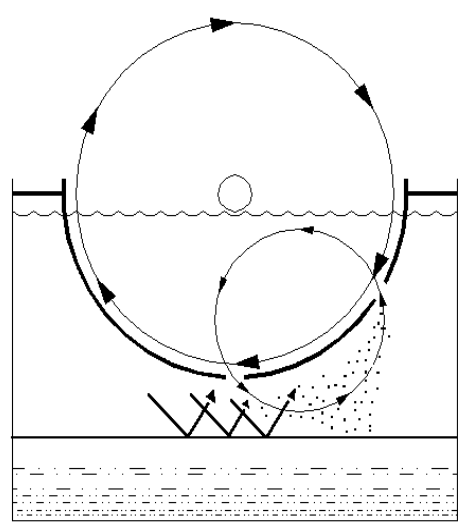


Figure d- unit operating with excess accumulations. Influent flows may disturb sludge blanket and increase BOD and solids loads to Rotorzone to levels above treatment design.

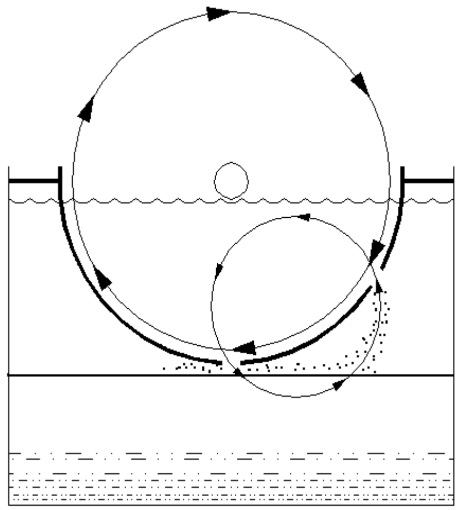


Figure e-Unit operating with excess sludge accumulated to base of Rotorzone. Both influent flows and re-circulation flows will disturb and carry sludge solids. Increase in BOD and solids loads entering Rotorzone will be substantially above design treatment levels, increase accumulated masses on rotating assembly, produce potential for damage to structure and drive unit.

3.6 - PUMPOUT PROCEDURES FOR ROTORDISK® TREATMENT SYSTEMS (summary)

Using suction hose, floating or surface scum should be removed first. Place the suction hose directly to the bottom of the tank and withdraw sludge only, while taking as little as possible of the volume of waste liquid above the sludge blanket (supernatant).

Move the hose at multiple number of points along the bottom of the settlement tanks. Do not wash off biological growth (biomass) on the disks. The exception to this is excess accumulated biomass on the disks due to an overdue sludge pump-out. Excess accumulated biomass is when a disk bank is 100% fully covered with biomass and the colour is grey with a slight odour.

Keep a record of all pump-outs to arrive at an actual normal operating interval for sludge pump-outs. For systems with several flow meters, it is also beneficial to note the total flow generated between pump-outs.

3.7 - START-UP PROCEDURES OF ROTORDISK®

WARNING: A VALVE LOCATED AT THE BOTTOM OF THE DENITRIFICATION TANK AND EQUIPPED WITH A REMOTE ACTUATION MECHANISM WAS PROVIDED WITH YOUR UNIT. THIS VALVE:

- Needs to be OPEN: when the plant is first filled with water, during draining if the plant ever requires such operation and during subsequent refilling operations. FAILURE TO OPEN THIS VALVE DURING FILLING AND DRAINING WILL RESULT IN SERIOUS DAMAGE TO THE PLANT. This is because, during a filling operation, the water rising in the PST would push the denitrification tank upwards while it is empty (this tank wouldn't have had a chance to fill with water until the water level reaches the inlet slot between the PST and the aerobic ROTORDISK®. Th open valves provide a mean of filling the PST and the through (denitrification tank included) at the same time.

- Needs to be CLOSED: during normal operation of the plant. Indeed, the denitrification section contains water already partly treatment thus this water and that contained in the PST shouldn't mix. FAILURE TO CLOSING THIS VALVE DURING NORMAL OPERATION OF THE PLANT WILL RESULT IN A POOR QUALITY EFFLUENT.

The ROTORDISK® sewage treatment plant is based on a fixed film treatment process referred to as the Rotating Biological Contactor (RBC). In this process, micro-organisms or bugs are attached and grown on the surface of a media, the quantity of bugs being directly proportional to the amount of food in the wastewater. When starting up a new system, it will normally take about two weeks to get organic removal from the wastewater and three to four weeks to establish the nitrification process at normal domestic sewage temperatures. The method of and effluent discharge during system start-up should be discussed and thoroughly communicated with the environmental authority. The primary sedimentation tank and RBC of the system should, preferably, be filled with fresh water before admitting wastewater to the system. A flow less than design is not a problem. The biomass will develop themselves on the media. If there is a small flow only a portion of the disk will have biomass. As the flow increases the amount of biomass will increase.

Seeding a ROTORDISK® with activated sludge, although not required, can be accomplished. The activated sludge should be at the same temperature as the influent. Sudden changes in wastewater temperature cause biomass sloughing. In most cases, the use of domestic waste as a seed culture has provided the required biomass for continuous operation. When seeding the ROTORDISK® with activated sludge is decided, the primary sedimentation tank and RBC of the system should first be filled with fresh water (preferably) and the activated sludge added to the RBC. The RBC should be rotating at all times. The wastewater introduced to the tank needs to have only 20% of the disks covered with waste. This can already provide the needed wetting and still provide some time to reach normal operating levels when source flow is introduced. The final clarifier does not need to be filled with anything.

Alternately, seeding can be accomplished using dry bacteria and a source of organic carbon such as raw molasses or sugar. This can be done, for example, in situations where wastewater or activated sludge are not available and the plant needs to be ready to treat wastewater very shortly after it begins receiving it. By simulating the conditions encountered in wastewater (where large amounts of organic carbon and bacteria are present), biomass will establish on the ROTORDISK® and the plant can thus be prepared to work under actual conditions before these are actually encountered. SEPROTECH SYSTEMS INCORPORATED can help find appropriate supplies of both dry bacteria and raw molasses.

The preferred start up is the introduction of source wastewater at design or less than design loading. The disks need to be rotating at all times. When the disks are rotating and wastewater is introduced the biomass will develop and the pollutants will be removed.

The practice of starting up a sewage plant with a charge of septage or activated sludge may be appropriate for suspended growth systems where sludge return is an essential and necessary part of the process. However, start-up with septage is <u>not</u> an appropriate practice for fixed film systems such as the Rotating Biological Contactor process and is <u>not</u> recommended. This is especially true of the ROTORDISK® process and its static, internal storage of sludge.

Studies have shown that the natural start-up time for a ROTORDISK® is 2 1/2 – 3 weeks (normal temperatures and BOD reduction only), and that it has already developed sufficient biomass for 50% removals in only 1 week. These are time frames significantly shorter than respective ones for suspended growth systems. Thus there is little rationale for “pre-starting” a ROTORDISK® unit with septage.

Further, septage contains solids that are already well digested, and therefore not subject to further digestion-compaction in the storage zones. This contrasts to the fresh solids, which will undergo considerable digestion-compaction in the 6 – 9 months after initial settlement. Therefore, a charge of septage would contribute disproportionately to the accumulation of sludge levels, and necessitate a shorter interval to the first pump-out of the unit.

The ROTORDISK® concept of static sludge storage contributes greatly to its overall operation and maintenance simplicity. Following the above guidelines and recommendations will help ensure that the trouble-free simplicity of ROTORDISK® is maintained.

4.0 - STORAGE OF **ROTORDISK®** SEWAGE TREATMENT EQUIPMENT

If the unit is not to be operated for an extended period, then the motor-reducer assembly (drive unit) should be removed from its mound and stored at room temperature in a reasonably dry area (unless the whole unit is being stored in such an area).

Additionally:

1. Reducer: The input shaft should be given several turns once a month to re-lubricate the upper bearings.

NOTE: Some reducers are shipped to site filled with synthetic lubrication. Otherwise, fill the reducer with the lubricant (see reducer section of installation & maintenance instructions).

2. Motor: The motor has a tendency to take on moisture when not in operation. It requires no attention during storage, but before it goes into operation the insulation should be measured using a Meger. It should be at least 1.0 mega-ohm. If below 1.0 mega-ohm, it has taken on excessive condensation, and must be dried out before being operated. (Note: any electrical contractor or repair shop commonly understands these terms and procedures).

3. Support bearings on main ROTORDISK® shaft(s) should be re-lubricated prior to start-up.

4. The system should not be installed and operated in water. In the absence of sewage inputs and normal biological activity, freezing and consequent mechanical damage would be a distinct possibility. Water level in the primary settlement tank to be dropped to below the bottom of the Rotorzone tank level, if freezing of the tank contents is possible.

5.0 - ASSEMBLY PROCEDURE OF ROTORDISK® COMPONENTS SUPPLIED BY SEPROTECH SYSTEMS INCORPORATED

1. Upon receipt of mechanical components:

   a. Check packing list for any missing items on delivery.

   b. Motor/Reducer is shipped loose, for assembly on the reducer flange. The reducer is shipped completely filled with synthetic lubricant.

   c. Bearing components are shipped as a set. Open only when ready for assembly, to avoid moisture contamination.

   d. Chain and sprockets are shipped as a set. Check for the following:

   -Large sprocket bushing (O.D.) fits into the large sprocket bore.
   -Large sprocket bushing bore (I.D.) fits the Rotordisk® shaft drive end.
   -Small sprocket bore (I.D.) fits on the reducer output shaft.
   -Cottered chain fits or matches the teeth on the sprockets.

   e. Coupling (applicable only to split-shaft ROTORDISK® is shipped as a set. Check the coupling hubs if they fit the center stub ends of the ROTORDISK®shafts.

   f. Disk banks are shipped pre-assembled on the shaft by SEPROTECH SYSTEMS INCORPORATED and are shipped on A-frames. Handle with care, as the Fiberglass of the disk banks is brittle.

   g. Hardware (bolts, nuts, washers) for mounting the following items are provided:

   -Bearings
   -Reducer
   -Recycle trough

2. If, for any reason, the diskbanks must be removed from the shaft, the procedure for remounting them is as follows:

If disk banks are 5 ft. in diameter or larger (supplied in semicircular sections)

Mount them on shaft(s) as shown on Dwg.# GL-28D, with 1/2-20NFX1-1/2 Bolts. Connect two half sections with two connecting plates (see sketch of typical mounting details) Remove outer nuts on required tie rods, fit connecting plate on tie rods over the end plates, then fasten them together with nuts and washers.

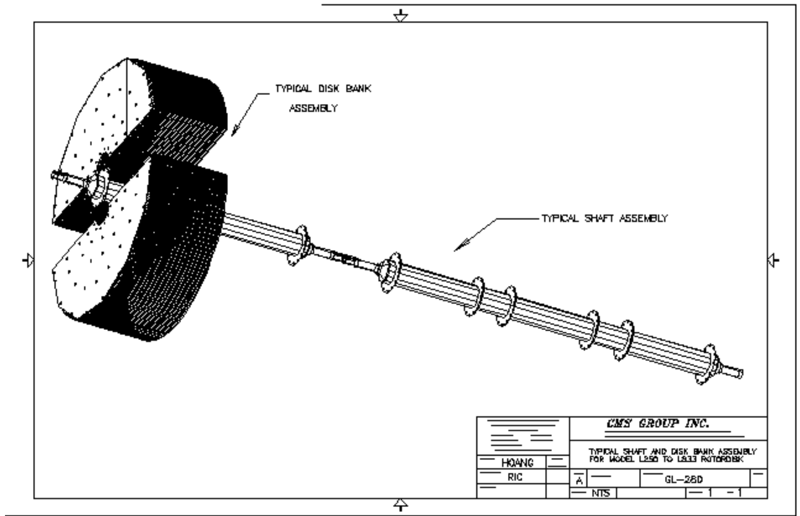


Figure f - typical mounting of disk banks on the shaft(s).

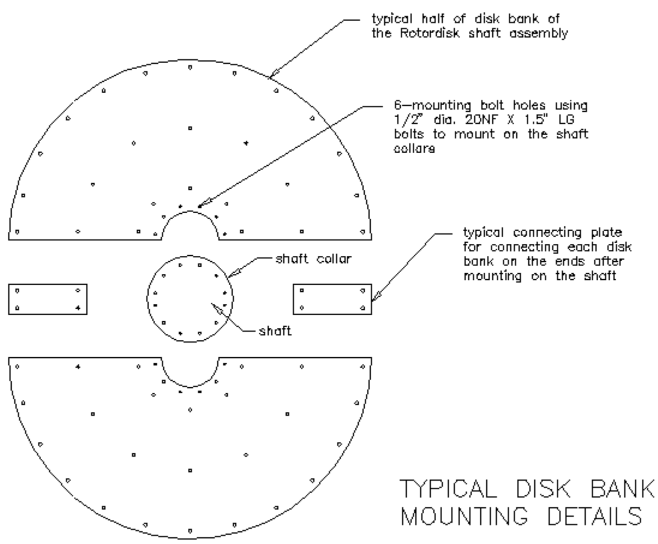


Figure g - exploded view of disk bank mounting parts.

3. Mount Bearings on Shaft(s).

a) Bearing should be mounted at the centre of stub end. Follow bearing manufacturer's installation instructions.
b) Use of the bearing fixing rings: one bearing of each pair is "fixed", the other "floating". Install the fixed bearing on the drive end of the shaft and the floating bearing on the non-drive end.

FOR 'L'Rotordisk® models ONLY: On the shaft where the large sprocket will be mounted, fix the bearing into its housing closest to the sprocket. On the other shaft fix the bearing into its housing closest to the coupling (i.e. one bearing should be fixed on every shaft).

NOTE: All bearings mounted on tapered sleeves have to be driven up the taper to the tolerances given in the manual, using a bearing locking tool or equal. See installation, operation and maintenance instructions section of this manual regarding bearings.

4. Mount coupling hubs on their respective shafts (if applicable) so that hub face is flush with the end of its shaft (for direct drive and 'L' models). See installation, operation and maintenance instructions section of this manual regarding couplings.

5. Install shaft(s) in ROTORDISK® tank.

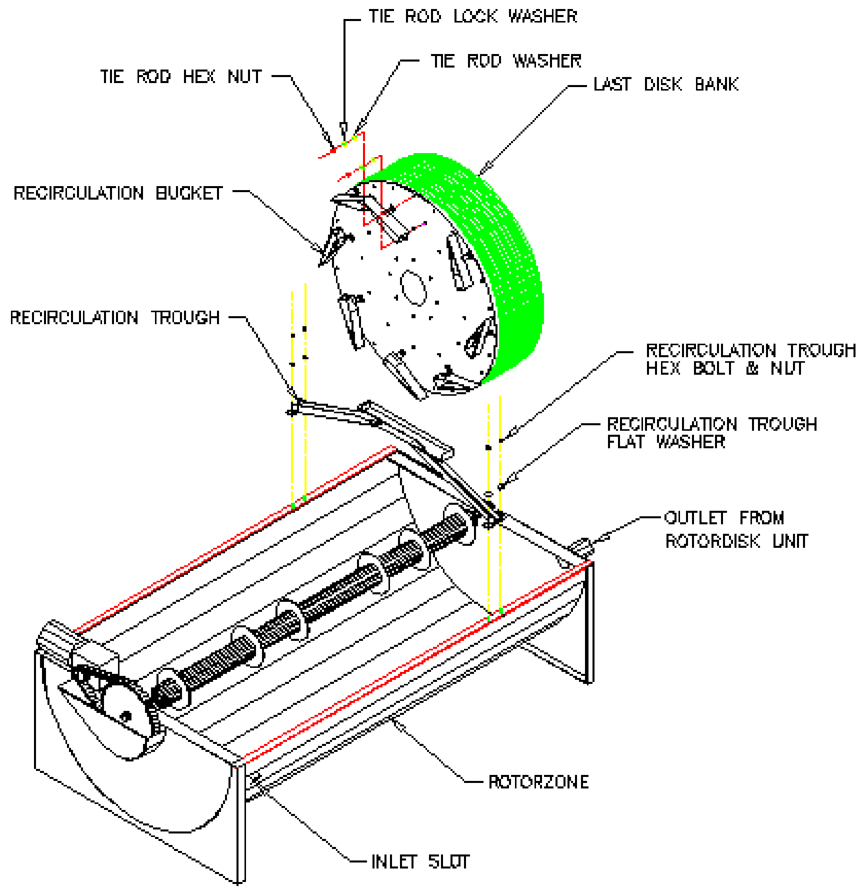
6. Mount small sprocket/coupling hubs on reducer output shaft (whichever is applicable).

7. Install Reducer-Motor Assembly in place. The reducer comes completely filled with synthetic lubricant. Ensure that the breather plug (mounted on top of one of the reducer oil intake ports) is installed on the reducer, after it is mounted on the ROTORDISK®. It is recommended that the motor be mounted into the reducer prior to assembly into the ROTORDISK® tank. Allow for some play in the reducer mounting bolt tightness so the chain tightness can be adjusted later.

8. Connect sprockets with chain. Check the axial alignment of the sprockets while tightening the chain. Tighten the previously loosened reducer mounting bolts after the sprockets are aligned and set in place. See installation, operation and maintenance instructions section of this manual regarding roller chain drives.

9. Connect two coupling hubs, grease, and fit coupling cover (if applicable). Before mounting, check bore on both hubs to match the shaft diameter. See installation, operation and maintenance instructions section of this manual regarding couplings.

10. Mount the stainless steel recycle trough on the ROTORDISK® tank with the bucket opening points to the proper rotation of the shaft.



NOTES:

1. Follow manufacturers instructions in the "Installation & Maintenance Manuals" included by SEPROTECH SYSTEMS INCORPORATED for mounting bearings, couplings (if applicable), reducer, sprockets and chain (if applicable).

2. Make sure all setscrews on sprockets and coupling hubs; bolts on reducer and bearings, are all well tightened before machine goes into operation.

6.0 - ROUTINE MECHANICAL MAINTENANCE OF **ROTORDISK®** SEWAGE TREATMENT PLANTS

6.1 - MOTOR:

If motor is equipped with grease fittings and relief plugs, it should be re-lubricated using a low-pressure gun once a year with Shell Alvenia R2" grease (DO NOT OVER-LUBRICATE). There is no lubrication required for motors without grease fittings and relief plugs

6.2 - REDUCER:

Reduction gear on ROTORDISK® units is filled with synthetic long life lubricant. No inspection or maintenance outside of periodic visual inspection is normally required. If there are no evidence of oil leaks on the seals, the synthetic lubricant must be changed every five (5) years for ROTORDISK® units running 24 hours a day.

Reduction Gear on medium and large ROTORDISK® size units are filled with Shell Tivela 75 oil and does not require oil changes (permanent lubrication). Periodic visual inspection is required. Check oil level and top up to required level with same oil, if necessary.

6.3 - BEARINGS:

Lubricant will deteriorate in time and rate of deterioration is a function of the operating conditions encountered. Lubrication cycle can be determined by analysing the samples taken near the bearing. See bearing manufacturer's maintenance instructions.

6.4 - SPROCKETS AND CHAIN:

(Applicable to non-direct drive ROTORDISK® units)

Chain drive should be inspected every six- (6) months for following points:
- If Chain is covered with grit or chips, it should be cleaned in kerosene and re-lubricated.
- Inspect oil for contamination, such as chips, dirt or grit. Replace oil if necessary (Oil with viscosity of SAE30 at ambient temperature 40^{o} to 100^{o} F is recommended).
- Milky white colour of the oil is indicative of flooding. Replace oil and determine the cause of the flood.
-Check Chain tension and adjust if required.

6.5 - COUPLING:

(Applicable for direct drive ROTORDISK® units and 'L' models)

Coupling should be checked for lubricant level. Lubricant is to be added if required. Re-lubrication with NLGI#2 or LTG Grease once a year is usually adequate.

7.0 - TROUBLE SHOOTING

7.1 - MECHANICAL HARDWARE

TROUBLE	PROBABLE CAUSE	CORRECTIVE ACTION
Noisy chain	1. Loose chain 2. Faulty lubrication 3. Misalignment 4. Worn Parts 5. Moving parts rubbing stationary parts	1. Tighten chain 2. Lubricate properly 3. Correct sprocket alignment 4. Replace worn chain 5. Align & tighten chain to clear oil bath
Rapid wear on chain	1. Faulty lubrication 2. Loose or misalign parts	1. Lubricate properly 2. Align & tighten entire drive
Chain climbing sprockets	1. Worn out chain and sprockets 2. Loose chain	1. Replace worn out parts 2. Tighten chain
Stiff chain	1. Misalignment 2. Worn out chain or sprockets 3. Faulty lubrication 4. Rust corrosion	1. Correct alignment 2. Replace worn out parts 3. Lubricate properly 4. Clean and lubricate
Noisy Bearing	Rollers or bearings damaged	Replace bearing cartridge
Bearing grease discoloured or mixed with water	Insufficient grease in the bearings	Purge bearing with grease and increase lubrication interval
Hot bearing	1. Improper lubrication 2. Rollers or bearing race damaged	1. Purge bearing with grease and decrease lubrication interval 2. Replace bearing cartridge
Reducer temperature rises above 200 degrees Fahrenheit.	Oil level too high or too low	Maintain proper oil level
Oil leakage from reducer	1. Oil seals need to be replaced 2. Ventilators/breather plugged causing pressure build-up inside the reducer. 3. Oil level too high	1. Replace oil seals 2. Clean Ventilators 3. Correct oil level
Noisy reducer	1. Bearing failure 2. Misalignment in worm gear inside 3. Coupling between motor and reducer worn out and misalign	1. Check bearings and replace if necessary 2. Align worm gear shafts. 3. Replace coupling between motor and reducer. Align coupling hub vertically
Noisy Motor	Bearing damage	Replace damaged bearings
Motor overheating	1. Reducer overheating 2. Cooling fins on motor are clogged 3. Overload 4. Rotor rubbing on stator 5. Over greasing or lubrication	1. Check reducer 2. Clean fins 3. Check for excess friction or imbalance 4. Replace bearings 5. Avoid packing grease too tightly
Motor won’t start	1. Power trouble 2. Single phasing at station 3. Fuse blown	1. Check source of power supply 2. Do not try to make it go and “fry” motor. Check starter windings 3. Replace fuse
Knocking/rumbling on motor bearings	1. Bearing worn due to lack of lubrication or excessive mechanical overload 2. bearings slack in housing	1. Replace bearing and put new grease of recommended grade. 2. Fir new end shields
Rotordisk® shaft doesn’t turn	1. Power failure 2. Motor failure 3. Reducer failure 4. chain drive failure	1. Check power supply 2. Check and replace motor and bearings. 3. Check teeth worn gears and bearings. Replace necessary parts 4. Replace chain

7.2 - ROTORDISK® PROCESS

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
1. Slime on media appears shaggy with a brown colour	PROPER OPERATION	NO PROBLEM NORMAL CONDITION
2. Black slime growing on disks	Solids and/or BOD overloading	**a.** Pre-aerate RBC influent **b.** For severe organic overloads, increase recycle rate **c.** De-sludge unit **d.** Place another RBC unit in parallel
3. Rotten egg or other obnoxious odors	Solids or BOD overloading	See Problem 2, solutions a, b, c and d, above
4. Development of odors and white biomass over most of the media surface	1. Septic influent wastewater or high hydrogen sulfide or sulfate concentration	**e.** Determine the cause of the problem and correct it at source. For example, aerate equalization tank **f.** Pre-aerate influent wastewater **g.** Determine the cause of the problem, possibly with the addition of chlorine or hydrogen peroxide; potassium permanganate has also been used
	2. Overload first stage	**a.** Check dissolved oxygen levels to confirm overload problem **b.** Increase number of recycle buckets
5. White slime	1. Bacteria that feed on sulfur compounds. Also, industrial discharges containing sulfur compounds may cause an overload	▪ See Problem 2, solutions a and b above
	2. Grease on the disks	**a.** Remove grease at source **b.** Install grease traps
6. Sloughing or loss of slime (biomass)	1. Toxic or inhibitory substances in influent, including abrupt pH changes	**a.** Eliminate source of toxic or inhibitory substances **b.** Reduce peaks of toxic or inhibitory substances by carefully regulating inflow to plant **c.** Dilute influent using plant effluent or any other source of water **d.** See Problem 7.4
	2. Variation in flow or organic loading	**a.** - During low flow or loading periods, pump from secondary clarifier or 4th stage RBC unit effluent to recycle water with food and dissolved oxygen through the RBC unit **b.** - During high flow or loading conditions, attempt to throttle plant inflow during peak periods **c.** - For severe organic under loads, add a cheap source of soluble carbon in the PST such as molasses

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
7. Decrease in process efficiency	1. Reduced wastewater temperature	**a.** Decrease air opening in RBC building **b.** Heat air inside RBC unit cover or building
	2. Unusual variations in flow or organic loading	▪ See Problem 6, cause 2, solutions a and b above
	3. Sustained flows or loads above design levels	▪ Install additional treatment units
	4. High or low pH values	▪ Adjust pH to near neutral
	5. Improper rotation of media	▪ Inspect chain tension and adjust
8. Accumulation of solids and clogging in the RBC system	Solids removal in pre-treatment steps is not adequate	**a.** Improve pre-treatment efficiencies **b.** Provide supplemental aeration to help prevent solids from settling **c.** De-sludge primary tank
9. Floating or rising sludge in the secondary clarifier	Removal of sludge from the clarifier is inadequate	**a.** Increase the duration of pumping sludge from the clarifier **b.** Remove sludge from the clarifier more often
10. Excess shaft weight or biomass thickness	1. Organic loading too high	▪ Decrease organic loading
	2. Stage loading too high	**a.** Increase number of recycle buckets
	3. Inorganic solids accumulation because of inadequate pre-treatment	▪ Check primary treatment and grit removal equipment for proper operation
	4. Accumulation of minerals	▪ Use chemical pre-treatment to eliminate minerals
	5. Digester supernatant adding excessive BOD or sulfides	▪ Modify supernatant pumping frequency
11. Shaft rotation non-uniform or "jerky"	1. Normal variations in balance	▪ Time rotation by quarters. A difference of less than 3 seconds in quarter rotation time is normal
	2. Uneven biomass weight due to power outage	**a.** If severe, shut unit down and wash down disks **b.** Turn off the unit temporarily and rotate manually to uniformly wet biomass growth before restarting **c.** Decrease or stop flow of wastewater to affected units **d.** contact manufacturer for assistance

ROTORDISK® TROUBLESHOOTING GUIDE

Problem	Cause	Corrective Action
12. Effluent quality apparently below requirements	1. Organic loading too high	**a.** Add additional operating RBCs **b.** Identify cause of additional loading and eliminate at source **c.** Add supplemental air to RBC trough
	2. Sampling or testing procedures inaccurate	**a.** If nitrification is occurring, analyze for carbon BOD only by using nitrification inhibitor **b.** Check for contaminated dilution water, sampler lines, or improper sampling storage
	3. Inadequate secondary clarifier operation	**a.** Clean and de-sludge clarifier **b.** Modify sludge removal procedures to eliminate BOD kickback **c.** Install filters after clarifier **d.** Increase alum dose to enhance flocculation
	4. Anaerobic solids in the RBC tanks producing BOD kickback	▪ Flush or drain tanks
13. Snails or other nuisance organisms in RBC tanks	Nutritional and conducive environment for reproduction of hard-bodied shell snails ($^1/_8$" - $^1/_2$" in size)	**a.** Addition of controlled dosages of chlorine. Physical removal may be required with taking units out of service temporarily **b.** Contact manufacturer

Contact SEPROTECH SYSTEMS INCORPORATED for advice on how to resolve problems related to the process before making changes to the process or equipment.

Adapted from Water Pollution Control Federation "Manual of Practice OM-10", 1988.

8.0 - MAINTENANCE PROGRAM – Do’s and Don’ts

DO'S

1. Do use biodegradable soap if at all possible. The system will however handle a certain amount of normal soap. When laundering clothes, please follow manufacturer's instructions regarding quantity of detergent. Excessive use of detergent can cause odour in the system.

2. Do put large amounts of grease in a container and dump in garbage. The system will handle a certain amount of fat and grease. If a tile bed is used and if fats and grease get into it, they may plug the pores of the soil and seal up the bed. Never put large amounts of grease (i.e. old grease from deep fryer) into the sewer lines.

3. Have your system pumped out a minimum of once a year to remove sludge and scum to maintain top operating treatment in your system and filter bed.

4. For small systems equipped with a service hatch, keep the service hatch above the ground. Do not let run-off water enter system, as this will cause hydraulic overload.

5. If a tile bed is used, do keep traffic such as cars, snowmobiles, etc., away from the system bed areas as they will break pipes and seal the soil over the bed.

6. If a tile bed is used, do leave the raised filter in place without disturbing it. The filter is specifically designed to provide maximum dispersal of the water. Altering it by adding fill, covering it up or changing in any way may destroy its water dispersal characteristics and result in bed failure.

7. If a tile bed is used, do encourage a growth of ground cover over the filter bed as it helps disperse water by evaporation and transpiration.

DON'Ts

1. Do not put non-biodegradable materials downs the drain, put them in the garbage, these include any plastics, rubber, disposable diapers, sanitary napkins, rubber goods, cigarettes, children's toys, cellophane, etc. They will plug the system, and a pump out will be needed.

2. Do not put harsh chemicals down the drain. They will kill the bacteria necessary for efficient treatment. These include acid or caustic cleaners, gasoline, oil, turpentine, photographic chemicals, etc. Disinfectant and chlorine bleaches should be kept to domestic uses.

3. Do not leave taps running or faulty toilets. The excess water may overload the system and, if used, tile field causing breakout and poor treatment.

4. If you do not have access to workers with appropriate training, do not attempt to fix the mechanical parts yourself. Your dealer is trained to repair your plant and work safely with electrical and mechanical components. Call him if you have a problem or concerns.

5. Do not connect any other electrical load to the fuse or breaker feeding the plant as it will cause damage to the controls.

6. Never put large amounts of grease (i.e. old grease from deep fryer) into the sewer lines.

YOUR CO-OPERATION WITH RESPECT TO THE ABOVE POINTS SHOULD ENSURE TROUBLE-FREE OPERATION OF YOUR TREATMENT PLANT AND WILL BE GREATLY APPRECIATED.

9.0 - INSTALLATION, OPERATION AND MAINTENANCE INSTRUCTIONS FOR VARIOUS MECHANICAL PARTS OF THE **ROTORDISK®** AND OTHER EQUIPMENT SUPPLIED

9.1 INSTALLATION & MAINTENANCE DETAILS FOR ROLLER CHAIN DRIVES

CHAIN TENSIONING:

The proper fit of a chain may be obtained by adjusting the sprocket centres. When a chain is correctly tensioned, the total mid-span movement (double amplitude) in the slack span should be 4-6% of the span length for normal drives.

Where there is no adjustment means, adjustment may be made by removing links to compensate for elongation due to wear (Drives with fixed centres). Proper lubrication and proper drive maintenance may minimize chain wear.

LUBRICATION:

Although many slow speed drives operate successfully with little or no lubrication beyond the initial factory lubrication, proper lubrication will greatly extend the useful life of every chain drive.

A good grade of clean petroleum oil without additives, free from flowing at the prevailing temperatures should be used.

Chain drives should be protected from abrasive and corrosive conditions, and the oil supply kept free of contamination. Periodic oil change is desirable. The lubricant viscosity recommended for ambient temperature 40^o - 100^oF is SAE 30.

OIL BATH:

With bath lubrication, the lower strand of chain runs through a sump of oil in the drive housing. The oil level should reach the pitch line of the chain at its lowest point while operating. Only a short length of chain should run through oil.

INSTALLATION RECOMMENDATIONS:

Shafting, bearings and foundations should be supported rigidly to maintain the initial alignment. Roller chain should be free of grit and dirt. Wash chain in kerosene when required. Re-lubricate!

Misalignment results in uneven loading across the width of the chain and may cause roller link-plate and sprocket tooth wear. Drive alignment involves two things:

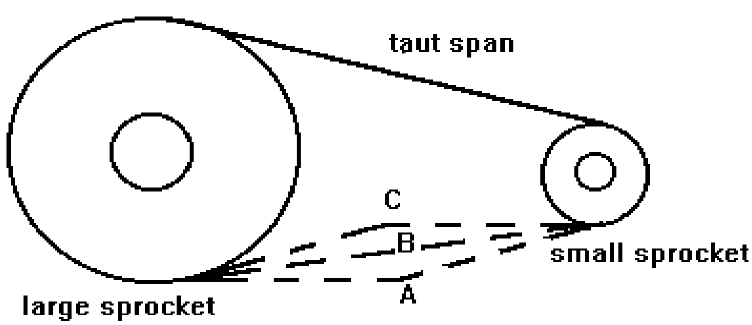
a) Parallel shaft alignment: Shafts should be parallel and level.
b) Axial sprocket alignment: Sprocket axial alignment can be checked with a straight edge, which will extend across the finished sides of the two sprockets.

Normally, it is good practice to align sprockets as close to the shaft bearings as possible.

Installing the Chain: Recheck all preceding adjustments for alignment and make sure all setscrews, bolts and nuts are tight. Fit chain around both sprockets and bring free ends together around one sprocket for connection.

Chain Tension: Check chain tension to be sure that the slack span has 4-6% mid-span movement in horizontal drives.

Recommended Possible Mid-Span Movement AC									
Drive	Tangent Length Between Sprockets								
Center-Line									
	5”	10”	15”	20”	30”	40”	60”	80”	100”
Horizontal to 45	.25”	.5”	.75”	1”	1.5”	2”	3”	4”	5”
Vertical to 45	.12”	.25”	.38”	.5”	.75”	1”	1.5”	2”	2.5”



AC = Total Possible Mid-Span Movement
Depth of Free Sag = .866 AB, approximately

MAINTENANCE RECOMMENDATIONS:

Regular maintenance schedules should be followed for all chain drives. Each drive should be inspected every six months. At each inspection period the following points should be checked:

a) Check Lubrication: If chain is covered with grit or chips, it should be cleaned in kerosene and re-lubricated before reinstalling. With bath lubrication, oil should be maintained at the proper level, as shown in lubrication instructions. Add oil if necessary. At each inspection, oil should be checked for contamination, such as chips, dirt or grit.

b) Check sprocket alignment: If the chain is properly aligned, no wear will show on the inner surfaces of the chain roller link-plates. If wear is apparent, this is evidence that sprockets are misalign and should be realigned as outlined in the installation instructions to prevent further chain and sprocket wear.

c) Check sprocket tooth wear: If sprocket shows evidence of wear high on the sprocket teeth, this is evidence of excessive wear in the chain, the chain should be replaced. If the sprocket teeth are severely worn, the sprocket should be replaced. Do not run new chain on worn sprockets.

d) Check chain tension: At each inspection period, the chain tension should be adjusted. If excessive slack has accumulated which cannot be removed by available shaft centre adjustment (i.e. by moving reducer away from large sprocket using chain tensioning bolts), two or more pitches of chain should be removed and chain reconnected.

9.2 PROCEDURE FOR ASSEMBLING BEARINGS AND PILLOW BLOCKS

Shaft Preparation
Clean shaft and remove any burrs or sharp edges. Check the shaft diameter to given specifications.

Seal Installation
Place seal, which consists of: Double lip 'G' type seal

MOUNTING OF BEARING ON SHAFT

Adapter Sleeve Mounting
Position adapter sleeve on the shaft to correct location with respect to required bearing centerline. A smear of lubricating oil (SAE 10 or 20) applied to the sleeve outside diameter surface results in easier bearing mounting and removal. (For pillow blocks mounted close to a pulley hub or similar obstruction, mount the adapter sleeve with threads inboard for easy removal. Remember to slide lock-nut, lock-washer and bearing onto the shaft before positioning the sleeve.)

NOTE: All bearings mounted on tapered sleeves have to be driven up the taper to the tolerances given in SKF tables, to ensure correct fits. Spherical roller bearings can be measured between the unloaded rollers and the outer ring sphere surface.

Un-mounted Clearance, Spherical Roller Bearings
Measure the un-mounted internal clearance in the bearing by inserting and sliding progressively larger feeler blades the full length of the roller between the most vertical unloaded rollers and the outer ring sphere. Never run the rollers over the feeler blade, as the wrong value will be obtained. Record the measurement of the largest size blade that will slide through. This is the un-mounted internal clearance.

Bearing
Mount the bearing hand tight on the adapter sleeve. Be sure the large end of the bore of the inner ring matches the taper of the adapter. To avoid damage to the bearing it is most important during this and subsequent operation that the shaft is blocked up so the bearing is unloaded. Do not apply lock-washer. Drive up procedure may damage it.

Bearing Drive Up, Spherical Roller Bearings
Lubricate the face and thread of the lock nut and apply to sleeve with chamfered face toward the bearing. Tighten the lock nut. Do not attempt to tighten the lock nut with a hammer and drift (use proper wrenches), the lock nut can be damaged and chips can enter the bearing. Further tighten the lock nut and measure the internal clearance until the internal clearance is less than the un-mounted clearance figure by the amount shown in the attached table (see last page). Finally, remove lock nut, position lock washer with outer tangs facing away from the bearing, and inner tang properly seated in the slot provided in the adapter. Replace lock nut and tighten until firmly seated.

PREPARATION OF PILLOW BLOCK HOUSING

Check to be sure all pillow block parts are free of burrs and are completely clean. Internal surfaces should be removed. Apply a thin coat of grease to the bearing seat in the base. Fit the bearing and seal inserts into the pillow block base, being careful not to damage to O-rings. For assembling larger sizes where hoists must be used, it may be convenient to seat both bearings into their housing bases simultaneously.

FIXING RINGS

On each shaft one bearing is generally "Held" and other bearings are "Free", to permit shaft expansion. For "Held" bearing housings, use two fixing rings. Place one on each side of bearing.

CAPPING THE PILLOW BLOCK

Place the cap on the base so that the dowel pins in the base align with the holes in the cap, being careful not to damage the O-rings. Caps and bases are not manufactured for interchangeable assembly. They must be kept together. Install cap-bolts with lock washers and tighten securely.

GREASE LUBRICATED BLOCKS

Lubrication Notes

Grease Lubrication

If grease is used as a lubricant, it should be smeared between the rolling elements and worked in. The lower half of the housing should be packaged $^1/_2$ to $^3/_4$ full.

PROCEDURE FOR APPLYING LUBRICANT TO BEARINGS AND PILLOW BLOCKS

Pack each bearing as completely full of the specified grease as possible by swiveling the outer ring open and rotating it as necessary to inject the grease. Then, swivel the outer ring closed being careful not to use force in the event a roller end catch the corner of the outer ring sphere.

B) Before assembling the pillow block cap to the base, and after completing bearing and base assembly, fill $^1/_2$ to $^3/_4$ of the pillow block base with the same lubricant that was used to pack the bearing.

LUBRICATION PROCEDURE TO BE USED AT START-UP

A) All pillow block assemblies that have not been prepared for stage are ready for use, assuming the installation procedures have been correctly followed.

B) While shaft is rotating, lubricate each seal through the outside lubricant fittings until grease is seen emerging from the labyrinth areas. Make sure the outside of the lubricant fitting is clean before applying grease.

RE LUBRICATION

Lubricants deteriorate in time, and the rate of deterioration is a function of the lubricant used at the operating conditions encountered. Determining the re-lubrication cycle depends on sampling the grease and analysis of the samples. Provisions must be made to adequately evaluate the contamination by solids. Samples for grease evaluation should be taken from near the bearing, and evaluation of the samples should dictate the re-lubrication cycle.

Remove caps once a year and re-apply new grease.

Each seal assembly should be lubricated <u>once a month</u>, while the bearing is rotating, with the same grease that is used in the bearing.

GREASE CLASSIFICATION

		Oil Viscosity Saybolt Second (approx. SSU)		
Class	Type of Base (1)	@ 100 F	@ 210 F	NLGI (2) Grade
A	Lithium or Equal	200 - 500	48 – 55	0
B	Lithium or Equal	400 - 600	58 – 68	1
C	Lithium or Equal	800 - 1,000	75 – 82	1
D	Lithium only	800 - 1,000	75 – 82	2

	Grease requirement from above			
Operating temperature of bearing (4)	Low (5)	Medium	High	Suggested Re-lube cycle
0 – 70	A or B			6 – 12 months
70 – 120	B or C			6 – 12 months
120 – 160	B or C	C or D (6)	D (7)	2 - 3 weeks
160 – 200	C	C or D (6)	D (7)	1 - 4 weeks

1) Calcium Complex Greases NOT recommended for spherical roller bearings.

2) National Lubricating Grease Institute Consistency Code.

3) Definition of speed categories:
Low: up to 1/4 of catalog speed limit for static oil lubrication.
Medium: 1/4 to 1/2 catalog speed limit for static oil lubrication.
High: 1/2 to full catalog speed limit for static oil lubrication.

4) Consult SKF Engineering if temperature is below 0^{o} or above 200^{o}F.

5) Extremely slow speed will require special consideration if loads are high.

* Under all conditions, application should be checked using the SKF lubricant film parameter found in the Engineer Data Catalog.

6) Use type "C" where load is heavy, 15,000 hours-rating life or less and/or speed are less than RPM.

7) Consult SKF Engineering - Grease lube not normally recommended under this combination of operating conditions.

8) Dry clean applications only. For moderate conditions of dirt and/or moisture, use cycle of 1 to 2 months. For extreme conditions of dirt and/or moisture, use cycle of 1 week. Vertical applications normally require shorter than normal re-lube cycle.

9) Never mix greases with unlike bases.

10) Remove old grease at least once a year.

10 - LIMITED WARRANTY

SEPROTECH SYSTEMS INCORPORATED warrants the parts in each treatment plant to be free from defects in material and workmanship; for a period of 15 months from shipment or 12 months from start-up, whichever occurs first, in the treatment of domestic wastewater. Sole obligation under this warranty is as follows:

SEPROTECH SYSTEMS INCORPORATED shall fulfil this warranty by repairing or exchanging any component part, F.O.B. our factory, that in SEPROTECH SYSTEMS' judgement, shows evidence of defects, provided said component part has been paid for and is returned through an authorized dealer, transportation prepaid. The warranty must also specify the nature of the defect to the manufacturer. New placed parts are under warranty for one year.

The warranty does not cover treatment plants that have been flooded, by external means, or that have been disassembled by unauthorized persons, improperly installed, subjected to external damage or damage due to altered or improper wiring or overload protection.

This warranty applies only to the treatment plant and does not include any other electrical wiring, plumbing, drainage, or disposal system. SEPROTECH SYSTEMS INCORPORATED is not responsible for any delay or damages caused by defective components or material, or for loss incurred because of interruption of service, or for any other special or consequential damages or incidental expenses arising from the manufacture, sale, or use of this plant.

SEPROTECH SYSTEMS INCORPORATED reserves the right to revise, change, or modify the construction and design of the treatment plant for domestic wastewater or any component part or parts thereof without incurring any obligation to make such changes for modifications in previously sold equipment. SEPROTECH SYSTEMS INCORPORATED also reserves the right, in making replacements of component parts under this warranty, to furnish a component part, which, in its judgement is equivalent to the Company part replaced.

Under no circumstance will SEPROTECH SYSTEMS INCORPORATED, be responsible to the warrantee for any other direct or consequential damages. Including but not limited to; lost profits, lost income, labour charges, delays in production, and/or idle production, which damages are caused by a defect in material and/or workmanship in its parts.

This warranty is expressly in lieu of any other expressed or implied warranty, excluding any warranty of merchantability or fitness, and of any other obligation on the part of SEPROTECH SYSTEMS INCORPORATED.

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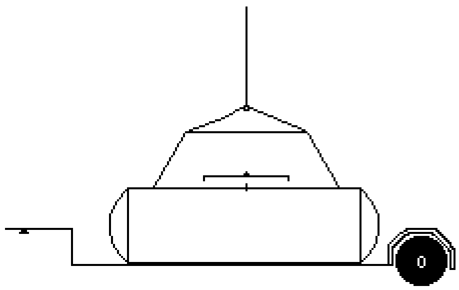
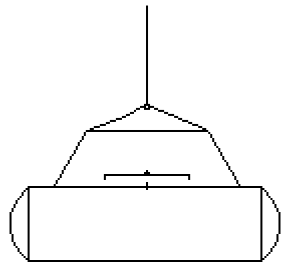
LIFTING

INSTRUCTIONS

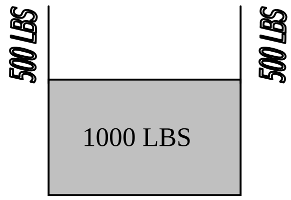
CENTER OF GRAVITY

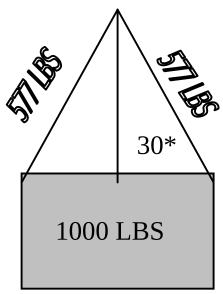
It is always important in rigging practice to rig the load so that it is stable. A stable load is one in which the center of gravity of the load is directly below the main hook and below the lowest point of attachment of the slings. The center of gravity of an object is that point at which the object will balance. The entire weight may be considered as concentrated at this point. A suspended object will always move so that the center of gravity is below the point of support. In order to make a level or stable lift, the crane or hook block must be directly above this point. Thus a load, which is slung above and through the center of gravity, will be stable and will not tend to topple or slide out of the slings.

Predicting the center of mass for an object to be lifted is not a trivial matter. It may require several attempts at rigging to find the appropriate balance point. Many objects are not rectangular such that predicting the center of mass is often difficult. In all crane lifts the center of mass must remain below the hook and below the point of attachment for any rigging. A center of mass above the hook is inherently unstable and will cause the load to flip. Similarly, loads that are not balanced in the horizontal plane may slip form the rigging. The overall stability of the load is a combination of balance with respect to the center of mass, weight distribution, and rigging tightness.

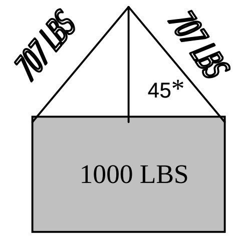
Crane operators should adjust the rigging and test for the actual center of gravity before the load is lifted.

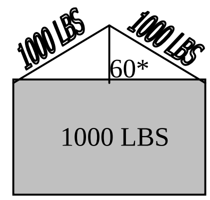
WEIGHT vs. ANGLE





Sling Angle With Vertical	Stresses per Sling Leg Per 1000 LBS Total Load
0	500
5	502
10	508
15	518
20	532
25	552
30	577
35	610
40	653
45	707
50	778
55	872
60	1000
80	2880





The angle at which a sling holds a given load influences the effective weight of the load. Stresses are minimal for loads with slings held perpendicular to the load, as shown in Figure A. For distributing the load vertically among more than a single leg of a sling, a spreader bar may be used. As shown in figures B-D, increasing the angle of the sling to the hook from 30 to 60 degrees increases the effective mass of the load from 1154 lbs. to 2000 lbs., essentially doubling the weight on each leg of the sling at 60 degrees. The chart in the middle offers a handy guide for assessing the effective angle of the sling to the relative weight. Thus, it is always better to limit the angle of the sling. Further, such changes in sling angle must be accounted for in lifts that are close to the sling weight limit and/or for critical lifts (greater than 90% of the crane limit). Crane operators should download a copy of this chart and carry it with them during crane operations.

RIGGING

- Loads should be well secured
- Slings should be adequate to the task
- Slings should be un-kinked and load balanced and secured
- No sudden stops
- No obstructions while lifting or traveling
- No loose items on load or crane before lift
- Bumping into runway stops is prohibited
- Hoist line must be vertical prior to the lift (remove slack in the hoist slowly)
- No crane load should pass overhead of personnel, clear the area before making the lift
- No one is to ride the crane without permission

The most important job of any crane operation is rigging of the load. Poor rigging may result in personnel injury, property damage, or other serious hazards. Rigging is the most time consuming of any crane operation and represents the single most hazardous potential of crane operation. In a multi-sling operation, each leg must be of the same length and must contribute equally to load distribution. Nylon slings are susceptible to damage by sharp corners on the item to be rigged. Caution must be taken to ensure that slings are not damaged by sharp corners or by excessive loading. Rigging requires years of practice to perfect. If in doubt about the security of your rigging, ask for help. Rigging should be checked by lifting the load a few inches off the ground to ensure that no swing develops and that the load is completely secure. Remember it is important to take the time to accomplish this task correctly. Not doing so may result in catastrophic consequences. One of the most important things to check before lifting a load is to look for loose items, such as screws or tools, which may have been used to secure the load. Such items can become projectiles during a lift. This is the reason why crane operators or especially tag line operators should wear hard hats when operating the crane and why it is essential to make sure the path of the crane does not pass over the head of any individual.

Spreader bars must be used when lifting the B30. Slings are to be attached at the lifting lugs located at the Four Inside Corners of the B30.

Overall Weight	34, 200 Lbs
- Weight Trough	3,650
- Weight Shaft	4,634
- Weight Hood	3,900
- Miscellaneous	22,000

Overall Dimensions 311 Inch Long x 143 Inch Wide x 186 Inch High

(Refer to the General Arrangement Drawing for exact dimensions)

The following handling and installation instructions are intended to help customers install the RBC properly and efficiently.

Handling and installation instructions are only recommendations. They do not relieve the purchaser from full responsibility for proper inspection, handling and installation. Improper handling or installation, which results in damage or tank failure, is the sole responsibility of the purchaser. Failure by the customer to comply with the handling or installation instructions will void the tank warranty. Unknown situations or conditions are also the burden of the purchaser.

The presence of SEPROTECH SYSTEMS personnel or an authorized representative at the installation site does not relieve the purchaser of their responsibilities.

DO NOT fully assemble RBC prior to lifting. First install the tank, and then assemble the shaft and other components onto installed tank.

INSPECTION

At the time of delivery, the customer shall be responsible for inspecting the tank for damage during transit. Both the inside and the outside of the tank must be inspected. If damage has occurred it should be noted on the delivery receipt prior to signing acceptance, whether it be a SEPROTECH SYSTEMS truck of common carrier. If a SEPROTECH SYSTEMS truck makes delivery, the factory should be immediately contacted prior to unloading or acceptance. The customer accepts all future responsibility for a damaged tank if the procedures set forth are not followed.

Minor damage can be repaired at the delivery site.

SEPROTECH SYSTEMS tanks are designed to withstand normal handling. Note the following handling precautions:

1. NEVER roll or slide a RBC. Lift the tank using a crane or other approved method.
2. Operators of hoist equipment should follow proper rigging procedures at all times. NEVER allow RBC to swing out of control.
3. Do not drop or allow hard impact from tools, spreader bars, etc.
4. Avoid the use of equipment inside the tank that could scratch or damage the inner corrosion barrier.
5. NEVER use cables or chains around tank.
6. NEVER lift tank by using fittings. Use designated lifting lugs.
7. If RBC is being stored prior to installation, be sure to lay on padded surface and tie down securely.

APPENDIX F

PWSP EFFLUENT DISCHARGE PLAN AND SLUDGE MANAGEMENT STRATEGY

Appendix F.1

PWSP Effluent Discharge Plan

Technical Memorandum

To:	Jim Millard, Baffinland Iron Mines	Project:	TR1596
From:	Jered Munro, AMEC Dave Ellis, AMEC Joel Westberg, AMEC		
Tel:	(519) 886-7500		
Date:	March 29, 2010		

Subject: **PWSP Effluent Discharge Plan**

AMEC was retained by Baffinland Iron Mines Corporation to develop and design a polishing treatment system for treating the stored effluent from the Mary River biological sanitary treatment system.

This technical memorandum identifies the design criteria, discharge procedures, polishing system treatment components and functionality as well as the operating activities performed during 2009.

POLISHING SYSTEM DESIGN CRITERIA

Discharge Quality

The design criteria for the effluent discharge quality are defined in the water licence issued by the Nunavut Water Board, Licence 2BB-MRY0710 and the approved WWMP (rev. 1) and are summarized below:

Table 1: Discharge Criteria of PWSP effluent

Parameter	Discharge Criteria	
Location	**Mary River WWTF**	**Milne Inlet WWTF**
BOD_5[1]	30 mg/ L	100 mg/L
TSS[1]	35 mg/L	120 mg/ L
Faecal Coliform[1]	1,000 CFU/100mL	10,000 CFU/100mL
Oil and Grease[1]	No visible sheen	No visible sheen
pH[1]	Between 6.0 and 9.5	Between 6.0 and 9.5
Toxicity[1]	Final effluent not acutely toxic	Final effluent not acutely toxic
Ammonia[2]	N/A	N/A
Total Phosphorus[3]	0.5 – 1.0 mg/L	N/A

Notes: 1. Discharge criteria based on water licence effluent limits for maximum average concentration.
2. No specific criteria for ammonia, but effluent must be acutely non-toxic.
3. The range set for total phosphorus discharge target levels to Sheardown Lake were set based on results of the mass loading model developed by North South Consultants.

The phosphorus limit was confirmed to not be detrimental to the receiving aquatic environment by North/South Consultants, who employed modelling software to predict the effects of the effluent discharge based on the maximum design parameters listed in Table 1.

Discharge Flow

The design polishing system system flow rate was determined based on an assumed operating schedule of 24 hours per day, 7 days per week, for a duration of 3 weeks. The combined storage volume contained in the Mary River PWSPs No. 2 and 3 was estimated at approx 4 million liters (~1,000,000 USG).

The effluent discharge pipe to Sheardown Lake is a 3” diameter, HDPE pipe that is approximately 1.5 km long. Two pumps connected in series were required to provide the discharge pressure necessary to achieve a discharge flow rate of 375 L/min (100 USgpm). This flow rate of 375 L/min (100 USgpm) was set as the design flowrate for the polishing system. This design flow rate was required to treat the majority of the stored water during the 2009 open water season.

PWSP EFFLUENT DISCHARGE OPTIONS

Once the water in the PWSPs begins to thaw in the spring, a sample from each of the PWSPs is submitted for the regulated effluent criteria parameters. Depending on the water quality confirmed in the respective PWSP, discharge may commence, as detailed below.

Option #1:

If the PWSP melt water sample is in compliance with the regulated criteria, Baffinland will commence discharge of the compliant effluent. Once discharge has commenced, Baffinland will field test for pH, and turbidity and complete confirmatory sampling using bench-top screening methods to monitor the effluent quality. Discharge will be discontinued if any of the tests approach effluent criteria limits.

Option #2:

If the water quality in the PWSPs does not meet the effluent discharge criteria, then the effluent would be treated using the polishing treatment system. During the start-up of the polishing treatment system, the effluent is discharged back into the PWSP that it is being drawn from. The treated effluent would not be discharged until laboratory analytical results confirmed that the polishing treatment system was producing compliant effluent. Following confirmation of effluent quality, the polishing system is operated and the treated water discharged to Sheardown Lake until the PWSPs have been emptied or weather conditions become unfavourable for treatment.

POLISHING TREATMENT SYSTEM UNIT PROCESSES

The polishing treatment system was designed to provide additional treatment for total suspended solids (TSS) and total phosphorus TP removal, as well as pH control.

The polishing system contains the following unit processes, as shown in the attached Process Flow Diagram, PFD-01 (Attachment A) and the attached photographs (Attachment B):

Influent Pump and Flow Meter

A pump draws from one of the ponds and feeds water at a design flow of 100 USgpm. A flow meter is used to monitor this influent flow. Flow to the polishing system can be controlled by throttling the influent pump speed or by adjusting a 3-inch ball-valve that bleeds water back into the pond.

Chemical addition

Water treatment chemicals were added to the influent water to aid in the treatment process. The following chemicals were used in the 2009 polishing system:

- Aluminum sulphate (commonly called “alum”), and
- A polymer, marked “Polyfloc AP1138” by the manufacturer, GE Betz Inc.

Aluminum Sulphate (Alum) Addition

Aluminum sulphate is added to achieve three goals:

- Precipitation of soluble phosphorous to a solid,
- Coagulation of suspended solids, and
- Reduction of pH.

Alum is dosed into the influent pipe by means of a chemical metering pump and then mixed in the piping to promote precipitation and coagulation chemical reactions. Mixing is achieved in the piping by forcing the water through a serpentine section of piping constructed using a series of elbows that create mild turbulence and mixing of the bulk fluid.

Polymer Addition

Polymer is added, after the alum, to further enhance the formation of larger solids allowing them to separate more quickly from the bulk liquid once in the DAF tank. The polymer serves as a flocculatant which promotes the agglomeration of smaller coagulated solids into larger flocs. These larger flocs are more readily removed by downstream processes. As with the alum, the polymer is dosed into the influent pipe by means of a chemical metering pump and then mixed in the piping to promote flocculation. Mixing is achieved in the piping by forcing the water through a serpentine section of piping.

Dissolved Air Flotation System

Water containing alum and polymer is combined with a recirculating stream of water which is supersaturated with dissolved air. As the dissolved air comes out of solution microscopic air bubbles are formed on the flocculated solids, thus increasing their buoyancy. These buoyant solids float to the surface and can be easily skimmed off.

Air Dissolving Pump

The dissolved air flotation (DAF) system is comprised of a number of components. The heart of the system is a Hellbender-brand air dissolving pump. This pump is specifically designed to accept large amounts of air mixed with water, and operates under high pressure to dissolve and shear the air into fine micro bubbles. When the high pressure, air-rich, stream meets the lower pressure flocculated influent water, dissolved air comes out of solution forming small air bubbles. These small bubbles attach to the flocculated solids causing them to rise to the surface once inside the DAF tank.

DAF Tank

Influent water that has already been combined with the air-rich recirculation water is distributed across the width of the rectangular DAF tank through a relatively large, 6-inch diameter distribution header. This large inlet header is used to minimize water entrance velocity and facilitate a quiescence of the water in the tank.

These quiescent conditions in the DAF tank allow the buoyant solids to float to the surface. Solids are periodically skimmed off the top of the tank, over a collection beach, into a sludge trough. The sludge trough discharges collected solids by gravity to two large totes for disposal.

At the opposite end of the DAF tank from the inlet is the outlet. Clarified water is collected through a 4-inch diameter effluent header located halfway up the height of the tank. The clarified water is directed to the final effluent clear-well tanks.

Final pH Adjustment

Two effluent clear-well tanks are connected in series so that the water can be pH adjusted with sodium bicarbonate, if needed.

Floated Solids Storage and Pumping

Two parallel solids holding tanks have been provided to capture the floated solids. A 3-inch diaphragm pump is used to pump the float solids into PWSP No. 1 for storage.

Effluent pumping and flow monitoring

Clarified water is pumped through two 4-inch Tsurumi brand trash pumps, connected in series, that discharge into the 3-inch Sheardown discharge pipeline. The treated water discharge flow is measured using a Badger brand 3-inch paddle wheel flowmeter with totalizer.

POLISHING SYSTEM – GENERAL OPERATING PROCEDURES

The treatment process was designed to operate 24 hours per day, 7 days per week. The system requires two operators to operate and maintain the treatment equipment. The following are the general procedures required for successful operation of the DAF system.

Preparation for Start-up

- Ensure all pumps are filled with fuel
- Ensure all generators are filled with fuel
- Make sure a full alum barrel has been made up (see procedure below)
- Make sure a full polymer barrel has been made up (see procedure below)

DAF pump start-up

- Ensure that the water level in the DAF tank is high enough so that the inlet to the DAF pump is submerged
- Ensure that the DAF pump is flooded with water by opening the 2-inch ball-valve on the suction side of the DAF pump piping, making sure the globe let-down valve is at least partially open and verifying water is flowing out of the sample port on the 6-inch influent header.
- Ensure the air eductor-loop valves are closed
- Turn on the DAF pump, and have one person standing at the generator to shut it down if the pump cavitates or vapor locks.
- As soon as the pump is turned on, adjust the globe valve so that the pressure in the pump discharge piping (pressurized side) reads 92 psi. This high discharge pressure is necessary for proper DAF pump function, and will allow sufficient back pressure in the DAF pump to shear and dissolve air into the fine bubbles needed for effective solids separation. Read the Hellbender manual for more detail on the DAF pump operation.

- Once the recirculation pump is operating, and the required backpressure has been achieved, slowly open the valves on the eductor loop, making sure the rotameter is off initially. If the pressure in the pump drops quickly, shut the eductor loop valves, and start again. Once the eductor loop valves are open, re-adjust the backpressure valve back to 92 psi.
- Slowly open the rotameter and begin introducing air into the pump. From 2009 operating experience an air flow rate of 20-30 scfh appears to be sufficient to achieve the dissolved air requirements. If a gravel-like sound can be heard in the pump, turn down the air or shut it off. Wait for the sound to disappear, and slowly introduce air again.
- While starting up the influent to the system, make sure someone is watching the backpressure valve. If the pressure drops off quickly, immediately shut the eductor loops. If this does not bring the pressure up, the pump has already vapour-locked, and needs to be immediately shut down.

Influent Start-up

- Prime the raw influent pump by using flow from the DAF pump, opening the influent line to the influent pump, and removing the plug at the top of the pump casing to allow the displaced air to escape. Close the pump discharge valve to isolate the pump. Start the pump, and watch for the water to move up the suction line. Repeat the priming process if needed. Once primed, replace the plug in the pump casing and open the pump discharge valve to permit forward-flow.
- Once water is flowing into the system, measure the flow rate on the flowmeter and ensure that the flow is 100 gpm.
- Open the alum supply valve and turn on the alum dosing pump
- Open the polymer supply valve and turn on the polymer dosing pump
- Take a sample from the alum sample port, and measure the pH, and observe the water for coagulation and floc formation.
- Based on 2009 operating experience, for treating PWSP No. 3, the target pH will be approximately 7.15 units.
- Adjust the alum dosing pump as needed to achieve this target pH.
- Take a sample from the polymer sample port, and observe for floc formation. Compare the alum sample and the polymer sample and verify that the polymer is increasing the floc size and decreasing the formation time.
- Initially, take frequent pH readings to ensure consistent alum dose.

Alum Make Down

- New alum solution will likely have to be made up every 4 to 8 hours. Check the alum level in the barrel every hour.
- When 50L, or about 6 inches, of alum solution is left, fill the barrel with water and add one bag of alum
- Mix the alum right away to prevent formation of an alum paste that is harder to dissolve.
- The 50 L level should be marked at the bottom of the barrel, and the new alum and water should be added at this same point every time as best as possible to ensure a consistent alum solution is being dosed. Always check that the influent pH has not changed after making up a new alum solution. Adjust the alum dose to maintain the same pH if the concentration of the dosed solution has shifted the pH.

Polymer Make Down

- Based on 2009 operating experience, the target polymer dose is 1 ppm for PWSP No. 3. The polymer dosing pump appears to have an upper flow limit of approximately 10 L/hr. Therefore, at

100 USgpm pond water flor rate, a polymer concentration of 2500 mg/L is needed to achieve this 1 ppm dose. This 2500 mg/L concentration is equivalent to 750 g of dry polymer per 300 L barrel

- Polymer is most effective when it has been wetted and allowed to age for a minumim of 1 hour. To achieve this, and remain operating, add 50g of polymer powder per 20L bucket of water added. The operators should not to let the polymer make-down barrel empty very much. Ideally only 40 L of make-up water/polymer should be added at one time, which will be needed approximately every 4 hours.
- Dry polymer powder needs to be added to water very slowly so it doesn't form into large clumps that are difficult to dissolve. When adding the dry polymer, make sure the mixer is running, and sprinkle the dry polymer over the surface of the barrel. Watch that clumps are not forming. If clumps form, slow down the addition even further. Keep the polymer agitated, but shut the mixer off periodically so that the motor does not overheat.

Sludge Skimming and Removal

The floating sludge that comes to the surface in the DAF tank has to be skimmed off frequently. Once the floating sludge mat has formed to about ¾ of the length of the DAF tank, it is time to skim. Use a large piece of styrofoam to pull the sludge to the effluent end, up the sludge beach, and into the sludge trough. Monitor the height of sludge in the totes and pump them out when full. Pumping the contents of the sludge totes to PWSP No. 1 is required approximately once per hour when carefull skimming techniques are employed and the water level is not too high in the DAF tank.

Refuelling

- When refueling a pump, make sure it is turned off and all safety procedures all followed. If the influent pump is being refuelled, turn off the alum and polymer dosing pumps, and close the injection point valves. The DAF recirculation pump should still be left on and can just recirculate in the tank.
- When refuelling the effluent pumps, disconnect the effluent hose from the clear well, and send the effluent to the pond while refuelling

Shut down

- If the system is being shut-down for any reason, the following sequence should occur:
- Shut down the final effluent pumps, and disconnect the pumps, allowing the effluent clear-well tanks to empty back to the pond.
- Turn off the alum pump and close the injection valve.
- Turn off the polymer pump and close the injection valve.
- Turn off the influent pump.
- Shut down the DAF recirculation pump as per the Hellbender pump manual.
- Open the air-break (anti-siphon) point at the top of the DAF influent header to prevent siphoning of the DAF tank contents.
- If freezing is a risk, disconnect and drain all lines.
- Close the DAF pump recirculation valve

Sampling and Monitoring

- Frequent sampling and monitoring of the system is needed to document consistent operation of the system.

- Upon start-up, pH measurements should be taken at the influent every 5 minutes for half and hour and adjustments to the alum dose made accordingly.
- Once the alum addition is confirmed to be stable, take samples from the polymer sampling point to visually confirm good floc formation. Make adjustments to the polymer dosing as required.

SAMPLING AND PERFORMANCE MONITORING

During operation, the treatment system is attended on a continuous basis. A daily field log was collected for each day of operation of the polishing system during 2009. A sample of the field log is attached (Attachment C).

The polishing system was controlled using field testing devices for pH and turbidity. Adjustments were made to the aluminum sulphate dosing pump to control the pH and the polymer dosing pump was used to control the turbidity (indicative of total suspended solids-TSS). Physical inspection of the DAF inlet and discharge streams, as well as the consistency of the floated solids layer, indicated to the operators how well the system was operating. In the event of a suspect result a bypass valve was used to redirect effluent back to the PWSP while the system operation was adjusted and retested.

A complete summary of the field, onsite lab, and 3rd party analytical testing is contained in the following Table.

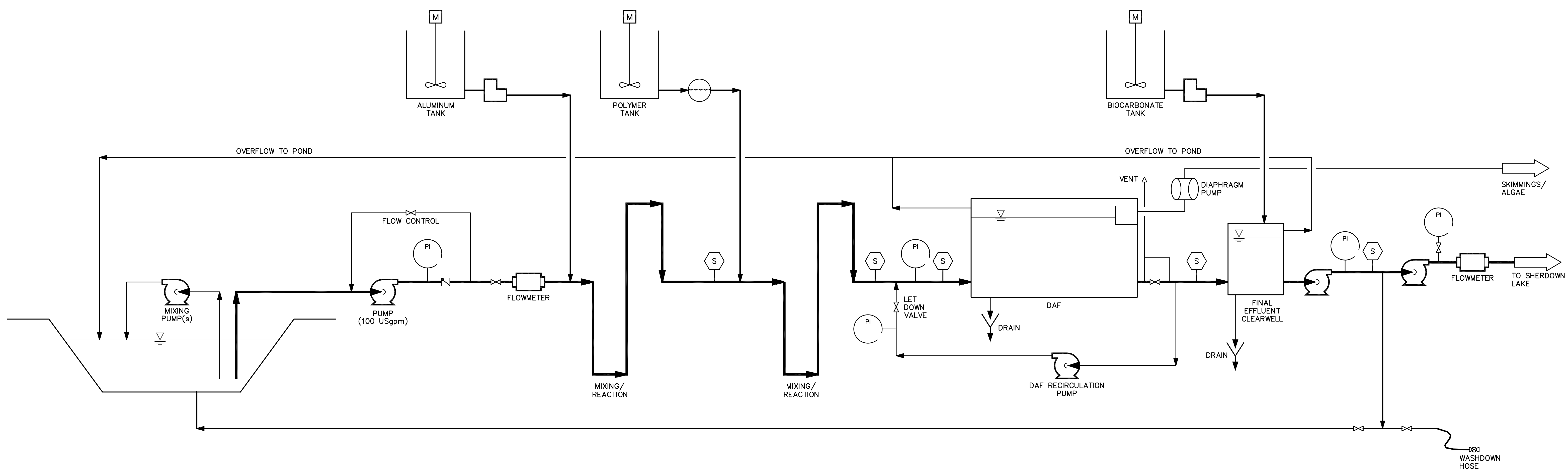
Table 2: Summary of PWSP Polishing Monitoring

In House Analysis	Pre Discharge	Middle of Discharge	End of Discharge	Weekly (3rd party)	Daily (onsite lab)	Hourly (in field)
pH	√	√	√		√	√
Temperature	√	√	√		√	√
Turbidity	√	√	√		√	√
TP	√	√	√		√	
Ammonia	√	√	√		√	
COD	√	√	√		√	
External Lab Analysis						
BOD	√			√		
COD	√			√		
TSS	√			√		
TP	√			√		
Fecal Coliforms	√			√		
Toxicity		√	√			
O&G	√			√		

Continuous field monitoring and attendance of the system resulted in 100% compliance during the 2009 operating season. A conservative operating philosophy was adopted during the discharge season which involved using field analytical instruments to test effluent samples for multiple parameters during operation. Daily sample analysis was completed using benchtop analytical equipment available onsite. Samples were submitted for laboratory analysis on a weekly basis to confirm the screening results and develop a correlation between the two testing methods.

Attachment A

PWSP Polishing System Process Flow Diagram (PFD-01)



CAUTION: THIS PLAN MAY BE REDUCED 0 25mm 50mm ORIGINAL SCALE

NO.	REVISION	DATE	APRVD

DRAWN JR JULY 2009
DESIGNED JW JULY 2009
CHECKED
REVIEWED

AMEC Geomatrix
AMEC Geomatrix Limited
420 Weber Street, North, Unit G
Waterloo, Ontario N2L 4E7
(519) 886-7500

PROCESS FLOW DIAGRAM

BAFFINLAND IRON MINES
POND WASTEWATER TREATMENT

DATE: JULY 2009
SCALE: N.T.S.
SHEET: 1 OF 1 SHEETS
PROJ No: W01446
PFD–01

Filepath: T:\ Pete Geomatrix 2009 092245-E Baffinland (W01446)\ W01446-PFD.dwg
Plot Time: Jul 22, 2009 - 12:44pm, Plotted By: Dell Survey2

Attachment B

PWSP Polishing System Photographs (2010)

PHOTOGRAPH LOG
Baffinland Iron Mines
Effluent Discharge Treatment System (2010)

Photograph 1 Treatment System Influent Pump and Flowmeter

Photograph 2 Aluminum Sulphate and Polymer Dosing Systems with Flocculation Piping

PHOTOGRAPH LOG

Baffinland Iron Mines

Effluent Discharge Treatment System (2010)

Photograph 3 Dissolved Air Floatation Tank

Photograph 4 Dissolved Air Floatation Pump

PHOTOGRAPH LOG
Baffinland Iron Mines
Effluent Discharge Treatment System (2010)

Photograph 5 Floated Solids Tanks(left) and Effluent Clear Well Tanks (right)


Photograph 6 Effluent Discharge Pump

PHOTOGRAPH LOG
Baffinland Iron Mines
Effluent Discharge Treatment System (2010)

Photograph 7 Treatment System Aerial View

Photograph 8

Attachment C

PWSP Polishing System Field Log, Sample Sheet

Baffinland Iron Mines Pond Water Treatment
Daily Field Log Sheet

Pond being treated:

		Field Parameters			Lab Parameters				Observations/Notes
Date	**Time**	**pH**	**Turbidity**	**Temperature**	**Ammonia as N**	**TP as P**	**COD**	**Turbidity**	
dd/mm/yy	(24hr)		NTU	deg C	mg/L	mg/L	mg/L	NTU	

Appendix F.2

Sludge Management Strategy

Technical Memorandum

To: Jim Millard, Baffinland Iron Mines   Project: TR1596, Phase 1

From: Jered Munro, AMEC
Dave Ellis, AMEC
Joel Westberg, AMEC

Tel: (519) 886-7500

Date: March 26, 2010

Subject: 2010 Sludge Management Plan Strategy

AMEC was retained by Baffinland Iron Mines Corporation in 2008 to develop a sludge management plan for sewage sludge contained at the Mary River and Milne Inlet Polishing Waste Stabilization Ponds (PWSPs). The 2008 report identified potential conceptual options that would be investigated in future open water seasons.

This technical memorandum identifies the sludge management efforts that were completed in 2009 and outlines the proposed workplan for the 2010 operating season.

2009 SLUDGE MANAGEMENT PROGRAM

As part of the 2009 sludge management activities, a portion of the clarified aqueous phase at the top of Mary River PWSP No.1 was transferred to PWSP No. 2. The quality of the water was expected to be similar to the stored effluent in PWSP No. 2 and suitable for treatment and discharge. The transfer also increased the storage capacity in PWSP No. 1 to allow for future sludge disposal from the RBC at Mary River.

2009 Solids Inventory Summary

A sludge survey was conducted prior to the effluent discharge to establish the quantity of sludge present in Mary River PWSP No.'s 1, 2 and 3. The survey results are presented below.

Table 1: PWSP No.1

Depth	Matrix	Volume
0 - 4.5'	Water	2118 m3
4.5 - 6'	Sludge	392 m3

Over time, the sludge solids transferred to PWSP No. 1 from the rotating biological contactor (RBC) system settled in the pond formed a thickened, heavier settled solids sludge layer with a supernatant aqueous phase. The sludge layer is considered to be the layer where the settled solids concentration is significantly different than the supernatant water phase.

The physical sludge characteristics for the Mary River site are of relatively light density for primary sewage solids and as a result the concentration is estimated to be approximately 10,000 mg/L. The lighter weight solids cause the intermediate water depths to have relatively high concentrations of suspended solids and have been measured between 700-1000 mg/L in the majority of the water column.

Additional solids that were captured as part of the 2009 PWSP effluent treatment activities were captured and stored in PWSP No.1 but were not included in the solids inventory.

Table 2: PWSP No.2

Depth	Matrix	Volume
0 – 5.5’	Water	2800 m3
5.5 - 6’	Sludge	150 m3

The sludge present in pond No.2 is a mixture of deceased algal biomass and sewage sludge that was stored in the pond once pond No.1 had reached maximum capacity. The sludge exhibits the same characteristics as the solids stored in pond 1.

PWSP No.3:

There is a very minor layer of solids in the bottom of pond No. 3 resulting from settled alum solids generated in the RBC treatment process plus a small amount of deceased algal biomass. For the purposes of sludge treatment, the sludge contribution from PWSP No. 3 is not significant enough to quantify in estimations.

Bench Scale Treatment Testing

Bench Scale Treatability Testing was completed during the 2009 season to simulate two separate passive sludge dewatering methods. These two tests are discussed in more detail below:

1. Geotextile dewatering bags (Geotube brand geosynthetic dewatering material)

   Tencate, the manufacturer of Geotube, was contacted to supply preliminary estimates on the number and size of geotextile bags required based on preliminary sludge estimates from the PWSP. A complete overview of the Tencate product has been included in Attachment A including product brochures, technical specification sheets, and preliminary volumetric estimates for the PWSP’s.

   The following tables contains a summary of the testing procedure and results from the initial Geotube sampling.

Table 3: PWSP No.1 Sludge Dewatering Test

Tencate geotextile filter testing, Sept 1, 2009

Polymer Dose (ppm) / Alum Dose (ppm)	10	20	30	40	80
0					
250					
400					
500					

Legend
- Poor Coagulation/Poor Filtering
- Good Floc Formation, Poor Filtration
- Good Floc Formation and Good Filtration

Table 4: PWSP No.1 Sludge Dewatering Test

Tencate geotextile filter testing, Sept 2, 2009

Polymer Dose (ppm) / Alum Dose (ppm)	6	9.4	12.5	19	25	50	100
350							
500	**250 and 90**	**275**	**130**	**105**	**50**	**200 and 120**	**170**
600		**170**					
700							

Legend
- Poor Coagulation/Poor Filtering
- Good Floc Formation, Poor Filtration
- Good Floc Formation and Good Filtration
- 275 — Numerical values represent the volume (mL) of free draining liquid from the filter during 3 minutes. All samples started with 400 mL of sample.

Photos of the field testing are contained in Attachment B.

2. <u>Freeze/Thaw Sludge Dewatering Test</u>

A group of undergraduate students from the University of Waterloo completed a laboratory analysis on the effects of freeze/thaw cycling on sewage sludge. The purpose of the test was to determine possible sludge dewatering opportunities resulting from seasonal climatic variations at the Baffinland mine site.

The sludge drying bed test was setup to mimic:

- the freezing of the ponds,
- periodic discharge of sewage sludge to the pond from the RBC during the winter,
- subsequent freezing of the periodic discharges in layers, and
- melt water formation during the spring thaw.

The subsequent melt water and sludge solids were sampled and initial quality measurements made. The following procedure was followed for the testing:

- The testing setup was completed in a freezer at -20° C.
- Sewage sludge (waste activated sludge, WAS) from the City of Waterloo sewage treatment plant was collected prior to the testing and placed in the lab fridge until the time of the test.
- A two large wash basins were used to mimic lined sludge drying beds. A sand underdrain system and sample valve was installed in each basin.
- Waste activated sludge was added to the basin to a depth of approximately two-inches and allowed to freeze solid for a minimum of 48 hours prior to adding the next layer.
- Two additional layers of waste activated sludge were added using this same procedure.
- The frozen sample was left in the freezer for 4 weeks at approximately -20° C.
- The basin was removed from the freezer and allowed to thaw in a walk-in refrigerator at 5° C.
- Samples of the produced melt water were collected and submitted for analytical measurement of chemical oxygen demand (COD) and total suspended solids (TSS) concentrations to characterize the melted filtrate from the drying bed. Two samples were collected from each test basin.
- One sample of the residual sludge solids was collected from each test basin and the total solids concentration measured.

The following table summarizes the preliminary results from the sludge drying bed testing.

Table 5: Sludge Drying Bed Simulation Results

Sample	Tank 1 TSS (mg/L)	Tank 2 TSS (mg/L)
Raw Sewage Sample	3530	4100
Filtrate Sample No.1	45	76
Filtrate Sample No.2	22	39
Sample	**Tank 1 TS (%)**	**Tank 2 TS (%)**
Sludge solids	22	4
Notes: TSS – total suspended solids concentration TS – total solids concentration		

Initial results suggest that significant solids separation occurs during the freezing of the sewage sludge. The resulting filtrate captured from the melt water suggests that the liberated water could be potentially captured and transferred to the effluent storage pond or returned to the RBC for subsequent polishing and discharge of effluent.

It is expected that this process could be repeated annually to concentrate the sludge solids prior to final disposal.

The resulting total solids concentration of the captured sludge solids indicates a significant increase from the original samples. Further investigation into the viability of this process for a long-term sludge drying solution could be pursued.

2010 SLUDGE MANAGEMENT ACTIVITIES

Planned 2010 sludge management activities will build on the results of previous work, presented above. Planned work will also include investigation of additional technologies which can address treatment requirements in a shortened operating schedule. The following are the strategies that have been identified to be reviewed and assessed in 2010.

1. Short Term (1-2 years) Dewatering and Disposal Strategy

    - Containerized Geotubes

    - Mechanical Dewatering (e.g. centrifuge, belt press)

2. Long Term (3-5 years) Management and Disposal Strategy

    - Sludge drying bed
    - Geotubes
    - Mechanical Dewatering (centrifuge, belt press)

The chosen strategy will be dependant on the status of operations at the mine site. To dispose of the sewage sludge solids it is expected that the chosen technology will need to meet the following criteria:

- Pass the slump test (Attachment C),
- Pass the TLCP test for landfill disposal (Attachment D), and
- Allow easy material handling of the dewatered sludge utilizing existing equipment on site.

It is also expected that the solids would need to be stabilized using an amendment such as lime in order to raise the pH and avoid anaerobic offgasing of the dewatered sludge during shipping/storage.

The aqueous by-product stream generated by all the dewatering technologies will require further treatment prior to discharge. This further treatment could be accomplished in the PWSP's or the RBC for treatment prior to discharge.

2010 Sludge Management Workplan

In order to develop a successful and sustainable sludge handling, treatment, and disposal process for the Mary river site, AMEC requires additional site specific information to a) increase the confidence in the proposed technologies and b) provide further field testing to confirm the results of the previous season.

The following workplan is proposed for the 2010 season:

1. Confirm sludge disposal criteria
2. Gather site specific weather data
3. Literature review of best available technology economically achievable (BATEA)
4. Prepare a summary of current industry standards
5. Redevelop the list of dewatering options depending on the preferred timescale
    a. Extended timescale (3-5years)
    b. Moderate timescale (1-3 years)
    c. Short timescale (1 year)
6. 2010 Field Testing program:
    a. Geotube bench test (MI and MR PWSP No.1 sewage sludge)

b. Decanting of PWSP No.1 (pending resource availability)

c. Pilot sludge drying bed study (Containerized Field Test)

d. Pilot sludge dewatering (Geotube) study

e. Sample submittal for centrifuge and/or belt press dewatering performance testing

Attachment A

Geotube Brand Geotextile Dewatering bag Vendor Information

TENCATE

Geotube

INDUSTRIAL FABRICS
Dewatering Systems

Geotube® Dewatering Technology

Protective & Outdoor Fabrics
Aerospace Composites
Armour Composites

Geosynthetics
Industrial Fabrics
Synthetic Grass

TENCATE
materials that make a difference

The Low Cost, High Volume Dewatering Solution

Geotube® dewatering technology has become the dewatering method of choice for organizations around the world. Geotube® dewatering technology is used for projects large and small, and there's good reason—simplicity and low cost.

There are no belts or gears. Geotube® containers are available in a variety of sizes, depending on your volume and space requirements. Geotube® systems can even be mounted in mobile roll-off containers that can be transported around your property as necessary. It's one of the most versatile dewatering technologies available.

And one of the most effective. Volume reduction can be as much as 90%, with high solid levels that make removal and disposal easy.

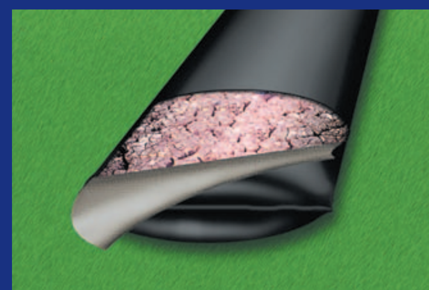
Sludge before (left) and after (right) treatment with Geotube® dewatering technology.

1. Filling

Sludge is pumped into the Geotube® container. Environmentally safe polymers are added to the sludge, which make the solids bind together and water separate.

2. Dewatering

Clear effluent water simply drains from the Geotube® container. Over 99% of solids are captured, and clear filtrate can be collected and recirculated through the system.



3. Consolidation

Solids remain in the bag. Volume reduction can be up to 90%. When full, the Geotube® container and contents can be deposited at a landfill, or the solids removed and land-applied when appropriate.

Case Study

application	**Dewatering of PCB Contaminated Soil**
location	**Appleton, WI**
product	**Geotube® Dewatering Technology**

For more than 50 years, paper mills along the Fox River have contributed to the contamination of local waterways with PCBs. Geotube® dewatering technology is being used to dewater 750,000 to 1 million cubic yards of contaminated soil. Sixty-foot circumference Geotube® containers were stacked three and four layers high, and have kept pace with dredges operating in excess of 2,000 gallons per minute. Dewatered solids are in excess of 50%, and the process is much more cost-effective than belt presses or other methods of dewatering.

Environmental Remediation

Effective Containment for Large and Small-Scale Projects

Rivers, bays, harbors, marinas, ports, and dock facilities have been collecting contaminated sediments from industrial runoff for many years. In many cases, these sediments pose significant environmental hazards, and remediation is a difficult and expensive task.

Marine sediments can be contained and dewatered easily with the Geotube® dewatering technology. This can be accomplished at or very near the site by utilizing a dewatering basin where Geotube® containers can be stacked several layers high to maximize space. Geotube® units can be sized for large-scale or smaller applications, and effectively contain even hazardous materials, reducing their volume dramatically and saving thousands in disposal costs.

Dewatered sludge being removed from a Geotube® container with a backhoe.

Pulp and Paper
Multiple Uses

Geotube® dewatering technology is used for a variety of applications within pulp and paper mills, including:

- Primary and secondary lagoon cleanout
- Fly ash and alum sludge
- Contaminated sediments
- Continuous systems clarifier, sentrate, process waste stream
- Process rejects
- Separation dikes
- Emergency uses, such as cleanouts, spills, dumps, or exceeding discharge limits.

The rapidity with which a Geotube® dewatering operation can be set up has also been an advantage in paper mill applications, particularly in emergency situations where mills ran the risk of having to shut down.

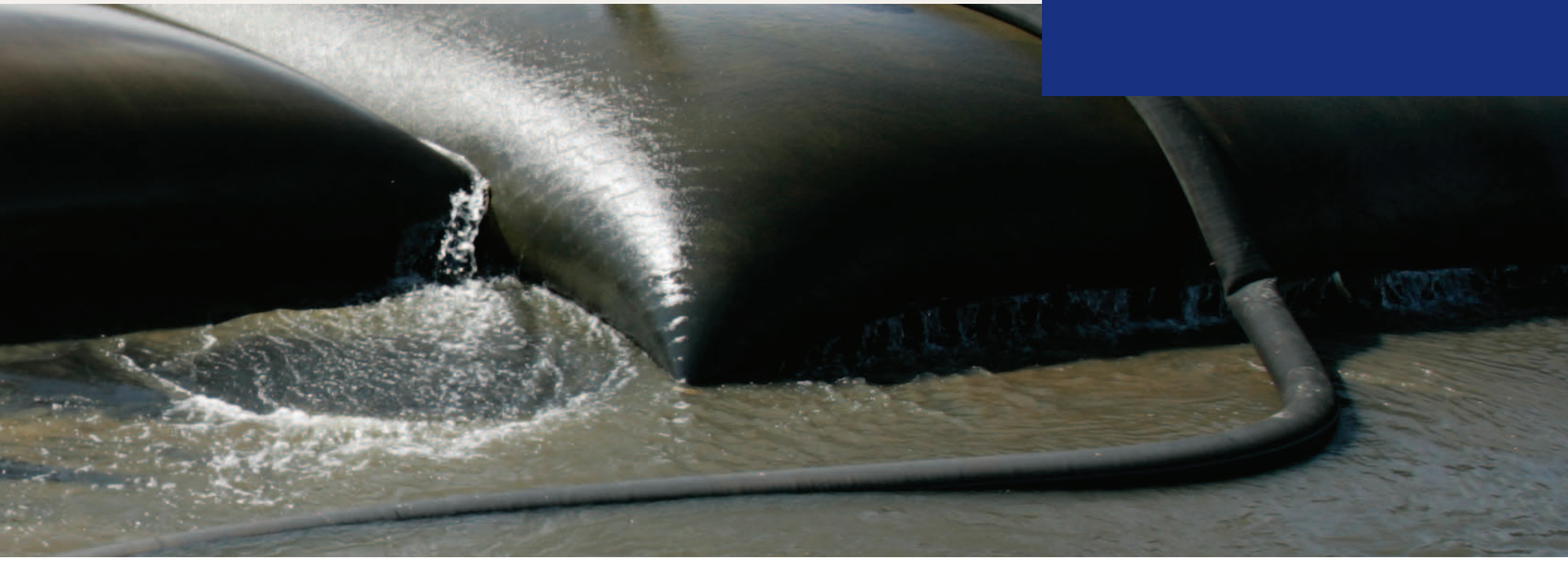
Geotube® containers in activated sludge basin at paper plant.

Case Study

application	**Cleanout of Black Liquor Lagoon**
location	**St. George, NB**
product	**Geotube® Dewatering Technology**

The black liquor sludge lagoon at the Lake Utopia paper mill was full and in danger of overflowing. To solve this problem, 1,400 linear feet of Geotube® containers were placed in a landfill area and were used to dewater and contain the material dredged from the lagoon.

The process took less than seven days. Over 19,800 cubic yards of material were dewatered, and they solidified within the Geotube® containers to more than 50% in about three months. The containers will remain in the landfill permanently.



Case Study

application	**Dewatering of Acidic Mine Tailings**
location	**Skytop Mountain, PA**
product	**Geotube® Dewatering Technology**

During the construction of I-99 in Pennsylvania, workers unearthed more than 700,000 cubic yards of pyritic rock left over from mining. The acid runoff from this material threatened local streams and groundwater. The solution: a process using Geotube® dewatering technology.

The pyritic rock is crushed and treated with a neutralizing agent. Acid runoff from this process is collected in sediment ponds, which is treated and pumped through Geotube® containers. Water, clear and neutralized, flows from the Geotube® container without requiring further treatment.

Mining and Mineral Processing

Flexible Enough for Available Space

Mine tailings, coal sludge, and other materials can be managed and handled cost-effectively with Geotube® dewatering technology. Because Geotube® containers can be custom-sized to the application, they can be placed in available space between other structures, and removed once dewatering is complete. Geotube® dewatering technology is a cost-effective alternative to mechanical processes. It reduces disposal cost by consolidating higher solids with very little maintenance.

Coal sludge dewatering using Geotube® dewatering technology.

Effluent can be pumped directly from the process; or if a clarifier/thickener is used, effluent from the underflow can be diverted through the Geotube® container, eliminating the requirement for an expensive mechanical dewatering device. Geotube® units can be used to capture fines, silts, and clays from the tailings effluent prior to discharge into the ponds or directly into streams. Geotube® units will separate and dewater the fines and allow disposal without expensive dredging and transporting operations. In some cases, conditioners or polymers are used to promote flocculation to improve solids retention and filtrate quality.

Geotube® containers can also be used to utilize the fines to build dikes and containment berms.

Power Generation

A Solution for Fly Ash and Bottom Ash

Power generation by-products such as fly ash and bottom ash can be a real challenge to remove and manage. But the simple technology of Geotube® dewatering allows facilities large and small to easily consolidate these materials—and make adjustments as needed based on volume.

Geotube® dewatering technology safely contains fly ash, preventing airborne particle contamination from windblown ash piles. The ash can then be used for road base applications or even to build up the berms around a lagoon to increase its capacity. In many fly ash operations, there is no need to add polymer to the dewatering process, making it simple and affordable.

Geotube® containers at fossil fuel power plant being used to dewater fly ash.

Case Study

application	**Dewatering of Boiler Ash**
location	**Camden, TX**
product	**Geotube® Dewatering Technology**

Geotube® dewatering technology was used for dewatering a lagoon containing approximately one million gallons of boiler ash, with solids 2.6% by dry weight. Previous dewatering attempts using a long stick Trac Hoe were only partially successful, and the sludge had been laid up on the bank of the lagoon to dry—not an ideal approach.

However, by using Geotube® dewatering technology, the facility was able to remove and dewater practically all the solids in the lagoon. After 30 days, the material had consolidated to 37% solids. It is estimated that this approach saved the power plant more than $60,000 annually.

Water and Wastewater Treatment

For Applications Large and Small

Geotube® dewatering technology has been used in water and wastewater treatment applications including lagoon, tank, and digester cleanouts. It can provide dewatering and containment in one operation, with 85% to 90% reduction of BOD in the effluent.

Geotube® dewatering technology can be used seasonally, with solids safely stored onsite between uses. It works even with fine-grained sediments, and solids can be disposed of in a landfill or land applied. It can also be a very effective way of handling septage, either at a private receiving station or a municipal site.

Geotube® unit in municipal wastewater treatment drying beds.

Units available in sizes to fit drying beds. There is also a unit designed to fit in a roll-off box (Geotube® MDS) for convenience.

Case Study

application	**Emergency Addition of 3x Septage Capacity**
location	**Rio das Ostras, Brazil**
product	**Geotube® Dewatering Technology**

The population of Rio das Ostras swells to three times its normal size during holiday season in Brazil, overloading the city's water treatment facilities. Geotube® dewatering technology was used to provide the extra capacity. In addition to dewatering units at the city's small wastewater treatment plant, a large scale septage receiving facility was constructed at the city's landfill, using 60-foot circumference x 200 foot long Geotube® containers.

The dewatering system was so efficient that effluent could be filtered through a reed bed and discharged into local waterways without additional treatment.

Light Industrial

Managing an Ongoing Challenge

For many industrial applications, dewatering is a necessary evil. It disrupts operations, adds cost, and requires complicated and expensive equipment. But this doesn't have to be the case. One of the real values of Geotube® dewatering technology is that it can provide a quick lagoon cleanout solution, or it can add capacity by making drying beds much more efficient.

In some cases, companies have dewatered the material in their lagoons using Geotube® dewatering technology, then used the solid-filled Geotube® containers as berms to expand the capacity of their lagoons. Dewatering efficiency can be improved because Geotube® containers protect the dewatered solids from becoming saturated again in wet weather. And Geotube® containers can be stacked on top of each other to further add capacity.

Water draining from a Geotube® container.

Case Study

application	**Dewatering Adhesive Production Residuals**
location	**Panama City, FL**
product	**Geotube® Dewatering Technology**

The residual material left over from Arizona Chemical's adhesive production process contains inorganic compounds and is too abrasive to dewater with a belt press. Geotube® dewatering technology proved a more effective solution.

The dewatered cake solids from Geotube® dewatering technology far exceeded any other form of dewatering previously utilized. This increase in efficiency saved 38% over belt press dewatering—plus a 50% reduction in time to complete the job. Because the dewatering efficiency was so much greater and the cake solids drier, there was a 40% reduction in disposal costs.

Case Study

application	**Farm Lagoon Cleanout**
location	**New Bern, NC**
product	**Geotube® Dewatering Technology**

A hog farm lagoon had reached capacity and was in need of cleanout. Geotube® dewatering technology was used as a simple, effective way of accomplishing this.

Solids at 4% were pumped from the lagoon. These dewatered to over 25% in the Geotube® container. The container retained 93% of solids, plus 78% of nitrogen and 90% of phosphorous.

The costs for dewatering were less than 1/2 cent per gallon of the sludge pumped.

Agriculture

Ideal for Swine, Dairy, Poultry, and Other Uses

Geotube® dewatering technology is an effective way for managing waste from Confined Animal Feeding Operations (CAFO's). It works for lagoon cleanout and closure, and manages nutrients very effectively (over 90% phosphorous and heavy metal removal; 50% or greater nitrogen reduction). It also controls odor and produces irrigation quality effluent water.

Geotube® dewatering technology is designated as a Practice Standard (Federal Practice Number 632) by the USDA NRCS (Natural Resource Conservation Service). As such it can qualify for up to 75% matching funds under the Environmental Quality Incentives Program (EQIP). Ask your TenCate Geotube representative for more details.

You can even set up a Geotube® dewatering system inline, so you prevent solids from entering a lagoon. You store water for irrigation, not waste you have to deal with later. The system doesn't interrupt other operations.

Geotube® dewatering technology used in agricultural applications qualifies for EQIP funding.

Aquaculture

Simple, Cost-Effective Waste Removal for Applications Large and Small

Now approved as a Best Management Practice for Aquaculture by the State of North Carolina, Geotube® dewatering technology works for fresh water or marine finfish, shrimp, and other aquatic species. It simplifies the process for water recirculation, and retains more than 99% of suspended solids.

Geotube® dewatering technology reduces nutrient loading in filtrate. It can be used continuously or intermittently year-round in most climates. It is ideal for lagoon, retention pond, and filter waste applications. It can be used for cage waste removal, benthic table waste cleanup, recirculation waste removal for hatcheries, and processing plant waste dewatering. Dewatered solids can be land applied or disposed of in a landfill.

Aquaculture benthic deposit water before and after Geotube® treatment.

Geotube® dewatering technology has been tested extensively in programs at North Carolina State University, Freshwater Institute, Mote Marine Aquaculture Park, and Virginia Institute of Technology. More importantly, Geotube® dewatering technology has been used in the field with solid success.

Test Your Material

A simple bench-scale test can determine if Geotube® dewatering technology is right for your application.

Our Geotube® Dewatering Test (GDT) uses an actual sample of the material you need dewatered. The results from this test have been proven to be an accurate indicator of how Geotube® dewatering technology will work in full-scale operation. You can effectively estimate effluent quality, solids, and dewatering rates.

See your Geotube® representative to schedule a test for your material.

See Our Presentation

To learn more about this technology, we invite you to look at our CD presentation, which provides detailed information. We can even schedule “lunch and learn” sessions for larger groups. For details, visit www.geotube.com or call 888-795-0808.

TenCate develops and produces materials that function to increase performance, reduce cost, and deliver measurable results by working with our customers to provide advanced solutions.

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QUALITY ASSURANCE
ACCREDITED LABORATORY

TENCATE
materials that make a difference

Attachment B

Field Dewatering Trial Photographs (2010)

PHOTOGRAPH LOG
Baffinland Iron Mines
Field Sludge Dewatering Testing (2010)

Photograph 1 Geotube test equipment at PWSP No. 1.

Photograph 2 Preparing sludge sample from PWSP No. 1.

PHOTOGRAPH LOG
Baffinland Iron Mines
Field Sludge Dewatering Testing (2010)

Photograph 3 Geotube test results (L to R: Raw PWSP No. 1 sludge, coagulated/flocculated sludge sample, Geotube filtrate)

Attachment C

Slump Test Procedure

A23.2-5C
Slump of Concrete

Δ 1. Scope
This Test Method describes the procedure to be used for determining slump of concrete, both in the laboratory and in the field.

2. Apparatus
The apparatus shall consist of the following:
(a) a test specimen mould made of metal not thinner than 1.5 mm, not readily attacked by cement paste, and in the form of the lateral surface of the frustum of a cone with the base 200 mm in diameter, the top 100 mm in diameter, and the height 300 mm. The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The mould shall be provided with foot pieces and handles as shown in Figure 1;
(b) the tamping rod shall be a round, straight steel rod 16 mm in diameter and not less than 450 mm nor more than 600 mm in length, having one end rounded to a hemispherical tip with a diameter of 16 mm.

3. Sample
The sample of concrete from which test specimens are made shall be representative of the entire batch. It shall be obtained in accordance with the requirements of CSA Test Method A23.2-1C.

Note: *If the concrete contains coarse aggregate particles that would be retained on a* 56 mm *sieve, the sample should be wet-sieved over a* 40 mm *screen by procedures of CSA Test Method A23.2-1C.*

4. Procedure

4.1 Time Constraint
The test for slump shall be completed within 10 min after the sampling is completed.

4.2
Dampen the mould and place it on a flat, moist, nonabsorbent (rigid) surface. Hold it firmly in place during filling by the operator standing on the two foot pieces. From the sample of concrete obtained in accordance with Clause 3, immediately fill the mould in three layers, each approximately one-third the volume of the mould.

Note: *One-third of the volume of the slump mould fills it to a depth of* 70 mm; *two-thirds of the volume fills it to a depth of* 160 mm.

4.3
Rod each layer with 25 strokes of the tamping rod. Uniformly distribute the strokes over the cross-section of each layer. For the bottom layer, this will necessitate inclining the rod slightly and making approximately half of the strokes near the perimeter, and then progressing with vertical strokes in spirals

toward the centre. Rod the bottom layer throughout its depth. Rod both the second layer and the top layer throughout their depth, so that the strokes penetrate about 25 mm into the underlying layer.

4.4

In filling and rodding the top layer, heap the concrete above the mould before rodding begins. If the rodding operation results in subsidence of the concrete below the top edge of the mould, add additional concrete to keep an excess of concrete above the top of the mould at all times. After the top layer has been rodded, strike off the surface of the concrete with a screeding and rolling motion of the tamping rod. Remove the spilled concrete from the base of the mould. Withdraw the mould immediately from the concrete by raising it carefully in a vertical direction. Perform the operation of raising the mould in approximately 5 s by a steady upward lift. Ensure that no lateral or torsional motion is imparted to the concrete. Carry out the entire operation, from the start of the filling to removal of the mould, without interruption and within an elapsed time of 2 min.

4.5

The slump shall be determined immediately thereafter by measuring the difference between the height of the mould and the average height of the top surface of the concrete after subsidence. Slump specimens that break or slump laterally give incorrect results. For this condition, the test shall be repeated with a new sample.

Notes:

(1) *If two consecutive tests on a sample of concrete show a falling away or shearing off of a portion of the concrete from the mass of the specimen, the concrete probably lacks the necessary plasticity and cohesiveness for the slump test to be applicable.*

(2) *Duplicate tests on two portions of the same sample should not vary more than* 10 mm.

5. Report

Record the slump, in millimetres, to the nearest 10 mm of subsidence of the specimen during the test.

Attachment D

TCLP Test Procedure

METHOD 1311

TOXICITY CHARACTERISTIC LEACHING PROCEDURE

1.0 SCOPE AND APPLICATION

1.1 The TCLP is designed to determine the mobility of both organic and inorganic analytes present in liquid, solid, and multiphasic wastes.

1.2 If a total analysis of the waste demonstrates that individual analytes are not present in the waste, or that they are present but at such low concentrations that the appropriate regulatory levels could not possibly be exceeded, the TCLP need not be run.

1.3 If an analysis of any one of the liquid fractions of the TCLP extract indicates that a regulated compound is present at such high concentrations that, even after accounting for dilution from the other fractions of the extract, the concentration would be above the regulatory level for that compound, then the waste is hazardous and it is not necessary to analyze the remaining fractions of the extract.

1.4 If an analysis of extract obtained using a bottle extractor shows that the concentration of any regulated volatile analyte exceeds the regulatory level for that compound, then the waste is hazardous and extraction using the ZHE is not necessary. However, extract from a bottle extractor cannot be used to demonstrate that the concentration of volatile compounds is below the regulatory level.

2.0 SUMMARY OF METHOD

2.1 For liquid wastes (i.e., those containing less than 0.5% dry solid material), the waste, after filtration through a 0.6 to 0.8 µm glass fiber filter, is defined as the TCLP extract.

2.2 For wastes containing greater than or equal to 0.5% solids, the liquid, if any, is separated from the solid phase and stored for later analysis; the particle size of the solid phase is reduced, if necessary. The solid phase is extracted with an amount of extraction fluid equal to 20 times the weight of the solid phase. The extraction fluid employed is a function of the alkalinity of the solid phase of the waste. A special extractor vessel is used when testing for volatile analytes (see Table 1 for a list of volatile compounds). Following extraction, the liquid extract is separated from the solid phase by filtration through a 0.6 to 0.8 µm glass fiber filter.

2.3 If compatible (i.e., multiple phases will not form on combination), the initial liquid phase of the waste is added to the liquid extract, and these are analyzed together. If incompatible, the liquids are analyzed separately and the results are mathematically combined to yield a volume-weighted average concentration.

3.0 INTERFERENCES

3.1 Potential interferences that may be encountered during analysis are discussed in the individual analytical methods.

4.0 APPARATUS AND MATERIALS

4.1 Agitation apparatus: The agitation apparatus must be capable of rotating the extraction vessel in an end-over-end fashion (see Figure 1) at 30 ± 2 rpm. Suitable devices known to EPA are identified in Table 2.

4.2 Extraction Vessels

4.2.1 Zero-Headspace Extraction Vessel (ZHE). This device is for use only when the waste is being tested for the mobility of volatile analytes (i.e., those listed in Table 1). The ZHE (depicted in Figure 2) allows for liquid/solid separation within the device, and effectively precludes headspace. This type of vessel allows for initial liquid/solid separation, extraction, and final extract filtration without opening the vessel (see Section 4.3.1). The vessels shall have an internal volume of 500-600 mL, and be equipped to accommodate a 90-110 mm filter. The devices contain VITON®[1] O-rings which should be replaced frequently. Suitable ZHE devices known to EPA are identified in Table 3.

For the ZHE to be acceptable for use, the piston within the ZHE should be able to be moved with approximately 15 psi or less. If it takes more pressure to move the piston, the O-rings in the device should be replaced. If this does not solve the problem, the ZHE is unacceptable for TCLP analyses and the manufacturer should be contacted.

The ZHE should be checked for leaks after every extraction. If the device contains a built-in pressure gauge, pressurize the device to 50 psi, allow it to stand unattended for 1 hour, and recheck the pressure. If the device does not have a built-in pressure gauge, pressurize the device to 50 psi, submerge it in water, and check for the presence of air bubbles escaping from any of the fittings. If pressure is lost, check all fittings and inspect and replace O-rings, if necessary. Retest the device. If leakage problems cannot be solved, the manufacturer should be contacted.

Some ZHEs use gas pressure to actuate the ZHE piston, while others use mechanical pressure (see Table 3). Whereas the volatiles procedure (see Section 7.3) refers to pounds per square inch (psi), for the mechanically actuated piston, the pressure applied is measured in torque-inch-pounds. Refer to the manufacturer's instructions as to the proper conversion.

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[1] VITON® is a trademark of Du Pont.

4.2.2 Bottle Extraction Vessel. When the waste is being evaluated using the nonvolatile extraction, a jar with sufficient capacity to hold the sample and the extraction fluid is needed. Headspace is allowed in this vessel.

The extraction bottles may be constructed from various materials, depending on the analytes to be analyzed and the nature of the waste (see Section 4.3.3). It is recommended that borosilicate glass bottles be used instead of other types of glass, especially when inorganics are of concern. Plastic bottles, other than polytetrafluoroethylene, shall not be used if organics are to be investigated. Bottles are available from a number of laboratory suppliers. When this type of extraction vessel is used, the filtration device discussed in Section 4.3.2 is used for initial liquid/solid separation and final extract filtration.

4.3 Filtration Devices: It is recommended that all filtrations be performed in a hood.

4.3.1 Zero-Headspace Extractor Vessel (ZHE): When the waste is evaluated for volatiles, the zero-headspace extraction vessel described in Section 4.2.1 is used for filtration. The device shall be capable of supporting and keeping in place the glass fiber filter and be able to withstand the pressure needed to accomplish separation (50 psi).

NOTE: When it is suspected that the glass fiber filter has been ruptured, an in-line glass fiber filter may be used to filter the material within the ZHE.

4.3.2 Filter Holder: When the waste is evaluated for other than volatile analytes, any filter holder capable of supporting a glass fiber filter and able to withstand the pressure needed to accomplish separation may be used. Suitable filter holders range from simple vacuum units to relatively complex systems capable of exerting pressures of up to 50 psi or more. The type of filter holder used depends on the properties of the material to be filtered (see Section 4.3.3). These devices shall have a minimum internal volume of 300 mL and be equipped to accommodate a minimum filter size of 47 mm (filter holders having an internal capacity of 1.5 L or greater, and equipped to accommodate a 142 mm diameter filter, are recommended). Vacuum filtration can only be used for wastes with low solids content (<10%) and for highly granular, liquid-containing wastes. All other types of wastes should be filtered using positive pressure filtration. Suitable filter holders known to EPA are shown in Table 4.

4.3.3 Materials of Construction: Extraction vessels and filtration devices shall be made of inert materials which will not leach or absorb waste components. Glass, polytetrafluoroethylene (PTFE), or type 316 stainless steel equipment may be used when evaluating the mobility of both organic and inorganic components. Devices made of high density polyethylene (HDPE), polypropylene (PP), or polyvinyl chloride (PVC) may be used only when evaluating the mobility of metals. Borosilicate glass bottles are recommended for use over other types of glass bottles, especially when inorganics are analytes of concern.

4.4 Filters: Filters shall be made of borosilicate glass fiber, shall contain no binder materials, and shall have an effective pore size of 0.6 to 0.8 µm, or equivalent. Filters known to EPA which meet these specifications are identified in Table 5. Pre-filters must not be used. When evaluating the mobility of metals, filters shall be acid-washed prior to use by rinsing with 1N nitric acid followed by three consecutive rinses with deionized distilled water (a minimum of 1 L per rinse is recommended). Glass fiber filters are fragile and should be handled with care.

4.5 pH Meters: The meter should be accurate to ± 0.05 units at 25 °C.

4.6 ZHE Extract Collection Devices: TEDLAR®[2] bags or glass, stainless steel or PTFE gas-tight syringes are used to collect the initial liquid phase and the final extract of the waste when using the ZHE device. The devices listed are recommended for use under the following conditions:

4.6.1 If a waste contains an aqueous liquid phase or if a waste does not contain a significant amount of nonaqueous liquid (i.e., <1% of total waste), the TEDLAR® bag or a 600 mL syringe should be used to collect and combine the initial liquid and solid extract.

4.6.2 If a waste contains a significant amount of nonaqueous liquid in the initial liquid phase (i.e., >1% of total waste), the syringe or the TEDLAR® bag may be used for both the initial solid/liquid separation and the final extract filtration. However, analysts should use one or the other, not both.

4.6.3 If the waste contains no initial liquid phase (is 100% solid) or has no significant solid phase (is 100% liquid), either the TEDLAR® bag or the syringe may be used. If the syringe is used, discard the first 5 mL of liquid expressed from the device. The remaining aliquots are used for analysis.

4.7 ZHE Extraction Fluid Transfer Devices: Any device capable of transferring the extraction fluid into the ZHE without changing the nature of the extraction fluid is acceptable (e.g., a positive displacement or peristaltic pump, a gas tight syringe, pressure filtration unit (see Section 4.3.2), or other ZHE device).

4.8 Laboratory Balance: Any laboratory balance accurate to within ± 0.01 grams may be used (all weight measurements are to be within ± 0.1 grams).

4.9 Beaker or Erlenmeyer flask, glass, 500 mL.

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[2] TEDLAR® is a registered trademark of Du Pont.

4.10 Watchglass, appropriate diameter to cover beaker or Erlenmeyer flask.

4.11 Magnetic stirrer.

5.0 REAGENTS

5.1 Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available. Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

5.2 Reagent Water. Reagent water is defined as water in which an interferant is not observed at or above the method's detection limit of the analyte(s) of interest. For nonvolatile extractions, ASTM Type II water or equivalent meets the definition of reagent water. For volatile extractions, it is recommended that reagent water be generated by any of the following methods. Reagent water should be monitored periodically for impurities.

5.2.1 Reagent water for volatile extractions may be generated by passing tap water through a carbon filter bed containing about 500 grams of activated carbon (Calgon Corp., Filtrasorb-300 or equivalent).

5.2.2 A water purification system (Millipore Super-Q or equivalent) may also be used to generate reagent water for volatile extractions.

5.2.3 Reagent water for volatile extractions may also be prepared by boiling water for 15 minutes. Subsequently, while maintaining the water temperature at 90 $\pm$ 5 degrees C, bubble a contaminant-free inert gas (e.g. nitrogen) through the water for 1 hour. While still hot, transfer the water to a narrow mouth screw-cap bottle under zero-headspace and seal with a Teflon-lined septum and cap.

5.3 Hydrochloric acid (1N), HCl, made from ACS reagent grade.

5.4 Nitric acid (1N), HNO_3, made from ACS reagent grade.

5.5 Sodium hydroxide (1N), NaOH, made from ACS reagent grade.

5.6 Glacial acetic acid, CH_3CH_2OOH, ACS reagent grade.

5.7 Extraction fluid.

5.7.1 Extraction fluid # 1: Add 5.7 mL glacial CH_3CH_2OOH to 500 mL of reagent water (See Section 5.2), add 64.3 mL of 1N NaOH, and dilute to a volume of 1 liter. When correctly prepared, the pH of this fluid will be 4.93 $\pm$ 0.05.

5.7.2 Extraction fluid # 2: Dilute 5.7 mL glacial CH_3CH_2OOH with reagent water (See Section 5.2) to a volume of 1 liter. When correctly prepared, the pH of this fluid will be 2.88 $\pm$ 0.05.

NOTE: These extraction fluids should be monitored frequently for impurities. The pH should be checked prior to use to ensure that these fluids are made up accurately. If impurities are found or the pH is not within the above specifications, the fluid shall be discarded and fresh extraction fluid prepared.

5.8 Analytical standards shall be prepared according to the appropriate analytical method.

6.0 SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1 All samples shall be collected using an appropriate sampling plan.

6.2 The TCLP may place requirements on the minimal size of the field sample, depending upon the physical state or states of the waste and the analytes of concern. An aliquot is needed for preliminary evaluation of which extraction fluid is to be used for the nonvolatile analyte extraction procedure. Another aliquot may be needed to actually conduct the nonvolatile extraction (see Section 1.4 concerning the use of this extract for volatile organics). If volatile organics are of concern, another aliquot may be needed. Quality control measures may require additional aliquots. Further, it is always wise to collect more sample just in case something goes wrong with the initial attempt to conduct the test.

6.3 Preservatives shall not be added to samples before extraction.

6.4 Samples may be refrigerated unless refrigeration results in irreversible physical change to the waste. If precipitation occurs, the entire sample (including precipitate) should be extracted.

6.5 When the waste is to be evaluated for volatile analytes, care shall be taken to minimize the loss of volatiles. Samples shall be collected and stored in a manner intended to prevent the loss of volatile analytes (e.g., samples should be collected in Teflon-lined septum capped vials and stored at 4 °C. Samples should be opened only immediately prior to extraction).

6.6 TCLP extracts should be prepared for analysis and analyzed as soon as possible following extraction. Extracts or portions of extracts for metallic analyte determinations must be acidified with nitric acid to a pH < 2, unless precipitation occurs (see Section 7.2.14 if precipitation occurs). Extracts should be preserved for other analytes according to the guidance given in the individual analysis methods. Extracts or portions of extracts for organic analyte determinations shall not be allowed to come into contact with the atmosphere (i.e., no headspace) to prevent losses. See Section 8.0 (QA requirements) for acceptable sample and extract holding times.

7.0 PROCEDURE

7.1 Preliminary Evaluations

Perform preliminary TCLP evaluations on a minimum 100 gram aliquot of waste. This aliquot may not actually undergo TCLP extraction. These preliminary evaluations include: (1) determination of the percent solids (Section 7.1.1); (2) determination of whether the waste contains insignificant solids and is, therefore, its own extract after filtration (Section 7.1.2); (3) determination of whether the solid portion of the waste requires particle size reduction (Section 7.1.3); and (4) determination of which of the two extraction fluids are to be used for the nonvolatile TCLP extraction of the waste (Section 7.1.4).

7.1.1 Preliminary determination of percent solids: Percent solids is defined as that fraction of a waste sample (as a percentage of the total sample) from which no liquid may be forced out by an applied pressure, as described below.

7.1.1.1 If the waste will obviously yield no liquid when subjected to pressure filtration (i.e., is 100% solids) proceed to Section 7.1.3.

7.1.1.2 If the sample is liquid or multiphasic, liquid/solid separation to make a preliminary determination of percent solids is required. This involves the filtration device described in Section 4.3.2 and is outlined in Sections 7.1.1.3 through 7.1.1.9.

7.1.1.3 Pre-weigh the filter and the container that will receive the filtrate.

7.1.1.4 Assemble the filter holder and filter following the manufacturer's instructions. Place the filter on the support screen and secure.

7.1.1.5 Weigh out a subsample of the waste (100 gram minimum) and record the weight.

7.1.1.6 Allow slurries to stand to permit the solid phase to settle. Wastes that settle slowly may be centrifuged prior to filtration. Centrifugation is to be used only as an aid to filtration. If used, the liquid should be decanted and filtered followed by filtration of the solid portion of the waste through the same filtration system.

7.1.1.7 Quantitatively transfer the waste sample to the filter holder (liquid and solid phases). Spread the waste sample evenly over the surface of the filter. If filtration of the waste at 4 °C reduces the amount of expressed liquid over what would be expressed at room temperature then allow the sample to warm up to room temperature in the device before filtering.

NOTE: If waste material (>1% of original sample weight) has obviously adhered to the container used to transfer the sample to the filtration apparatus, determine the weight of this residue and subtract it from the sample weight determined in Section 7.1.1.5 to determine the weight of the waste sample that will be filtered.

Gradually apply vacuum or gentle pressure of 1-10 psi, until air or pressurizing gas moves through the filter. If this point is not reached under 10 psi, and if no additional liquid has passed through the filter in any 2 minute interval, slowly increase the pressure in 10 psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if the pressurizing gas has not moved through the filter, and if no additional liquid has passed through the filter in any 2 minute interval, proceed to the next 10 psi increment. When the pressurizing gas begins to move through the filter, or when liquid flow has ceased at 50 psi (i.e., filtration does not result in any additional filtrate within any 2 minute period), stop the filtration.

NOTE: Instantaneous application of high pressure can degrade the glass fiber filter and may cause premature plugging.

7.1.1.8 The material in the filter holder is defined as the solid phase of the waste, and the filtrate is defined as the liquid phase.

NOTE: Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. Even after applying vacuum or pressure filtration, as outlined in Section 7.1.1.7, this material may not filter. If this is the case, the material within the filtration device is defined as a solid. Do not replace the original filter with a fresh filter under any circumstances. Use only one filter.

7.1.1.9 Determine the weight of the liquid phase by subtracting the weight of the filtrate container (see Section 7.1.1.3) from the total weight of the filtrate-filled container. Determine the weight of the solid phase of the waste sample by subtracting the weight of the liquid phase from the weight of the total waste sample, as determined in Section 7.1.1.5 or 7.1.1.7.

Record the weight of the liquid and solid phases. Calculate the percent solids as follows:

$$\text{Percent solids} = \frac{\text{Weight of solid (Section 7.1.1.9)}}{\text{Total weight of waste (Section 7.1.1.5 or 7.1.1.7)}} \times 100$$

7.1.2 If the percent solids determined in Section 7.1.1.9 is equal to or greater than 0.5%, then proceed either to Section 7.1.3 to determine whether the solid material requires particle size reduction or to Section 7.1.2.1 if it is noticed that a small amount of the filtrate is entrained in wetting of the filter. If the percent solids determined in Section 7.1.1.9 is less than 0.5%, then proceed to Section 7.2.9 if the nonvolatile TCLP is to be performed and to Section 7.3 with a fresh portion of the waste if the volatile TCLP is to be performed.

7.1.2.1 Remove the solid phase and filter from the filtration apparatus.

7.1.2.2 Dry the filter and solid phase at 100 $\pm$ 20 °C until two successive weighing yield the same value within $\pm$ 1%. Record the final weight.

NOTE: Caution should be taken to ensure that the subject solid will not flash upon heating. It is recommended that the drying oven be vented to a hood or other appropriate device.

7.1.2.3 Calculate the percent dry solids as follows:

$$\text{Percent dry solids} = \frac{\text{(Wt. of dry waste + filter) - tared wt. of filter}}{\text{Initial wt. of waste (Section 7.1.1.5 or 7.1.1.7)}} \times 100$$

7.1.2.4 If the percent dry solids is less than 0.5%, then proceed to Section 7.2.9 if the nonvolatile TCLP is to be performed, and to Section 7.3 if the volatile TCLP is to be performed. If the percent dry solids is greater than or equal to 0.5%, and if the nonvolatile TCLP is to be performed, return to the beginning of this Section (7.1) and, with a fresh portion of waste, determine whether particle size reduction is necessary (Section 7.1.3) and determine the appropriate extraction fluid (Section 7.1.4). If only the volatile TCLP is to be performed, see the note in Section 7.1.4.

7.1.3 Determination of whether the waste requires particle size reduction (particle size is reduced during this step): Using the solid portion of the waste, evaluate the solid for particle size. Particle size reduction is required, unless the solid has a surface area per gram of material equal to or greater than 3.1 cm^2, or is smaller than 1 cm in its narrowest dimension (<u>i.e.</u>, is capable of passing through a 9.5 mm (0.375 inch) standard sieve). If the surface area is smaller or the particle size larger than described above, prepare the solid portion of the waste for extraction by crushing, cutting, or grinding the waste to a surface area or particle size as described above. If the solids are prepared for organic volatiles extraction, special precautions must be taken (see Section 7.3.6).

NOTE: Surface area criteria are meant for filamentous (<u>e.g.</u>, paper, cloth, and similar) waste materials. Actual measurement of surface area is not required, nor is it recommended. For materials that do not obviously meet the criteria, sample specific methods would need to be developed and employed to measure the surface area. Such methodology is currently not available.

7.1.4 Determination of appropriate extraction fluid: If the solid content of the waste is greater than or equal to 0.5% and if the sample will be extracted for nonvolatile constituents (Section 7.2), determine the appropriate fluid (Section 5.7) for the nonvolatiles extraction as follows:

NOTE: TCLP extraction for volatile constituents uses only extraction fluid #1 (Section 5.7.1). Therefore, if TCLP extraction for nonvolatiles is not required, proceed to Section 7.3.

7.1.4.1 Weigh out a small subsample of the solid phase of the waste, reduce the solid (if necessary) to a particle size of approximately 1 mm in diameter or less, and transfer 5.0 grams of the solid phase of the waste to a 500 mL beaker or Erlenmeyer flask.

7.1.4.2 Add 96.5 mL of reagent water to the beaker, cover with a watchglass, and stir vigorously for 5 minutes using a magnetic stirrer. Measure and record the pH. If the pH is <5.0, use extraction fluid #1. Proceed to Section 7.2.

7.1.4.3 If the pH from Section 7.1.4.2 is >5.0, add 3.5 mL 1N HCl, slurry briefly, cover with a watchglass, heat to 50 °C, and hold at 50 °C for 10 minutes.

7.1.4.4 Let the solution cool to room temperature and record the pH. If the pH is <5.0, use extraction fluid #1. If the pH is >5.0, use extraction fluid #2. Proceed to Section 7.2.

7.1.5 If the aliquot of the waste used for the preliminary evaluation (Sections 7.1.1 - 7.1.4) was determined to be 100% solid at Section 7.1.1.1, then it can be used for the Section 7.2 extraction (assuming at least 100 grams remain), and the Section 7.3 extraction (assuming at least 25 grams remain). If the aliquot was subjected to the procedure in Section 7.1.1.7, then another aliquot shall be used for the volatile extraction procedure in Section 7.3. The aliquot of the waste subjected to the procedure in Section 7.1.1.7 might be appropriate for use for the Section 7.2 extraction if an adequate amount of solid (as determined by Section 7.1.1.9) was obtained. The amount of solid necessary is dependent upon whether a sufficient amount of extract will be produced to support the analyses. If an adequate amount of solid remains, proceed to Section 7.2.10 of the nonvolatile TCLP extraction.

7.2 Procedure When Volatiles are not Involved

A minimum sample size of 100 grams (solid and liquid phases) is recommended. In some cases, a larger sample size may be appropriate, depending on the solids content of the waste sample (percent solids, See Section 7.1.1), whether the initial liquid phase of the waste will be miscible with the aqueous extract of the solid, and whether inorganics, semivolatile organics, pesticides, and herbicides are all analytes of concern. Enough solids should be generated for extraction such that the volume of TCLP extract will be sufficient to support all of the analyses required. If the amount of extract generated by a single TCLP extraction will not be sufficient to perform all of the analyses, more than one extraction may be performed and the extracts from each combined and aliquoted for analysis.

7.2.1 If the waste will obviously yield no liquid when subjected to pressure filtration (i.e., is 100% solid, see Section 7.1.1), weigh out a subsample of the waste (100 gram minimum) and proceed to Section 7.2.9.

7.2.2 If the sample is liquid or multiphasic, liquid/solid separation is required. This involves the filtration device described in Section 4.3.2 and is outlined in Sections 7.2.3 to 7.2.8.

7.2.3 Pre-weigh the container that will receive the filtrate.

7.2.4 Assemble the filter holder and filter following the manufacturer's instructions. Place the filter on the support screen and secure. Acid wash the filter if evaluating the mobility of metals (see Section 4.4).

NOTE: Acid washed filters may be used for all nonvolatile extractions even when metals are not of concern.

7.2.5 Weigh out a subsample of the waste (100 gram minimum) and record the weight. If the waste contains <0.5% dry solids (Section 7.1.2), the liquid portion of the waste, after filtration, is defined as the TCLP extract. Therefore, enough of the sample should be filtered so that the amount of filtered liquid will support all of the analyses required of the TCLP extract. For wastes containing >0.5% dry solids (Sections 7.1.1 or 7.1.2), use the percent solids information obtained in Section 7.1.1 to determine the optimum sample size (100 gram minimum) for filtration. Enough solids should be generated by filtration to support the analyses to be performed on the TCLP extract.

7.2.6 Allow slurries to stand to permit the solid phase to settle. Wastes that settle slowly may be centrifuged prior to filtration. Use centrifugation only as an aid to filtration. If the waste is centrifuged, the liquid should be decanted and filtered followed by filtration of the solid portion of the waste through the same filtration system.

7.2.7 Quantitatively transfer the waste sample (liquid and solid phases) to the filter holder (see Section 4.3.2). Spread the waste sample evenly over the surface of the filter. If filtration of the waste at 4 °C reduces the amount of expressed liquid over what would be expressed at room temperature, then allow the sample to warm up to room temperature in the device before filtering.

NOTE: If waste material (>1% of the original sample weight) has obviously adhered to the container used to transfer the sample to the filtration apparatus, determine the weight of this residue and subtract it from the sample weight determined in Section 7.2.5, to determine the weight of the waste sample that will be filtered.

Gradually apply vacuum or gentle pressure of 1-10 psi, until air or pressurizing gas moves through the filter. If this point is not reached under 10 psi, and if no additional liquid has passed through the filter in any 2 minute interval, slowly increase the pressure in 10 psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if the pressurizing gas has not moved through the filter, and if no additional liquid has passed through the filter in any 2 minute interval, proceed to the next 10 psi increment. When the pressurizing gas begins to move through the filter, or when the liquid flow has ceased at 50 psi (i.e., filtration does not result in any additional filtrate within a 2 minute period), stop the filtration.

NOTE: Instantaneous application of high pressure can degrade the glass fiber filter and may cause premature plugging.

7.2.8 The material in the filter holder is defined as the solid phase of the waste, and the filtrate is defined as the liquid phase. Weigh the filtrate. The liquid phase may now be either analyzed (See Section 7.2.12) or stored at 4 °C until time of analysis.

NOTE: Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. Even after applying vacuum or pressure filtration, as outlined in Section 7.2.7, this material may not filter. If this is the case, the material within the filtration device is defined as a solid and is carried through the extraction as a solid. Do not replace the original filter with a fresh filter under any circumstances. Use only one filter.

7.2.9 If the waste contains <0.5% dry solids (see Section 7.1.2), proceed to Section 7.2.13. If the waste contains >0.5% dry solids (see Section 7.1.1 or 7.1.2), and if particle size reduction of the solid was needed in Section 7.1.3, proceed to Section 7.2.10. If the waste as received passes a 9.5 mm sieve, quantitatively transfer the solid material into the extractor bottle along with the filter used to separate the initial liquid from the solid phase, and proceed to Section 7.2.11.

7.2.10 Prepare the solid portion of the waste for extraction by crushing, cutting, or grinding the waste to a surface area or particle size as described in Section 7.1.3. When the surface area or particle size has been appropriately altered, quantitatively transfer the solid material into an extractor bottle. Include the filter used to separate the initial liquid from the solid phase.

NOTE: Sieving of the waste is not normally required. Surface area requirements are meant for filamentous (e.g., paper, cloth) and similar waste materials. Actual measurement of surface area is not recommended. If sieving is necessary, a Teflon coated sieve should be used to avoid contamination of the sample.

7.2.11 Determine the amount of extraction fluid to add to the extractor vessel as follows:

$$\text{Weight of extraction fluid} = \frac{20 \times \text{percent solids (Section 7.1.1)} \times \text{weight of waste filtered (Section 7.2.5 or 7.2.7)}}{100}$$

Slowly add this amount of appropriate extraction fluid (see Section 7.1.4) to the extractor vessel. Close the extractor bottle tightly (it is recommended that Teflon tape be used to ensure a tight seal), secure in rotary agitation device, and rotate at 30 ± 2 rpm for 18 ± 2 hours. Ambient temperature (i.e., temperature of room in which extraction takes place) shall be maintained at 23 ± 2 °C during the extraction period.

NOTE: As agitation continues, pressure may build up within the extractor bottle for some types of wastes (e.g., limed or calcium carbonate containing waste may evolve gases such as carbon dioxide). To relieve excess pressure, the extractor bottle may be periodically opened (e.g., after 15 minutes, 30 minutes, and 1 hour) and vented into a hood.

7.2.12 Following the 18 ± 2 hour extraction, separate the material in the extractor vessel into its component liquid and solid phases by filtering through a new glass fiber filter, as outlined in Section 7.2.7. For final filtration of the TCLP extract, the glass fiber filter may be changed, if necessary, to facilitate filtration. Filter(s) shall be acid-washed (see Section 4.4) if evaluating the mobility of metals.

7.2.13 Prepare the TCLP extract as follows:

7.2.13.1 If the waste contained no initial liquid phase, the filtered liquid material obtained from Section 7.2.12 is defined as the TCLP extract. Proceed to Section 7.2.14.

7.2.13.2 If compatible (e.g., multiple phases will not result on combination), combine the filtered liquid resulting from Section 7.2.12 with the initial liquid phase of the waste obtained in Section 7.2.7. This combined liquid is defined as the TCLP extract. Proceed to Section 7.2.14.

7.2.13.3 If the initial liquid phase of the waste, as obtained from Section 7.2.7, is not or may not be compatible with the filtered liquid resulting from Section 7.2.12, do not combine these liquids. Analyze these liquids, collectively defined as the TCLP extract, and combine the results mathematically, as described in Section 7.2.14.

7.2.14 Following collection of the TCLP extract, the pH of the extract should be recorded. Immediately aliquot and preserve the extract for analysis. Metals aliquots must be acidified with nitric acid to pH <2. If precipitation is observed upon addition of nitric acid to a small aliquot of the extract, then the remaining portion of the extract for metals analyses shall not be acidified and the extract shall be analyzed as soon as possible. All other aliquots must be stored under refrigeration (4 °C) until analyzed. The TCLP extract shall be prepared and analyzed according to appropriate analytical methods. TCLP extracts to be analyzed for metals shall be acid digested except in those instances where digestion causes loss of metallic analytes. If an analysis of the undigested extract shows that the concentration of any regulated metallic analyte exceeds the regulatory level, then the waste is hazardous and digestion of the extract is not necessary. However, data on undigested extracts alone cannot be used to demonstrate that the waste is not hazardous. If the individual phases are to be analyzed separately, determine the volume of the individual phases (to $\pm$ 0.5%), conduct the appropriate analyses, and combine the results mathematically by using a simple volume-weighted average:

$$\text{Final Analyte Concentration} = \frac{(V_1)\ (C_1) + (V_2)\ (C_2)}{V_1 + V_2}$$

where:

V_1 = The volume of the first phase (L).
C_1 = The concentration of the analyte of concern in the first phase (mg/L).
V_2 = The volume of the second phase (L).
C_2 = The concentration of the analyte of concern in the second phase (mg/L).

7.2.15 Compare the analyte concentrations in the TCLP extract with the levels identified in the appropriate regulations. Refer to Section 8.0 for quality assurance requirements.

7.3 Procedure When Volatiles are Involved

Use the ZHE device to obtain TCLP extract for analysis of volatile compounds only. Extract resulting from the use of the ZHE shall not be used to evaluate the mobility of nonvolatile analytes (e.g., metals, pesticides, etc.).

The ZHE device has approximately a 500 mL internal capacity. The ZHE can thus accommodate a maximum of 25 grams of solid (defined as that fraction of a sample from which no additional liquid may be forced out by an applied pressure of 50 psi), due to the need to add an amount of extraction fluid equal to 20 times the weight of the solid phase.

Charge the ZHE with sample only once and do not open the device until the final extract (of the solid) has been collected. Repeated filling of the ZHE to obtain 25 grams of solid is not permitted.

Do not allow the waste, the initial liquid phase, or the extract to be exposed to the atmosphere for any more time than is absolutely necessary. Any manipulation of these materials should be done when cold (4 °C) to minimize loss of volatiles.

7.3.1 Pre-weigh the (evacuated) filtrate collection container (See Section 4.6) and set aside. If using a TEDLAR® bag, express all liquid from the ZHE device into the bag, whether for the initial or final liquid/solid separation, and take an aliquot from the liquid in the bag for analysis. The containers listed in Section 4.6 are recommended for use under the conditions stated in Sections 4.6.1 - 4.6.3.

7.3.2 Place the ZHE piston within the body of the ZHE (it may be helpful first to moisten the piston O-rings slightly with extraction fluid). Adjust the piston within the ZHE body to a height that will minimize the distance the piston will have to move once the ZHE is charged with sample (based upon sample size requirements determined from Section 7.3, Section 7.1.1 and/or 7.1.2). Secure the gas inlet/outlet flange (bottom flange) onto the ZHE body in accordance with the manufacturer's instructions. Secure the glass fiber filter between the support screens and set aside. Set liquid inlet/outlet flange (top flange) aside.

7.3.3 If the waste is 100% solid (see Section 7.1.1), weigh out a subsample (25 gram maximum) of the waste, record weight, and proceed to Section 7.3.5.

7.3.4 If the waste contains < 0.5% dry solids (Section 7.1.2), the liquid portion of waste, after filtration, is defined as the TCLP extract. Filter enough of the sample so that the amount of filtered liquid will support all of the volatile analyses required. For wastes containing $\geq$ 0.5% dry solids (Sections 7.1.1 and/or 7.1.2), use the percent solids information obtained in Section 7.1.1 to determine the optimum sample size to charge into the ZHE. The recommended sample size is as follows:

7.3.4.1 For wastes containing < 5% solids (see Section 7.1.1), weigh out a 500 gram subsample of waste and record the weight.

7.3.4.2 For wastes containing $\geq$ 5% solids (see Section 7.1.1), determine the amount of waste to charge into the ZHE as follows:

$$\text{Weight of waste to charge ZHE} = \frac{25}{\text{percent solids (Section 7.1.1)}} \times 100$$

Weigh out a subsample of the waste of the appropriate size and record the weight.

7.3.5 If particle size reduction of the solid portion of the waste was required in Section 7.1.3, proceed to Section 7.3.6. If particle size reduction was not required in Section 7.1.3, proceed to Section 7.3.7.

7.3.6 Prepare the waste for extraction by crushing, cutting, or grinding the solid portion of the waste to a surface area or particle size as described in Section 7.1.3. Wastes and appropriate reduction equipment should be refrigerated, if possible, to 4 °C prior to particle size reduction. The means used to effect particle size reduction must not generate heat in and of itself. If reduction of the solid phase of the waste is necessary, exposure of the waste to the atmosphere should be avoided to the extent possible.

NOTE: Sieving of the waste is not recommended due to the possibility that volatiles may be lost. The use of an appropriately graduated ruler is recommended as an acceptable alternative. Surface area requirements are meant for filamentous (e.g., paper, cloth) and similar waste materials. Actual measurement of surface area is not recommended.

When the surface area or particle size has been appropriately altered, proceed to Section 7.3.7.

7.3.7 Waste slurries need not be allowed to stand to permit the solid phase to settle. Do not centrifuge wastes prior to filtration.

7.3.8 Quantitatively transfer the entire sample (liquid and solid phases) quickly to the ZHE. Secure the filter and support screens onto the top flange of the device and secure the top flange to the ZHE body in accordance with the manufacturer's instructions. Tighten all ZHE fittings and place the device in the vertical position (gas inlet/outlet flange on the bottom). Do not attach the extract collection device to the top plate.

NOTE: If waste material (>1% of original sample weight) has obviously adhered to the container used to transfer the sample to the ZHE, determine the weight of this residue and subtract it from the sample weight determined in Section 7.3.4 to determine the weight of the waste sample that will be filtered.

Attach a gas line to the gas inlet/outlet valve (bottom flange) and, with the liquid inlet/outlet valve (top flange) open, begin applying gentle pressure of 1-10 psi (or more if necessary) to force all headspace slowly out of the ZHE device into a hood. At the first appearance of liquid from the liquid inlet/outlet valve, quickly close the valve and discontinue pressure. If filtration of the waste at 4 °C reduces the amount of expressed liquid over what would be expressed at room temperature, then allow the sample to warm up to room temperature in the device before filtering. If the waste is 100% solid (see Section 7.1.1), slowly increase the pressure to a maximum of 50 psi to force most of the headspace out of the device and proceed to Section 7.3.12.

7.3.9 Attach the evacuated pre-weighed filtrate collection container to the liquid inlet/outlet valve and open the valve. Begin applying gentle pressure of 1-10 psi to force the liquid phase of the sample into the filtrate collection container. If no additional liquid has passed through the filter in any 2 minute interval, slowly increase the pressure in 10 psi increments to a maximum of 50 psi. After each incremental increase of 10 psi, if no additional liquid has passed through the filter in any 2 minute interval, proceed to the next 10 psi increment. When liquid flow has ceased such that continued pressure filtration at 50 psi does not result in any additional filtrate within a 2 minute period, stop the filtration. Close the liquid inlet/outlet valve, discontinue pressure to the piston, and disconnect and weigh the filtrate collection container.

NOTE: Instantaneous application of high pressure can degrade the glass fiber filter and may cause premature plugging.

7.3.10 The material in the ZHE is defined as the solid phase of the waste and the filtrate is defined as the liquid phase.

NOTE: Some wastes, such as oily wastes and some paint wastes, will obviously contain some material that appears to be a liquid. Even after applying pressure filtration, this material will not filter. If this is the case, the material within the filtration device is defined as a solid and is carried through the TCLP extraction as a solid.

If the original waste contained <0.5% dry solids (see Section 7.1.2), this filtrate is defined as the TCLP extract and is analyzed directly. Proceed to Section 7.3.15.

7.3.11 The liquid phase may now be either analyzed immediately (See Sections 7.3.13 through 7.3.15) or stored at 4 °C under minimal headspace conditions until time of analysis. Determine the weight of extraction fluid #1 to add to the ZHE as follows:

$$\text{Weight of extraction fluid} = \frac{20 \times \text{percent solids (Section 7.1.1)} \times \text{weight of waste filtered (Section 7.3.4 or 7.3.8)}}{100}$$

7.3.12 The following Sections detail how to add the appropriate amount of extraction fluid to the solid material within the ZHE and agitation of the ZHE vessel. Extraction fluid #1 is used in all cases (See Section 5.7).

7.3.12.1 With the ZHE in the vertical position, attach a line from the extraction fluid reservoir to the liquid inlet/outlet valve. The line used shall contain fresh extraction fluid and should be preflushed with fluid to eliminate any air pockets in the line. Release gas pressure on the ZHE piston (from the gas inlet/outlet valve), open the liquid inlet/outlet valve, and begin transferring extraction fluid (by pumping or similar means) into the ZHE. Continue pumping extraction fluid into the ZHE until the appropriate amount of fluid has been introduced into the device.

7.3.12.2 After the extraction fluid has been added, immediately close the liquid inlet/outlet valve and disconnect the extraction fluid line. Check the ZHE to ensure that all valves are in their closed positions. Manually rotate the device in an end-over-end fashion 2 or 3 times. Reposition the ZHE in the vertical position with the liquid inlet/outlet valve on top. Pressurize the ZHE to 5-10 psi (if necessary) and slowly open the liquid inlet/outlet valve to bleed out any headspace (into a hood) that may have been introduced due to the addition of extraction fluid. This bleeding shall be done quickly and shall be stopped at the first appearance of liquid from the valve. Re-pressurize the ZHE with 5-10 psi and check all ZHE fittings to ensure that they are closed.

7.3.12.3 Place the ZHE in the rotary agitation apparatus (if it is not already there) and rotate at 30 $\pm$ 2 rpm for 18 $\pm$ 2 hours. Ambient temperature (i.e., temperature of room in which extraction occurs) shall be maintained at 23 $\pm$ 2 °C during agitation.

7.3.13 Following the 18 $\pm$ 2 hour agitation period, check the pressure behind the ZHE piston by quickly opening and closing the gas inlet/outlet valve and noting the escape of gas. If the pressure has not been maintained (i.e., no gas release observed), the device is leaking. Check the ZHE for leaking as specified in Section 4.2.1, and perform the extraction again with a new sample of waste. If the pressure within the device has been maintained, the material in the extractor vessel is once again separated into its component liquid and solid phases. If the waste contained an initial liquid phase, the liquid may be filtered directly into the same filtrate collection container (i.e., TEDLAR® bag) holding the initial liquid phase of the waste. A separate filtrate collection container must be used if combining would create multiple phases, or there is not enough volume left within the filtrate collection container. Filter through the glass fiber filter, using the ZHE device as discussed in Section 7.3.9. All extract shall be filtered and collected if the

TEDLAR® bag is used, if the extract is multiphasic, or if the waste contained an initial liquid phase (see Sections 4.6 and 7.3.1).

NOTE: An in-line glass fiber filter may be used to filter the material within the ZHE if it is suspected that the glass fiber filter has been ruptured.

7.3.14 If the original waste contained no initial liquid phase, the filtered liquid material obtained from Section 7.3.13 is defined as the TCLP extract. If the waste contained an initial liquid phase, the filtered liquid material obtained from Section 7.3.13 and the initial liquid phase (Section 7.3.9) are collectively defined as the TCLP extract.

7.3.15 Following collection of the TCLP extract, immediately prepare the extract for analysis and store with minimal headspace at 4 °C until analyzed. Analyze the TCLP extract according to the appropriate analytical methods. If the individual phases are to be analyzed separately (i.e., are not miscible), determine the volume of the individual phases (to 0.5%), conduct the appropriate analyses, and combine the results mathematically by using a simple volume-weighted average:

$$\text{Final Analyte Concentration} = \frac{(V_1)\ (C_1) + (V_2)\ (C_2)}{V_1 + V_2}$$

where:

V_1 = The volume of the first phases (L).
C_1 = The concentration of the analyte of concern in the first phase (mg/L).
V_2 = The volume of the second phase (L).
C_2 = The concentration of the analyte of concern in the second phase (mg/L).

7.3.16 Compare the analyte concentrations in the TCLP extract with the levels identified in the appropriate regulations. Refer to Section 8.0 for quality assurance requirements.

8.0 QUALITY ASSURANCE

8.1 A minimum of one blank (using the same extraction fluid as used for the samples) must be analyzed for every 20 extractions that have been conducted in an extraction vessel.

8.2 A matrix spike shall be performed for each waste type (e.g., wastewater treatment sludge, contaminated soil, etc.) unless the result exceeds the regulatory level and the data are being used solely to demonstrate that the waste property exceeds the regulatory level. A minimum of one matrix spike must be analyzed for each analytical batch. As a minimum, follow the matrix spike addition guidance provided in each analytical method.

8.2.1 Matrix spikes are to be added after filtration of the TCLP extract and before preservation. Matrix spikes should not be added prior to TCLP extraction of the sample.

8.2.2 In most cases, matrix spikes should be added at a concentration equivalent to the corresponding regulatory level. If the analyte concentration is less than one half the regulatory level, the spike concentration may be as low as one half of the analyte concentration, but may not be not less than five times the method detection limit. In order to avoid differences in matrix effects, the matrix spikes must be added to the same nominal volume of TCLP extract as that which was analyzed for the unspiked sample.

8.2.3 The purpose of the matrix spike is to monitor the performance of the analytical methods used, and to determine whether matrix interferences exist. Use of other internal calibration methods, modification of the analytical methods, or use of alternate analytical methods may be needed to accurately measure the analyte concentration in the TCLP extract when the recovery of the matrix spike is below the expected analytical method performance.

8.2.4 Matrix spike recoveries are calculated by the following formula:

$$\%R\ (\%Recovery) = 100\ (X_s - X_u)/K$$

where:
X_s = measured value for the spiked sample,
X_u = measured value for the unspiked sample, and
K = known value of the spike in the sample.

8.3 All quality control measures described in the appropriate analytical methods shall be followed.

8.4 The use of internal calibration quantitation methods shall be employed for a metallic contaminant if: (1) Recovery of the contaminant from the TCLP extract is not at least 50% and the concentration does not exceed the regulatory level, and (2) The concentration of the contaminant measured in the extract is within 20% of the appropriate regulatory level.

8.4.1. The method of standard additions shall be employed as the internal calibration quantitation method for each metallic contaminant.

8.4.2 The method of standard additions requires preparing calibration standards in the sample matrix rather than reagent water or blank solution. It requires taking four identical aliquots of the solution and adding known amounts of standard to three of these aliquots. The forth aliquot is the unknown. Preferably, the first addition should be prepared so that the resulting concentration is approximately 50% of the expected concentration of the sample. The second and third additions should be prepared so that the concentrations are approximately 100% and

150% of the expected concentration of the sample. All four aliquots are maintained at the same final volume by adding reagent water or a blank solution, and may need dilution adjustment to maintain the signals in the linear range of the instrument technique. All four aliquots are analyzed.

8.4.3 Prepare a plot, or subject data to linear regression, of instrument signals or external-calibration-derived concentrations as the dependant variable (y-axis) versus concentrations of the additions of standard as the independent variable (x-axis). Solve for the intercept of the abscissa (the independent variable, x-axis) which is the concentration in the unknown.

8.4.4 Alternately, subtract the instrumental signal or external-calibration-derived concentration of the unknown (unspiked) sample from the instrumental signals or external-calibration-derived concentrations of the standard additions. Plot or subject to linear regression of the corrected instrument signals or external-calibration-derived concentrations as the dependant variable versus the independent variable. Derive concentrations for unknowns using the internal calibration curve as if it were an external calibration curve.

8.5 Samples must undergo TCLP extraction within the following time periods:

SAMPLE MAXIMUM HOLDING TIMES [DAYS]				
	From: Field collection To: TCLP extraction	From: TCLP extraction To: Preparative extraction	From: Preparative extraction To: Determinative analysis	Total elapsed time
Volatiles	14	NA	14	28
Semi-volatiles	14	7	40	61
Mercury	28	NA	28	56
Metals, except mercury	180	NA	180	360

NA = Not applicable

If sample holding times are exceeded, the values obtained will be considered minimal concentrations. Exceeding the holding time is not acceptable in establishing that a waste does not exceed the regulatory level. Exceeding the holding time will not invalidate characterization if the waste exceeds the regulatory level.

9.0 METHOD PERFORMANCE

9.1 Ruggedness. Two ruggedness studies have been performed to determine the effect of various perturbations on specific elements of the TCLP protocol. Ruggedness testing determines the sensitivity of small procedural variations which might be expected to occur during routine laboratory application.

9.1.1 Metals - The following conditions were used when leaching a waste for metals analysis:

Varying Conditions	
Liquid/Solid ratio	19:1 vs. 21:1
Extraction time	16 hours vs. 18 hours
Headspace	20% vs. 60%
Buffer #2 acidity	190 meq vs. 210 meq
Acid-washed filters	yes vs. no
Filter type	0.7 µm glass fiber vs. 0.45 µm vs. polycarbonate
Bottle type	borosilicate vs. flint glass

Of the seven method variations examined, acidity of the extraction fluid had the greatest impact on the results. Four of 13 metals from an API separator sludge/electroplating waste (API/EW) mixture and two of three metals from an ammonia lime still bottom waste were extracted at higher levels by the more acidic buffer. Because of the sensitivity to pH changes, the method requires that the extraction fluids be prepared so that the final pH is within ± 0.05 units as specified.

9.1.2 Volatile Organic Compounds - The following conditions were used when leaching a waste for VOC analysis:

Varying Conditions	
Liquid/Solid ratio	19:1 vs. 21:1
Headspace	0% vs. 5%
Buffer #1 acidity	60 meq vs. 80 meq
Method of storing extract	Syringe vs. Tedlar® bag
Aliquotting	yes vs. no
Pressure behind piston	0 psi vs. 20 psi

None of the parameters had a significant effect on the results of the ruggedness test.

9.2 Precision. Many TCLP precision (reproducibility) studies have been performed, and have shown that, in general, the precision of the TCLP is comparable to or exceeds that of the EP toxicity test and that method precision is adequate. One of the more significant contributions to poor precision appears to be related to sample homogeneity and inter-laboratory variation (due to the nature of waste materials).

9.2.1 Metals - The results of a multi-laboratory study are shown in Table 6, and indicate that a single analysis of a waste may not be adequate for waste characterization and identification requirements.

9.2.2 Semi-Volatile Organic Compounds - The results of two studies are shown in Tables 7 and 8. Single laboratory precision was excellent with greater than 90 percent of the results exhibiting an RSD less than 25 percent. Over 85 percent of all individual compounds in the multi-laboratory study fell in the RSD range of 20 - 120 percent. Both studies concluded that the TCLP provides adequate precision. It was also determined that the high acetate content of the extraction fluid did not present problems (i.e., column degradation of the gas chromatograph) for the analytical conditions used.

9.2.3 Volatile Organic Compounds - Eleven laboratories participated in a collaborative study of the use of the ZHE with two waste types which were fortified with a mixture of VOCs. The results of the collaborative study are shown in Table 9. Precision results for VOCs tend to occur over a considerable range. However, the range and mean RSD compared very closely to the same collaborative study metals results in Table 6. Blackburn and Show concluded that at the 95% level of significance: 1) recoveries among laboratories were statistically similar, 2) recoveries did not vary significantly between the two sample types, and 3) each laboratory showed the same pattern of recovery for each of the two samples.

10.0 REFERENCES

1. Blackburn, W.B. and Show, I. "Collaborative Study of the Toxicity Characteristics Leaching Procedure (TCLP)." Draft Final Report, Contract No. 68-03-1958, S-Cubed, November 1986.

2. Newcomer, L.R., Blackburn, W.B., Kimmell, T.A. "Performance of the Toxicity Characteristic Leaching Procedure." Wilson Laboratories, S-Cubed, U.S. EPA, December 1986.

3. Williams, L.R., Francis, C.W.; Maskarinec, M.P., Taylor D.R., and Rothman, N. "Single-Laboratory Evaluation of Mobility Procedure for Solid Waste." EMSL, ORNL, S-Cubed, ENSECO.

Table 1.
Volatile Analytes[1,2]

Compound	CAS No.
Acetone	67-64-1
Benzene	71-43-2
n-Butyl alcohol	71-36-3
Carbon disulfide	75-15-0
Carbon tetrachloride	56-23-5
Chlorobenzene	108-90-7
Chloroform	67-66-3
1,2-Dichloroethane	107-06-2
1,1-Dichloroethylene	75-35-4
Ethyl acetate	141-78-6
Ethyl benzene	100-41-4
Ethyl ether	60-29-7
Isobutanol	78-83-1
Methanol	67-56-1
Methylene chloride	75-09-2
Methyl ethyl ketone	78-93-3
Methyl isobutyl ketone	108-10-1
Tetrachloroethylene	127-18-4
Toluene	108-88-3
1,1,1,-Trichloroethane	71-55-6
Trichloroethylene	79-01-6
Trichlorofluoromethane	75-69-4
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1
Vinyl chloride	75-01-4
Xylene	1330-20-7

[1] When testing for any or all of these analytes, the zero-headspace extractor vessel shall be used instead of the bottle extractor.

[2] Benzene, carbon tetrachloride, chlorobenzene, chloroform, 1,2-dichloroethane, 1,1-dichloroethylene, methyl ethyl ketone, tetrachloroethylene, and vinyl chloride are toxicity characteristic constituents.

Table 2.
Suitable Rotary Agitation Apparatus[1]

Company	Location	Model No.
Analytical Testing and Consulting Services, Inc.	Warrington, PA (215) 343-4490	4-vessel extractor (DC20S) 8-vessel extractor (DC20) 12-vessel extractor (DC20B) 24-vessel extractor (DC24C)
Associated Design and Manufacturing Company	Alexandria, VA (703) 549-5999	2-vessel (3740-2-BRE) 4-vessel (3740-4-BRE) 6-vessel (3740-6-BRE) 8-vessel (3740-8-BRE) 12-vessel (3740-12-BRE) 24-vessel (3740-24-BRE)
Environmental Machine and Design, Inc.	Lynchburg, VA (804) 845-6424	8-vessel (08-00-00) 4-vessel (04-00-00)
IRA Machine Shop and Laboratory	Santurce, PR (809) 752-4004	8-vessel (011001)
Lars Lande Manufacturing	Whitmore Lake, MI (313) 449-4116	10-vessel (10VRE) 5-vessel (5VRE) 6-vessel (6VRE)
Millipore Corp.	Bedford, MA (800) 225-3384	4-ZHE or 4 2-liter bottle extractor (YT31ORAHW)

[1] Any device that rotates the extraction vessel in an end-over-end fashion at 30 $\pm$ 2 rpm is acceptable.

Table 3.
Suitable Zero-Headspace Extractor Vessels[1]

Company	Location	Model No.
Analytical Testing & Consulting Services, Inc.	Warrington, PA (215) 343-4490	C102, Mechanical Pressure Device
Associated Design and Manufacturing Company	Alexandria, VA (703) 549-5999	3745-ZHE, Gas Pressure Device
Lars Lande Manufacturing[2]	Whitmore Lake, MI (313) 449-4116	ZHE-11, Gas Pressure Device
Millipore Corporation	Bedford, MA (800) 225-3384	YT30090HW, Gas Pressure Device
Environmental Machine and Design, Inc.	Lynchburg, VA (804) 845-6424	VOLA-TOX1, Gas Pressure Device
Gelman Science	Ann Arbor, MI (800) 521-1520	15400 Gas Pressure Device

[1] Any device that meets the specifications listed in Section 4.2.1 of the method is suitable.

[2] This device uses a 110 mm filter.

Table 4.
Suitable Filter Holders[1]

Company	Location	Model/ Catalogue No.	Size
Nucleopore Corporation	Pleasanton, CA (800) 882-7711	425910 410400	142 mm 47 mm
Micro Filtration Systems	Dublin, CA (800) 334-7132 (415) 828-6010	302400 311400	142 mm 47 mm
Millipore Corporation	Bedford, MA (800) 225-3384	YT30142HW XX1004700	142 mm 47 mm

[1] Any device capable of separating the liquid from the solid phase of the waste is suitable, providing that it is chemically compatible with the waste and the constituents to be analyzed. Plastic devices (not listed above) may be used when only inorganic analytes are of concern. The 142 mm size filter holder is recommended.

Table 5.
Suitable Filter Media[1]

Company	Location	Model	Pore Size (μm)
Millipore Corporation	Bedford, MA (800) 225-3384	AP40	0.7
Nucleopore Corporation	Pleasanton, CA (415) 463-2530	211625	0.7
Whatman Laboratory Products, Inc.	Clifton, NJ (201) 773-5800	GFF	0.7
Micro Filtration Systems	Dublin, CA (800) 334-7132 (415) 828-6010	GF75	0.7
Gelman Science	Ann Arbor, MI (800) 521-1520	66256 (90mm) 66257 (142mm)	0.7

[1] Any filter that meets the specifications in Section 4.4 of the Method is suitable.

Table 6. Multi-Laboratory TCLP Metals, Precision

Waste	Extraction Fluid	Metal	$\bar{X}$	S	%RSD
Ammonia	#1	Cadmium	0.053	0.031	60
Lime Still	#2		0.023	0.017	76
Bottoms	#1	Chromium	0.015	0.0014	93
	#2		0.0032	0.0037	118
	#1	Lead	0.0030	0.0027	90
	#2		0.0032	0.0028	87
API/EW	#1	Cadmium	0.0046	0.0028	61
Mixture	#2		0.0005	0.0004	77
	#1	Chromium	0.0561	0.0227	40
	#2		0.105	0.018	17
	#1	Lead	0.0031	0.0031	100
	#2		0.0124	0.0136	110
Fossil	#1	Cadmium	0.080	0.069	86
Fuel Fly	#2		0.093	0.067	72
Ash	#1	Chromium	0.017	0.014	85
	#2		0.070	0.040	57
	#1	Lead	0.0087	0.0074	85
	#2		0.0457	0.0083	18
				%RSD Range = 17 - 118 Mean %RSD = 74	

NOTE: $\bar{X}$ = Mean results from 6 - 12 different laboratories
Units = mg/L
Extraction Fluid #1 = pH 4.9
#2 = pH 2.9

Table 7. Single-Laboratory Semi-Volatiles, Precision

Waste	Compound	Extraction Fluid	$\bar{X}$	S	%RSD
Ammonia Lime Still Bottoms	Phenol	#1	19000	2230	11.6
		#2	19400	929	4.8
	2-Methylphenol	#1	2000	297	14.9
		#2	1860	52.9	2.8
	4-Methylphenol	#1	7940	1380	17.4
		#2	7490	200	2.7
	2,4-Dimethylphenol	#1	321	46.8	14.6
		#2	307	45.8	14.9
	Naphthalene	#1	3920	413	10.5
		#2	3827	176	4.6
	2-Methylnaphthalene	#1	290	44.8	15.5
		#2	273	19.3	7.1
	Dibenzofuran	#1	187	22.7	12.1
		#2	187	7.2	3.9
	Acenaphthylene	#1	703	89.2	12.7
		#2	663	20.1	3.0
	Fluorene	#1	151	17.6	11.7
		#2	156	2.1	1.3
	Phenanthrene	#1	241	22.7	9.4
		#2	243	7.9	3.3
	Anthracene	#1	33.2	6.19	18.6
		#2	34.6	1.55	4.5
	Fluoranthrene	#1	25.3	1.8	7.1
		#2	26.0	1.8	7.1
API/EW Mixture	Phenol	#1	40.7	13.5	33.0
		#2	19.0	1.76	9.3
	2,4-Dimethylphenol	#1	33.0	9.35	28.3
		#2	43.3	8.61	19.9
	Naphthalene	#1	185	29.4	15.8
		#2	165	24.8	15.0
	2-Methylnaphthalene	#1	265	61.2	23.1
		#2	200	18.9	9.5
				%RSD Range = 1 - 33	
				Mean %RSD = 12	

NOTE: Units = μg/L
Extractions were performed in triplicate
All results were at least 2x the detection limit
Extraction Fluid #1 = pH 4.9
#2 = pH 2.9

Table 8. Multi-Laboratory Semi-Volatiles, Precision

Waste	Compound	Extraction Fluid	$\bar{X}$	S	%RSD
Ammonia Lime	BNAs	#1	10043	7680	76.5
Still Bottoms (A)		#2	10376	6552	63.1
API/EW	BNAs	#1	1624	675	41.6
Mixture (B)		#2	2074	1463	70.5
Fossil Fuel	BNAs	#1	750	175	23.4
Fly Ash (C)		#2	739	342	46.3
					Mean %RSD = 54

NOTE: Units = μg/L
X = Mean results from 3 - 10 labs
Extraction Fluid #1 = pH 4.9
#2 = pH 2.9

%RSD Range for Individual Compounds

A, #1	0 - 113
A, #2	28 - 108
B, #1	20 - 156
B, #2	49 - 128
C, #1	36 - 143
C, #2	61 - 164

Table 9. Multi-Laboratory (11 Labs) VOCs, Precision

Waste	Compound	$\bar{X}$	S	%RSD
Mine Tailings	Vinyl chloride	6.36	6.36	100
	Methylene chloride	12.1	11.8	98
	Carbon disulfide	5.57	2.83	51
	1,1-Dichloroethene	21.9	27.7	127
	1,1-Dichloroethane	31.4	25.4	81
	Chloroform	46.6	29.2	63
	1,2-Dichloroethane	47.8	33.6	70
	2-Butanone	43.5	36.9	85
	1,1,1-Trichloroethane	20.9	20.9	100
	Carbon tetrachloride	12.0	8.2	68
	Trichloroethene	24.7	21.2	86
	1,1,2-Trichloroethene	19.6	10.9	56
	Benzene	37.9	28.7	76
	1,1,2,2-Tetrachloroethane	34.9	25.6	73
	Toluene	29.3	11.2	38
	Chlorobenzene	35.6	19.3	54
	Ethylbenzene	4.27	2.80	66
	Trichlorofluoromethane	3.82	4.40	115
	Acrylonitrile	76.7	110.8	144
Ammonia Lime Still Bottoms	Vinyl chloride	5.00	4.71	94
	Methylene chloride	14.3	13.1	92
	Carbon disulfide	3.37	2.07	61
	1,1-Dichloroethene	52.1	38.8	75
	1,1-Dichloroethane	52.8	25.6	49
	Chloroform	64.7	28.4	44
	1,2-Dichloroethane	43.1	31.5	73
	2-Butanone	59.0	39.6	67
	1,1,1-Trichloroethane	53.6	40.9	76
	Carbon tetrachloride	7.10	6.1	86
	Trichloroethene	57.3	34.2	60
	1,1,2-Trichloroethene	6.7	4.7	70
	Benzene	61.3	26.8	44
	1,1,2,2-Tetrachloroethane	3.16	2.1	66
	Toluene	69.0	18.5	27
	Chlorobenzene	71.8	12.0	17
	Ethylbenzene	3.70	2.2	58
	Trichlorofluoromethane	4.05	4.8	119
	Acrylonitrile	29.4	34.8	118

%RSD Range = 17 - 144
Mean %RSD = 75

NOTE: Units = µg/L

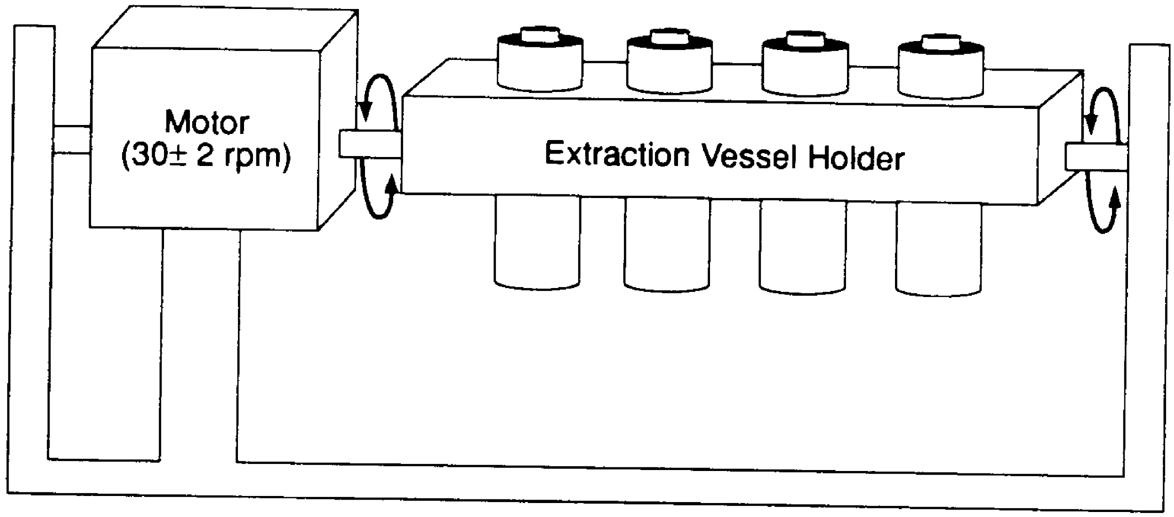


Figure 1. Rotary Agitation Apparatus

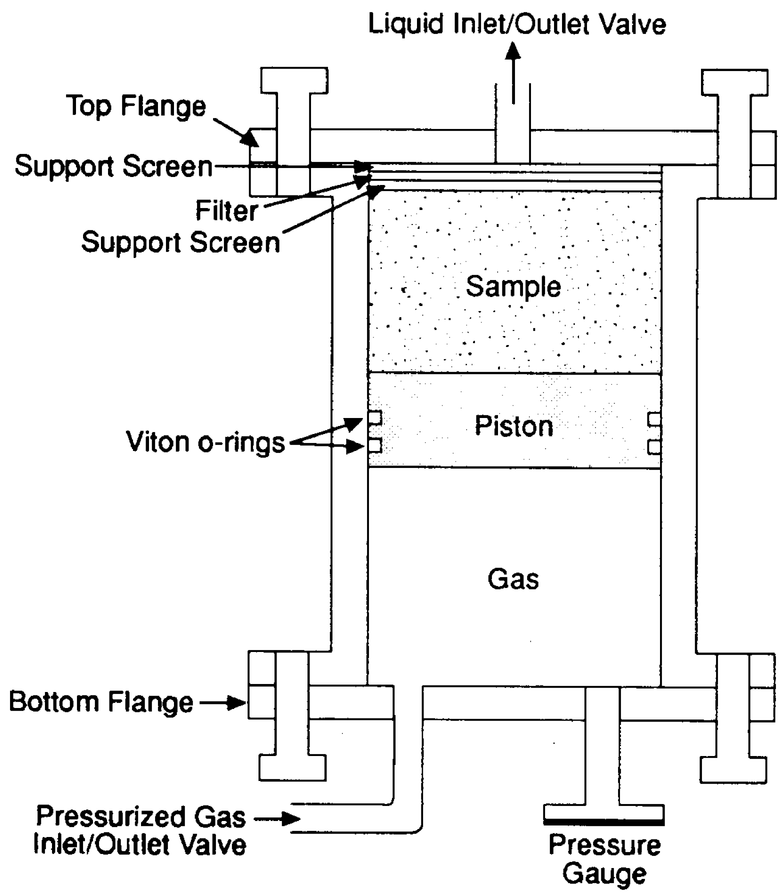
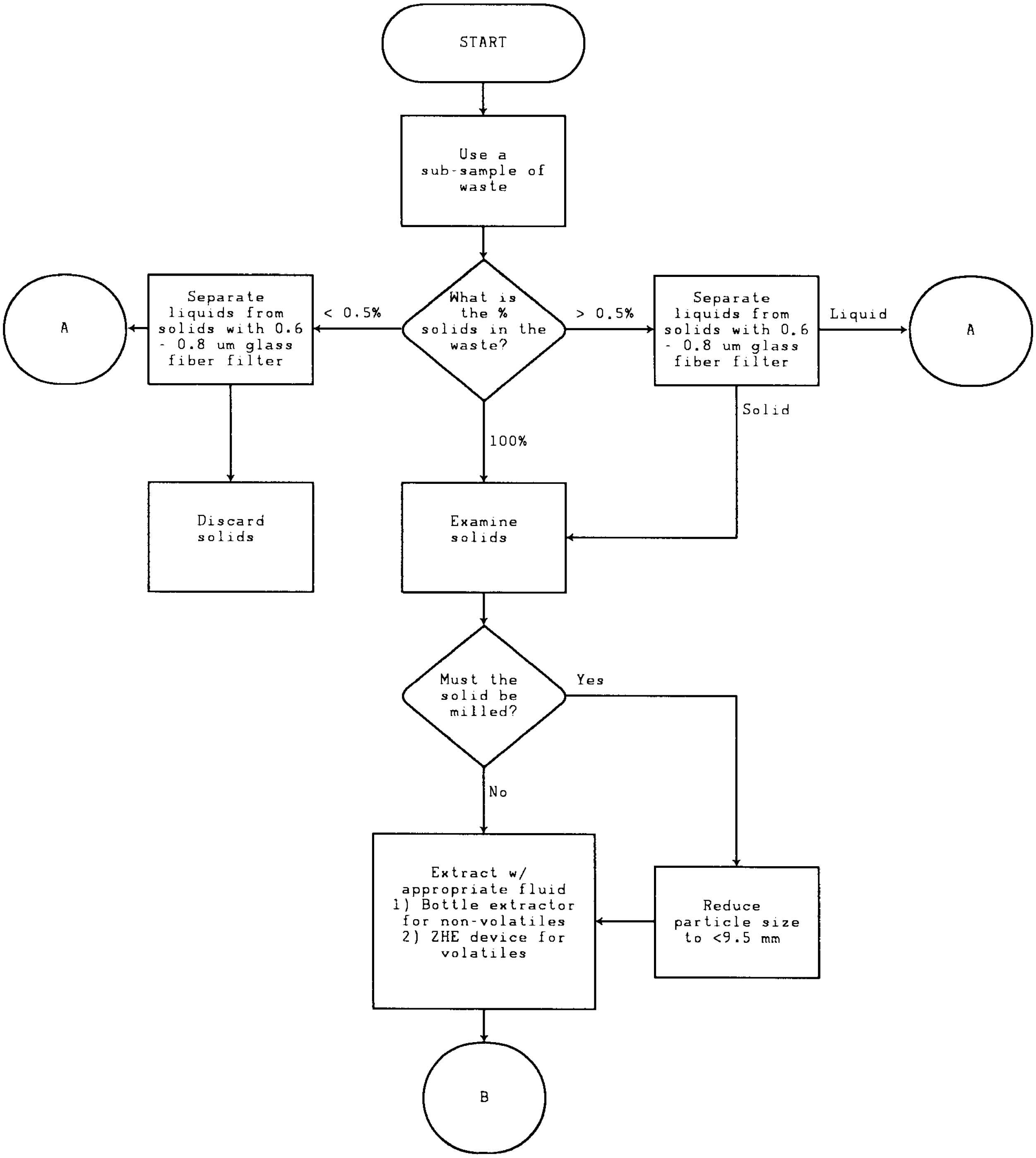
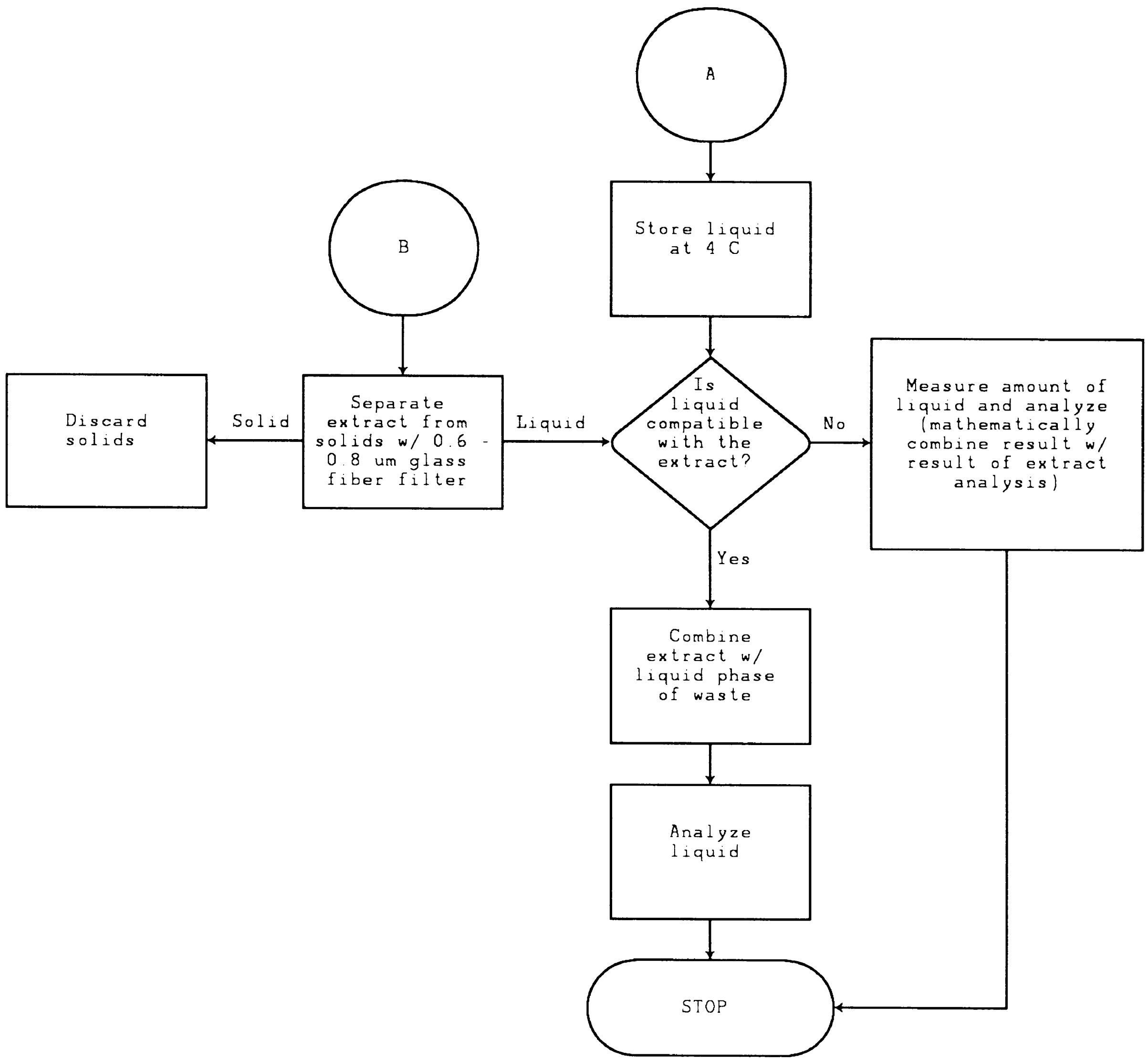


Figure 2. Zero-Headspace Extractor (ZHE)

TOXICITY CHARACTERISTIC LEACHATE PROCEDURE



TOXICITY CHARACTERISTIC LEACHATE PROCEDURE



APPENDIX G

ASSESSMENT OF POTENTIAL EFFECTS OF SEWAGE EFFLUENT DISCHARGE FROM THE MARY RIVER MINE CAMP SITE ON WATER QUALITY.

Technical Memorandum

Date: March 30, 2010

To: Jim Millard
Environmental Superintendent
Baffinland Iron Mines Corporation

From: North/South Consultants Inc.
83 Scurfield Blvd.
Winnipeg, MB, R3Y 1G4

Project: **MARY RIVER PROJECT**

Subject: Assessment of effects of sewage effluent discharge from the Mary River Camp Site on water quality.

INTRODUCTION

Knight Piesold Ltd. (KPL) and North/South Consultants (NSC) were retained by Baffinland Iron Mines Corporation (BIM) in 2007 to assess potential effects on the receiving waters from their Waste Water Treatment Facilities (WWTFs) at their Mary River Project and confirm that facility designs were appropriate given the projected operating schedule, and projected discharge concentrations and loadings. NSC was again retained in early 2009 to update the BIM Wastewater Management Plan submitted as a requirement under BIM's Water Licence 2BB-MRY0710 issued by the Nunavut Water Board (NWB), based on a revised wastewater discharge regime. This submission provided a revised assessment of potential effects of discharge of the treated sewage effluent that was projected to begin in the summer of 2009 and continue for a period of approximately one to two years (BIM 2009).

Since the previous wastewater management plan submission (BIM 2009), treated sewage effluent was discharged from 22-31 August 2009 to Sheardown Lake NW. The timing, volume, and loading of the effluent discharge in August 2009 were different than originally anticipated in early 2009 at the time of submission of the 2009 wastewater management plan (BIM 2009). Specifically, the actual effluent discharge event in 2009 was of much shorter duration and involved a much smaller loading to the receiving environment than was assessed previously.

The following technical memorandum was prepared to provide:

- An update to include additional baseline water quality data collected in Sheardown Lake NW prior to discharge of treated sewage effluent;
- A description of the results of water quality monitoring conducted in Sheardown Lake NW near the end of the sewage effluent release period in 2009; and

- An overall assessment of the effects of the sewage discharge event on water quality in Sheardown Lake NW, including mass-balance modeling based on the effluent discharge data.

<u>SOURCES OF INFORMATION AND APPROACH</u>

Baseline lake water quality was measured in the open-water seasons of 2006, 2007, and 2008, and in the ice-cover seasons of 2007 and 2009. Open-water season means were calculated for key water quality parameters for Sheardown Lake NW using data collected in 2007 and 2008; data collected in 2006 were excluded as they are of limited quantity and quality.

Water quality sampling included analysis of nutrients and "routine" water quality as well as collection of *in situ* measurements across depth at all sites and times excepting the sampling conducted in winter 2009 which included *in situ* measurements only. Sampling was conducted two times during the open-water seasons in 2007 and 2008. Samples for laboratory analysis were collected 1 m from the water surface and 1 m from the sediments.

A water quality monitoring program was also conducted in Sheardown Lake NW and at one site in Sheardown Lake SE on August 31, 2009 near the end of the effluent discharge period. Sampling included collection of depth profile measurements and samples for laboratory analysis (routine variables and metals). Laboratory samples were collected at mid-depth. This information provided the foundation for assessing effects of effluent discharge on water quality in the receiving environment. Specifically, the monitoring results were examined for:

- Differences relative to baseline water quality conditions measured in the open-water seasons of 2007 and 2008;
- Spatial differences in water quality conditions across Sheardown Lake NW, in relation to distance from the effluent outfall; and
- Comparison to the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life (PAL).

Sewage effluent quality, discharge rates, and acute toxicity were monitored for both wastewater streams (PWSP Nos. 2 and 3) discharged to Sheardown Lake NW in August 2009. As an additional screening tool, effluent quality was also compared to CCME PAL water quality guidelines. As CCME guidelines are representative of "chronic" conditions, this comparison to effluent quality is highly conservative. However, where parameters are shown to meet CCME guidelines at the end-of-pipe, there is high certainty that the effluent would not lead to in-lake chronic toxicity.

Lastly, to provide an additional measure of potential effects of the discharge of treated sewage effluents on water quality in Sheardown Lake, a mass balance modelling approach was applied using the measured effluent discharge volume and effluent quality for the discharge period in August 2009. Lake volume was obtained from the bathymetric survey conducted in August 2007. The mass-balance modeling approach assumed a “closed” system (i.e., no inflow or outflow), no settling or degradation of effluent parameters (i.e., conservative approach), and cumulative loading associated with effluent releases from August 22-31, 2009 inclusive. To maintain a conservative approach, the loadings associated with these cumulative releases were calculated and assumed to be instantaneously released to the lake.

BASELINE LAKE WATER QUALITY

Detailed descriptions of water quality in Sheardown Lake NW were provided in the previous Wastewater Management Plan document (BIM 2009) and included information collected up to the fall of 2008. The following provides an updated overview of the baseline (i.e., pre-discharge) water quality and limnology of Sheardown Lake NW, which includes *in situ* water quality data collected under ice in April and May 2009.

Figure 1 presents the locations of baseline water quality sampling sites. Table 1 presents lake-wide means for the open-water seasons of 2007 and 2008 for key water quality parameters.

Thermal stratification has been observed in Sheardown Lake NW in summer at some locations but temperature was relatively uniform across depth in winter 2007 and 2009 and in September 2007 and 2008 (Figures 2-4). In general, dissolved oxygen (DO) has also been relatively uniform across depth and above the CCME PAL guidelines in the open-water season (Figures 2 and 3). The exception included depletion at depth at site DL0-01-2 in September 2007. Lower DO concentrations at depth have been observed at several sites in winter and concentrations were below the CCME PAL guidelines at one site in 2007 (Figure 2) and numerous sites in winter 2009 (Figure 4).

In general, Sheardown Lake NW is a relatively clear lake (low turbidity and high Secchi Disk depth), is alkaline in the open-water season (pH > 7) and near neutral in the winter (Mean pH of 7.03 in May 2007), soft (hardness typically at or below 60 mg/L), and contains a relatively low concentration of dissolved solids (mean of 71 mg/L in the open-water season and 102 mg/L in winter). Like other lakes in the area, Sheardown Lake NW is nutrient-poor and contains low levels of total phosphorus (TP) and inorganic forms of nitrogen. TP was generally near or below the analytical detection limit (0.003 mg/L) over the period of baseline studies. Lake-wide mean TP concentrations were somewhat higher in the open-water season of 2008 than 2007. Similarly, nitrate, nitrite, and ammonia concentrations are low and were generally not detected over the baseline studies.

According to the CCME phosphorus guidance framework, Sheardown Lake would be classified as "ultra-oligotrophic" and "oligotrophic" on the basis of TP concentrations measured in 2007 and 2008 (Table 2). Similarly, on the basis of chlorophyll *a* concentrations measured in the open-water seasons of 2007 and 2008, Sheardown Lake would be categorized as ultra-oligotrophic or oligotrophic (Table 3).

<u>EFFLUENT DISCHARGE AND EFFLUENT QUALITY</u>

Treated sewage effluent was discharged to Sheardown Lake NW from August 22-25 (inclusive) from PWSP No.3 and from August 27-31 (inclusive) from PWSP No. 2. Effluent quality measured over the period of discharge is presented in Tables 4 and 5.

Toxicity testing was conducted on the sewage effluent collected from PWSP No. 2 and PWSP No. 3 during the period of effluent discharge. All effluent samples were not acutely lethal to *Daphnia magna* and rainbow trout (*Oncorhynchus mykiss*) and no mortalities of either test organism occurred over the duration of the toxicity tests.

Effluent quality monitored over the period of discharge was also compared to CCME PAL guidelines (CCME 1999; updated to 2010) to assess chronic toxicity of undiluted effluent (Tables 4 and 5). All measurements of pH were within CCME PAL guidelines (Table 4). All measurements of ammonia were less than 0.2 mg N/L and concentrations were therefore below CCME PAL guidelines in the effluent, based on the effluent pH (7.5-8) and a water temperature of 10 ^{o}C (ambient temperature was 8 ^{o}C near the outfall). Aluminum measured in a single sample was an order of magnitude above the CCME PAL guideline (0.1 mg/L) in the effluent (Table 5). This likely reflects an upset associated with the use of aluminum in the sewage treatment process. As noted below, aluminum was below the CCME PAL guideline in Sheardown Lake NW in August 2009, including the site nearest the effluent outfall.

<u>AMBIENT WATER QUALITY MONITORING</u>

Water quality monitoring was conducted on August 31, 2009 in Sheardown Lake NW through two approaches:

- <u>Effluent plume monitoring</u>: specific conductance and other *in situ* variables (DO, pH, and temperature) were measured at a total of 32 sites ranging from the vicinity of the effluent outfall to a site near the outlet of the lake (Figure 5); and

- <u>Core water quality monitoring</u>: *in situ* measurements were collected and samples were collected at mid-depth for detailed analysis at an accredited analytical laboratory at five sites (four sites in Sheardown Lake NW and one site in Sheardown Lake SE; Figure 5).

The plume monitoring was intended to define the mixing properties and the plume dimensions within Sheardown Lake NW. The core water quality monitoring was intended to provide more detailed water quality monitoring data for comparison to pre-discharge (i.e., baseline) water quality conditions measured in 2007 and 2008. Laboratory results of the core water quality monitoring program conducted in 2009 are presented in Tables 6 and 7 and *in situ* measurements are presented in Appendix 1.

Plume Monitoring

The specific conductance of the PWSP No. 2 effluent, which was the wastewater stream being discharged during the ambient water quality monitoring, was approximately 600 µS/cm and this parameter was used as a tracer of the effluent plume within Sheardown Lake NW. Specific conductance measured *in situ* in Sheardown Lake NW on August 31, 2009 was approximately 117 µS/cm and very consistent across the 32 sites sampled in the lake (Appendix 1). Therefore, there was no indication of an effluent plume at the time of monitoring. Other *in situ* parameters were also relatively similar across sites and all sites were well-oxygenated indicating that the effluent did not cause critical DO depletion (all measurements were at or above saturation). *In situ* pH could not be measured due to a meter malfunction.

Core Water Quality Monitoring

For most routine water quality variables measured across four sampling sites in Sheardown Lake NW on August 31, 2009 were similar to lake-wide means obtained in 2007 and 2008 indicating that effluent discharge had no notable effect on water quality in the lake (Table 8). Although conductivity, TDS, alkalinity, and total phosphorus were slightly elevated relative to the means obtained in 2007 and 2008, these parameters were quite similar to conditions measured in September 2008. In addition, the single measurement of TP obtained in Sheardown Lake SE was notably higher than the ranges measured in Sheardown Lake NW in August 2009. Chlorophyll *a* was higher in August 2009 relative to the mean baseline data obtained in 2007 and 2008, most notably at the two sampling sites nearest the effluent outfall. However, the concentrations of chlorophyll *a* measured in August 2009 were within the ranges measured in 2007 and 2008 in Sheardown Lake.

Spatially, most routine water quality variables were similar across sites sampled in Sheardown Lake and there was no clear gradient from the effluent outfall to more distant sampling sites (Table 6). In addition, water quality was generally similar between the NW basin of Sheardown Lake, including sites near the sewage outfall, and the SE basin of Sheardown Lake (the reference location, Table 1). The primary exception occurred for chlorophyll *a*, which was higher at the two sites nearest the outfall in August 2009. All measurements of routine water quality variables (nitrate, ammonia, pH, dissolved oxygen, and total suspended solids) were within CCME PAL guidelines in August 2009 and feacal coliform bacteria were not detected in the lake.

A comparison of mean concentrations of total and dissolved metals for the open-water seasons of 2007 and 2008 and the August 2009 monitoring results indicates that conditions were relatively similar across years. Several metals were slightly elevated in August 2009 relative to 2007 and 2008, most notably major salts (potassium, calcium, magnesium, and sodium). In addition, most metals were below CCME PAL guidelines in Sheardown Lake prior to effluent discharge (i.e., 2007 and 2008) as well as during the monitoring conducted in 2009 near the end of the effluent discharge period (a single sample contained cadmium at the site-specific guideline in 2009). Therefore, in general, metal concentrations were not notably affected in Sheardown Lake as a result of effluent discharge. The key exceptions were notably higher concentrations of total aluminum and sodium measured near the effluent outfall relative to other more distant sites. Although aluminum was within the range observed in Sheardown Lake NW in 2008, sodium was elevated relative to baseline studies.

POTENTIAL EFFECTS OF EFFLUENTS ON SHEARDOWN LAKE: MASS-BALANCE MODELING

A whole-lake mass balance model was used to estimate the cumulative effects of treated sewage effluent discharged to Sheardown Lake NW in August 2009 (Table 9). The mass balance model indicates that if all effluents were instantaneously mixed in the lake (with no losses of water quality constituents), that the effects of the effluent on whole-lake pH, ammonia, TKN, TSS, TP, BOD, and faecal coliform bacteria would not be detectable.

SUMMARY AND CONCLUSIONS

Treated sewage effluent was not acutely toxic to rainbow trout or *Daphnia magna* and both effluents were within the CCME PAL guidelines for ammonia and pH at the end-of-pipe indicating no chronic toxicity.

Results of ambient water quality monitoring conducted in Sheardown Lake NW on August 31, 2009 during the period of treated sewage effluent discharge indicate the following:

- Plume delineation using specific conductance as a tracer did not indicate a plume in the vicinity of the outfall;

- Conductivity and DO were very similar across the lake and across depth and there was no indication of stratification;

- All measurements of DO collected at approximately 30 sites were above the CCME PAL guideline;

- In general, routine water quality variables were relatively similar to conditions measured in 2007 and 2008, as well as to conditions measured concurrently in Sheardown Lake SE;

- Lake-wide means for some routine variables were slightly higher in August 2009 than lake-wide means measured in the open-water seasons of 2007 and 2008, including TP, TDS, conductivity, chlorophyll *a*, and alkalinity. Of these variables, only TP and chlorophyll *a* were somewhat higher at the site nearest the outfall. Concentrations of TP, TDS, alkalinity, and conductivity were similar to conditions in September 2008;

- The lake-wide mean chlorophyll *a* and the concentrations measured at the two sites nearest the outfall were higher than means for 2007 and 2008 indicating some increase in algal productivity may have occurred in a localized area. However, chlorophyll *a* concentrations were within the ranges measured in Sheardown Lake during the baseline studies;

- All routine variables, including ammonia, pH, DO, and nitrate were within CCME PAL guidelines in August 2009;

- Some metals were slightly higher in August 2009 relative to earlier studies, notably major salts (calcium, magnesium, sodium, and potassium);

- All but a single measurement of total cadmium, which was at the CCME PAL guideline, were below CCME PAL guidelines in August 2009;

- Routine parameters and all but three metals (aluminum, potassium and sodium) were similar across sites in Sheardown Lake in August 2009 and there was no evidence of a gradient in conditions from the outfall to more distant sites;

- Total sodium was highest near the outfall and higher at all sites sampled in August 2009 than the ranges measured in baseline studies; and

- Total aluminum was higher near the outfall in August 2009 but was well within the ranges measured in the lake in September 2008.

Overall, the available water quality monitoring results indicate that discharge of treated sewage effluent did not result in notable changes in water quality in Sheardown Lake in August 2009, with the possible exceptions of slight elevations in total sodium and aluminum and chlorophyll *a* near the outfall. Effluent discharge does not appear to have caused or contributed to exceedences of CCME PAL water quality guidelines.

Mass-balance modeling indicated that the effects of discharge of the PWSP Nos. 2 and 3 effluent to Sheardown Lake NW in August 2009 would not have been expected to cause a detectable change in routine water quality lake-wide.

REFERENCES

CANADIAN COUNCIL OF MINISTERS OF THE ENVIRONMENT. (CCME). 1999. Canadian environmental quality guidelines. Canadian Council of Ministers of the Environment, Winnipeg. Updated to 2010.

CHAMBERS, P.A., M. GUY, E.S. ROBERTS, M.N. CHARLTON, R. KENT, C. GAGNON, G. GROVE, and N. FOSTER. 2001. Nutrients and their impact on the Canadian Environment. Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans Canada, Health Canada and Natural Resources Canada. 241 pp.

NÜRNBERG, G.K. 1996. Trophic state of clear and colored, soft- and hardwater lakes with special consideration of nutrients, anoxia, phytoplankton and fish. Lake Reserv. Manag. 8: 17-30.

ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT (OECD). 1982. Eutrophication of waters: Monitoring, assessment and control. Final Report. OECD cooperative programme on monitoring of inland waters (eutrophication control). Environment Directorate, OECD, Paris, France.

WETZEL, R.G. 1983. Limnology. Second Edition. New York. Saunders College Publishing. 767 pp.

Table 1. Mean routine water quality parameters for the open-water seasons of 2007 and 2008. HTE = holding time exceeded.

Parameter	Units	MRL	2007 Statistics			2008 Statistics				2007-2008 Mean	
			Mean Aug	Mean Sept	Mean 2007	Mean July	Mean August	Mean Sept	Mean 2008	Half the DL	At the DL
Alkalinity as $CaCO_3$	mg/L	5	51	53	52	52	53	56	53	53	53
pH	-		8.26	8.02	8.14	7.87	7.87	7.85	7.86	8.00	8.00
Conductivity	µS/cm	5	104	109	107	107	107	118	111	109	109
TDS (COND - CALC)	mg/L	5	68	71	70	70	70	77	72	71	71
Total Suspended Solids	mg/L	2	<2	<2	<2	1	5	<2	2	2	2
Turbidity	NTU	0.1	0.4	0.4	0.4	HTE	2.4	1.0	1.7	1.0	1.0
Bromide	mg/L	0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Chloride	mg/L	1	1	2	2	2	2	2	2	2	2
Sulphate	mg/L	1	2	3	2	1	1	1	1	2	2
Phenols	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Total Organic Carbon	mg/L	0.5	1.9	1.8	1.8	1.7	1.9	2	2	1.8	1.8
Dissolved Organic Carbon	mg/L	0.5	1.9	1.7	1.8	1.6	1.9	2	2	1.8	1.8
Total Kjeldahl Nitrogen	mg/L	0.10	0.14	<0.10	<0.10	0.19	0.17	0.19	0.18	0.12	0.12
Ammonia	mg N/L	0.02	0.02	<0.02	<0.02	0.03	0.01	<0.02	<0.02	<0.02	<0.02
Nitrite	mg N/L	0.005	<0.002	<0.002	<0.002	HTE	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate	mg N/L	0.10	<0.10	<0.10	<0.10	HTE	<0.1	<0.1	<0.1	<0.1	<0.1
Nitrate/nitrite	mg N/L	0.10	<0.10	<0.10	<0.10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Total Phosphorus	mg/L	0.003	<0.003	0.004	<0.003	0.003	0.006	0.004	0.004	0.003	0.004
Chlorophyll *a*	µg/L	0.2	0.3	0.5	0.4	HTE	0.3	<0.2	0.3	0.3	0.3
Pheophytin *a*	µg/L	0.2	1.3	0.6	1.0	HTE	1.8	4.4	3.1	2.0	2.0
BOD	mg/L	1	-	-	-	<1	<1	<1	<1	<1	<1
Total Coliforms	ct/100mL	-	-	-	-	-	1	3	2	2	2
Escherichia Coli	ct/100mL	-	-	-	-	-	0	<1	<1	<1	<1
Heterotrophic Plate Count	ct/1mL	-	-	-	-	-	243	113	178	178	178
Faecal Coliforms	ct/100mL	-	-	-	-	-	0	<1	<1	<1	<1
Faecal Streptococcus	ct/100mL	-	-	-	-	-	1	2	1	1	1

Table 2. Summary of TP concentrations and trophic status for Sheardown Lake NW. Values represent mean concentrations for the lake basin obtained by sampling period, by open-water period for 2007, 2008, for both combined, and for August 2009. Means have been calculated using two methods, for values that were reported below the analytical detection limit (DL): (1) applying a value of one-half the detection limit (DL); and (2) applying a value equal to the DL.

Sampling Period	TP (mg/L)		CCME Trophic Status	
	Using Half the DL	Using the DL	Using Half the DL	Using the DL
August 2007	<3	3	Ultra-Oligotrophic	Ultra-Oligotrophic
September 2007	4	4	Oligotrophic (boundary)	Oligotrophic (boundary)
Mean 2007 open-water	<3	4	Ultra-Oligotrophic	Oligotrophic (boundary)
July 2008	3	3	Ultra-Oligotrophic	Ultra-Oligotrophic
August 2008	6	6	Oligotrophic	Oligotrophic
September 2008	4	4	Oligotrophic (boundary)	Oligotrophic (boundary)
Mean 2008	4	4	Oligotrophic (boundary)	Oligotrophic (boundary)
Mean 2007 and 2008	3	4	Ultra-Oligotrophic	Oligotrophic (boundary)
August 2009	5	5	Oligotrophic	Oligotrophic

Table 3. Summary of selected trophic status categorization schemes for lakes based on chlorophyll *a* and concentrations measured in Sheardown Lake NW.

<table>
<tr><th colspan="7">Lake Trophic Status</th><th rowspan="2">Reference</th></tr>
<tr><th>Ultra-oligotrophic</th><th>Oligotrophic</th><th>Oligo-mesotrophic</th><th>Mesotrophic</th><th>Meso-eutrophic</th><th>Eutrophic</th><th>Hypereutrophic</th></tr>
<tr><td colspan="8">Chlorophyll a (µg/L)</td></tr>
<tr><td>-</td><td><2.5</td><td>-</td><td>2.5 - 8</td><td>-</td><td>8 - 25</td><td>> 25</td><td>OECD (1982)</td></tr>
<tr><td>0.01 - 0.5</td><td>0.3 - 3</td><td>-</td><td>2 - 15</td><td>-</td><td>10 - 500</td><td>-</td><td>Wetzel (1983)</td></tr>
<tr><td>-</td><td><3.5</td><td>-</td><td>3.5 - 9</td><td>-</td><td>9.1 - 25</td><td>> 25</td><td>Nürnberg (1996)</td></tr>
<tr><td colspan="2">0.3</td><td></td><td></td><td></td><td></td><td></td><td>Sheardown Lake NW: Mean August 2007</td></tr>
<tr><td colspan="2">0.5</td><td></td><td></td><td></td><td></td><td></td><td>Sheardown Lake NW: Mean September 2007</td></tr>
<tr><td colspan="2">0.4</td><td></td><td></td><td></td><td></td><td></td><td>Sheardown Lake NW: Mean open-water season of 2007</td></tr>
<tr><td colspan="2">0.3</td><td></td><td></td><td></td><td></td><td></td><td>Sheardown Lake NW: Mean August 2008</td></tr>
<tr><td><0.2</td><td></td><td></td><td></td><td></td><td></td><td></td><td>Sheardown Lake NW: Mean September 2009</td></tr>
<tr><td colspan="2">0.3</td><td></td><td></td><td></td><td></td><td></td><td>Sheardown Lake NW: Mean open-water season of 2008</td></tr>
<tr><td colspan="2">0.3</td><td></td><td></td><td></td><td></td><td></td><td>Sheardown Lake NW: Mean open-water seasons of 2008/2009</td></tr>
<tr><td></td><td>1.5</td><td></td><td></td><td></td><td></td><td></td><td>Sheardown Lake NW: Mean August 2008</td></tr>
</table>

Table 4. Effluent quality from PWSP Nos. 2 and 3.

PARAMETER	UNITS	MRL	Effluent Outfall:	PWSP No. 3				PWSP no. 2							
			Sample ID:	MRY-4C	MRY-4c 7am	MRY-4c 11pm	Mean August 23-24	MRY-4b	MRY-4b01	MRY-4b - 2000HRS	MRY-4b - 800HRS	MRY-4b 18:00	MRY-4b 14:00	MRY-4b	Mean August 27-31
			Sample Date:	2009-08-23	2009-08-24	2009-08-24		2009-08-23	2009-08-23	2009-08-27	2009-08-28	2009-08-29	2009-08-30	2009-08-31	
pH	-	-		7.54	7.89	7.87	7.77	7.44	7.47	7.58	7.49	7.45	7.58	7.56	7.53
Conductivity [1]	µS/cm	-		1265	-	1233 [2]	1249	684	-	-	-	-	-	-	-
Total Suspended Solids	mg/L	2		10	7	7	8	13	9	10	23	11	18	16	16
Total Kjeldahl Nitrogen	mg/L	0.10		1.99	2.11	2.18	2.09	2.73	2.83	2.54	3.06	2.17	2.19	2.61	2.51
N-NH3 (Ammonia)	mg/L	0.02		0.07	0.07	0.07	0.07	0.07	0.06	0.13	0.07	0.07	0.13	0.08	0.10
Total Phosphorus	mg/L	0.003		0.046	0.064	0.056	0.055	0.268	0.300	0.239	0.593	0.220	0.327	0.432	0.362
Biochemical Oxygen Demand	mg/L	1		4	4	6	5	6	5	8	8	8	8	8	8
Chemical Oxygen Demand	mg/L	5		47	39	45	44	64	68	71	71	65	64	72	69
Faecal Coliforms	CFU/100mL	10		-	<10	<10	<10	<10	<10	<10	<10	-	-	0	<10
Oil and Grease	mg/L	1		<1	<1	<1	<1	<1	<1	<1	12	-	-	<1	3

[1] Measurements made at site laboratory.
[2] Mean of two measurements.

Table 5. Major ions and metals measured in PWSP No. 2 effluent and in Sheardown Lake. Values in blue exceeded the CCME PAL guidelines.

Parameter	Units	MRL	CCME PAL guideline	PWSP No. 2 Effluent	Sheardown Lake - NW							Sheardown Lake - SE
					2007	2008	August 2009					August 2009
				2009-08-30	Lake Wide Mean	Lake Wide Mean	DL0-OF	DLO-01-08	DL0-01-5	DLO-01-1	Lake-Wide Mean August 2009	DLO-02-3
Hardness (as $CaCO_3$)	mg/L	1	-	35	53	57	58	58	57	58	58	52
Calcium	mg/L	1	-	9	10.8	11.3	12.4	12.5	12.5	12.5	12.5	10.8
Magnesium	mg/L	1	-	3	6.40	6.92	7.42	7.44	7.48	7.42	7.44	6.42
Potassium	mg/L	1	-	21	<2.0	0.749	0.910	0.838	0.849	0.847	0.861	0.817
Sodium	mg/L	2	-	106	<2.0	0.640	1.35	0.928	0.873	0.888	1.01	0.888
Aluminum	mg/L	0.01	0.1	1.85	0.0053	0.0336	0.0434	0.0229	0.0247	0.0238	0.0287	**0.158**
Iron	mg/L	0.03	0.3	<0.03	<0.030	<0.030	0.032	<0.03	<0.03	0.031	<0.03	0.176

Table 6. Routine water quality measurements collected in Sheardown Lake NW and SE collected in August 2009 during effluent discharge.

		Lake:	Sheardown Lake - NW					Sheardown Lake - SE
		Field Site ID:	DL0-OF	DLO-01-08	DL0-01-5	DLO-01-1	Mean	DLO-02-3
		Sample Date:	2009-08-31	2009-08-31	2009-08-31	2009-08-31	2009-08-31	2009-08-31
PARAMETER	**UNITS**	**MRL**						
Depth of sample collection	m		6	9	11	10	-	7
Alkalinity (as $CaCO_3$)	mg/L	**5**	58	58	57	58	58	52
pH	pH units	**-**	7.91	7.91	7.89	7.91	8	7.81
Conductivity	µS/cm	**5**	122	122	120	121	121	109
Total Dissolved Solids	mg/L	**5**	79	79	78	79	79	71
Total Suspended Solids	mg/L	**2**	<2	<2	<2	<2	<2	3
Turbidity	NTU	**0.1**	0.8	0.8	0.8	0.7	1	4.5
Colour	TCU	**2**	2	2	2	<2	<2	5
Chloride	mg/L	**1**	3	3	3	3	3	3
Sulphate	mg/L	**1**	4	3	3	3	3	3
Total Kjeldahl Nitrogen	mg/L	**0.1**	0.16	0.20	0.17	<0.1	0.15	0.22
Ammonia	mg N/L	**0.02**	<0.02	0.04	0.04	<0.02	0.03	0.02
Nitrate	mg N/L	**0.1**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate/nitrite	mg N/L	**0.1**	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Total Phosphorus	mg/L	**0.003**	0.006	0.005	0.004	0.004	0.005	0.009
Dissolved Reactive Phosphorus	mg/L	**0.01**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chlorophyll *a*	µg/L	**0.2**	2.3	2.9	<0.2	0.7	1.5	<0.2
Pheophytin *a*	µg/L	**0.2**	<0.2	<0.2	3.5	<0.2	1.0	1.4
Faecal Coliform Bacteria	ct/100mL	-	0	-	-	-	0	-

Table 7. Lake-wide mean concentrations of metals measured in Sheardown Lake NW in 2007 and 2008 prior to effluent discharge and in August 2009 during effluent discharge. Data collected in Sheardown Lake NE in August 2009 are also shown for comparison. Values in blue indicate measurements that exceeded CCME PAL guidelines (CCME 1999; updated to 2010).

				Sheardown Lake - NW							Sheardown Lake - SE
				2007	2008	August 2009					August 2009
Parameter	Units	MRL	CCME PAL guideline	Lake Wide Mean	Lake Wide Mean	DL0-OF	DLO-01-08	DL0-01-5	DLO-01-1	Lake-Wide Mean August 2009	DLO-02-3
Hardness (as $CaCO_3$)	mg/L	0.5		53	57	58	58	57	58	58	52
Hardness (dissolved as $CaCO_3$)	mg/L	0.5		-	57	62	63	62	62	62	56
Dissolved Metals											
Aluminum	mg/L	0.0010		0.0043	0.0017	0.0067	0.0036	0.0053	0.0025	0.0045	0.0070
Antimony	mg/L	0.00010		0.00013	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Arsenic	mg/L	0.00010		<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Barium	mg/L	0.000050		0.00449	0.00489	0.00547	0.00551	0.00569	0.00551	0.00555	0.00559
Beryllium	mg/L	0.00050		<0.00050	<0.00050	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Bismuth	mg/L	0.00050		<0.00050	<0.00050	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	mg/L	0.010		<0.010	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	mg/L	0.000010		<0.000017	<0.000010	0.00001	<0.00001	0.00001	<0.00001	<0.00001	<0.00001
Calcium	mg/L	0.050		10.8	11.4	12.2	12.5	12.3	12.3	12.3	11.4
Chromium	mg/L	0.00050		<0.00050	<0.00050	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cobalt	mg/L	0.00010		<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.00010		0.0009	0.00097	0.00081	0.00083	0.00102	0.00086	0.00088	0.00075
Iron	mg/L	0.030		<0.030	<0.030	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Lead	mg/L	0.00005		0.000063	<0.000050	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Lithium	mg/L	0.0050		<0.0050	<0.0050	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Magnesium	mg/L	0.10		6.39	6.97	7.56	7.60	7.47	7.55	7.55	6.62
Manganese	mg/L	0.000050		0.00117	0.00014	0.00025	0.00022	0.00017	0.00017	0.00020	0.00070
Mercury	mg/L	0.000010		<0.000050	<0.000010	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001

Table 7. - continued -

				Sheardown Lake - NW							Sheardown Lake - SE August 2009
				2007	2008	August 2009					
Parameter	Units	MRL	CCME PAL guideline	Lake Wide Mean	Lake Wide Mean	DL0-OF	DLO-01-08	DL0-01-5	DLO-01-1	Lake-Wide Mean August 2009	DLO-02-3
Dissolved Metals											
Molybdenum	mg/L	0.000050		0.000647	0.000586	0.000666	0.000682	0.000685	0.000703	0.000684	0.000482
Nickel	mg/L	0.00050		0.00063	0.00064	0.00059	0.00060	0.00061	0.00065	0.00061	<0.0005
Potassium	mg/L	0.050		<2.0	0.738	0.895	0.841	0.881	0.875	0.873	0.725
Selenium	mg/L	0.0010		<0.0010	<0.0010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silicon	mg/L	0.050		0.611	0.604	0.622	0.625	0.617	0.617	0.620	0.620
Silver	mg/L	0.000010		<0.000010	<0.000010	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Sodium	mg/L	0.050		<2.0	0.685	1.20	0.916	1.07	0.868	1.01	0.807
Strontium	mg/L	0.00010		0.00693	0.00740	0.00841	0.00837	0.00880	0.00858	0.00854	0.00952
Thallium	mg/L	0.00010		<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Tin	mg/L	0.00010		<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Titanium	mg/L	0.010		<0.010	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Uranium	mg/L	0.000010		0.000547	0.000672	0.000735	0.000701	0.000779	0.000820	0.000759	0.000709
Vanadium	mg/L	0.0010		<0.0010	<0.0010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.0010		0.0014	<0.0010	0.0010	<0.001	0.0015	<0.001	<0.001	<0.001
Total Metals											
Aluminum	mg/L	0.0010	0.1	0.0053	0.0336	0.0434	0.0229	0.0247	0.0238	0.0287	**0.158**
Antimony	mg/L	0.00010		<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Arsenic	mg/L	0.00010	0.005	<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
Barium	mg/L	0.000050		0.00449	0.00512	0.00568	0.00556	0.00557	0.00567	0.00562	0.00722
Beryllium	mg/L	0.0005		<0.00050	<0.00050	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Bismuth	mg/L	0.0005		<0.00050	<0.00050	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron	mg/L	0.010		<0.010	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Cadmium	mg/L	0.00001	0.000015 – 0.000032	<0.000017	<0.000010	<0.00001	0.00001	**0.00002**	0.00002	0.000016	**0.00005**
Calcium	mg/L	0.050		10.8	11.3	12.4	12.5	12.5	12.5	12.5	10.8

Table 7. - continued -

Parameter	Units	MRL	CCME PAL guideline	Sheardown Lake - NW: 2007 Lake Wide Mean	2008 Lake Wide Mean	August 2009: DL0-OF	DLO-01-08	DL0-01-5	DLO-01-1	Lake-Wide Mean August 2009	Sheardown Lake - SE August 2009: DLO-02-3
Total Metals											
Chromium	mg/L	0.00050		<0.00050	<0.00050	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0009
Cobalt	mg/L	0.00010		<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Copper	mg/L	0.00010	0.002	0.00083	0.00122	0.0009	0.0010	0.0009	0.0009	0.0009	0.0012
Iron	mg/L	0.030	0.3	<0.030	<0.030	0.032	<0.03	<0.03	0.031	<0.03	0.176
Lead	mg/L	0.000050	0.001-0.002	<0.000050	<0.000050	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00020
Lithium	mg/L	0.0050		<0.0050	<0.0050	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Magnesium	mg/L	0.10		6.40	6.92	7.42	7.44	7.48	7.42	7.44	6.42
Manganese	mg/L	0.000050		0.00157	0.00345	0.00158	0.00144	0.00151	0.00160	0.00153	0.00735
Mercury	mg/L	0.000010	0.00003	<0.000050	<0.000010	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	mg/L	0.000050	0.073	0.000534	0.000565	0.000646	0.000647	0.000652	0.000723	0.000667	0.000512
Nickel	mg/L	0.00050	0.025-0.065	0.00066	0.00074	0.00078	0.00069	0.00074	0.00078	0.00075	0.00112
Potassium	mg/L	0.050		<2.0	0.749	0.910	0.838	0.849	0.847	0.861	0.817
Selenium	mg/L	0.0010	0.001	<0.0010	<0.0010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silicon	mg/L	0.050		0.615	0.677	0.692	0.691	0.687	0.727	0.699	0.990
Silver	mg/L	0.000010	0.0001	<0.000010	<0.000010	0.00002	<0.00001	<0.00001	<0.00001	<0.00001	0.00002
Sodium	mg/L	0.050		<2.0	0.640	1.35	0.928	0.873	0.888	1.01	0.888
Strontium	mg/L	0.00010		0.00678	0.00734	0.00843	0.00829	0.00833	0.00844	0.00837	0.01040
Thallium	mg/L	0.00010	0.0008	<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Tin	mg/L	0.00010		<0.00010	<0.00010	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Titanium	mg/L	0.010		<0.010	<0.010	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Uranium	mg/L	0.000010		0.000551	0.000670	0.000805	0.000772	0.000824	0.000840	0.000810	0.000824
Vanadium	mg/L	0.0010		<0.0010	<0.0010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.0010	0.03	<0.0010	<0.0010	<0.001	<0.001	<0.001	<0.001	<0.001	0.0016

Table 8. Lake-wide mean routine water quality measurements for Sheardown Lake NW collected in 2007 and 2008 prior to effluent discharge and in August 2009 during effluent discharge.

			2007 Statistics			2008 Statistics				2009 Mean
Parameter	Units	MRL	Mean Aug	Mean Sept	Mean 2007	Mean July	Mean August	Mean Sept	Mean 2008	Mean August 31, 2009
Alkalinity (as $CaCO_3$)	mg/L	5	51	53	52	52	53	56	53	58
pH	-		8.26	8.02	8.14	7.87	7.87	7.85	7.86	7.91
Conductivity	µS/cm	5	104	109	107	107	107	118	111	121
Total dissolved solids	mg/L	5	68	71	70	70	70	77	72	79
Total Suspended Solids	mg/L	2	<2	<2	<2	1	5	<2	2	<2
Turbidity	NTU	0.1	0.4	0.4	0.4	-	2.4	1.0	1.7	0.8
Chloride	mg/L	1	1	2	2	2	2	2	2	3
Sulphate	mg/L	1	2	3	2	1	1	1	1	3
Total Kjeldahl Nitrogen	mg/L	0.10	0.14	<0.10	<0.10	0.19	0.17	0.19	0.18	0.15
Ammonia	mg N/L	0.02	0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	0.03
Nitrite	mg N/L	0.005	<0.002	<0.002	<0.002	-	<0.005	<0.005	<0.005	<0.10
Nitrate	mg N/L	0.10	<0.10	<0.10	<0.10	-	<0.1	<0.1	<0.1	<0.10
Total Phosphorus	mg/L	0.003	<0.003	0.004	<0.003	0.003	0.006	0.004	0.004	0.005
Chlorophyll *a*	µg/L	0.2	0.3	0.5	0.4	-	0.3	<0.2	0.3	1.5
Pheophytin *a*	µg/L	0.2	1.3	0.6	1.0	-	1.8	4.4	3.1	1.0
Faecal Coliform Bacteria	ct/100mL	-	-	-	-	-	0	<1	<1	0

Table 9. Comparison of mass-balance modeling results and water quality monitoring data collected from Sheardown Lake NW in August 2009.

Parameter	Units	MRL	Effluents		Background Lake Water Quality: 2007/08 Means	Mass-balance Concentrations in Sheardown Lake NW				Mass-balance Lake concentrations: Absolute change from background.				Water Quality in Sheardown Lake NW: August 2009					Sheardwon Lake SE
			PWSP No. 2	PWSP No. 3		Whole Lake (0.678 km^2)	0.001 km^2 area	0.01 km^2 area	0.1 km^2 area	Whole Lake (0.678 km^2)	0.001 km^2 area	0.01 km^2 area	0.1 km^2 area	DL0-OF	DLO-01-08	DL0-01-5	DLO-01-1	Mean	DLO-02-3
pH	-	-	7.53	7.77	8.00	8.00	7.81	7.98	8.00	0.0004	0.19	0.023	0.002	7.91	7.91	7.89	7.91	8	7.81
Total Suspended Solids	mg/L	2	16	8	2	2	5	3	2	0.004	2.8	0.28	0.028	<2	<2	<2	<2	<2	3
Total Kjeldahl Nitrogen	mg/L	0.10	2.51	2.09	0.12	0.12	0.66	0.17	0.13	0.0008	0.54	0.054	0.0054	0.16	0.20	0.17	<0.1	0.15	0.22
Ammonia	mg N/L	0.02	0.10	0.07	<0.02	0.01	0.03	0.01	0.01	0.00003	0.02	0.002	0.0002	<0.02	0.04	0.04	<0.02	0.03	0.02
Total Phosphorus	mg/L	0.003	0.362	0.055	0.003	0.003	0.051	0.008	0.003	0.00007	0.048	0.0048	0.00048	0.006	0.005	0.004	0.004	0.005	0.009
Biochemical Oxygen Demand	mg/L	1	8	5	<1	0.5	2.0	0.6	0.5	0.0022	1.5	0.1	0.015	0	-	-	-	0	-
Faecal Coliform Bacteria	CFU/100mL	10	<10	<10	<1	0.5	2.9	0.7	0.5	0.0035	2.4	0.2	0.024	0	-	-	-	0	-

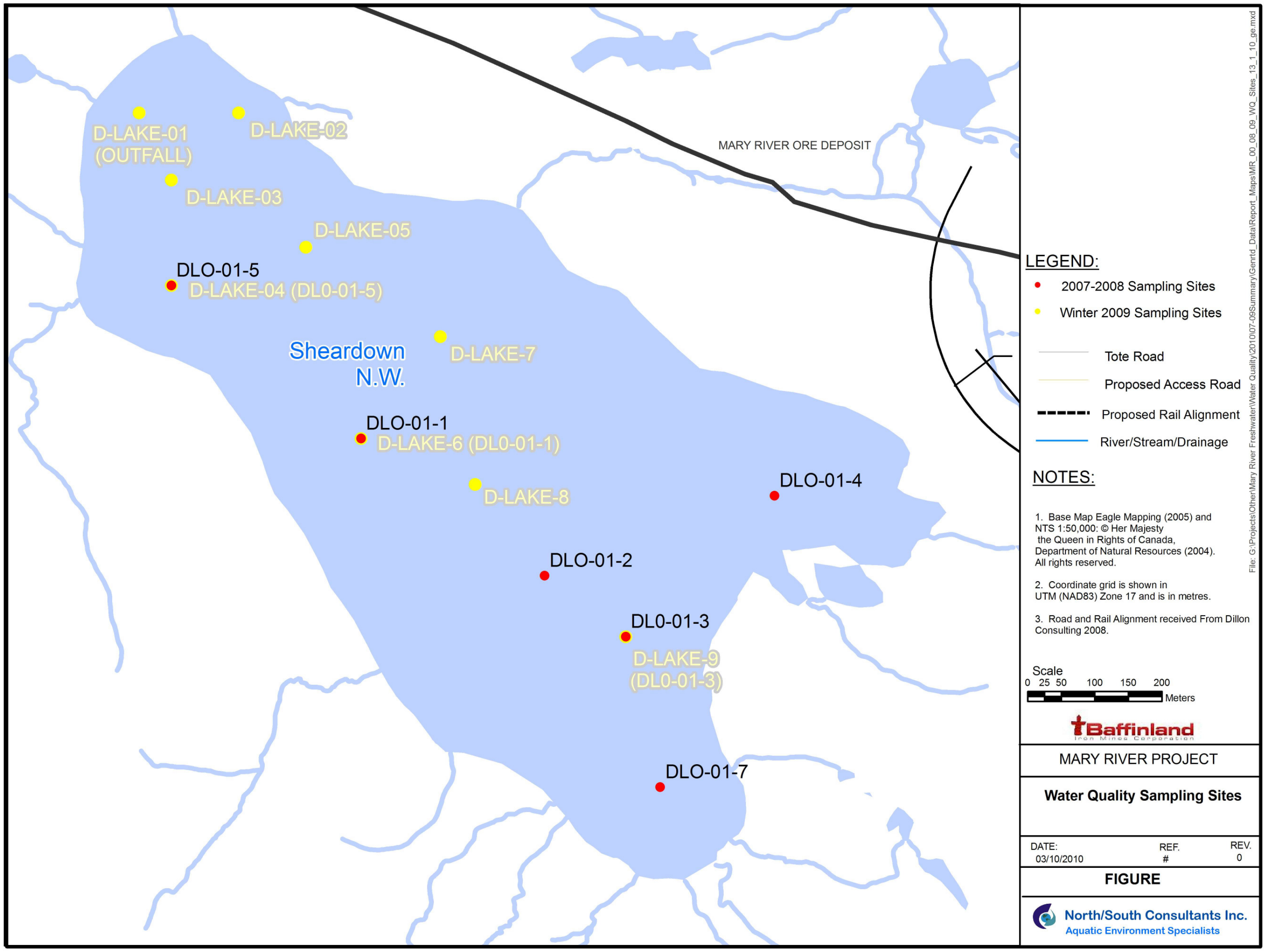


Figure 1. Locations of baseline water quality sampling sites in Sheardown Lake NW: 2007-2009. Laboratory and *in situ* water quality were sampled in 2007-2008 and *in situ* water quality was sampled in winter 2009.

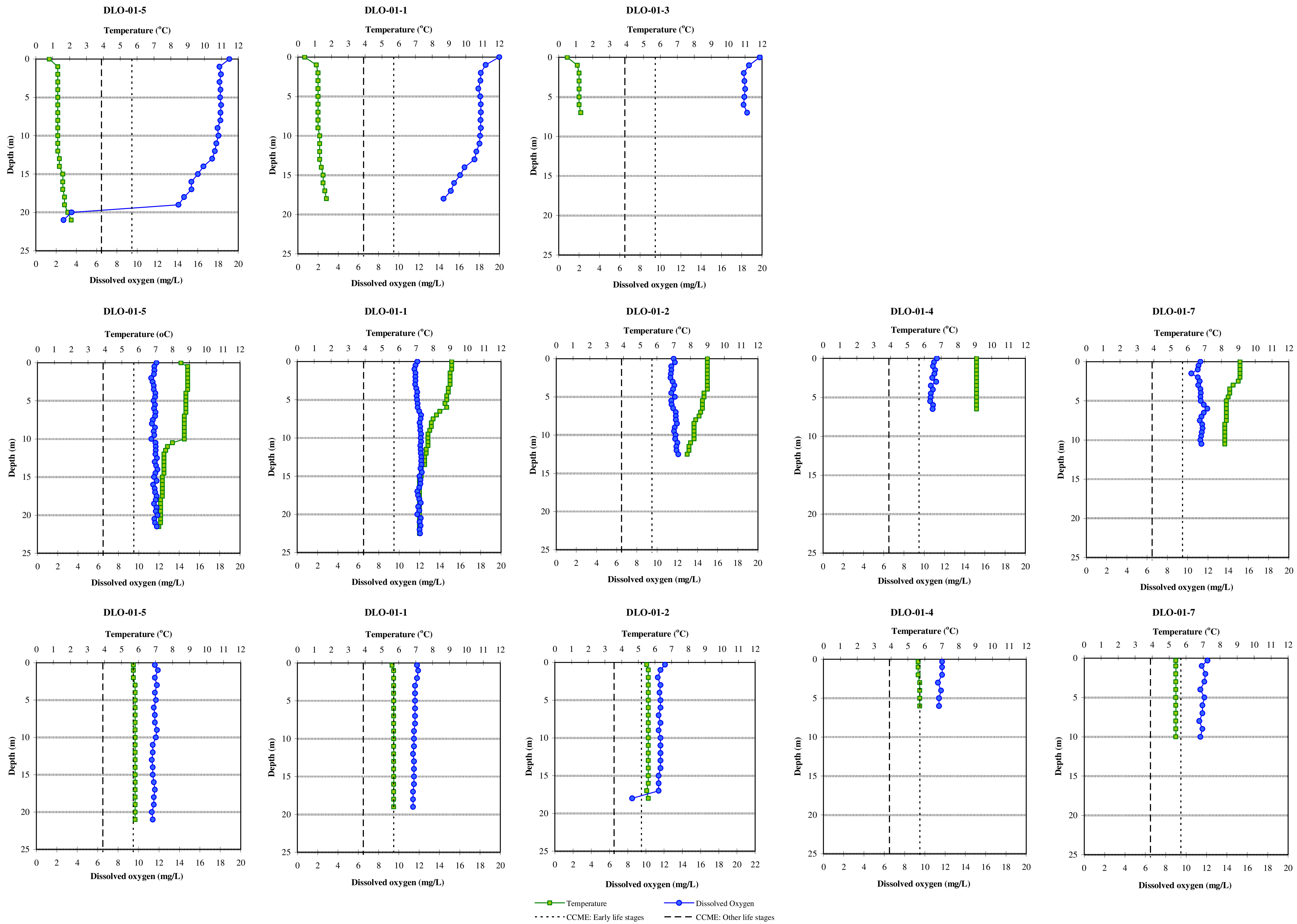


Figure 2. Dissolved oxygen and temperature depth profiles measured in Sheardown Lake NW in: (A) May; (B) Early August; and (C) Early September, 2007.

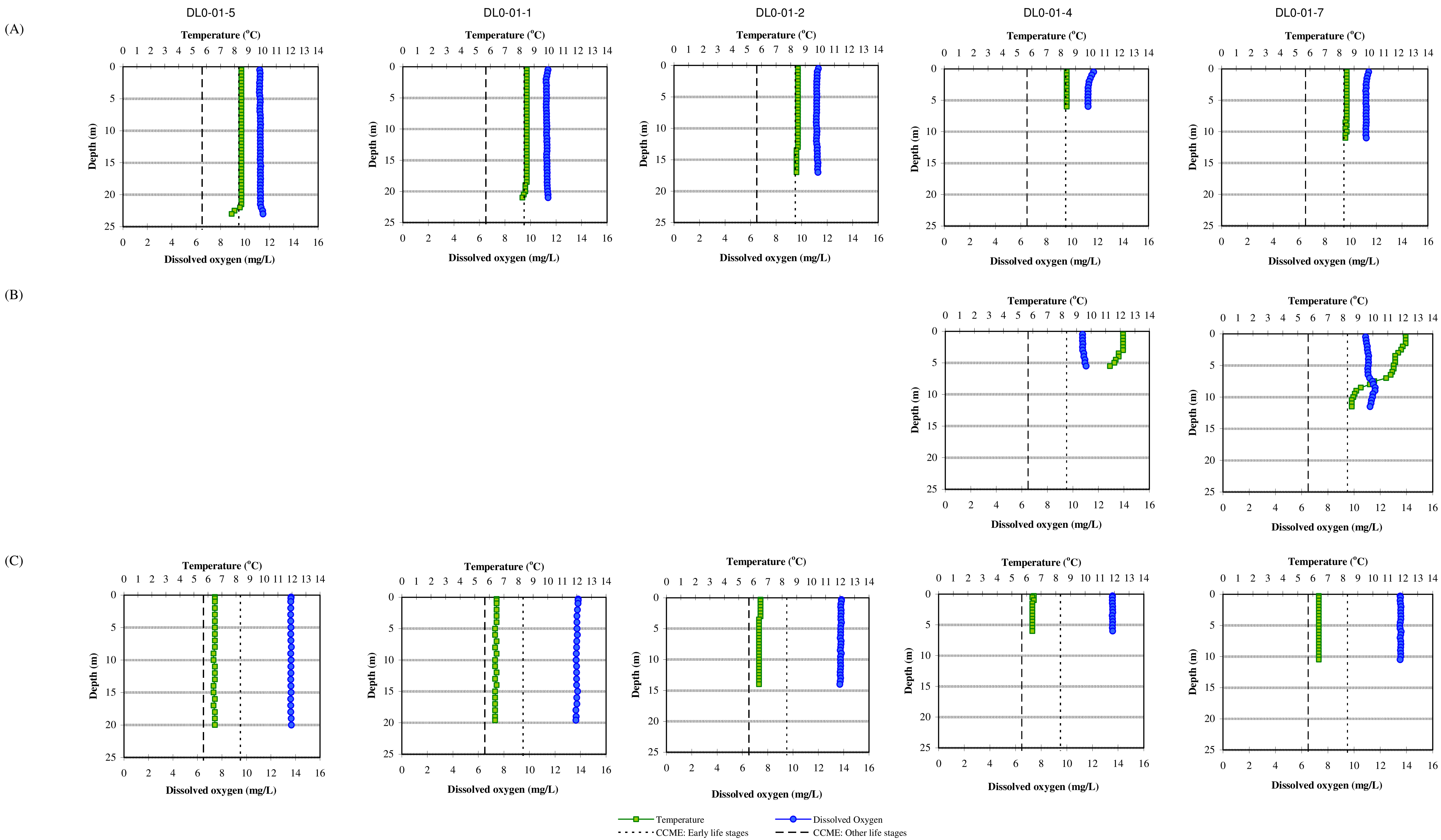


Figure 3. Dissolved oxygen and temperature depth profiles measured in Sheardown Lake NW in: (A) end of July; (B) Early August; and (C) Early September, 2008.

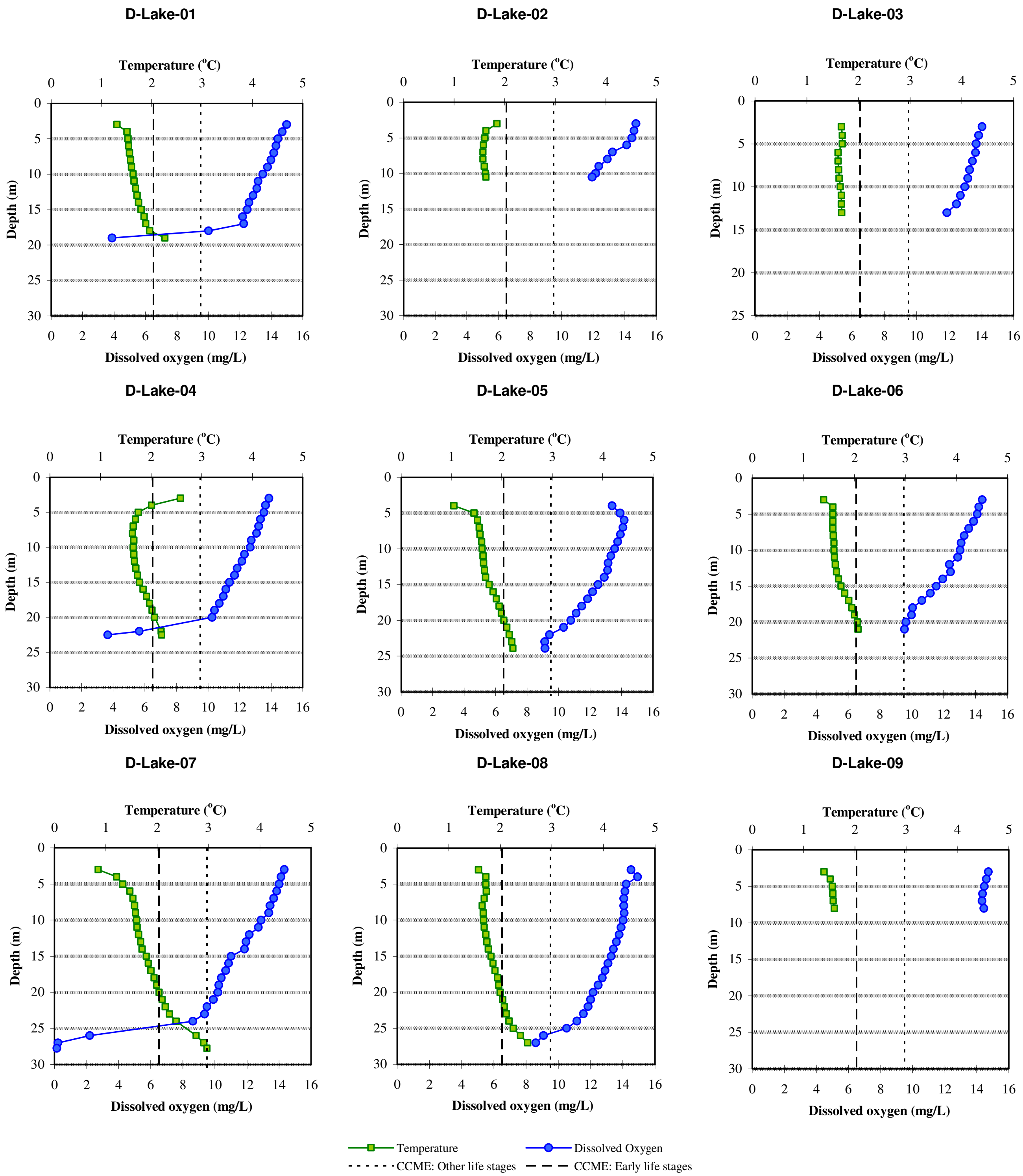


Figure 4. Dissolved oxygen and temperature depth profiles measured in Sheardown Lake NW in late April/early May 2009. Ice thickness was approximately 2 m.

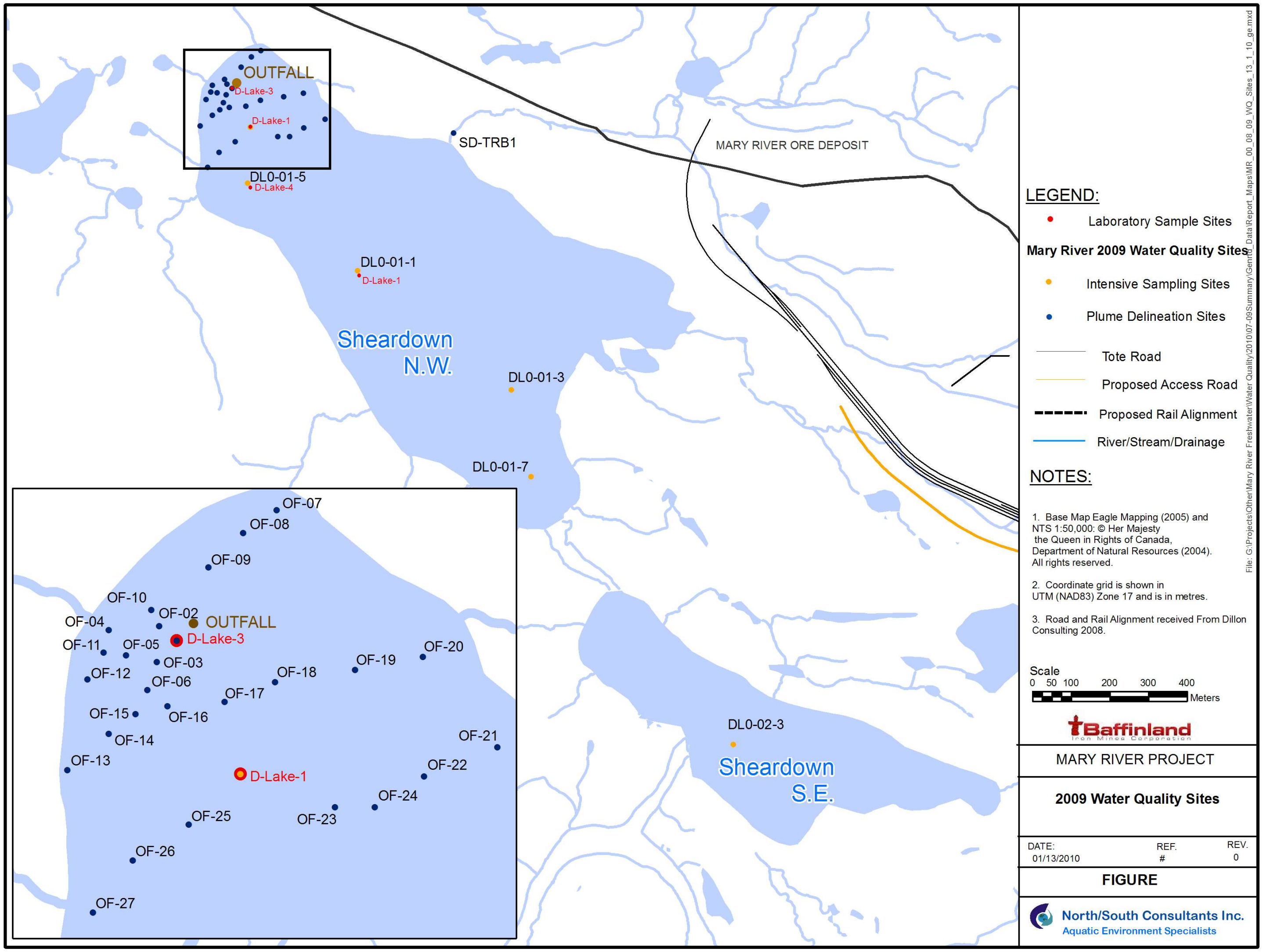


Figure 5. Locations of 2009 water quality sampling sites in Sheardown Lake NW and SE and the location of the sewage effluent outfall.

Appendix 1. *In situ* water quality measurements collected in Sheardown Lake NW and SE: August 31, 2009.

Location ID	Sample Date	Sample Time	Depth (m) Total	Depth (m) Measurement	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%Saturation)	Specific Conductance (µS/cm)
Sheardown Lake NW								
DL0-01-1	31-Aug-09	11:05	19.7	Surface	8.0	12.10	102	117
				2	7.9	12.10	102	117
				4	7.9	12.08	102	117
				6	7.9	12.06	102	117
				8	7.9	12.04	102	117
				10	7.9	12.02	101	117
				12	7.9	12.01	101	117
				14	7.9	12.01	101	117
				16	7.8	12.02	101	117
				18	7.7	11.99	101	117
DL0-01-3	31-Aug-09	10:42	9.8	Surface	7.8	12.31	105	117
				2	7.8	12.10	102	117
				4	7.8	11.83	100	117
				6	7.8	11.83	99	117
				8	7.8	11.84	99	117
DL0-01-5	31-Aug-09	17:25	24.6	Surface	8.2	13.90	117	117
				1	8.1	13.90	117	117
				2	8.1	13.90	117	117
				3	8.1	13.90	117	117
				4	8.1	13.85	117	117
				5	8.1	13.85	117	117
				6	8.1	13.85	117	117
				7	8.1	13.73	117	117
				8	8.1	13.73	117	117
				9	8.1	13.73	117	117
				10	8.0	13.69	116	117
				11	8.0	13.69	116	117
				12	8.0	13.68	116	117
				13	8.0	13.68	116	117
				14	8.0	13.67	116	117
				15	8.0	13.67	116	117
				16	8.0	13.67	116	117
				17	8.0	13.67	116	117
				18	8.0	13.67	116	117
				19	8.0	13.67	116	117
				20	7.3	13.54	114	116
				21	6.1	13.38	113	114
				22	5.9	13.38	113	112
DL0-01-7	31-Aug-09	10:31	9.4	Surface	7.7	11.93	100	117
				2	7.8	11.83	99	118
				4	7.8	11.78	99	117
				6	7.8	11.75	99	117
				8	7.8	11.72	99	117
DL0-01-8	31-Aug-09	-	19.1	Surface	8.2	13.75	117	117
				1	8.2	13.75	117	117
				2	8.2	14.00	117	117
				3	8.2	13.99	117	117
				4	8.1	13.99	117	117
				5	8.1	13.99	117	117
				6	8.1	13.97	117	117
				7	8.1	13.97	117	117
				8	8.1	13.97	117	117
				9	8.1	13.88	117	117
				10	8.1	13.88	117	117
				11	8.1	13.88	117	117
				12	8.1	13.77	117	117
				13	8.1	13.75	116	117

Appendix 1. - continued -

Location ID	Sample Date	Sample Time	Depth (m) Total	Depth (m) Measurement	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%Saturation)	Specific Conductance (µS/cm)
Sheardown Lake NW								
DL0-01-8				14	8.1	13.75	116	117
				15	8.1	13.75	116	117
				16	8.0	13.75	116	117
				17	8.0	13.70	116	117
				18	8.0	13.68	116	117
DL0-Outfall	31-Aug-09	-	11.2	Surface	8.2	12.50	106	117
				1	8.1	12.50	106	117
				2	8.1	12.48	106	117
				3	8.1	12.47	106	117
				4	8.1	12.45	105	117
				5	8.1	12.44	105	117
				6	8.1	12.43	105	117
				7	8.1	12.42	105	117
				8	8.1	12.42	105	117
				9	8.1	12.41	105	117
				10	8.1	12.40	105	118
				11	8.1	12.40	105	118
Outfall 2	31-Aug-09	-	11.6	Surface	8.1	12.46	105	117
				2	8.1	12.44	105	117
				4	8.1	12.42	105	117
				6	8.1	12.41	105	117
				8	8.1	12.40	105	117
				10	8.1	12.39	105	117
Outfall 3	31-Aug-09	-	14.1	Surface	8.1	12.52	106	117
				2	8.1	12.49	106	117
				4	8.1	12.48	106	117
				6	8.1	12.48	106	117
				8	8.1	12.47	106	117
				10	8.1	12.46	105	117
				12	8.1	12.46	105	117
				14	8.0	12.46	105	119
Outfall 4	31-Aug-09	-	4.1	Surface	8.1	12.65	107	117
				1	8.1	12.65	107	117
				2	8.1	12.61	107	117
				3	8.1	12.59	107	117
				4	8.1	12.58	107	117
Outfall 5	31-Aug-09	-	12.3	Surface	8.2	12.57	106	117
				2	8.1	12.56	106	117
				4	8.1	12.55	106	117
				6	8.1	12.55	106	117
				8	8.1	12.56	106	117
				10	8.1	12.57	106	117
				12	8.1	12.54	106	117
Outfall 6	31-Aug-09	-	15.6	Surface	8.1	12.66	107	117
				2	8.1	12.65	107	117
				4	8.1	12.80	108	117
				6	8.1	12.88	109	117
				8	8.1	13.03	110	117
				10	8.1	13.05	110	117
				12	8.1	13.05	110	117
				14	8.1	13.05	110	117
Outfall 7	31-Aug-09	-	6.7	Surface	8.1	13.14	111	117
				2	8.1	13.12	111	117
				4	8.1	13.11	111	117
				6	8.1	13.10	111	117

Appendix 1. - continued -

Location ID	Sample Date	Sample Time	Depth (m) Total	Depth (m) Measurement	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%Saturation)	Specific Conductance (µS/cm)
Sheardown Lake NW								
Outfall 8	31-Aug-09	-	8.0	Surface	8.2	13.08	111	117
				2	8.2	13.07	111	117
				4	8.1	13.08	111	117
				6	8.1	13.08	111	117
				8	8.1	13.10	111	117
Outfall 9	31-Aug-09	-	10.0	Surface	8.1	13.14	111	117
				2	8.1	13.12	111	117
				4	8.1	13.12	111	117
				6	8.1	13.12	111	117
				8	8.1	13.14	111	117
				10	8.1	12.87	110	117
Outfall 10	31-Aug-09	-	9.6	Surface	8.1	13.20	112	117
				2	8.1	13.21	112	118
				4	8.1	13.20	112	118
				6	8.1	13.21	112	118
				8	8.1	13.21	112	118
Outfall 11	31-Aug-09	-	7.3	Surface	8.1	13.27	112	117
				2	8.1	13.25	112	117
				4	8.1	13.24	112	117
				6	8.1	13.24	112	117
Outfall 12	31-Aug-09	-	4.1	Surface	8.1	13.28	112	117
				1	8.1	13.28	112	117
				2	8.1	13.27	112	117
				3	8.1	13.25	112	117
				4	8.1	13.28	112	117
Outfall 13	31-Aug-09	-	1.0	Surface	8.2	13.33	113	118
				0.75	8.2	13.35	113	118
Outfall 14	31-Aug-09	-	11.2	Surface	8.1	13.36	113	117
				2	8.1	13.33	113	117
				4	8.1	13.33	113	117
				6	8.1	13.31	113	117
				8	8.1	13.33	113	117
				10	8.1	13.34	113	117
Outfall 15	31-Aug-09	-	13.7	Surface	8.1	13.42	114	117
				2	8.1	13.39	113	117
				4	8.1	13.38	113	117
				6	8.1	13.37	113	117
				8	8.1	13.36	113	117
				10	8.1	13.36	113	117
				12	8.1	13.37	113	117
Outfall 16	31-Aug-09	-	16.0	Surface	8.1	13.43	114	117
				2	8.1	13.40	114	117
				4	8.1	13.39	113	117
				6	8.1	13.39	113	117
				8	8.1	13.39	113	117
				10	8.1	13.40	113	117
				12	8.1	13.40	113	117
				14	8.1	13.41	113	117
				15	8.1	13.10	111	117
Outfall 17	31-Aug-09	-	16.2	Surface	8.2	13.53	115	117
				2	8.2	13.54	115	117
				4	8.2	13.54	115	117
				6	8.1	13.54	115	117
				8	8.1	13.54	115	118

Appendix 1. - continued -

Location ID	Sample Date	Sample Time	Depth (m) Total	Depth (m) Measurement	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%Saturation)	Specific Conductance (µS/cm)
Sheardown Lake NW								
Outfall 17				10	8.1	13.54	115	117
				12	8.1	13.54	115	117
				14	8.1	13.53	115	117
				15	8.1	13.42	114	117
Outfall 18	31-Aug-09	-	15.7	Surface	8.2	13.58	115	117
				2	8.2	13.57	115	117
				4	8.1	13.57	115	117
				6	8.1	13.56	115	117
				8	8.1	13.57	115	117
				10	8.1	13.56	115	117
				12	8.1	13.56	115	117
				14	8.0	13.56	115	117
Outfall 19	31-Aug-09	-	13.0	Surface	8.1	13.69	116	117
				2	8.1	13.60	115	117
				4	8.1	13.59	115	117
				6	8.1	13.59	115	117
				8	8.1	13.58	115	117
				10	8.1	13.58	115	117
				12	8.0	13.59	115	117
Outfall 20	31-Aug-09	-	10.0	Surface	8.2	13.67	116	117
				2	8.1	13.63	116	117
				4	8.1	13.60	115	117
				6	8.1	13.60	115	117
				8	8.1	13.60	115	117
				10	8.1	13.61	115	117
Outfall 21	31-Aug-09	-	11.5	Surface	8.2	13.70	116	117
				2	8.1	13.67	116	117
				4	8.1	13.66	116	117
				6	8.1	13.63	116	117
				8	8.1	13.63	115	117
				10	8.1	13.65	115	117
Outfall 22	31-Aug-09	-	14.7	Surface	8.2	13.70	116	117
				2	8.1	13.68	116	117
				4	8.1	13.66	116	117
				6	8.1	13.66	116	117
				8	8.1	13.67	115	117
				10	8.0	13.67	116	117
				12	8.0	13.66	116	117
				14	8.0	13.67	116	117
Outfall 23	31-Aug-09	-	20.8	Surface	8.1	13.75	116	117
				2	8.1	13.74	116	117
Outfall 24	31-Aug-09	-	20.2	Surface	8.1	13.75	116	117
				2	8.2	13.75	116	117
				4	8.2	13.73	116	117
				6	8.1	13.73	116	117
				8	8.1	13.75	116	117
				10	8.1	13.73	116	117
				12	8.1	13.73	116	117
				14	8.0	13.74	116	117
				16	8.0	13.74	116	117
				18	7.8	13.74	115	117
Outfall 25	31-Aug-09	-	16.5	Surface	8.2	13.84	117	117
				2	8.1	13.76	117	117
				4	8.1	13.70	116	117
				6	8.1	13.74	116	117

Appendix 1. - continued -

Location ID	Sample Date	Sample Time	Depth (m) Total	Depth (m) Measurement	Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (%Saturation)	Specific Conductance (µS/cm)
Sheardown Lake NW								
Outfall 25				8	8.1	13.74	116	117
				10	8.1	13.74	116	117
				12	8.1	13.75	116	117
				14	8.1	13.75	116	117
				16	8.0	13.75	116	117
Outfall 26	31-Aug-09	-	13.6	Surface	8.1	13.88	117	117
				2	8.1	13.81	117	117
				4	8.1	13.77	116	117
				6	8.1	13.76	116	117
				8	8.0	13.76	116	117
				10	8.0	13.76	116	117
				12	8.0	13.76	116	117
Outfall 27	31-Aug-09	-	1.5	Surface	8.1	13.90	117	117
				1	8.1	13.82	117	117
Sheardown Trib #1	31-Aug-09	-		Surface	7.3	14.33	119	200
Sheardown Lake SE								
DL0-02-3	31-Aug-09	9:50	14.0	1	7.9	11.23	95	105
				2	7.9	11.20	94	105
				3	7.9	11.19	94	105
				4	7.9	11.17	94	105
				5	7.9	11.15	94	105
				6	7.9	11.15	94	105
				7	7.9	11.14	94	105
				8	7.9	11.14	94	105
				9	7.9	11.13	94	105
				10	7.9	11.13	94	105
				11	7.8	11.13	94	105
				12	7.8	11.13	94	105
				13	7.8	11.12	94	105
				Bottom	7.8	11.41	96	106