NWB Annual Report **Year being reported:** 2010

License No: 1BR-RES0916 **Issued Date:** June 10, 2009
Expiry Date: June 1, 2016

Project Name: Resolution Island Long-term Monitoring Project

Licensee: Indian and Northern Affairs Canada

Mailing Address:
PO Box 2200
Iqaluit NU
X0A 0H0

Name of Company filing Annual Report (if different from Name of Licensee please clarify relationship between the two entities, if applicable):

N/A

General Background Information on the Project (*optional):

The Former BAF-5 (Resolution Island) Pole Vault Line Site is located 320 km southeast of Iqaluit at the mouth of Frobisher Bay, within the Qikiqtani Region, Nunavut (at general latitude of 61 deg. 35 sec N and general longitude 64 deg. 38 min. W). The facility was constructed in 1953 and abandoned in 1972 with over 20 buildings, eight dump sites and over 4,000 barrels left on site.

Remediation of ths site was completed in 2005 and a long-term montioring program was initiated.

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Part B Item 1

A summary report of water use and waste disposal activities, including, but not limited to: methods of obtaining water; sewage and greywater management; drill waste management; solid and hazardous waste management.

Water Source(s):	Monitoring wells - water samples only; Old Water Lake	
Water Quantity:	5 per day	Quantity Allowable Domestic (cu.m)
	3 (total)	Actual Quantity Used Domestic (cu.m)
	N/A	Quantity Allowable Drilling (cu.m)
	N/A	Total Quantity Used Drilling (cu.m)

Waste Management and/or Disposal

- [x] Solid Waste Disposal
- [ ] Sewage
- [ ] Drill Waste
- [x] Greywater
- [x] Hazardous
- [x] Other: Licenced PCB storage facility is located on the site. Tier 1 and 2 soil stockpiles are located near the barge landing area.

Additional Details:

Less than 3 cu. m. of waste water was placed into an exisiting sewage lagoon. Fresh water was collected using 5 gallon containers from Old Water Lake for use at the monitoring camp. A small volume of bottled water was brought in from Iqaluit for drinking. Total water usage was approximately 3 cu. metres.

A licenced PCB storage facility is located in the warehouse at the beach which contains soil with PCB concentration greater than 50 ppm stored in drums.

A stockpile of Tier 1 and 2 level soils is also at the barge landing area. This soils was removed from PCB barriers on the site.

Combustible material was burned in a burn barrel. Other solid waste including old mattresses and other material from the monitoring camp were returned to Iqalui for disposal.

A list of unauthorized discharges and a summary of follow-up actions taken.

Spill No.: No Spills (as reported to the Spill Hot-line)
Date of Spill:
Date of Notification to an Inspector:

Additional Details: (impacts to water, mitigation measures, short/long term monitoring, etc)

N/A

Revisions to the Spill Contingency Plan

SCP submitted and approved - no revision required or proposed

Additional Details:

N/A

Revisions to the Abandonment and Restoration Plan

No Abandonment and Restoration (AR) Plan submitted or approved

Additional Details:

N/A

Progressive Reclamation Work Undertaken

Additional Details (i.e., work completed and future works proposed)

From 1993 – 1996, environmental work at the site was detailed in a set of reports entitled “Environmental Study of a Military Installation at Resolution Island, BAF-5” by Environmental Sciences Group.

From 1997 onwards, work at the site was managed by the Qikiqtaaluk Corporation. through a contribution agreement with INAC. Initial work included infrastructure improvements and included some remediation activities and training. From 2003-2005 remediation was conducted.

In 2005 approximately 12,000 m3 of contaminated soil was placed within the Tier II landfill. Following placement of all Tier II and Tier I soil the landfill was sealed and capped. The Beach Dump, PCL Dump, Maintenance Dump and North Slope Dump were excavated, compacted and capped. Miscellaneous debris on site was collected and landfilled in the new non-hazardous landfills which were compacted and capped. All hazardous waste found on-site was packaged, according to the Transportation of Dangerous Goods Regulation and transported to a southern facility for disposal.

Remediation efforts were completed in 2006 with the demolition of the camp which was placed in the non-hazardous landfill nearby and compacted and capped. Demobilization from site occured in September, leaving a Tier II landfill, two nonhazardous landfills, a remediated PHC landfarm, an experimental insitu landfarm, several regraded dump and borrow areas, and three Permeable Reactive Interceptor Barrier systems installed in the drainage pathways of the S1/S4 Valley, S1/S4 Beach and the Furniture Dump. A small camp to accommodate up to ten people to support the Long Term Monitoring (LTM) activities was also established.

In addition to the infrastructure described above, a number of original site buildings were left in place as they were either deemed to pose no risk to human or environmental health, or were left to support the LTM activities. Nine 32,000L and one 60,000L fuel storage tanks remain on site, these tanks contain a total of approximately 50,000L of product; they continue to be in used in support of LTM activities. However, current plans are to begin decommissioning these fuel systems.

Long-term monitoring activities have been conducted on site since 2005. The 5th year of LTM at the site was conducted in 2010. Reports and recommendations have been produced by Queen's University and Biogenie, Inc.and are provided for with this submission. Sediment from the PCB barriers was removed from the PCB barriers and stockpiled next to the barriers. Monitoring well and soil sampling and visual inspections of facilities were conducted by Queen's University in conjunction with Biogenie, Inc.

Other work included renovation of the monitoring camp to remove mold, repair the roof and windows, and repair the washroom and plumbing. In addition repairs to the airstrip building were made.

Immediate plans for 2011 field season include decommissioning of the 'camp tank' and removal PCB contaminated soils (in excess of 50 ppm) from site. Visual monitoring of landfills and thermistor readings and maintenancewill also be conducted, time permitting.

Queen's University will continue with research work associated with the PCB barriers.

Results of the Monitoring Program including:

The GPS Co-ordinates (in degrees, minutes and seconds of latitude and longitude) of each location where sources of water are utilized;

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Appendix B: Queen's University Resolution Island Monitoring and Research Report 2010
Appendix C: Biogenie Resolution Island Landfill Monitoring Report (Tier II, Airstrip Dump; Maintenance Dump)
Appendix D: Biogenie Revised Resolution Island Monitoring Program Recommendations (Letter)
Appendix E: Inuktitut Translations of Executive Summaries for Appendices A to C.
Appendix F: Biogenie Health and Safety Plan

Date Submitted: March 31, 2011

Submitted/Prepared by: Natalie Plato
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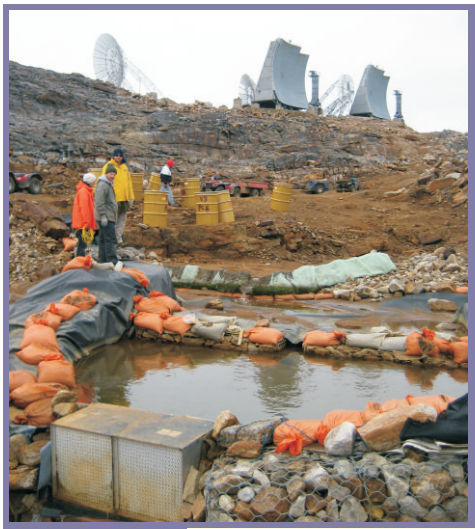
Submitted/Prepared by: Natalie Plato
Contact Information:
Tel: (867) 975-4730
Fax: (867) 975-4736
email: natalie.plato@inac-ainc.gc.ca

Appendix A: Queen's Univeristy Resolution Island Five Monitoring Report 2005-2010



Resolution Island Five Year Monitoring Report 2006-2010

Analytical Services Unit
Queen's University

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Resolution Island Five Year Monitoring Report 2006-2010

Prepared by

Analytical Services Unit
Queen's University
Kingston, Ontario

Canada

Indian and Northern Affairs Canada

Affaires indiennes et du Nord Canada

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Analytical Services Unit
March 2011

EXECUTIVE SUMMARY

Five years have now elapsed since the completion of the remediation project at Resolution Island. This report reviews the results of the monitoring program started in 2006. Generally the monitoring has shown that there are only minor concerns but there are a few areas that continue to require monitoring and possibly some further minor remediation.

The most immediate problem at the site is at the furniture dump drainage pathway. There is a permeable reactive barrier at the top of the cliff at the end of the drainage pathway. When this area was remediated in 2000, transformers leaking PCBs were found. The bedrock in the drainage pathway was thoroughly washed and vacuumed and the dump excavated, however the barrier continues to trap sediments which have PCB concentrations in the 50-200 ppm range; trapping 150 g of pure PCBs over the five years. It was thought that the volume and concentration of the PCB contaminated sediment would decrease with time but this has not happened - clearly some contaminated material remains. It is therefore recommended that an investigation of the source of this material be undertaken. If the source can be identified and removed this should be initiated in 2012. The barrier should be monitored annually and in addition the geosynthetics should be investigated to ensure their integrity. The soils fall under regulations arising from the Canadian Environmental Protection Act (CEPA) and have, therefore, to be handled accordingly. Currently four drums of CEPA soils are stored in a separate location within building B2; one drum filled in 2010 is near the barrier.

The major drainage pathway known as the S1/S4 valley and beach has two interceptor barriers placed across it, one atop the cliff and the other on the beach below the cliff. In this drainage pathway, levels of PCBs in the traps have been at the Tier I level (below 5 ppm) for the last two years with some lowering of PCB concentrations in the valley barrier sediment. It is therefore recommended that stabilization of soils in this drainage pathway be accelerated by encouraging revegetation, with mosses and willows from the site, and the use of additional traps. As the soils are stabilized, monitoring of the barriers should continue but the frequency can hopefully be reduced. Sediment trapped by the barriers over the 5 years has been shoveled out into steel overpack drums and waste wrangler containers. These are currently stored near the beaching area at building B2 (from 2007 and 2008) and by the barriers (2010).

The remaining buildings at the site are in poor shape, except for the monitoring camp which is being maintained. The buildings, however, do not represent an environmental risk. The fuel storage systems at the beaching area, camp and upper site helicopter pad will require inspections annually as required by regulation.

The Tier II landfill at the site has been monitored by the collection and analysis of water from monitoring wells, soil samples from monitoring points, thermal analysis and engineering inspections. The entombed contaminated material has become part of the permafrost and no significant contamination or erosion has been found. Monitoring the downstream wells at the Tier II landfill for metals and PCBs in 2012 and 2015 is recommended. Other landfills have also been monitored and no problems have been found. At the airstrip landfill some material was not completely covered in the remediation project and there is a small area where some erosion has been observed but these are having no adverse impact on the environment. No further monitoring is recommended at the maintenance dump and at the airstrip only PCBs in the wells need to be monitored in 2012 and 2015.

The cleanup of diesel fuel contaminated soils was accomplished by the establishment of a landfarm at the site. Levels of hydrocarbons within the landfarm are now much reduced and no further monitoring is required. An experimental landfarm was established to investigate in situ remediation of hydrocarbon contaminated soils without excavation. Useful results are still being obtained from these plots and therefore it is recommended that the study of these four plots continues.

This report contains a set of recommendations for each facet of the monitoring program at the end of each chapter. The final chapter of the report contains overall recommendations for the continued monitoring of the site and for some investigative work.

ACKNOWLEDGMENTS

The work was supported by Indian and Northern Affairs Canada through its office in Iqaluit, Nunavut. Special thanked go to Stephen Hooey and Natalie Plato from the Iqaluit Office for their support and encouragement.

This report was written by John Poland and edited by Allison Rutter.

TABLE OF CONTENTS

I. Introduction I-1

A. General I-1

B. Assessment and Remediation Program 1993-2005 ..... I-1

C. Monitoring Program 2006-2010 ..... I-2

II. PCB BARRIERS - RESIDUAL TERRESTRIAL PCBS II-1

A. Background II-1

B. Furniture Dump Barrier II-3

1. General II-3

2. Monitoring Results II-6

a) Water II-6

b) Sediment II-6

c) Filters II-7

C. S1/S4 Drainage Pathway II-8

1. General II-8

2. S1/S4 Valley Barrier II-9

a) Water II-12

b) Sediment II-12

c) Filters II-13

3. S1/S4 Beach Barrier II-14

a) Water II-18

a) Sediment II-18

b) Filters II-19

D. Conclusions II-20

E. Recommendations II-23

1. For 2011 ..... II-23

2. For 2011-2015 ..... II-23

III. PCBS AND METALS IN LANDFILLS III-1

A. Tier II Landfill III-1

1. Background III-1

2. Engineering Assessment III-2

3. Water and Soil Monitoring III-4

a) Metals in Soil III-5

b) Metals in Water III-7

c) PCBs III-10

d) TPH III-12

B. Airstrip Landfill Monitoring Program III-12

1. Background III-12

2. Engineering Assessment III-12

3. Water and Soil Monitoring III-13

C. Maintenance Dump Monitoring Program III-16

1. Background III-16

2. Engineering Assessment III-16
3. Water and Soil Monitoring III-17
D. Non Hazardous Landfills III-19
1. General III-19
E. Conclusions III-19
F. Recommendations III-20
IV. HYDROCARBONS IN SOILS AND SEDIMENTS IV-1
A. General IV-1
B. Main Landfarm IV-2
1. Operation IV-2
2. Monitoring Results IV-3
C. Ponding and Barrier Research IV-7
D. In Situ Landfarm Experiment IV-10
E. Conclusions IV-13
F. Recommendations IV-13
V. OTHER MONITORING ACTIVITIES V-1
A. PCB Transportation Routes V-1
B. Surface Water V-1
C. Plants V-3
D. Buildings and Debris V-7
E. Conclusions V-11
F. Recommendations V-11

VI. RECOMMENDATIONS FOR LONG TERM MONITORING VI-1

A. PCBs VI-1

1. PCB Excavated Soils VI-1

2. Furniture Dump VI-1

3. S1/S4 Valley and Beach VI-2

B. Landfills VI-3

C. Other Monitoring VI-3

1. Hydrocarbon Contamination VI-3

2. Plants and Waters VI-3

3. Buildings and Physical Debris VI-3

D. Logistical Considerations VI-4

VII. APPENDIX VII-1

A. The 2005 Monitoring Plan VII-1

1. Landfills VII-1

2. PCB Barriers VII-2

3. Landfarms and TPH Barrier System VII-2

4. Background PCB in Plants VII-3

5. Monitoring Frequency VII-3

6. Infrastructure and Logistics VII-3

B. Further Discussions Related to the Monitoring Plan in 2008 ..... VII-6

C. Further Discussions Related to the Monitoring Plan in 2009 ..... VII-8

D. Additional Tables of Data VII-10

I. INTRODUCTION

A. General

The remediation project at Resolution Island was completed in 2005. During the last five years, various components at the site have been monitored by the Analytical Services Unit at Queen's University while personnel were on site conducting associated research activities. This is the fifth year of the monitoring program which was earmarked as a milestone in the site monitoring plan when an assessment of the monitoring program should undergo a thorough review. This document fulfils that obligation.

B. Assessment and Remediation Program 1993-2005

Over the period 1993-1996, environmental work at the site was detailed in a set of reports entitled "Environmental Study of a Military Installation at Resolution Island, BAF-5". These reports[1] fully described items such as site characteristics, history, and previous investigations. Scientific investigations have continued and have been reported annually[2]. Temporary barriers were placed in areas where PCBs were found to be migrating to the ocean in 1994 which gave time to plan the remediation program. Cleanup of the site started in 1997 with infrastructure improvements and expanded from 1998 onwards to include both remediation activities and training. A three year plan to complete the work at the site was initiated in 2003[3] and was essentially completed in 2005. The site was demobilized in 2006 with the removal of the heavy equipment relating to the remediation project, and the mobile laboratory and demolition of the camp.

The main problem at Resolution Island was PCBs. At the start of the program there were approximately 5000 kg of PCBs in liquids and this was containerized and

[1] Environmental Sciences Group (1994). Volume One, Analytical Services Unit (1995) Volume Two, Analytical Services Unit and Environmental Sciences Group (1996) Volume Three, and Analytical Services Unit (1997) Volume Four: Environmental Study of a Military Installation at Resolution Island. BAF-5. Prepared for Indian and Northern Affairs Canada.

[2] Analytical Services Unit (1998), (1999), (2000), (2001), (2002) (2003) (2004) (2005) (2006) and (2007). Resolution Island 1997: Scientific Investigations, Resolution Island 1998: Scientific Investigations: Resolution Island 1999: Scientific Investigations, Resolution Island 2000: Scientific Investigations: Resolution Island 2001: Scientific Investigations: Resolution Island 2002: Scientific Investigations: Resolution Island 2003: Scientific Investigations and Research: Resolution Island 2004. Prepared for Indian and Northern Affairs Canada: Scientific Investigations and Research: Resolution Island 2005. Prepared for Indian and Northern Affairs Canada Scientific Investigations and Research: Resolution Island 2006. Prepared for Indian and Northern Affairs Canada.

[3] Analytical Services Unit (2003). Resolution Island Project Description and New Remediation Plan Revision 1 March 2003. Prepared for Indian and Northern Affairs Canada.

shipped off site for disposal. A further 5000 kg was present on the ground spread over a large area. Nearly all of this was excavated and all CEPA soil (containing > 50 ppm PCBs) was shipped off site for disposal by thermal destruction. Soil with contamination in the range 5 – 50 ppm PCBs along with metal contaminated soils was placed in a lined landfill. This Tier II facility also contained asbestos and Tier II debris along with all soils containing 1 – 5 ppm PCBs which were used as fill between layers of the Tier II soil and debris. The facility was completed by the addition a liner and of enough clean fill so as to ensure freeze back of all the entombed contaminated material. Not all the PCB contaminated soil could be removed because of the nature of the terrain, fractured rock and safety concerns. Permeable reactive barriers were designed and placed in the drainage pathways through which any residual PCBs might migrate. In addition hydrocarbon contaminated soil was placed in a landfarm where the hydrocarbon was to degrade by bioremediation through the addition of fertilizer. Both the PCB barriers and the landfarm were experimental. Landfarming in cold climates was an emerging technology at the time and the PCB barriers are unique. A large number of structures were demolished and placed in two non hazardous landfills along with debris lying around the site. Not all structures or physical debris were cleaned up. Several dumps were excavated but two were left. After removal of contaminants they were regraded and in the case of the airstrip landfill additional clean fill was added.

C. Monitoring Program 2006-2010

A monitoring plan[3] was an integral part of the 2003 remediation plan. This plan was further developed in 2005[4] and is reproduced in the Appendix A**.** The plan was flexible in that it allowed for the removal of parameters which became unnecessary through changes or by becoming predictable but also allowed for the addition of extra work if observations or changes warranted further testing or maintenance. In 2006 and 2007, the monitoring went smoothly with a team on site for 16 and 9 days respectively. The weather was good and all tasks set out were accomplished. In 2008, a lot more sediment was found at the S1/S4 barriers than in the previous two years but again all tasks were accomplished during the 9 day visit except that not all the sediment was removed from the S1/S4 beach barrier. Infrastructure at the site was found to have deteriorated over the winter both in terms of buildings, particularly the accommodation at the old training center and the beach building B2 and also the roadways. Equipment at the

[4] Analytical Services Unit (2006). Resolution Island 2005: Scientific Investigations and Research pages I-7 to I-11 Prepared for Indian and Northern Affairs Canada:

site including the ATVs and trailers were in poor condition and it was recommended that pre-site visit be undertaken in future years to facilitate logistics problems. It was also decided, that as a result of data obtained, some modifications to the monitoring plan could be made and several parameters were dropped temporarily from the program for 2009. The section relating to this, including the rationale, is reproduced in Appendix B. In 2009 difficulties were encountered with logistics and equipment and the weather was very poor. As a result only a limited program was possible and the team was only on site for four and a half days. The barriers were not shoveled out and no hydrocarbon monitoring was undertaken but the landfills were monitored as in previous years. Further comments and recommendations were made in the 2009 report and are reproduced in Appendix C. The program in 2010 went much more smoothly with good weather. The team was on site for 9 days and all planned tasks were accomplished.

The various components of the monitoring plan were mainly designed to address PCBs remaining at the site (Chapter II) along with landfills (Chapter III) and the hydrocarbon landfarming (Chapter IV). These are briefly outlined below. This report concludes with Chapter VI which outlines a revised monitoring plan in light of results discussed in the intervening chapters. Map I-1 shows the location and general layout of the site at Resolution Island.

Chapter II: Residual Terrestrial PCBs

The main problem remaining at the site is the PCBs that could not be excavated as part of the remediation plan. These fall into two categories. The first concerns PCB contaminated soils that could not be excavated due to safety concerns. These are present at the base and top of the cliff in the S1/S4 drainage pathway. The second is material left in rock fractures. To address these problem three interceptor barriers were designed and constructed, two in the S1/S4 drainage pathway and one at the furniture dump drainage pathway. The performance of these barriers and analytical results obtained by monitoring these barriers and their performance is discussed in detail in Chapter II.

Chapter III: PCBs and Metals in Landfills.

All PCB contaminated material (both excavated soil and building material) left at the site and below 50 ppm was placed in the Tier II landfill. This landfill was monitored annually through a series of monitoring wells and soil monitoring points, thermal monitoring to measure the extent of freeze back, and an engineering assessment

inspection. Two landfills which were not excavated but left in place with additional cover were similarly monitored but without thermal monitoring. The two non hazardous landfills were inspected but they produced no leachate and no water flowed through them.

Chapter IV: Hydrocarbons in Soils and Sediments

The main landfarm where all the hydrocarbon contaminated soil was placed was monitored to check the TPH levels along with nutrients and biodegrader levels. In addition an experiment area was set up with some TPH contaminated soil to investigate the potential for in situ biodegradation. Down gradient from the main landfarm an experimental interceptor barrier was constructed. Both of these were monitored for TPH, nutrients and biodegraders.

Chapter V: Other Monitoring Activities

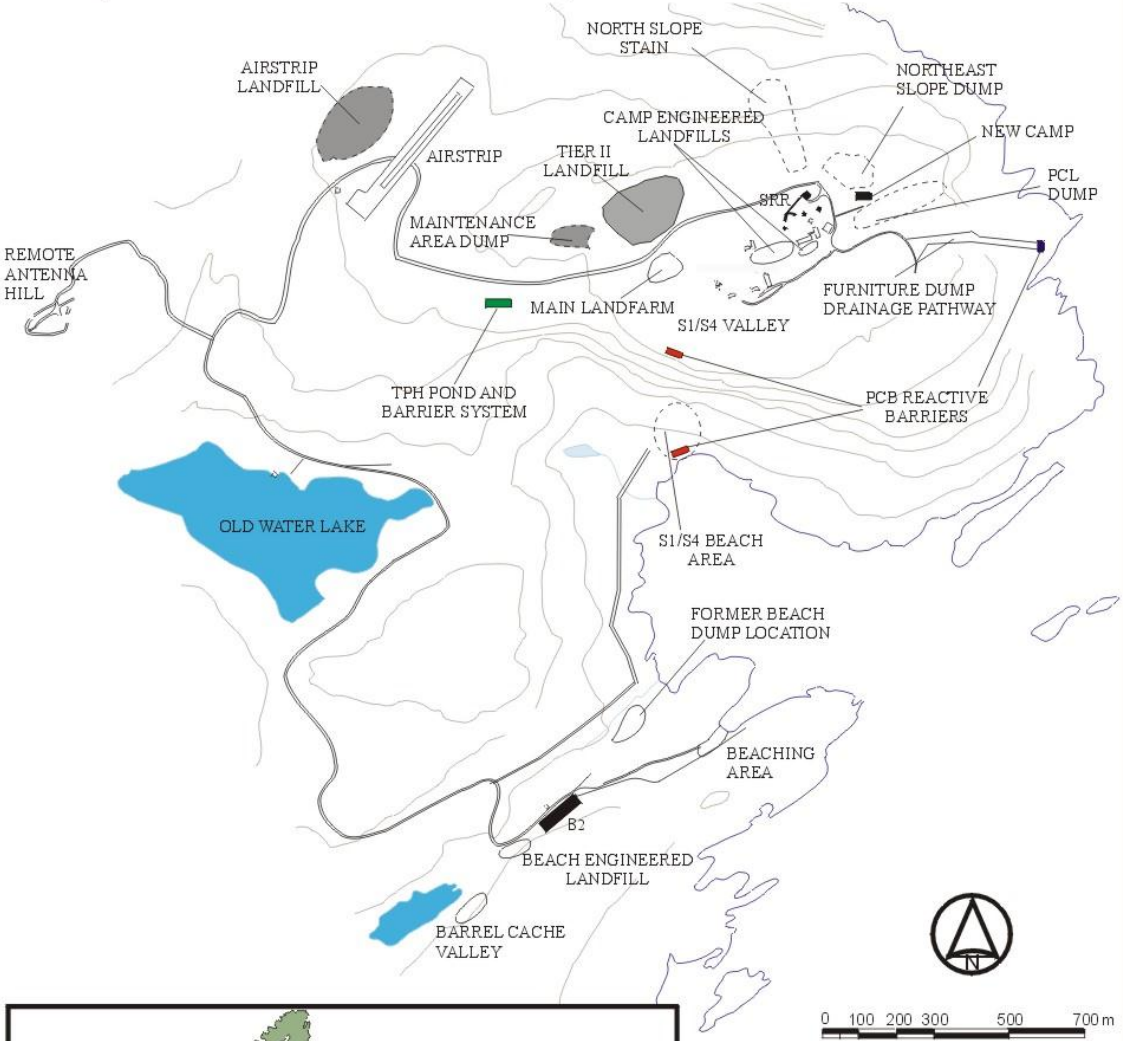
In order to monitor airborne PCBs, ten plant monitoring stations were established. Similarly six water monitoring point were set up around the site to monitor both PCBs and metals. This year a photographic inventory of all buildings and other physical debris was taken in order that their remediation could be planned in the event that more cleanup work was scheduled for the site. Wildlife seen at the site were recorded.

Chapter VI: Recommendations for Long Term Monitoring

Chapter VII. Appendix.

Appendix A is a reproduction of the 2005 Monitoring Plan. Appendix B and C contain comments and recommendations related to the monitoring plan from the annual ASU reports in 2008 and 2009 respectively. Appendix D contains additional tables of data.

Map I-1: Location and General Layout of the Site at Resolution Island



II. PCB BARRIERS - RESIDUAL TERRESTRIAL PCBS

A. Background

The excavation of PCB contaminated soils at Resolution Island was carried out in the same manner as would be done elsewhere in Canada. However, it was not possible to excavate all the PCB contaminated soil because some soil was trapped in fractured bedrock, or located on very steep terrain that could not be accessed for logistical and safety reasons. The soil surface prior to the cleanup was stabilized by lichens and dwarf plants and/or by compaction. The soil remaining after excavation was loose and subject to erosion, particularly during spring runoff or during a summer storm. In order to control the PCB migration from these two factors, it was decided that permanent barrier systems were required as a long term solution. The ASU was contracted to conduct the necessary research, design and development of these barrier systems.

In 2003, the first barrier was installed at the top of the cliff in the S1/S4 valley. Laboratory studies were conducted by the ASU in order to support the design and construction of this barrier system. As a result of these studies and field observations, the barrier was modified and two others were constructed; one at the S1/S4 beach adjacent to the shore and the other at the end of the furniture dump drainage channel. The barriers consist of a lined funnel formed by rock gabions through which all drainage must flow and a gate which contains various filters. Coarse sediment is trapped in the funnel while finer material is collected by the filters in the gate. The filters used in the gate also may remove dissolved material.

These permeable reactive barriers are novel and much research was conducted from 2003 to 2008 to inprove their effectiveness[5] The operation, and efficiency of the barriers has varied from year to year. The main factor affecting the barriers is the amount of sediment migrating into the funnel and the resulting amount of sediment to be removed from the trap each season. Another key factor is the particle size of the migrating

[5] Kalinovich I, Rutter A, Rowe RK, McWatters R and Poland JS, "The Application of Geotextile and Granular Filters for PCB Remediation, *Geosynthetics International* (2007) Vol 15, No. 3. pp 173-183.
Kalinovich I., Rutter, A., Poland, J.S., Cairns, G., Rowe, R.K. Remediation of PCB Contaminated Soils in the Canadian Arctic: Excavation and Surface PRB Technology. *Sci Total. Env*. (2008) 407: 53-66.

sediment which varies with time and with each barrier. In addition, the arrangement of the filters and their composition has also varied over the years of operation in order to optimize the effectiveness of the barriers. Clogging of the barriers was a problem in the initial years, however, the filter arrangements and other measures have eliminated this problem in the last couple of years.

From 2007-2010 sediments shoveled from the barriers were containerized and in 2009 moved and stored outside the beach building B2. Containers were also filled in 2010 but they currently reside at their respective barriers. The sediments in all containers were re-sampled and analysed in 2010 so that a complete record of all the excavated material now exists. This is presented as Tables VII-1, VII-2 and VII-3 in the Appendix and in summary form here as Table II-1 and Table II-2. Each drum has a capacity of 240 L while the waste wrangler each contain approximately 760 L of sediment. The options as to how to dispose of these soils is discussed in Chapter VI: Recommendations. Four drums containing CEPA soils are stored in the PCB storage facility located inside building B2 and one, generated in 2010, is by the furniture dump barrier.

Table II-1: Summary of the Number of Drums and Volumes of Material Stored at B2 and Collected This Year at the Three Barriers

Location	<1 ppm	Tier I	Tier II	CEPA
B2	7	23	5	4
Furniture Dump	0	0	1	1
S1/S4 Valley	0	6	1	0
S1/S4 Beach	3	4	0	0
Estimated Volume of Soil (m^3)	2.2	7.6	1.5	1.1

Table II-2: Summary of the Number of Waste Wranglers and Volumes of Material Stored at B2 and Collected This Year at the Three Barriers

Location	<1 ppm	Tier I	Tier II	CEPA
B2	1	5	1	0
Furniture Dump	0	0	0	0
S1/S4 Valley	0	0	1	0
S1/S4 Beach	0	1	0	0
Estimated Volume of Soil (m^3)	0.8	4.6	1.5	0

B. Furniture Dump Barrier

1. General

The furniture dump and its drainage pathway were excavated in 1999. Transformers containing nearly pure PCBs were removed from the dump. All soil containing > 1 ppm PCB was removed from the original dump and its drainage pathway and large areas of exposed boulders were washed and vacuum cleaned. As in other parts of the site, some PCBs were inaccessible at the furniture dump: a large hole was excavated beneath the dump as far as possible with the equipment available at the site in 2000. In 2003, a wooden experimental barrier was designed and constructed. This was replaced by a stainless steel one in 2005. Results of analyses of barrier sediment and filters in the period 2004-2006 showed that PCBs were being transported in the drainage pathway and were still present in the area previously occupied by the furniture dump and in the drainage pathway leading from it. This was despite considerable effort to remove any soil found to contain > 1 ppm PCBs with the vacuum truck; normally vacuuming was only undertaken for CEPA areas. Figure II-1 shows the arrangement of filters in the filter box at the end of the 2010 field season and Map II-1 the location of the soil and water monitoring points. Photographs II-1 and II-2 show the furniture dump barrier.

Figure II-1: Arrangement of Filters in the Furniture Dump Filter Box at the End of the 2010 Field Season

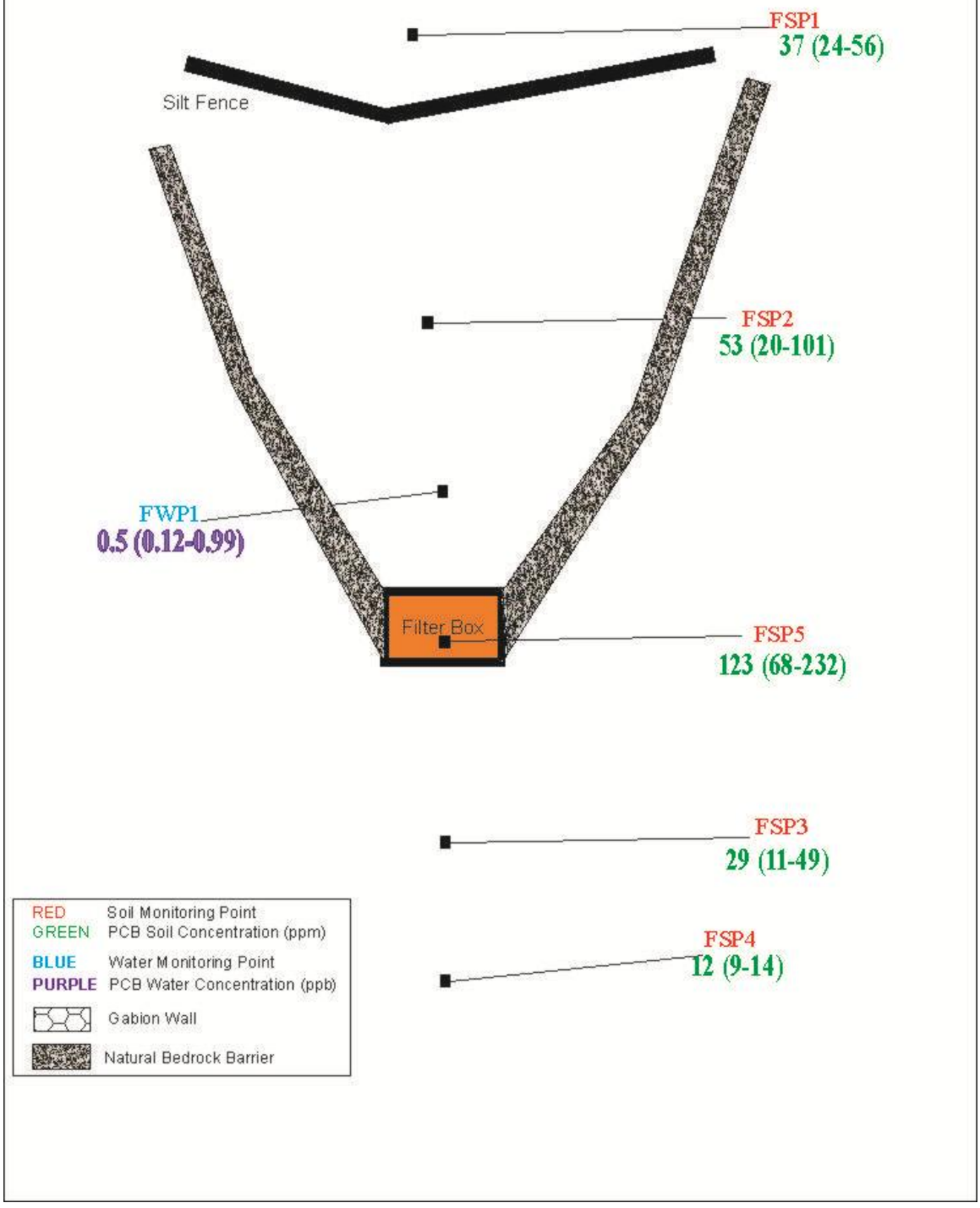
1200R	1200R
1200R	1200R
1200R	1200R
1200R	1200R
GAC	GAC
GAC	GAC
¾ full Gravel	¾ full Gravel

Direction of Flow

Photograph II-1: The Furniture Dump Barrier Filter Box Holding the Gravel, GAC and 1200R Geotextile Filters in 2008

Photograph II-2: The Silt Fence in Front of the Furniture Dump Barrier

Map II-1: Locations of Monitoring Points and Average PCB Concentrations of Soil and Water Samples at the Furniture Dump Barrier from 2006 - 2010in 2010



2. Monitoring Results

a) Water

Only a small amount of water is normally slowly flowing in the drainage pathway during the summer visits and sometimes none at all. However, during the spring melt there must be a considerable flow since large boulders have been seen to have moved between visits. The PCB levels found in the water as shown in Table II-3 are high generally, one to two orders of magnitude higher than in the S1/S4 drainage pathway.

Table II-3: PCB Concentration (ug/L) in Water From the Furniture Barrier Area

Monitoring Point	PCB Concentration (ppb)				
	2006	2007	2008	2009	2010
FWP1	-	0.53	0.12	0.21	0.99

b) Sediment

Table II-4 lists the levels of PCBs found at the five soil monitoring points at the furniture dump barrier for the past five years while Table II-5 gives the calculated quantities arising from these results. The PCB levels are in the range 10-250 ppm. This created a problem since all soils containing >50 ppm PCBs are subject to regulations arising from the Canadian Environmental Protection Act (1999). These are referred to as CEPA soils in this report. There are no clears trends from this data. With the exception of 2008 the amount of sediment collected and the amount of PCB within it are fairly constant. In 2008 much more sediment was collected and the PCB levels were higher. The monitoring point FSP5 represents the small amount of material present within the filter box and is material collected by the geotextile which has fallen to the base of the box. This material is composed of soil with a small particle size and is known to have a higher PCB concentration than the larger particle size fraction. The average PCB concentration of sediment collect by the facility over the five years is 46 ppm. The amount of pure PCB removed from the barrier trap over the five year period was 144 g.

Table II-4: PCB Concentration of Sediment From the Furniture Dump Barrier

Monitoring Point	PCB Concentration (ppm)				
	2006	2007	2008	2009	2010
FSP1	24	43	56	32	31
FSP2	20	32	101	54	53
FSP3	49	32	40	10.8	13.8
FSP4	-	-	-	9.5	13.6
FSP5	68	118	232	-	76

Table II-5: Volume of Sediment and Average Concentration and Mass of PCB in the Sediment From the Furniture Dump Barrier From 2005-2010

	2006	2007	2008	2009	2010
Volume (m^3)	0.3	0.25	0.6	nd	0.48
Concentration (ppm)	29	37	78	43	42
Mass (g)	15.5	16.9	76	18*	18*

nd not determined * Mass divided between two years

c) Filters

Table II-6 gives the average PCB levels in the various components of the filter box while Table II-7 gives the calculated quantities arising from these results. The PCB levels in the finer fraction collected by the geotextile 1200R are higher than for the gravel and sand which collect material with a larger particle size. The average PCB concentrations of the gravel, GAC and 1200R collect over the five years are 3.0, 16.8 and 104 ppm respectively. The amount of pure PCB collected on the filters over the five year period was 5.0 g.

Table II-6: Average PCB Concentration of Filter Box Materials From the Furniture Dump Barrier

Monitoring Point	PCB Concentration (ppm)				
	2006	2007	2008	2009	2010
Gravel	2.2	0.8	4.5	nd	4.5
GAC	9.6	4.7	30	nd	23
1200R	-	-	190	81	42

nd not determined

Table II-7: Mass of PCBs Collected in the Filter Box Materials at the Furniture Dump Barrier

Monitoring Point	PCB (g)				
	2006	2007	2008	2009	2010
Gravel	0.22	0.08	0.40	0.05*	0.05*
GAC	0.51	0.21	1.32	0.55*	0.55*
1200R	-	-	0.54	0.32	0.20
Total	0.73	0.29	2.26	0.92	0.70

* Mass divided between two years

C. S1/S4 Drainage Pathway

1. General

The drainage pathway which stretches from the summit, where the four buildings numbers S1 to S4 previously stood, to the sea via a 300 m cliff is now intercepted by two barriers systems. The S1/S4 valley barrier is near the top of the cliff while the S1/S4 beach barrier is very close to the sea. PCBs remain above the S1/S4 valley barrier in fractures in the rocks and in a few very small isolated pockets that were not reachable for excavation. PCBs also remain between the two barriers both at the top and bottom of the cliff. At the top there are pockets of soil, mostly well vegetated, where the terrain was too steep to safely excavate by machine in the area before the main steep descent. Above the base of the cliff is a larger area of soil and rocks which was too steep and dangerous to

excavate but which contains soil with PCBs > 50 ppm. The barriers are both in excellent condition and no modifications are needed.

2. S1/S4 Valley Barrier

Filters containing gravel, GAC and 1200R are currently arranged in the filter box as shown in Figure II-2. Although the box has the same dimensions as the other two barriers, because of the way it was constructed there is only room for two layers of the geotextile. Map II-2 shows the positions of the water and soil monitoring points. Photographs II-3, II-4, and II-5 show the S1/S4 Valley Barrier

Figure II-2: Arrangement of Filters in the S1/S4 Valley Filter Box at the End of the 2010 Field Season

1200R	1200R
1200R	1200R
GAC	GAC
GAC	GAC
Gravel	Gravel

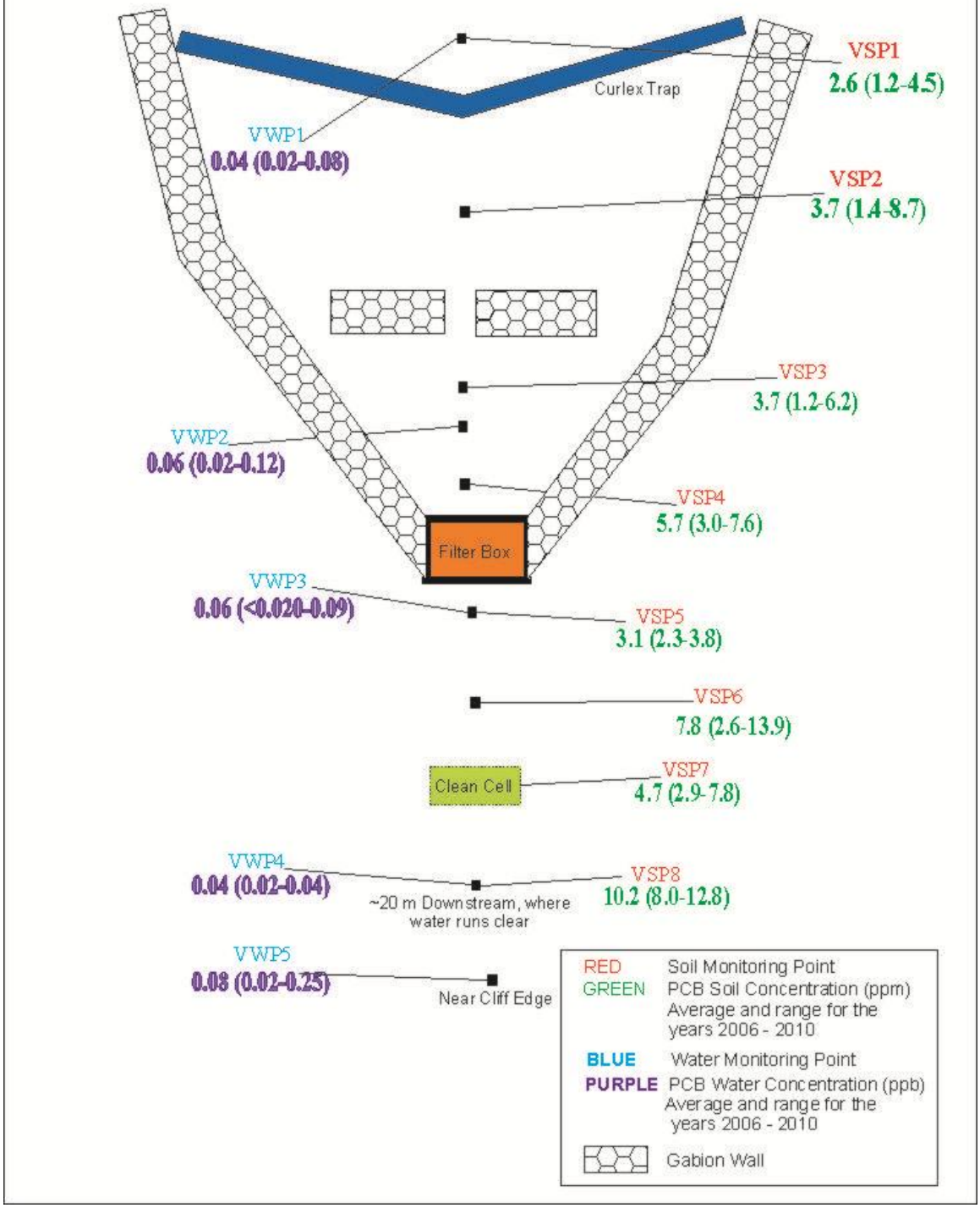
Direction of Flow

Photograph II-3: Vegetation on the Curlex Trap in 2007 After Only Two Years.

Photograph II-4: The S1/S4 Valley Barrier in 2006 Prior to Removal of Sediment

Photograph II-5: The S1/S4 Valley in 2008 With More Sediment and With the Filter Box Clogged

Map II-2: Locations of Monitoring Points and Average PCB Concentrations of Soil and Water Samples at the S1/S4 Valley Barrier from 2006 - 2010



a) Water

Table II-8 shows the average levels of PCBs at the five water monitioring points over the five year period. Levels are low and there is no obvious pattern with time. However, in the last two years all water has contained PCBs at below the 50 ppt level.

Table II-8: PCB Concentration (ug/L) in Water From the S1/S4 Valley Area

Monitoring Point	PCB Concentration (ppb)				
	2006	2007	2008	2009	2010
VWP1	0.02	0.08	0.06	0.02	0.02
VWP2	0.11	0.03	0.12	0.02	0.04
VWP3	0.09	0.07	0.07	0.02	<0.02
VWP4	-	0.02	0.08	0.03	0.04
VWP5	0.25	0.08	0.02	0.03	0.04

b) Sediment

Table II-9 lists the levels of PCBs found at the eight soil monitoring points at the S1/S4 valley barrier for the past five years while Table II-10 gives the calculated quantities arising from these results. The PCB levels are in the range 1.2–13.8 ppm. Monitoring points VSP6 and VSP8 are beyond the barrier and in an area where not all the PCB contaminated soil could be removed. The PCB levels in the sediment collected within the barrier have a concentration range from 1.2-8.7 with an average value of 3.8 ppm. The monitoring point at VSP7 was a clean cell. This was a small area filled with uncontaminated soil and designed to see whether contamination was getting through the barrier. Unfortunately these clean cells did not work well as they were frequently washed out and contaminated with material from between them and the barrier. The amount of pure PCB removed from the barrier trap over the five year period was 60.3 g. The amount of 25 g in 2006 is larger than in subsequent years due to site remediation activities still on going in the latter part of the 2005 field season. While there are no clear trends, the average level of PCBs in the trapped sediment (VSP1-4) was 5.9, 5.1, 3.7, 1.0 and 3.1

ppm in 2006, 2007, 2008, 2009 and 2010 respectively. Hence the PCB level in the sediment was Tier II in 2006 and 2007 but Tier I in 2008, 2009 and 2010.

Table II-9: PCB Concentration of Sediment From the S1/S4 Valley Barrier

Monitoring Point	PCB Concentration (ppm)				
	2006	2007	2008	2009	2010
VSP1	1.3	4.5	4.1	1.9	1.2
VSP2	8.7	3.7	2.9	1.7	1.4
VSP3	-	5.3	2.2	1.2	6.2
VSP4	7.6	6.7	5.5	-	3.0
VSP5	-	-	3.8	2.3	3.3
VSP6	13.9	2.6	13.8	4.4	4.2
VSP7	-	3.8	2.9	4.2	7.8
VSP8	8.0	-	-	12.8	9.9

Table II-10: Volume of Sediment and Concentration and Mass of PCB in the Sediment From the S1/S4 Valley Barrier

	2006	2007	2008	2009	2010
Volume (m^3)	2.2	1.0	2.6	nd	2.5
Concentration (ppm)	5.5	5.0	3.6	1.6	2.9
Mass (g)	25	8.5	13.6	6.6*	6.6*

nd not determined * Mass divided between two years

c) Filters

Table II-11 gives the average PCB levels in the various components of the filter box while Table II-12 gives the calculated quantities arising from these results. The PCB levels in the finer fraction collected by the geotextile 1200R are higher than for the gravel and sand which collect material with a larger particle size. The average PCB concentrations of the gravel, GAC and 1200R collected over the five years are 0.6, 1.0 and 3.3 ppm respectively. The amount of pure PCB trapped on the filters over the five year period was 0.64 g.

Table II-11: Average PCB Concentration of Filter Box Materials From the S1/S4 Valley Barrier

Medium	PCB Concentration (ppm)				
	2006	2007	2008	2009	2010
Gravel	0.7	0.3	1.2	nd	0.1
GAC	1.0	1.0	1.4	nd	0.7
1200R	-	-	1.7	4.6	3.5

nd not determined

Table II-12: Mass of PCBs Collected in the Filter Box Materials at the S1/S4 Valley Barrier

Medium	PCB (g)				
	2006	2007	2008	2009	2010
Gravel	0.11	0.02	0.06	0.002*	0.002*
GAC	0.02	0.27	0.08	0.018*	0.018*
1200R	-	-	0.008	0.014	0.017
Total	0.13	0.29	0.15	0.03	0.04

* Mass divided between two years

3. S1/S4 Beach Barrier

Figure II-3 shows the current arrangement of filters in the filter box at the end of the 2010 field season and Map II-3 the location of the soil and water monitoring points. Photographs II-6, II-7, and II-8 show the S1/S4 Beach Barrier

Figure II-3: Arrangement of Filters in the S1/S4 Beach Filter Box at the End of the 2010 Field Season

1200R	1200R	1200R
1200R	1200R	1200R
1200R	1200R	1200R
1200R	1200R	1200R
GAC	GAC	GAC
GAC	GAC	GAC
¾ full Gravel	¾ full Gravel	¾ full Gravel

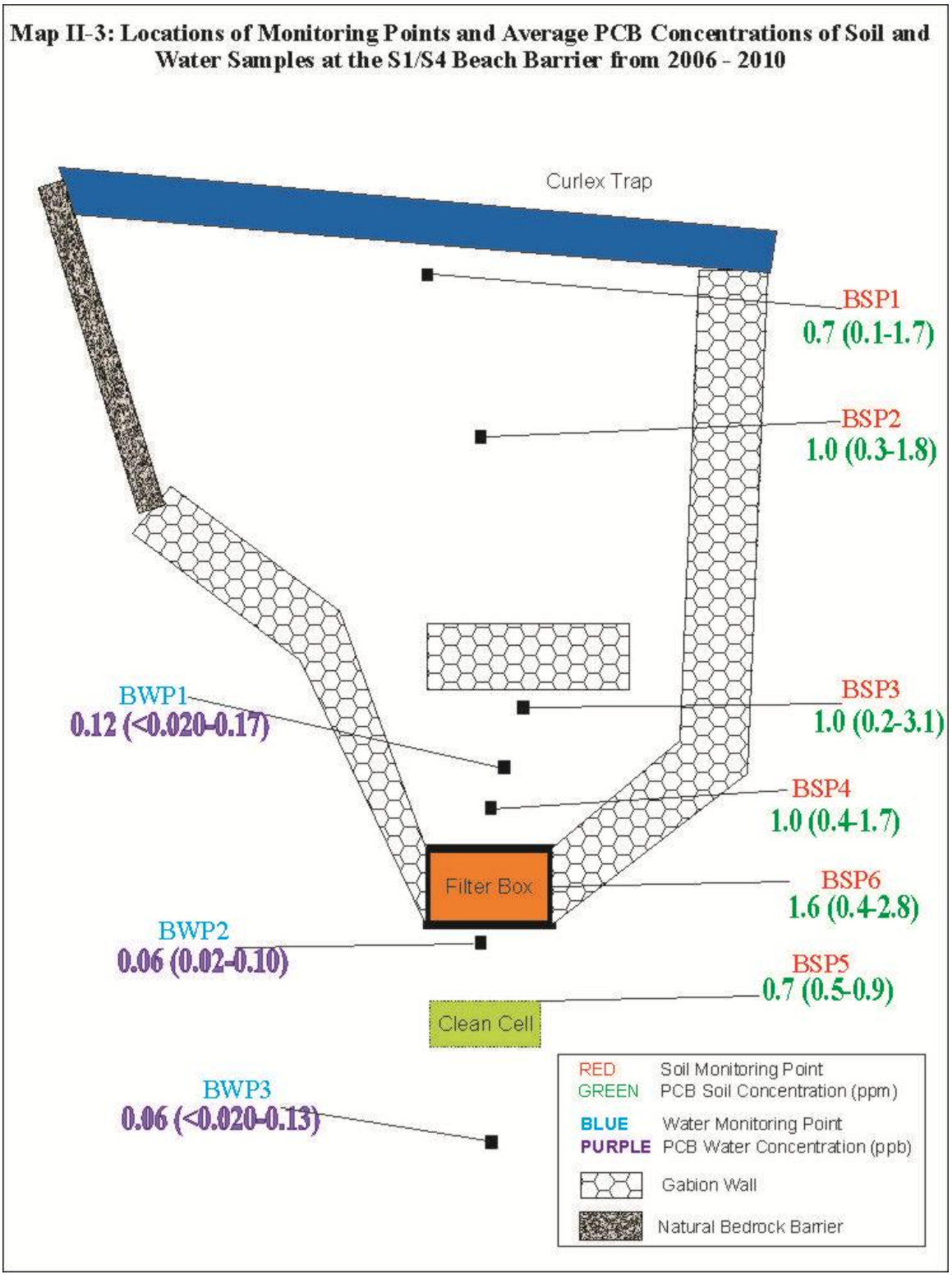
Direction of Flow

Photograph II-6: The S1/S4 Beach Barrier in 2005 Just After Its Construction

Photographs II-7: The Channel Above the Top Gabion Sediment Trap Was Lined With Cobbles In Order to Trap More Sediment

Photographs II-8: The S1/S4 Beach Barrier Being Shoveled Out in 2006

Map II-3: Locations of Monitoring Points and Average PCB Concentrations of Soil and Water Samples at the S1/S4 Beach Barrier from 2006 - 2010



a) Water

Table II-13 lists the PCB levels in water from the three monitoring points over the last five years. All are low but there are no clear trends.

Table II-13: PCB Concentration (ug/L) in Water From the S1/S4 Beach Area

Monitoring Point	PCB Concentration (ppb)				
	2006	2007	2008	2009	2010
BWP1	0.21	-	0.07	0.07	<0.02
BWP2	0.05	0.02	0.10	0.02	0.09
BWP3	0.04	0.03	0.13	0.04	<0.02

a) Sediment

Table II-14 lists the levels of PCBs found at the five soil monitoring points at the furniture dump barrier for the past five years while Table II-15 gives the calculated quantities arising from these results. The PCB levels are in the range 0.2-3.1 ppm with an average value of 1.0 ppm but show no trends. These values are less than for the S1/S4 valley and levels are at the low end of the Tier I category with average PCB concentrations of 0.6, 0.4, 1.3, 0.8 and 1.4 within the barrier over the five years.

Table II-14: PCB Concentration of Sediment From the S1/S4 Beach Barrier

Monitoring Point	PCB Concentration (ppm)				
	2006	2007	2008	2009	2010
BSP1	-	0.1	1.7	0.6	0.5
BSP2	1.3	0.6	1.8	0.9	0.3
BSP3	0.2	0.4	0.4	-	3.1
BSP4	0.4	0.5	1.3	-	1.7
BSP5	-	-	-	0.5	0.9
BSP6	-	-	-	0.4	2.8

Table II-15: Volume of Sediment and Concentration and Mass of PCB in the Sediment From the S1/S4 Beach Barrier

	2006	2007	2008	2009	2010
Volume (m^3)	2.0	1.2	5.3	nd	2.3
Concentration (ppm)	0.7	0.45	1.6	0.8	1.4
Mass (g)	2.5	1.2	15.3	2.9*	2.9*

nd not determined * Mass divided between two years

b) Filters

Table II-16 gives the average PCB levels in the various components of the filter box while Table II-17 gives the calculated quantities arising from these results. The average PCB concentrations of the gravel, GAC and 1200R collected over the five years are 0.2, 0.5 and 1.5 ppm respectively. As with the other barriers, the finer material collected by the 1200R contains the higher PCB levels. The amount of pure PCB trapped by the filters over the five year period was 0.28 g.

Table II-16: Average PCB Concentration of Filter Box Materials From the S1/S4 Beach Barrier

Monitoring Point	PCB Concentration (ppm)				
	2006	2007	2008	2009	2010
Gravel	0.2	0.2	0.1	nd	0.4
GAC	0.1	0.2	0.8	nd	0.7
1200R	-	0.2	3.2	1.9	0.6

nd not determined

Table II-17: Mass of PCBs Collected in the Filter Box Materials at the S1/S4 Beach Barrier

Monitoring Point	PCB (g)				
	2006	2007	2008	2009	2010
Gravel	0.03	0.04	0.01	0.007*	0.007*
GAC	0.02	0.03	0.06	0.025*	0.025*
1200R	-	<0.01	0.02	0.01	<0.01
Total	0.05	0.07	0.09	0.04	0.04

* Mass divided between two years

D. Conclusions

The barriers worked very well in containing the PCB contaminated sediment and preventing it from entering the environment. Table II-18 summarises the mass of PCBs collected by the various components of the three PCB barriers while Figure II-4 illustrates the change in volume of the sediment collected at the three barriers with time. The total amount of PCBs removed from the environment by the three barriers was 235 g or just over a quarter of a kilogram. While 235 g may not seem like a lot, it is enough to create 5 tonnes of CEPA soil. Of this amount 149 g or 63 % was from the furniture dump. By contrast, less than 1 g was removed by the filter boxes in the S1/S4 drainage pathway.

The main findings from the monitoring of the PCB in the two drainage pathways are as follows:

- The PCB levels in the sediment and filter material in the furniture dump barrier were much higher than those in the S1/S4 valley barrier which in turn were higher than those in the S1/S4 beach barrier. The average levels in the sediments were 46, 3.8 and 1.0 ppm respectively.

- The PCB levels in water flowing through the traps was much higher for the furniture dump drainage pathway than the S1/S4 pathway.

- The PCB levels in the sediments trapped by the S1/S4 valley barrier have changed from Tier II to Tier I during the five year monitoring period. For the S1/S4 beach barrier the PCB levels are well below the Tier II threshold

and it is hoped that the drop in the S1/S4 valley levels will ultimately lead to a lowering of the S1/S4 beach levels. At the furniture dump, however, the sediment PCB levels have not decreased with time and remain in the 20-100 ppm range.

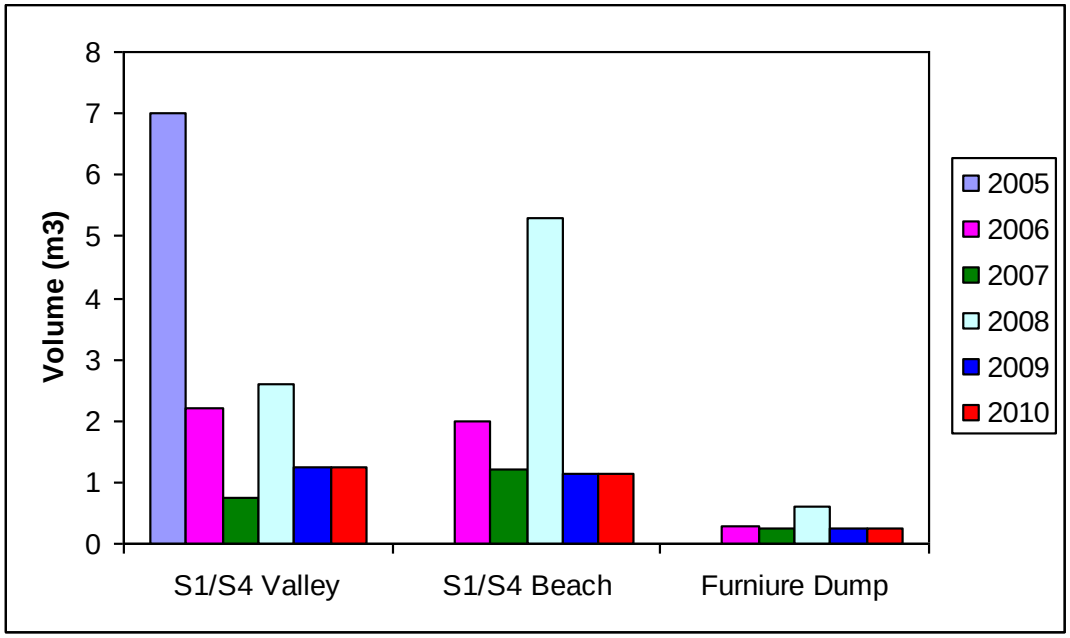
- The amount of PCBs removed from the environment by sediment removal was much larger than by the barrier filters. The amount of PCBs removed in the barrier sediment by the furniture dump, the S1/S4 valley and the S1/S4 beach was 144, 60 and 25 g respectively. The corresponding masses from the filter boxes were 5.0, 0.64 and 0.28 g respectively.

- The PCB concentrations in the 1200R geotextile were higher than in the GAC and gravel in each barrier. However, the mass of PCB removed was highest by the GAC and least in the 1200R in each barrier.

- The clean cells set up to monitor the performance of the barriers were ineffective.

- The barriers are overall in excellent shape however the geosynthetics need to be monitored. The current configuration of the filters is working well ie filtering out PCBs and not clogging.

Figure II-4: Change in Volume of Sediment at the Three Barriers With Time



The volumes in 2009 and 2010 were calculated by dividing the 2010 total by two

Table II-18: Mass of PCBs Collected from the Components of the Barrier as a Function of Time (g)

Medium	Barrier	2006	2007	2008	2009	2010	Total
Sediment	S1S4 Valley	25	8.5	13.6	6.6*	6.6*	60.3
Sediment	S1/S4 Beach	2.5	1.2	15.3	2.9*	2.9*	24.8
Sediment	Furniture Dump	15.5	16.9	76	18*	18*	144
Gravel	S1S4 Valley	0.11	0.02	0.06	0.002*	0.002*	0.194
Gravel	S1/S4 Beach	0.03	0.04	0.01	0.007*	0.007*	0.094
Gravel	Furniture Dump	0.22	0.08	0.40	0.05*	0.05*	0.8
GAC	S1S4 Valley	0.02	0.27	0.08	0.018*	0.018*	0.406
GAC	S1/S4 Beach	0.02	0.03	0.06	0.025*	0.025*	0.16
GAC	Furniture Dump	0.51	0.21	1.32	0.55*	0.55*	3.14
1200R	S1S4 Valley	-	-	0.01	0.01	0.02	0.04
1200R	S1/S4 Beach	-	<0.01	0.02	0.01	<0.01	0.03
1200R	Furniture Dump	-	-	0.54	0.32	0.20	1.06
All Filter Media	S1S4 Valley	0.13	0.29	0.15	0.03	0.04	0.64
All Filter Media	S1/S4 Beach	0.05	0.07	0.09	0.04	0.03	0.28
All Filter Media	Furniture Dump	0.73	0.29	2.7	0.92	0.70	5.00
All Filter Media	All Barriers	0.91	0.65	2.50	0.99	0.87	5.92
S1S4 Valley	Total Barrier	25.1	8.8	13.8	6.6	6.6	60.9
S1/S4 Beach	Total Barrier	2.6	1.3	15.4	2.9	2.9	25.1
Furniture Dump	Total Barrier	16.2	17.2	78.3	18.9	18.8	149
All Barriers	Total Barrier	43.9	27.3	107.4	28.5	28.4	235

* Mass divided between two years

E. Recommendations

1. For 2011

The most immediate problem at the site is the high PCB concentrations found at the furniture dump. It is recommended that a reassessment of the furniture dump and surrounding area be conducted to attempt to find the source of these PCBs. If the source can be identified and removed, this should proceed in 2012. Although the drainage pathway was carefully scraped, washed and vacuumed it should be remembered that transformers were actually leaking PCBs within the dump at the time of remediation and it is possible that not all the source of contamination was removed. Given the significant amounts of PCBs still being trapped by the furniture dump barrier, the barrier should be carefully inspected and assessed with particular focus on the geosynthetic liners.

In addition, research should be conducted to determine the best way to accelerate the stabilization of soils and sediments in the S1/S4 drainage pathway. Given the relatively lower masses of PCBs trapped in the filters, it is appropriate to initiate soil stabilization as a first step to removing the filters and ultimately the phasing out of the two barriers. The obvious solution is to stabilize these soils with plants and mosses. In addition further physical barriers should be placed above the current barriers. This could be done by duplicating the Curlex traps currently in use. Barriers of this type could be put in place without the need of heavy equipment. Gabion barriers would be also desirable as they are more durable.

These two actions should be initiated in 2011.

2. For 2011-2015

The furniture dump barrier should be shoveled out, maintained and monitored annually as during the past five years until the source is identified and removed or the levels drop with time.

The barriers in the S1/S4 drainage pathway should be inspected in 2011 and monitored by collecting and analyzing soil and water samples in year 7 (2012). The filters can be left in place and do not need to be monitored or replaced in 2012 given the small mass of PCBs trapped by them. Further action at these barriers will depend on the PCB levels found in soil in the barriers and the amount of sediment present ie the capacity of the barrier to accommodate more material. If the PCB levels and amount of

sediment are similar to those experienced in the last two years, then these barriers should be left until year 10 (2015) when a decision as to their fate can then be decided depending on the success of the soil stabilization. Hopefully if the PCB levels and volumes of sediment continue to fall then the barriers can be phased out.

The CEPA soils currently at B2 and those being generated at the furniture dump need to be dealt with. This could be by continued storage on site or by removal to another more accessible site (for monitoring purposes) or by transport to a certified disposal facility. A cost effective solution might be to store them on site until the source of the PCBs at the furniture dump is determined so that this source and the soils currently generated can be removed together. This of course would require approval by Environment Canada. It is unlikely that any other CEPA soils that can be safely removed will be found at the site.

Photograph II-9: Building B2 Near the Beaching Area and Drums and Waste Wranglers Filled With PCB Contaminated Sediment From the Barrier Traps

III. PCBS AND METALS IN LANDFILLS

The long-term, post-remediation monitoring program contained provisions for monitoring wells and associated soil points at the Tier II landfill, the airstrip landfill and the maintenance dump. In addition the two landfills used for demolition debris were also to be monitored. The following four sections detail this monitoring. They are followed by a summary of the conclusions and recommendations for future monitoring of these five locations.

A. Tier II Landfill

1. Background

The landfill was constructed over the period 2003-2005 at an already contaminated location. Isolated areas of soil together with the walls of the building were found to be contaminated with PCBs at the Tier II level. These were excavated and subsequently placed within the Tier II landfill. Hydrocarbon contamination was also present in soil at the site. Most of the hydrocarbon contaminated soil was removed. The base of the area to be occupied by the landfill was gridded and sampled. Table III-1 gives the average and range of the elements of the DLCU criteria along with TPH in the form of fuel or lubricating oil and grease. Concentration of metals were generally within site background levels though there was one high lead value (1140 ppm) and one high copper value (149 ppm). Hydrocarbons were present in 14 of the 19 samples and six contained concentrations greater than 1000 ppm. The volume of the hydrocarbon contaminated soil was low and as this material was to be below the bottom liner of the landfill it would remain frozen and immobile. Table III-1 is included here because soil adjacent to the landfill, where the soil monitoring points are located, might be expected to have similar levels of contaminants.

Four groundwater monitoring wells and associated soil monitoring points were established in 2003 and five additional monitoring wells added in 2004. These were sampled up to seven times during the 2004 and 2005 seasons in order to establish baseline data. No water could be obtained from wells 1B and 3B, and thus the Tier II monitoring well system was comprised of 7 wells and 6 associated soil monitoring points: soil monitoring point 5 is adjacent to both wells 5A and 5B. Most wells were screened from about 30 cm below the surface to around 3 m. Wells 3A and 5A monitored groundwater at a lower depth and were screened from 2.6 to 3.6 m below ground level.

Four thermister strings were placed in the landfill during construction, two within the landfill and two in the berms.

Table III-1: Results of Analyses for Metals, PCBs and TPH of Samples Taken From the Base of the Tier II Landfill Site Prior to Construction

	Units	Average	Range
As	ppm	1.3	<1.0 – 1.6
Cd	ppm	<1.0	<1.0
Co	ppm	13.9	9.2 – 18.8
Cr	ppm	38	28 - 48
Cu	ppm	69	47 - 149
Ni	ppm	60	41 - 88
Pb	ppm	96	<10 - 1140
Zn	ppm	111	46 - 315
PCBs	ppm	1.3	<1.0 – 4.2
TPH (fuel)	ppm	795	<40 - 5700
TPH (lube)	ppm	303	<40 - 930

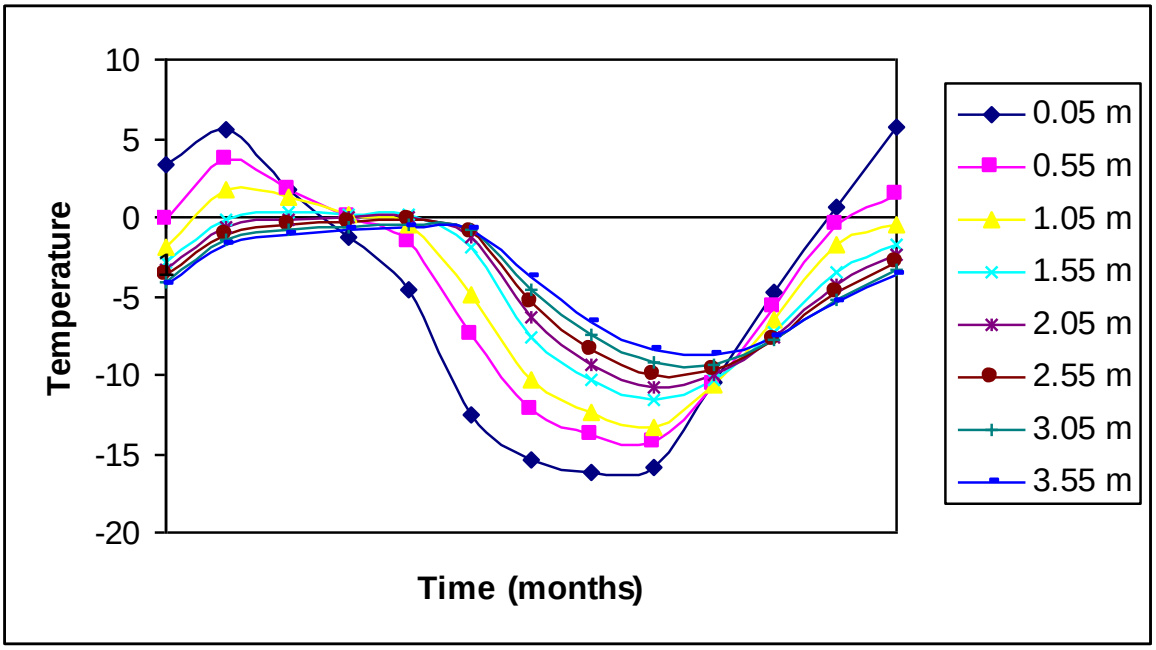
2. Engineering Assessment

Inspection of the stability of the landfill have been conducted each year since construction. There is some minor settling of the surface and ponding of surface water is visible in the area immediately adjacent to landfill; very minor erosion along the west berm was observed. The temperature of the material within the landfill and the berms has been recorded each year. Based on its design and construction, the depth of fill above the Tier II contaminated material is 2.7 m whereas the lowest depths of the 0 ºC isotherms within the landfill were found to be 1.9 m and 2.7 m in 2009. Thus the contents of the landfill are now likely all within the permafrost as per design. Figure III-1 shows the data obtained from one of the thermister strings within the landfill from July 2008 to July 2009. As can be seen the temperatures rise in the summer months but only above the freezing point at shallow depths.

Photograph III-1: The Tier II Landfill Being Prepared For the Top Liner in 2005

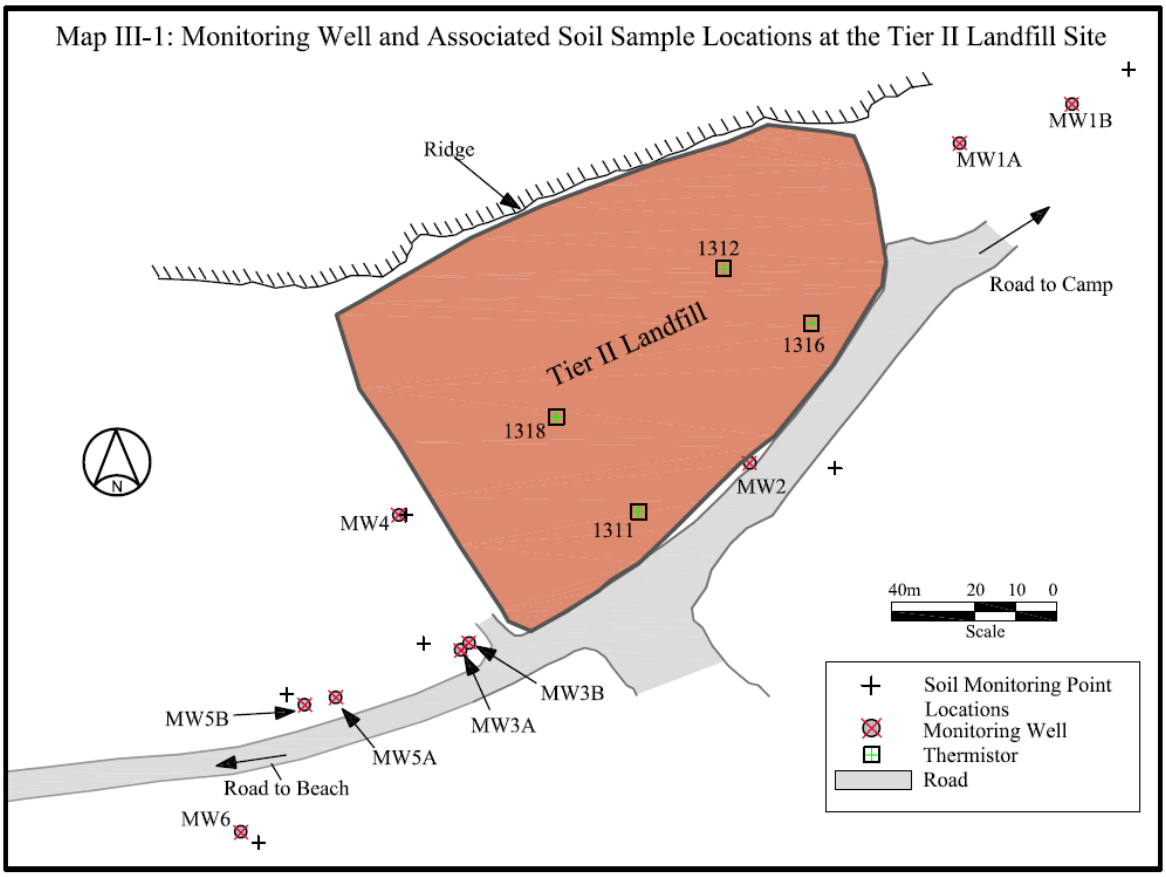
Photograph III-2: Sampling a Monitoring Well at the Tier II Landfill

Figure III-1: Thermister Data from Landfill East - Average Monthly Temperatures From July 2008 to July 2009



3. Water and Soil Monitoring

The position of the monitoring wells and their associated soil monitoring locations is given in Map III-1. The objective of the monitoring wells and associated soils program was to initially establish baseline values for levels of parameters in the soil and water in order to be able to identify increases in the levels of these parameters over time, which might then be attributed to failure of the landfill to contain the enclosed contaminants. As discussed above, the Tier II landfill site was situated on a site contaminated at levels that one might expect at an industrial site and the variability of some of the initial baseline levels was high. In 2005 the soil monitoring points were sampled twice during the season while the water points were sampled between three and six times and twice in 2006. Tables VII-4, VII-5 and VII-6 illustrate the variability of contaminant levels in soil and water at specific wells during the 2005 season. Tables VII-7 and VII-8 give results for all analytes each year. In the tables and graphs discussed below relating to these results from the soil and water monitoring points, the values obtained are the average values. Most tables are given in Chapter VII: Appendix at the end of the report while graphs illustrating the results are given in the text.



a) Metals in Soil

The average level of the eight elements of the DCC over the last 6 years in soil are shown in Figure III-2 for all but arsenic and cadmium which are present at very low concentrations. The average levels are also given for monitoring wells MW3, MW4 and MW5 in Figure III-3; these three wells are immediately down gradient from the landfill and would be the first to show any increases in contaminant concentration in the event there was seepage from the landfill. As can be seen there are no trends or indications of increases down gradient with time. The data do however show clearly the differences between metal levels at the six locations. For reference, Table VII-9 summarises the baseline results for the eight elements of the DCC from sampling in 2004 and 2005 prior to the start of the monitoring program. Generally results in subsequent years have fallen within the ranges of the baseline study. Figure III-4 shows the variation of zinc at the six locations as a function of time. The MW5 site shows the highest numbers and the greatest variability.

Figure III-2: Average Levels of Six Metals at the Soil Monitoring Points at the Tier II Landfill from 2005 to 2010 (ppm)

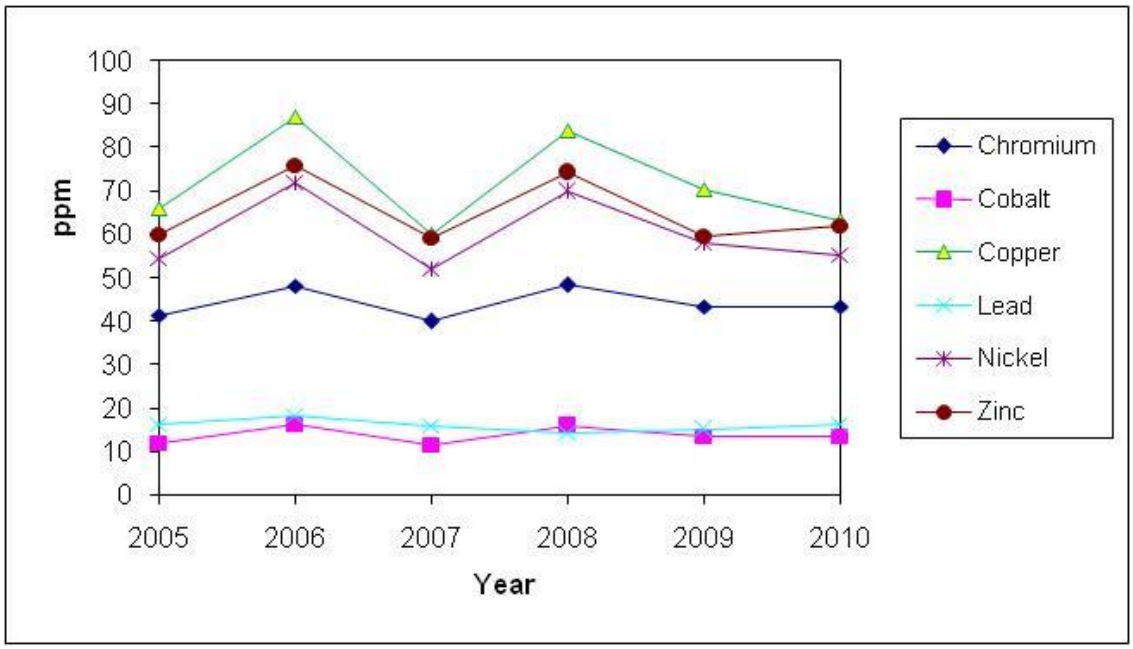


Figure III-3: Average Levels of Six Metals in the Soil Monitoring Points MW3, MW4, and MW5 at the Tier II Landfill from 2005 to 2010 (ppm)

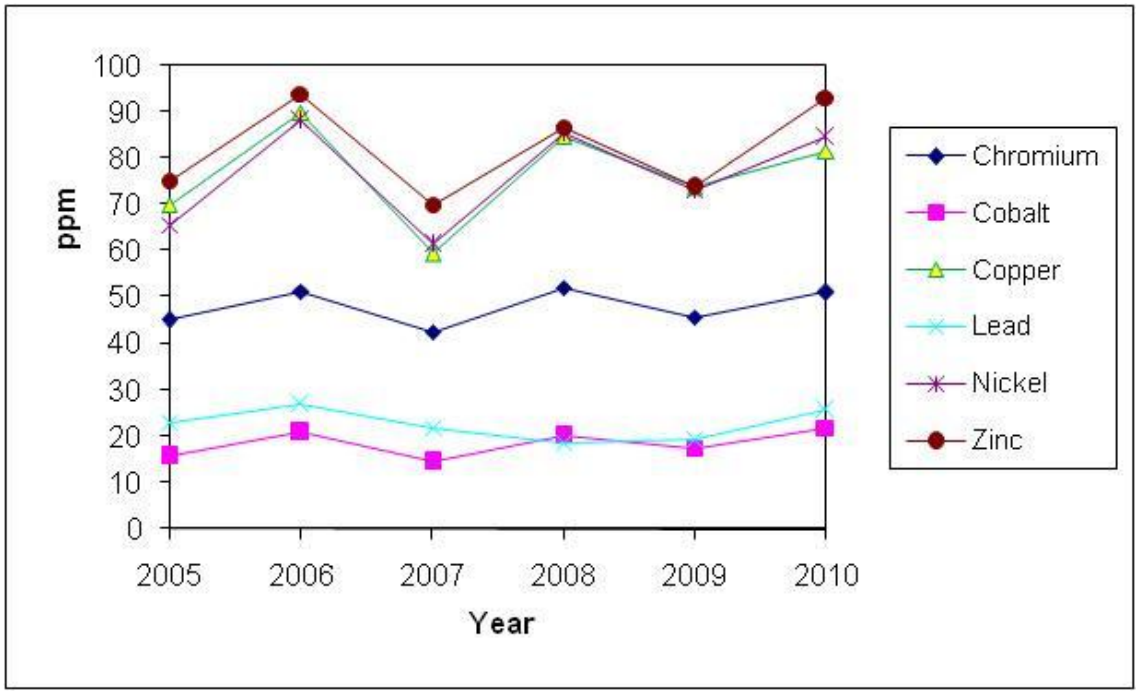
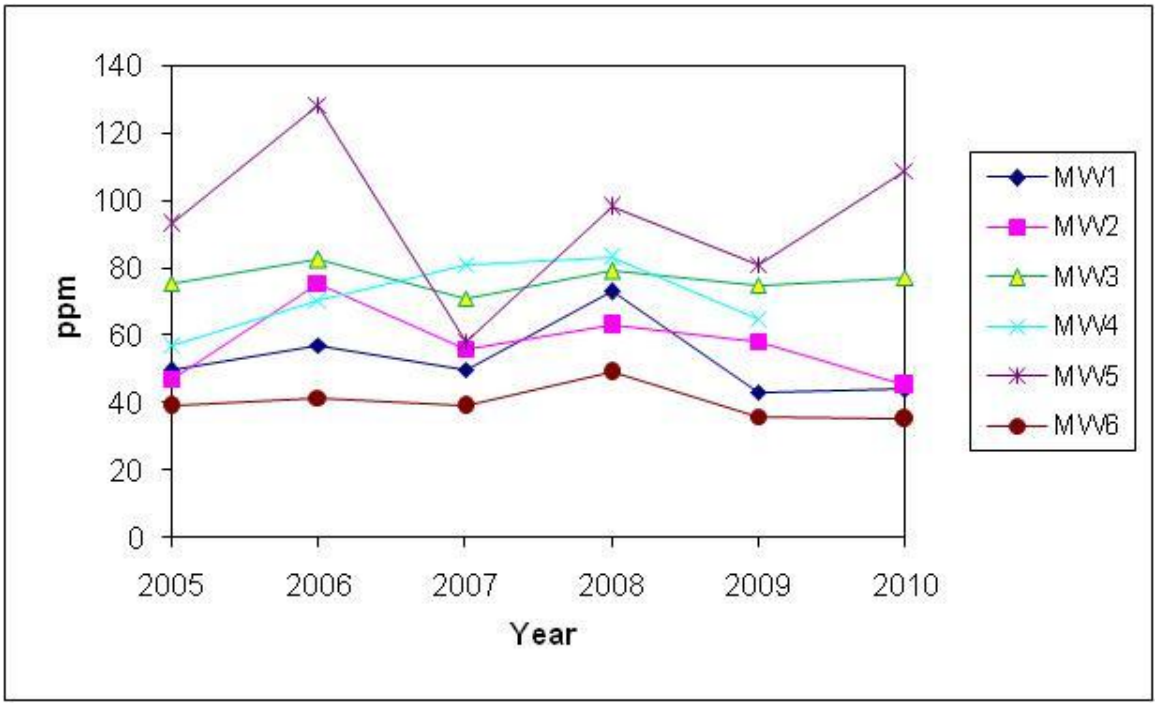


Figure III-4: Average Levels of Zinc at the Soil Monitoring Points at the Tier II Landfill from 2005 to 2010 (ppm)



b) Metals in Water

Similarly the average level of the eight elements of the DCC over the last 6 years in water are shown in Figure III-5 for six metals. The average levels are also given for monitoring wells MW3, MW4 and MW5 in Figure III-6. For comparison, Table VII-10 gives the baseline data for the eight analytes of the DCC from data collected in 2004 and 2005. As with the soil data, most results have fallen within the ranges given in Table VII-10.

Figure III-5: Average Levels of Metals at the Water Monitoring Points at the Tier II Landfill from 2005 to 2010 (ppm)

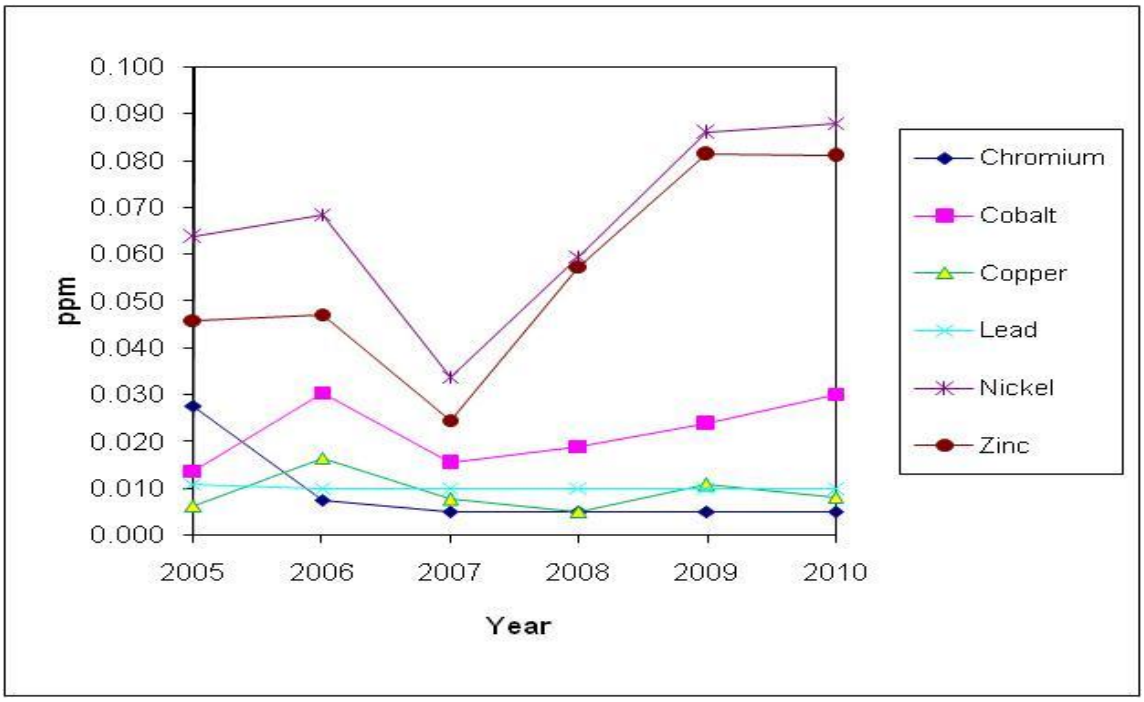
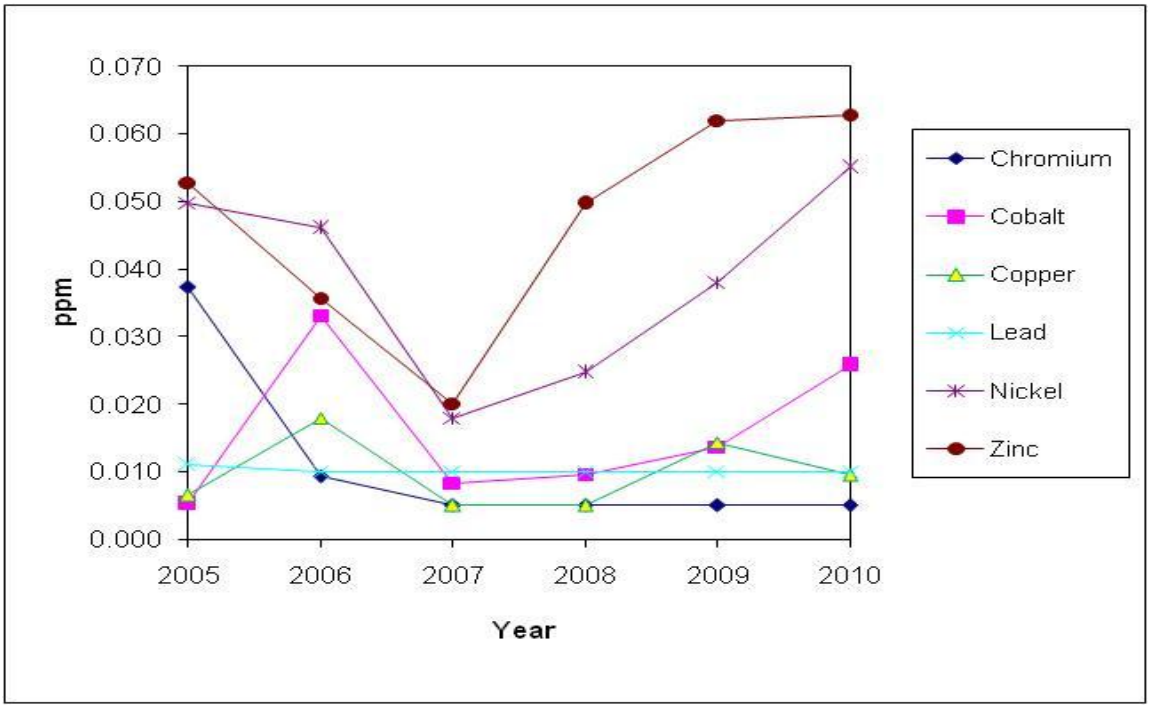


Figure III-6: Average Levels of Metals in the Water Monitoring Points MW3, MW4, and MW5 at the Tier II Landfill from 2005 to 2010 (ppm)



The levels of zinc and nickel appear graphically to be demonstrating an increase over the last three years. The nickel and zinc levels were examined more closely in the water samples as shown graphically in Figures III-7 and III-8 respectively. For nickel, the high average numbers are predominantly due to erratic results from MW2 with a possible increasing trend developing for MW6. For zinc the same is true for MW2 but for MW5B and MW6 there does appear to be an increase in the last three years. As can be seen in Figure III-4, the soil near to MW5 has the highest and most variable zinc levels. The maintenance building that was demolished to make room for the Tier II landfill was constructed with galvanized metal sheeting. It may be that some zinc from this activity was deposited on the ground around the area where MW5 is located and that this has now permeated into the groundwater. Water from the deeper well MW5A does not show the trend seen in the shallow well MW5B.

Figure III-7: Average Levels of Nickel at the Water Monitoring Points at the Tier II Landfill from 2005 to 2010 (ppm)

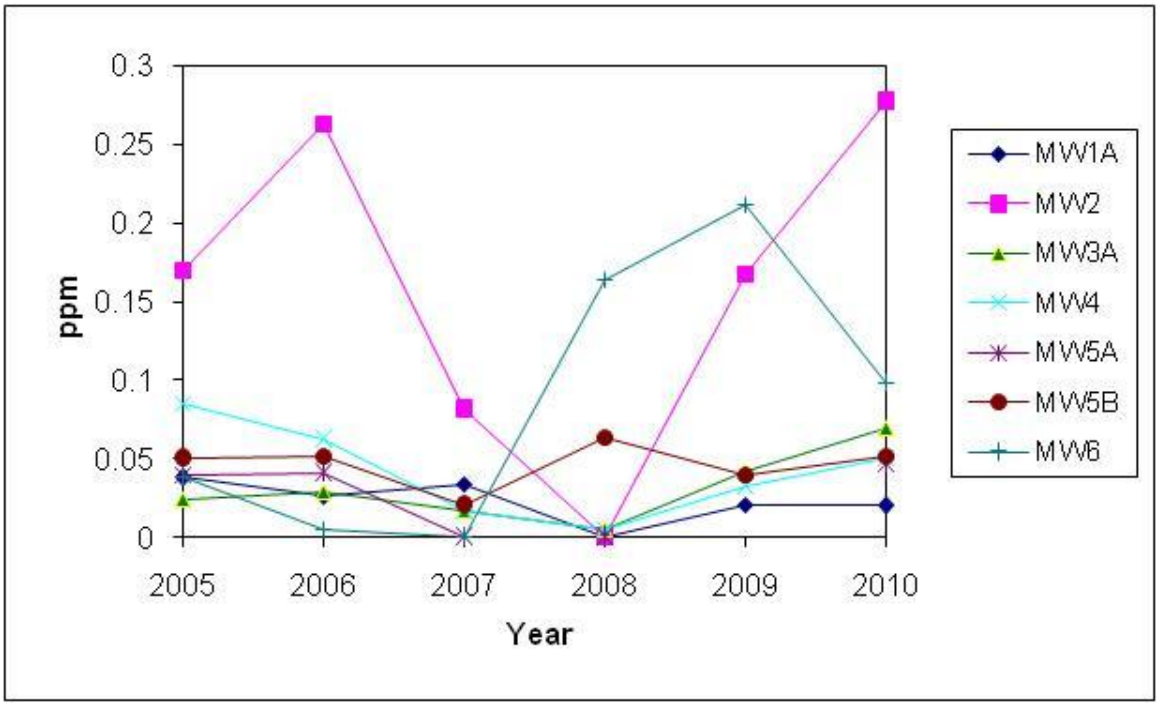
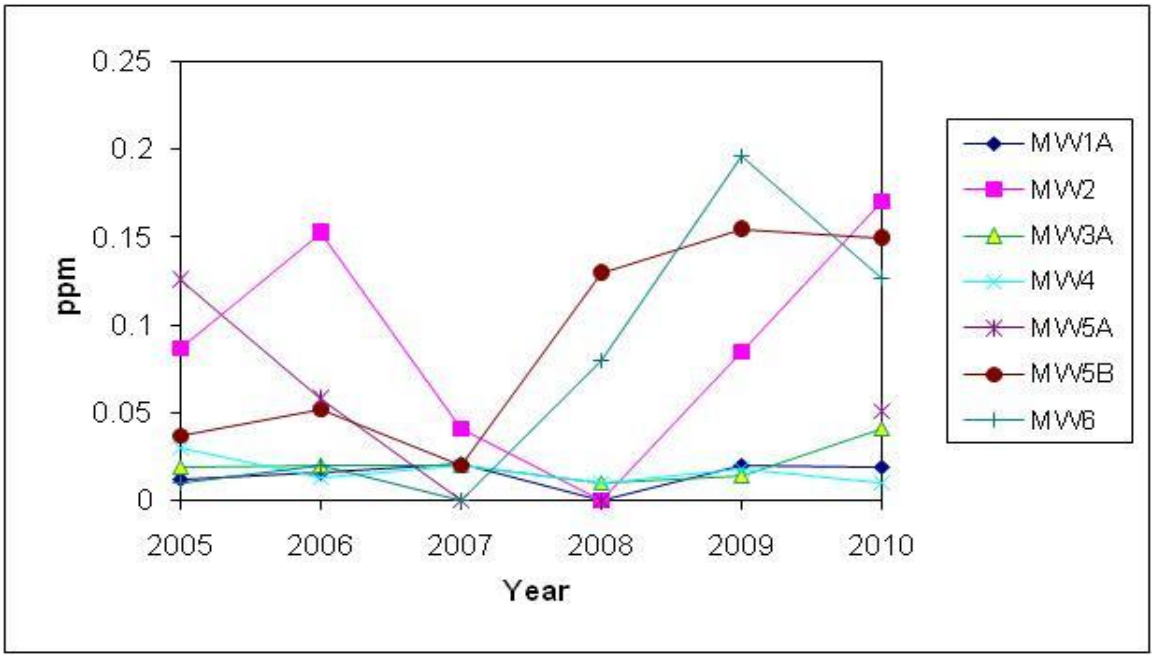


Figure III-8: Average Levels of Zinc at the Water Monitoring Points at the Tier II Landfill from 2005 to 2010 (ppm)



c) PCBs

The average level of the PCB in soil over the last 6 years are shown in Figure III-9. Similarly the levels in water from the monitoring wells are shown in Figure III-10. The data do however show clearly the differences between PCB levels in soil at the six locations with locations MW3 and MW5 giving higher and more erratic readings than the other four soil locations. As can be seen there are no trends or increases down gradient with time from the soil or water results. The average concentration of PCB's in soil measured at all six monitoring wells is 0.25 ppm or lower, which is lower than the current DCC Tier 1 threshold of 1ppm.

Given the level of PCBs in the nearby soil, any soil contamination in the water is likely to give measurable PCB levels in the water. The water results should be treated with caution as they may not represent the true picture. The water cannot be filtered for analysis since this process would remove the PCBs from the water. In the laboratory, the samples were allowed to stand for at least 24 hours and then the water to be analysed is carefully decanted. However several samples in the past contained soil particles floating on the surface and, in others, colloidal material was present especially for MW5B. Thus,

the results where PCBs were found in the water may well have been a measure of the soil contamination rather than actual levels in the water. This is particularly likely since PCB molecules tend to partition on to solid surfaces and to absorb on to particles rather than to dissolve in water.

Figure III-9: Average Levels of PCBs at the Soil Monitoring Points at the Tier II Landfill from 2005 to 2010 (ppb)

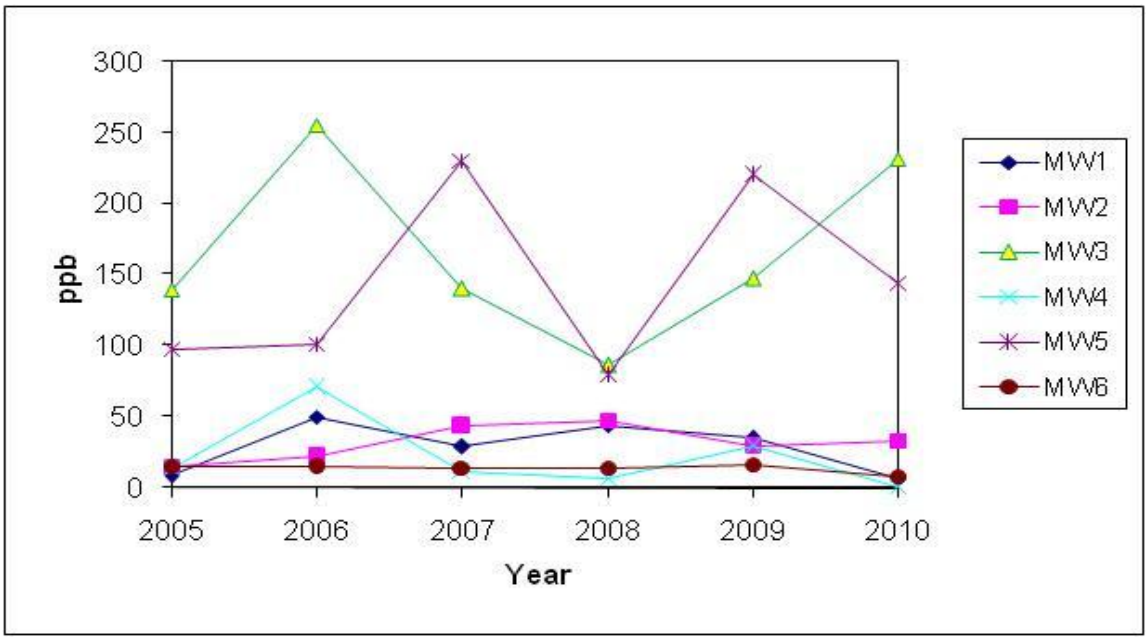
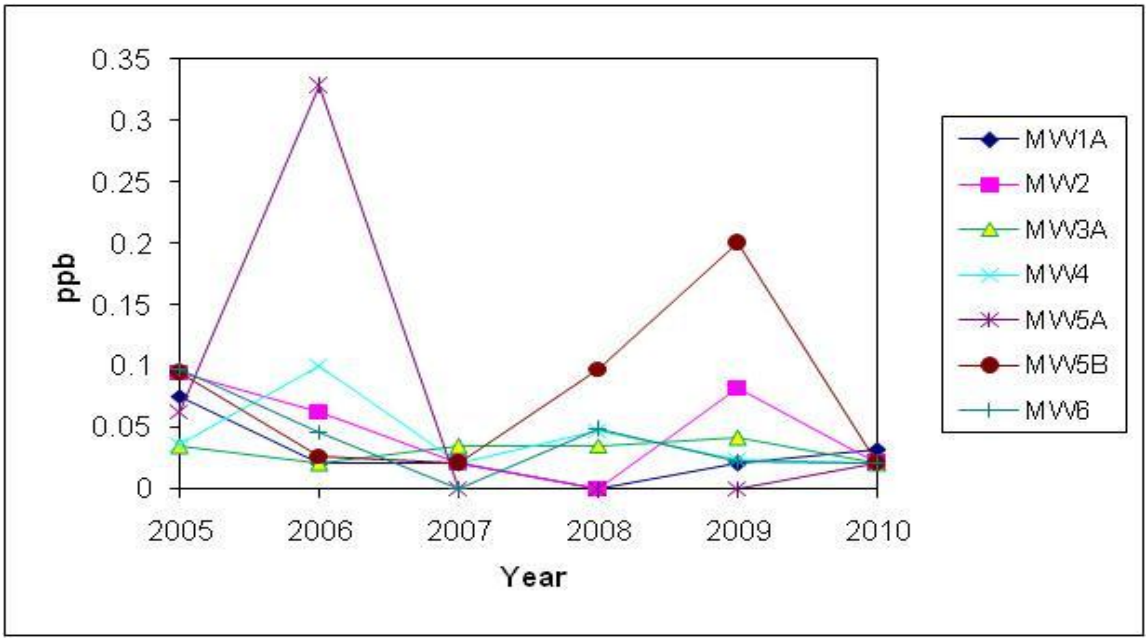


Figure III-10: Average Levels of PCBs at the Water Monitoring Points at the Tier II Landfill from 2005 to 2010 (ppb)



d) TPH

The hydrocarbon levels in the soil at the six locations in 2005 were highly variable as can be seen in Table VII-4. In that year, half of the 24 analytical results yielded positive values above the detection limit of 40 ppm. The 12 positive results had an average value of 365 ppm with a range from 50 to 1230 ppm. The number of positive results has decreasing significantly with time. For the years 2007, 2008, 2009 and 2010 the numbers of results above the detection limit were 3, 2, 0 and 2 respectively. The nature of the hydrocarbon has shifted with time toward the heavier fraction. Very little hydrocarbon has been detected in the water from the monitoring wells. All values have been below 2.0 ppm with the exception of a level of 33 ppm found in MW5B in 2009. The method detection limit is 1.0 ppm. Given the TPH contamination found in the area prior to construction, the results tend to show that any mobile TPH in the area has likely migrated away, been biodegraded or is tightly held on soil particles.

B. Airstrip Landfill Monitoring Program

1. Background

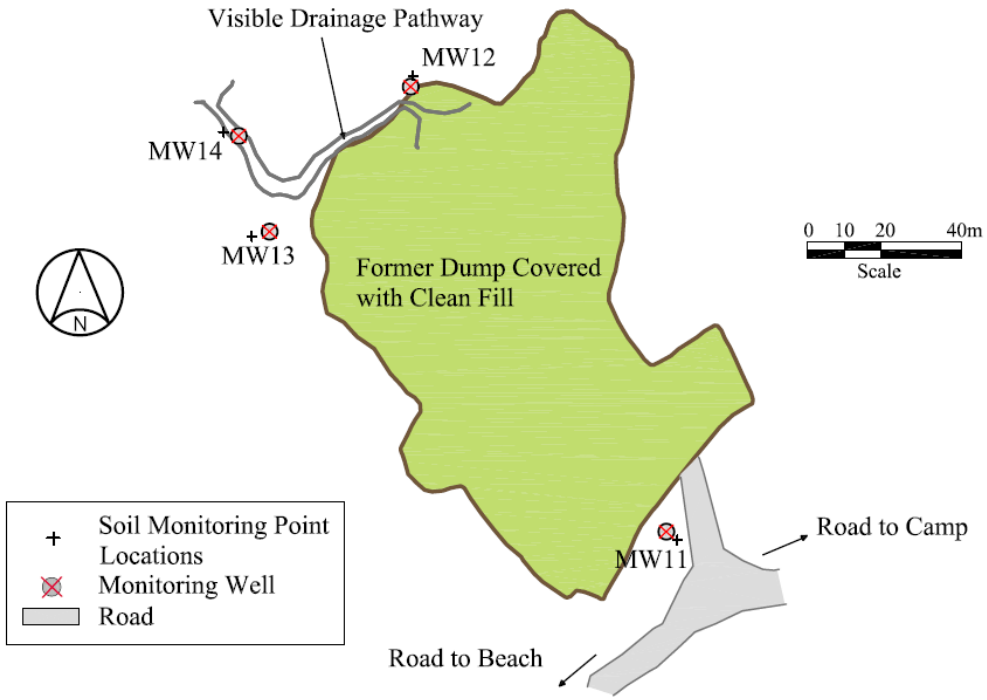
The remediation of the airstrip dump was completed in 2003. This involved the excavation of PCB contaminated soil and debris and the addition of extra fill on the surface of the landfill. This extra coverage was not adequate on portions of the toe of the landfill to cover all the debris. Four monitoring wells were placed around the landfill, one above and three in the leachate channel leading away from it as shown in Map III-2. However, it should be noted that the drainage channel for MW12, MW13 and MW14 is extremely narrow and the staked area for the soil samples straddles the channel.

2. Engineering Assessment

Inspection of the landfill confirmed the presence of partially buried debris near the north toe of the landfill but found the surface of the airstrip landfill was in good condition with minimal erosion. On the north west berm, there was, however, evidence of erosion. The gravel berm was built with large boulders on the top surface. Some of these boulders have migrated down the slope and gravel was also migrating down the slope

with the formation of several shallow gullies. Soil from the area was collected and analysed for PCBs in 2010. Only a trace of PCBs was found.

Map III-2: Monitoring Well and Soil Monitoring Sample Locations at the Airstrip Landfill



3. Water and Soil Monitoring

The average level of the eight elements of the DCC over the last 6 years in soil are given in Table VII-11 and shown in Figure III-11 for all but arsenic and cadmium which are present at very low concentrations. Similarly the water data are presented in Table VII-12 and Figure III-12. As can be seen there are no trends or increases with time. Figure III-13 shows the data for zinc in soil and indicate clearly the differences between metal levels at the four locations. The analogous water plot for zinc showed no trends or differences between well locations.

Figure III-11: Average Levels of Six Metals in the Soil Monitoring Points at the Airstrip Landfill from 2005 to 2010 (ppm)

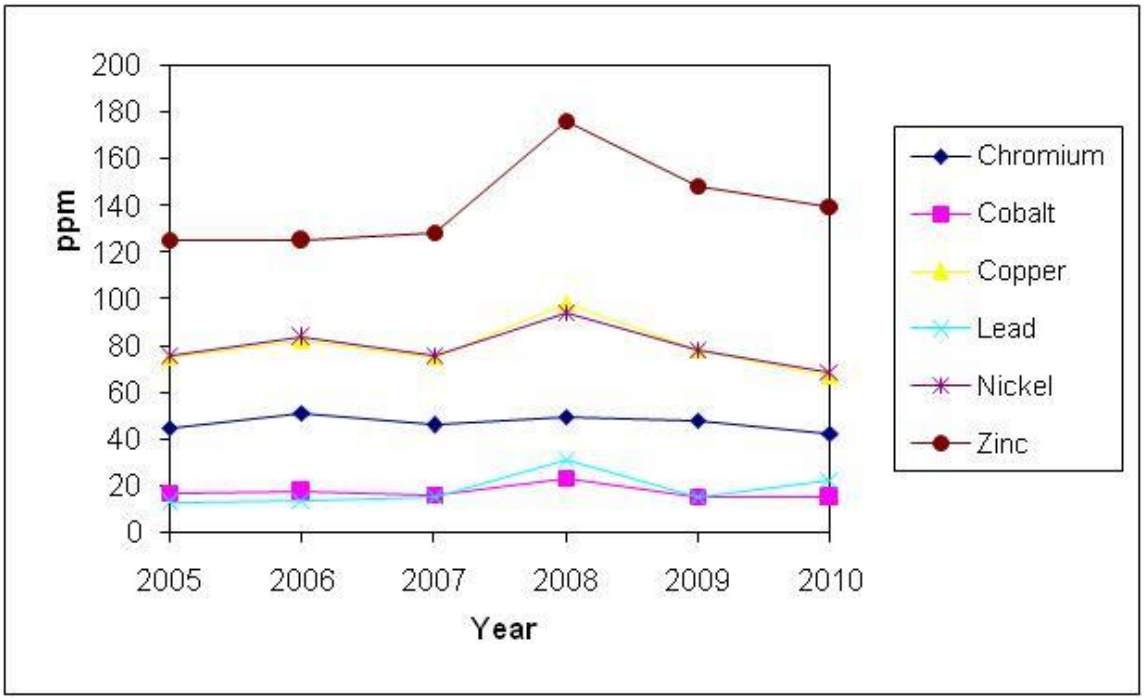


Figure III-12: Average Levels of Six Metals in the Water Monitoring Points at the Airstrip Landfill from 2005 to 2010 (ppm)

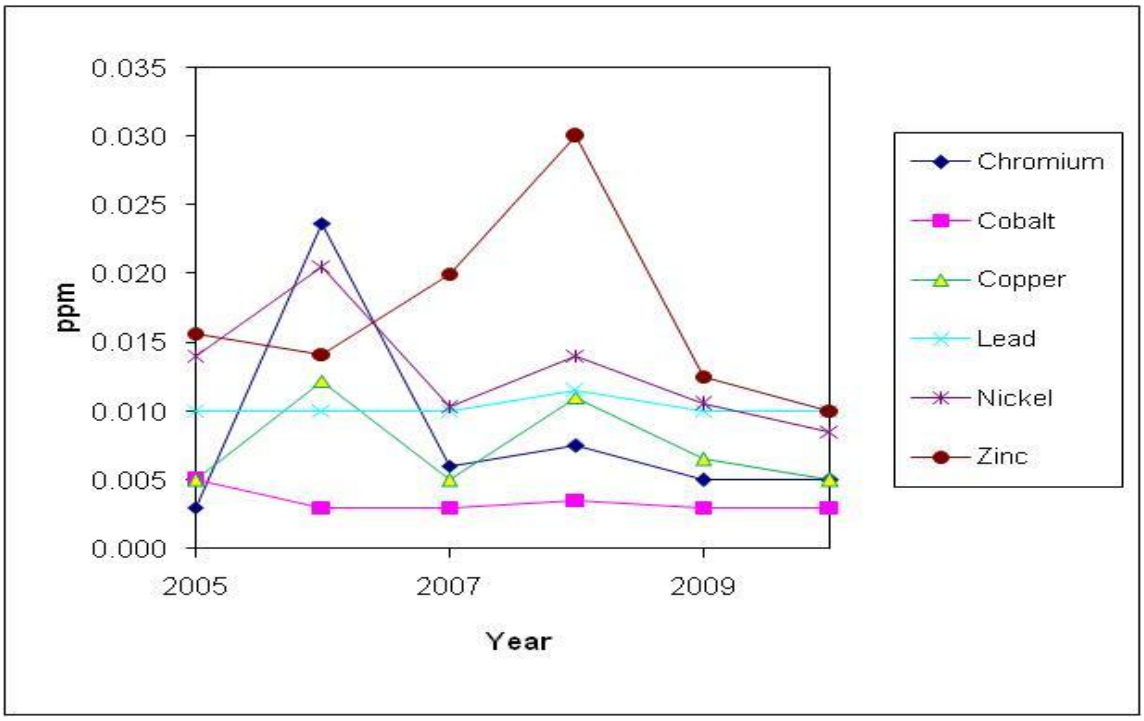
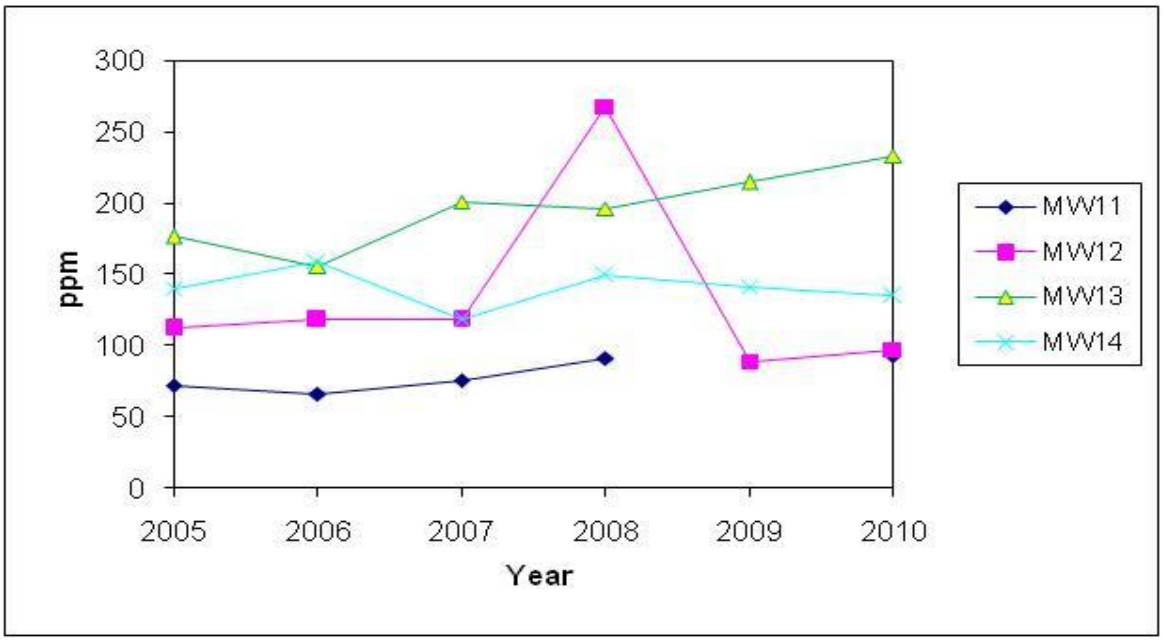


Figure III-13: Average Levels of Zinc in the Soil Monitoring Points at the Airstrip Landfill from 2005 to 2010 (ppm)



PCB levels in soil and water are given Figures III-14 and III-15. They show that there are no obvious trends and that water levels are low.

Figure III-14: Average Levels of PCBs at the Soil Monitoring Points at the Airstrip Landfill from 2005 to 2010 (ppb)

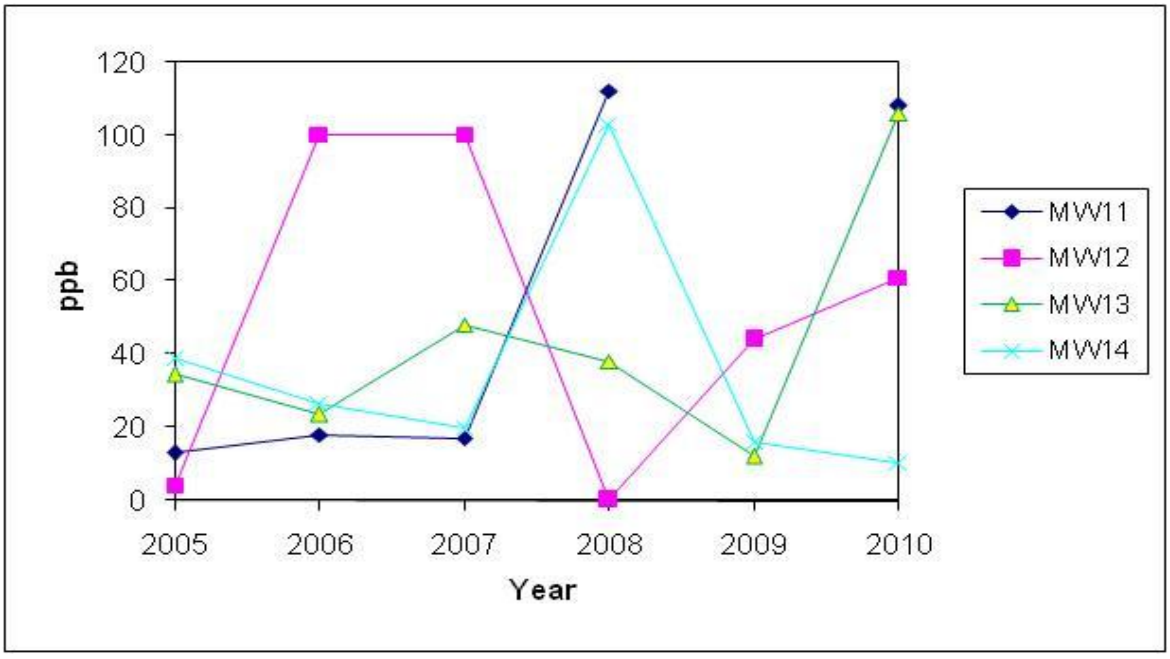
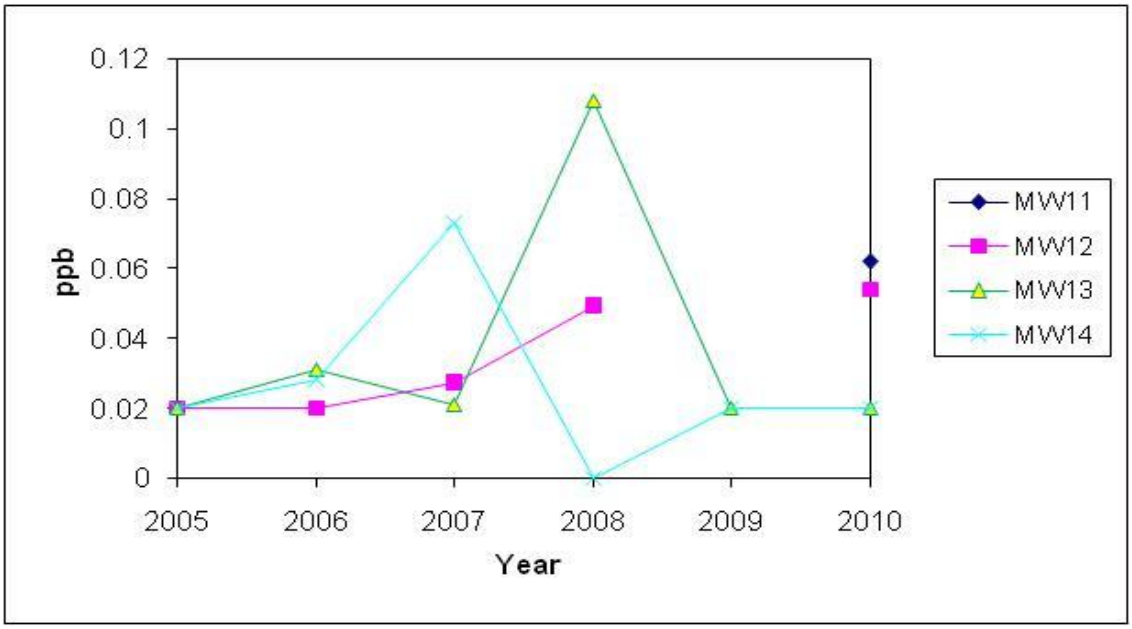


Figure III-15: Average Levels of PCBs in the Water Monitoring Points at the Airstrip Landfill from 2005 to 2010 (ppb)



No TPH has been found in any of the water samples from the wells in the last five years. The same is true of the four soil points with the exception of MW12 where levels of lubricating oil are consistently high with an average value of 2000 ppm. It seems likely some oil was spilled at this location in the past but is not mobile.

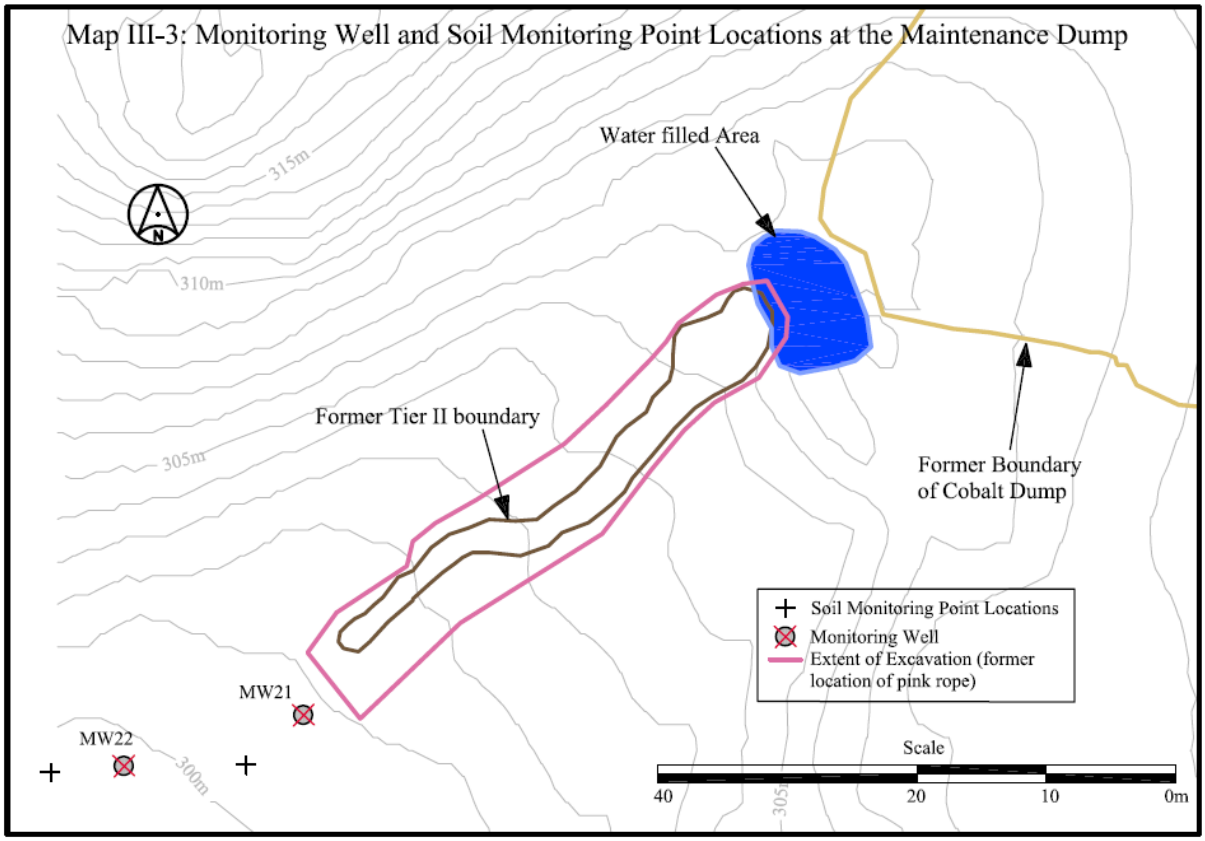
C. Maintenance Dump Monitoring Program

1. Background

The remediation of the maintenance dump was completed in 2005 and two monitoring wells and two soil monitoring points established (Map III-3). The channel leading from the dump contained elevated levels of cobalt. Soil in the drainage channel (extent of excavation shown in pink on Map III-3) and the visual debris which formed the actual maintenance dump (shown in yellow on Map III-3), were removed as part of the remediation program

2. Engineering Assessment

The area was regraded as part of the remediation program. There appears to be no erosion in the area which is showing signs of revegetation.



3. *Water and Soil Monitoring*

The average level of the eight elements of the DCC and PCBs over the last 6 years in soil are given in Table VII-13 and shown in Figure III-16 for all but arsenic and cadmium which are present at very low concentrations. Similarly the water data are presented in Table VII-14 and Figure III-17. As can be seen there are no trends or increases with time. Specifically the cobalt levels in both soil and water are as follows. In the soil the levels at MW21 are constant at 15 ± 1 ppm while at MW22 the levels are higher and more variable in the range 16 – 45 ppm. The levels in water at the two wells are very low in the range <0.004 to 0.004 ppm. No TPH has been detected in either soil or water from the monitoring sites during the five years of monitoring except for a soil sample from MW21 which gave a value of 160 ppm in 2010.

Figure III-16: Average Levels of PCBs and Metals in the Soil Monitoring Points at the Maintenance Dump from 2005 to 2010

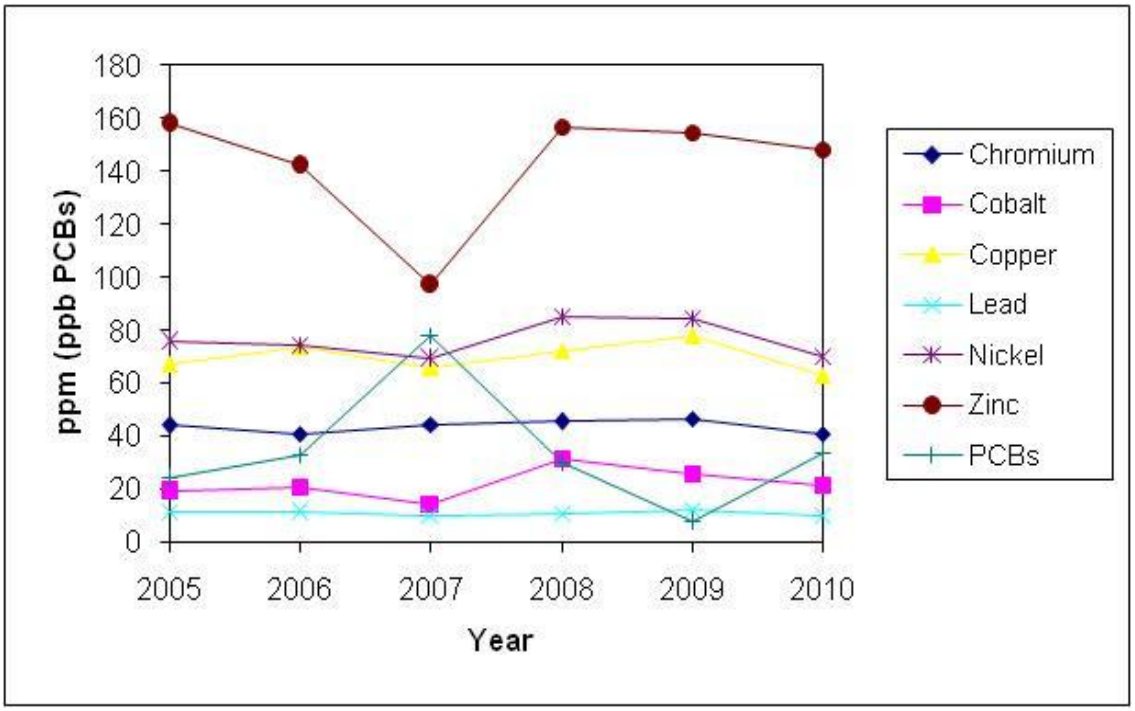
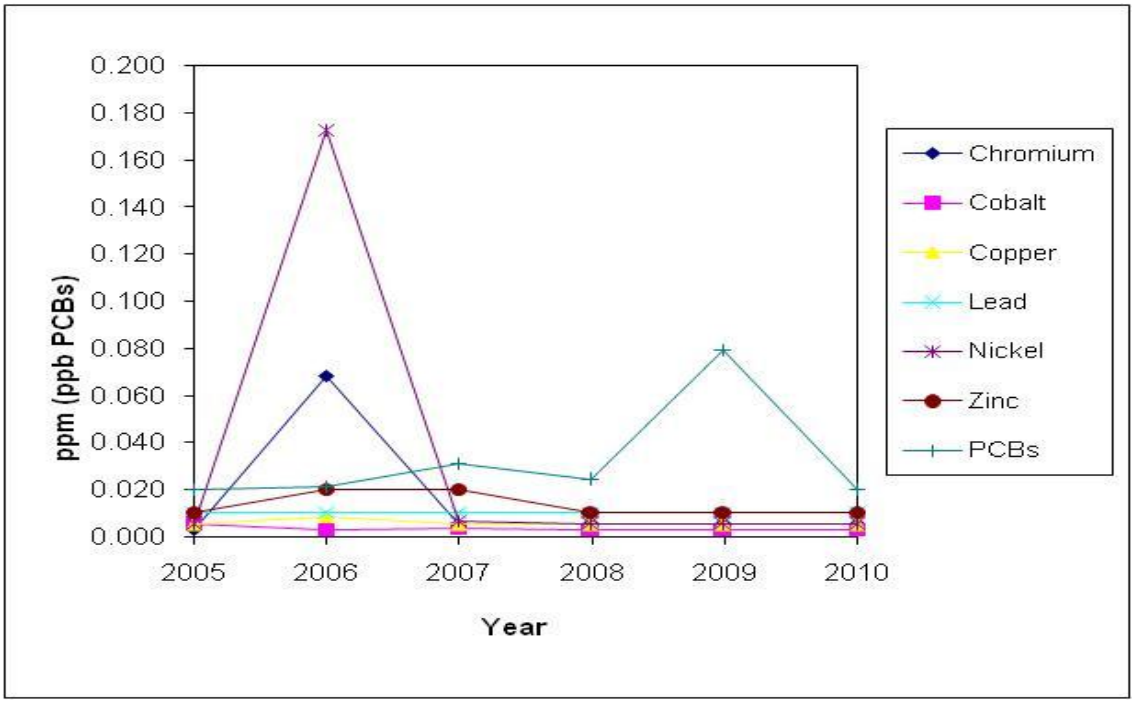


Figure III-17: Average Levels of PCBs and Metals in the Water Monitoring Points at the Maintenance Dump from 2005 to 2010



D. Non Hazardous Landfills

1. General

The two landfills were constructed to contain debris from demolition of buildings, empty barrels and other debris from around the site. Both are well situated in that no runoff passes near to them. The station landfill was found to be in good condition and no deterioration was observed during the annual engineering assessments of the site. Similarly the beach landfill, which is situated near the junction of the road from the camp and the barrel cache valley, was found to be well graded and firmly packed and there were no signs of erosion, water ponding or any vegetative growth. No water (leachate) is generated by either landfill so there is no water that can be collected to determine if the landfill is leaking contaminants into the surrounding area. There is no staining visible at either landfill at their lowest points to suggest any contaminant leaching.

E. Conclusions

There are no major concerns with any of the five landfills at the site.

The Tier II landfill was designed so that all the material buried in it in would be frozen and contained within liners. Results to date show that the material is indeed frozen and the landfill is stable. No PCBs or hydrocarbons have been detected as leaking from the landfill. The same is true for metals although there has been an apparent increase in zinc levels in the water from two monitoring wells during the last three years but this may be the result of the removal of a large galvanized steel structure from the area. No change in metal levels in soil with time was detected.

The airstrip landfill has an area on the north west toe where physical debris is visible. This area was not completely covered in the remediation program and some erosion channels have developed during the past two years. However, testing of the area in 2010 showed no PCBs were leaching. One of the early conclusions relating to the airstrip landfill was that although some PCBs had leached from the landfill through a well defined channel, the PCBs had not moved significantly in 30 years. Since that time PCB contaminated material has been removed from the landfill (source control) and therefore this is not considered a problem.

The maintenance dump exhibited no leaching of contaminants and appears stable. Both non hazardous landfills show no evidence of erosion or instability and no evidence of contaminant leaching.

F. Recommendations

According to the original 2005 monitoring program, the landfills should be monitored once a year for 5 years and then in year 7, 10, 15 and 25 if no problems are encountered. Some modifications such as a reduction in the analytical suite, or the number of wells monitored, was anticipated after the first 5 years. The first 5 years of monitoring are now complete and the data analyzed above.

In the Tier II landfill the only trend observed was a possible increase in Zn levels in the downstream wells. It is therefore recommended that in year 7 (2012) and year 10 (2015) the 5 downstream wells MW3, MW4, MW5A, MW5B and MW6 be tested for PCBs, arsenic, cadmium, chromium, cobalt, copper, lead, nickel and zinc only. No further soil testing is recommended at the Tier II landfill unless water testing shows an increase in levels. Thermistor data should be collected during each monitoring event to ensure permafrost is stable and any signs of erosion noted.

No trends were observed in the data from the airstrip dump however given the nature of the landfill it is recommended that soil and water should be monitored in year 7 and 10 for PCBs only.

No further monitoring is recommended for the maintenance dump.

Monitoring data should be reviewed after year 7 to determine the appropriate monitoring for years 10, 15 and 25.

IV. HYDROCARBONS IN SOILS AND SEDIMENTS

A. General

Hydrocarbon contaminated soils formed part of the Resolution Island remediation project. Most of these soils originated from beside the large fuel tanks but some was also from the beach dump excavation and stained areas in the barrel cache valley. The total volume of this material was about 700 m^3. A main landfarm was constructed in 2004 with small additions in 2005 in order to remediate this hydrocarbon contaminated material. A cleanup criteria of 8000 ppm[6] was employed for the cleanup. This was derived from the Canada-Wide Standards for Petroleum Hydrocarbons in Soil[7] which was introduced in 2001 and used, for the first time in the Arctic, on this project. An independent risk assessment proposed a higher criteria of 26,860 ppm. Landfarming in cold climates had rarely been employed prior to 2004 and little scientific work had been conducted to try to understand the factors involved in maximizing the performance of the method. Landfarming involves both bioremediation and aeration and the relative contributions of each at low temperatures was unknown. Indeed some landfarming attempts to remediate hydrocarbon contaminated soil in cold climates had failed. As a result, both field and laboratory work has since been carried out in order to fill these information gaps [8,9,10]. A set of trial plots was established in 2003 primarily to test the relative effectiveness of aeration and bioremediation. Figure IV-1 shows that both mechanisms worked well under the experimental conditions used. At the end of the work in 2005, the TPH levels were below 1000 ppm for three of these small trial plots with the control plot having a level of around 1500 ppm. The volume of soil in each of the plots was 7.5 m^3. Laboratory work confirmed these findings and led to a greater understanding of the mechanisms and factors that increased the performance of landfarming in cold climates.

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[6] Analytical Services Unit ((2004), Resolution Island 2003:: Scientific Investigations. Pages V-2 to V-6. Prepared for Indian and Northern Affairs Canada.

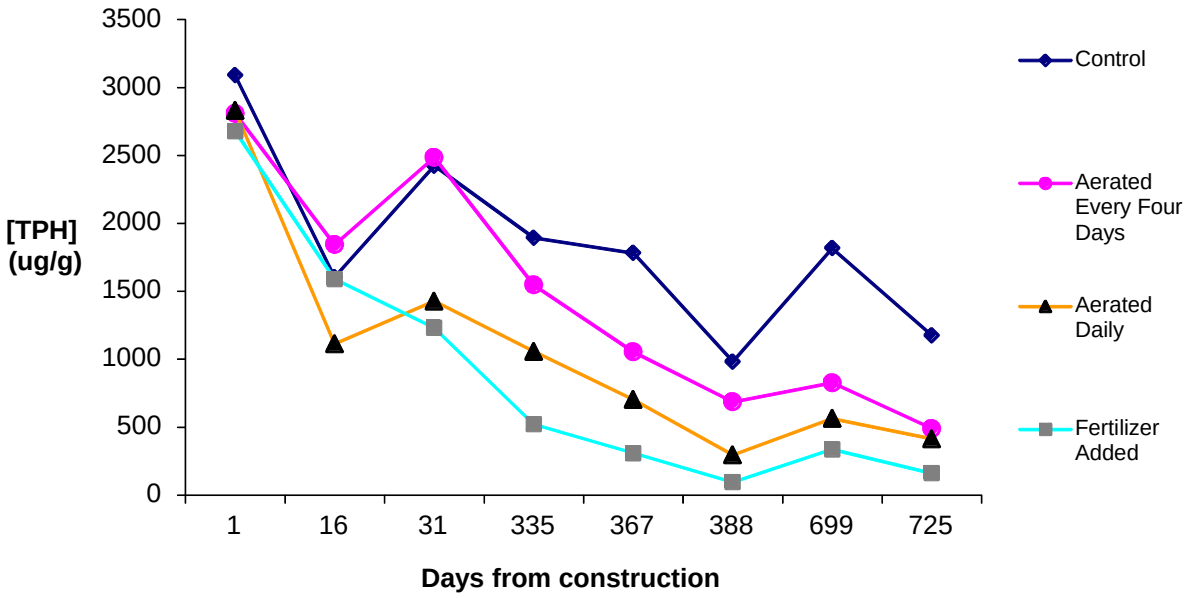
[7] Canadian Council of Ministers of the Environment (CCME) 2001. Canada-Wide Standard for Petroleum Hydrocarbon (PHC) in Soil User Guidance. April 2001

8 Paudyn, K, Rutter A, Rowe RK, Poland JS, "Remediation Of Hydrocarbon Contaminated Soils In The Canadian Arctic By Landfarming" *Cold Regions Sci. and Tech*. (2008) 53: 102-114.

[9] Paudyn, K., Remediation of Hydrocarbon Contaminateed Soils in the Canadin Arctic with Landfarming and Barrier Investigations, MSc Thesis, 2006.

[10] Walworth JL, Reynolds CM, Rutter A and Snape I "Landfaming" in *Bioremediation of Peteroleum Hydrocarbons in Cold Regions* ed DM Filler, I Snape and DL Barnes Cambridge Univ Press 2008.

Figure 1V-1: Change of TPH with Time at the Experimental Landfarm Plots



In addition to the experimental plots, three other facilities remained at the site after the conclusion of the remediation project in 2005. They are the main landfarm, a ponding and barrier system downstream of the main landfarm and four experimental in situ landfarm plots. The monitoring of these three facilities is discussed in detail below.

B. Main Landfarm

1. Operation

The main landfarm was set up in 2004 in order to remediate hydrocarbon contaminated soil with > 8000 ppm TPH at the site. Most of the hydrocarbon was in the form of fuel oil/diesel. The approximate size of the landfarm was 76 m by 21 m with a depth of about 0.6 m (Photograph IV-1). Fertilizer was added in the form of urea and diammonium phosphate (DAP). Fertilizer was again added in 2006 and 2010; laboratory

experiments conducted in in 2005 showed that the addition of more fertilizer significantly decreased the TPH level while similar experiments in 2010 showed no benefit of added nutrient. The landfarm was aerated with heavy equipment in 2004, 2005 and 2006 but not since. A small control plot at the corner of the landfarm had neither of these treatments.

2. Monitoring Results

The TPH levels in the main landfarm as a function of time are given in Figure IV-2 and Table IV-1. Hydrocarbon analyses are notorious for their lack of precision caused mainly by sample heterogeneity but also from differences in water content during sampling. Over the period 2004-2008, there was no significant difference between TPH levels in soils from the top horizon and those from lower levels. However, in 2010, results showed lower TPH levels in the upper horizon. Table IV-1 gives the TPH levels in the main plot and the small control plot for the set of results obtained from 2004 to 2010. Bioremediation leads to a reduction in the ratio of heptadecane (a straight chain hydrocarbon) to pristane (a branched hydrocarbon with similar boiling point) – the C_{17}/Pr ratio. Figure IV-3 shows this change in the ratio as a function of time for the main area and the control plot. This plot clearly shows that bioremediation is occurring in the main plot but not the control plot. The TPH in the landfarm was characterized by analysis for hydrocarbons by the CCME method Table VII-15) and by examination of the gas chromatograms. These tests showed that the material was weathered diesel fuel.

Table IV-1: TPH Levels (ppm) at the Main Landfarm as a Function of Time

	Main Landfarm		Control Plot
Sampling Date	TPH Range	TPH Mean and Standard Deviation	TPH Mean
August 2004	1440-4860	3320±970	3320
31 July 2005	670-2920	1630±840	3225
19 August 2005	1190-4280	3040±1370	4280
4 September 2005	1670-3550	2810±770	4620
27 July 2006	1070-3420	2140±690	2280
5 August 2006	540-2760	1510±560	3360
2 August 2007	360-1430	810±410	1690
18 July 2008	617-1860	1410±560	2470
9 August 2010	950-3940	1670±640	3160

Figure IV-2: Change of TPH with Time at the Main Landfarm

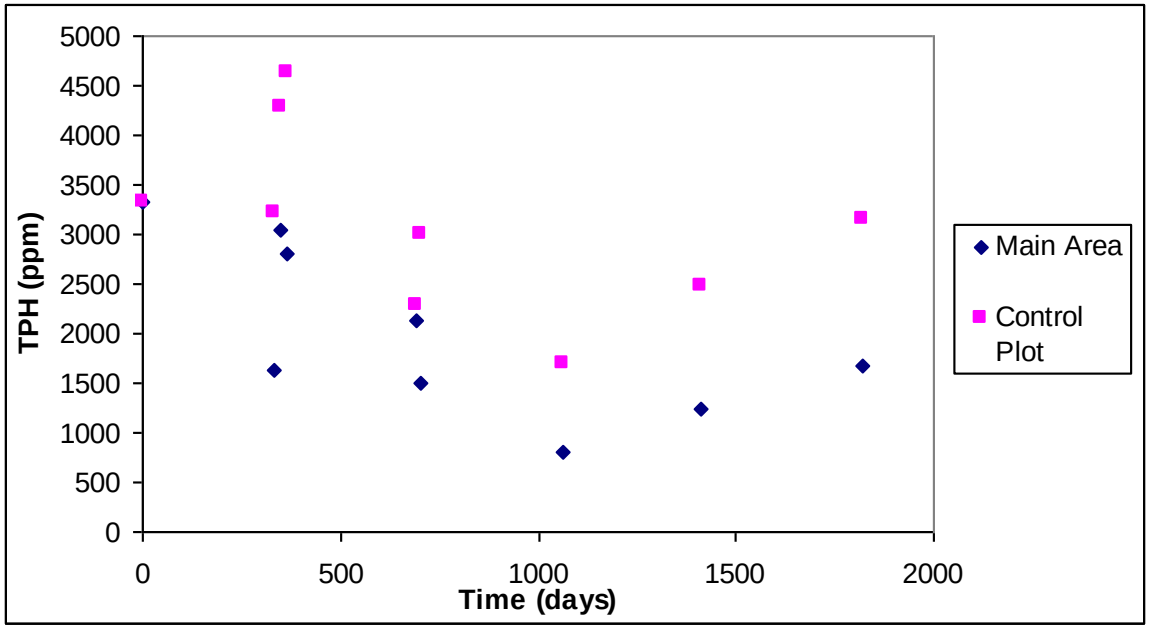
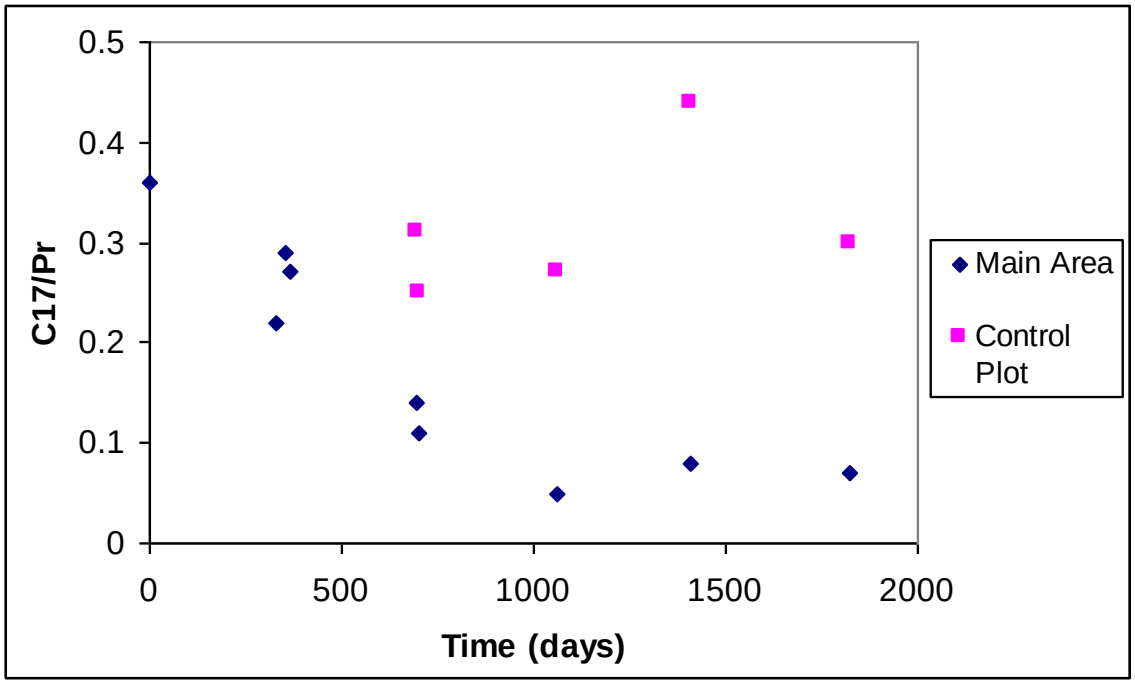


Figure IV-3: Change of C_{17}/Pr Ratios with Time at the Main Landfarm

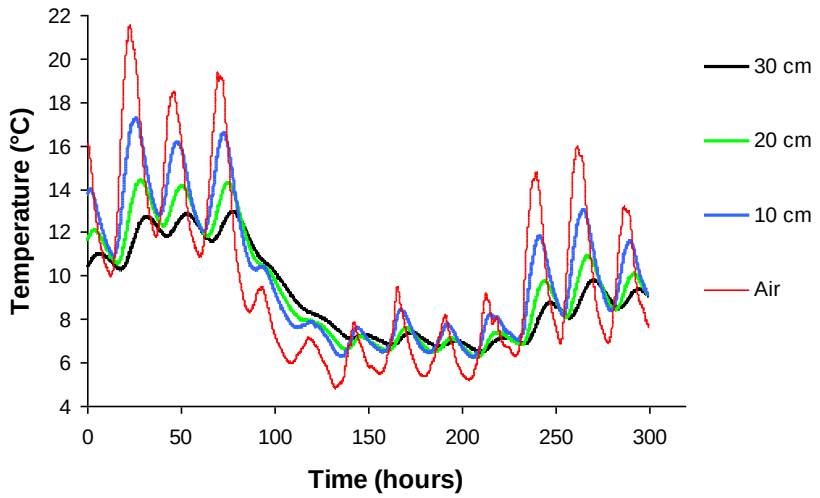


Monitoring of soil temperature within the landfarm in 2005 showed that in the last week of July and the first week of August the soil temperature rose as high as 18 C in the top 10 cm on a sunny day while at 40 cm temperatures were between 6.1 and 11.3 C. Table IV-2 shows the soil temperatures at various depths within the landfarm. Figure IV-4 shows some of the data obtained over a 12 day period in 2006. These results were compared to those obtained from the laboratory experiments which were carried out at various temperatures. They suggested that both aeration and bioremediation were important in the reduction of TPH levels at the main landfarm.

Table IV-2: Soil and Air Temperatures at the Main Landfarm From 17 July to 6 September 2005

	Soil Temperature (° C)					Air Temperature (° C)
Depth	10 cm	20 cm	30 cm	40 cm	10-40 cm	-
Average	8.6	7.8	7.3	6.9	7.7	8.6
Range	1.9-13.9	2.2-12.0	2.8-10.3	3.8-9.5	-	0.4-19.7

Figure IV-4: Soil and Air Temperatures at the Main Landfarm During a 12 Day Period in the Summer of 2006



Nutrients were monitored each year except for 2009 when the weather and other logistical problems interfered with the program. The total Kjeldahl nitrogen levels in the soil ranged from about 100-700 ppm. The available nitrogen in the form of extractable ammonia and nitrate were generally less than the detection limit except when fertilizer had been recently added. However some extractable nitrate and ammonia was detected in 2010 though no fertilizer had been added since 2006; sampling was undertaken prior to fertilizer addition in 2010. It may be that the available nutrient becomes bound but it is not clear whether it is still available to promote bioremediation. Phosphorus levels are low but extractable phosphate was present at low levels in all samples. Table VII-16 in the Appendix shows the data obtained over the 5 years of monitoring.

The level of hydrocarbon degraders have been determined on occasion. These levels are expected to parallel the rate of bioremediation. Table VII-17 shows levels that have been obtained both at the main area and the control plot but these are difficult to interpret.

Photograph IV-1: The Main Landfarm in 2009

C. Ponding and Barrier Research

A pond and barrier system was constructed in 2004 (Photograph IV-2). This novel system was installed to prevent further migration from the main landfarm and residual TPH in the imploded tank area and to examine its effectiveness in removing TPH from a drainage pathway under Arctic conditions. It was reasoned that a pond would help in the removal of volatile TPH by adding a large surface area for evaporation and the use of an oil absorbent boom on the surface of the pond would remove any hydrocarbon on the water surface. Additionally, the placement of a barrier system incorporating materials to absorb TPH from water would remove any TPH from the water or entrapped particles.

The soil and water monitoring points were established at locations upstream, downstream and within the system reservoirs in 2004 as shown on Map IV-1. Results of analyses of the soil and water samples are given in Tables IV-3 and IV-4. The 2005 numbers probably reflected upstream remediation activity rather than a decrease in TPH levels in the drainage pathway. For the subsequent years, the soil values represent variable contaminant levels at this contaminated area while no TPH could be detected in any water samples above or below the treatment system.

Table IV-3: Results of Soil Analyses for TPH at the Imploded Tank Drainage Area Ponds and Barriers

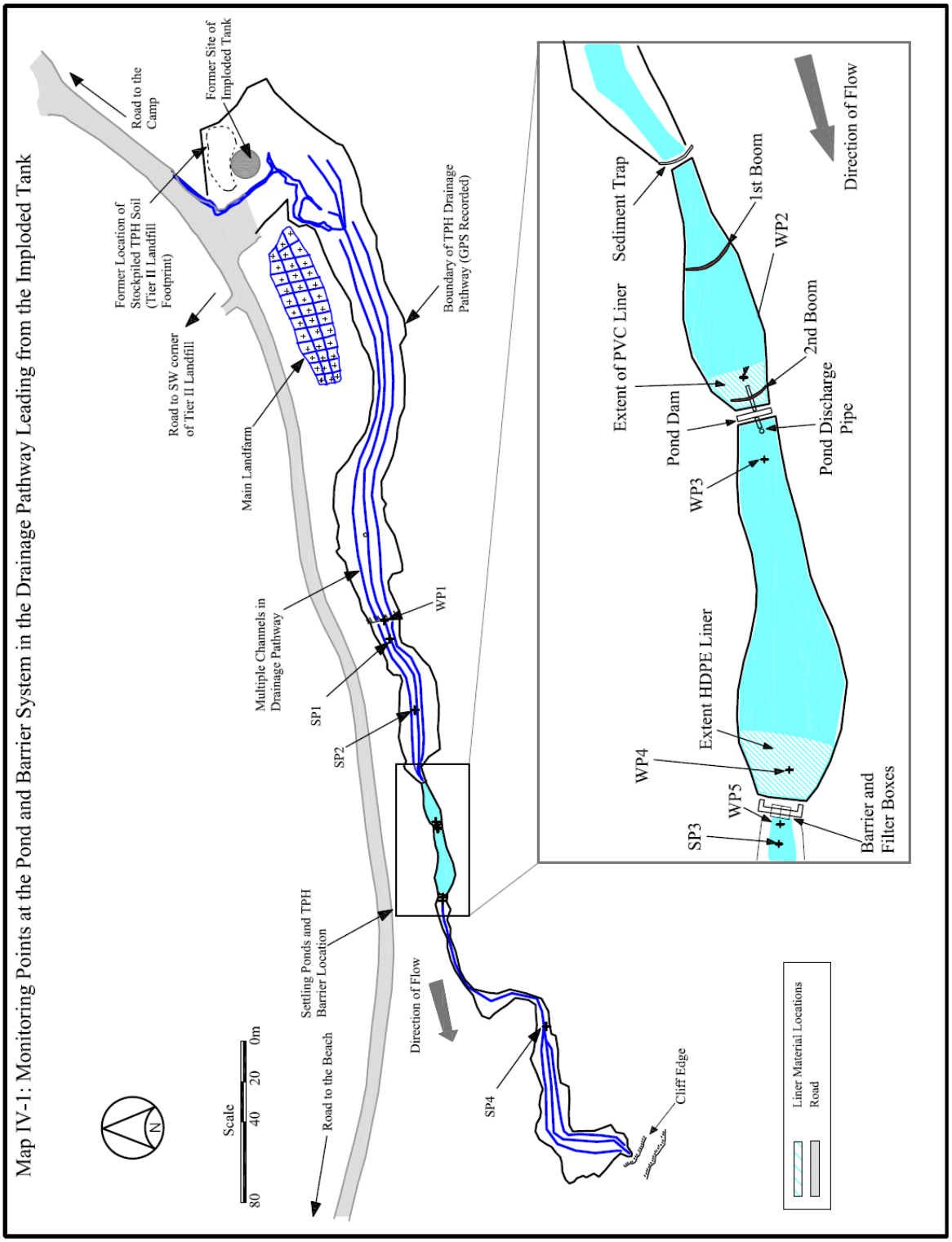
Soil Monitoring Point	Location	TPH (ppm)				
		2005	2006	2007	2008	2010
SP1	Below waterfall	710	310	370	430	280
SP2	Between waterfall and barrier	<40	<40	<40	400	<40
SP3	Just beyond barrier	600	182	290	310	860
SP4	Between barrier and cliff	100	<40	100	850	190

Table IV-4: Results of Water Analyses for TPH at the Imploded Tank Drainage Area Ponds and Barriers

Water Monitoring Point	Location	TPH (ppm)				
		2005	2006	2007	2008	2010
WP1	Waterfall Upstream of Pond	0.19	<0.20	<0.10	<0.10	<0.10
WP2	Pond #1	0.31	<0.20	<0.10	<0.10	<0.10
WP3	Pond #1 Discharge Pipe	0.16	<0.20	<0.10	<0.10	<0.10
WP4	Pond #2	0.29	<0.20	<0.10	<0.10	<0.10
WP5	Filter System Discharge	0.23	<0.20	<0.10	<0.10	<0.10

Nitrogen and phosphorus levels determined in soil samples from monitoring points suggest that there has been little or no leaching of fertilizer from the main landfarm (Table VII-18). Hydrocarbon degrader levels (Table VII-19) are generally lower than in the landfarm as might be expected, though natural bioremediation has been shown to be occurring in the imploded tank drainage pathway.

Photograph IV-2: The Hydrocarbon Pond and Barrier System in 2009


Map IV-1: Monitoring Points at the Pond and Barrier System in the Drainage Pathway Leading from the Imploded Tank
Road to the Camp
Former Site of Imploded Tank
Former Location of Stockpiled TPH Soil (Tier II Landfill Footprint)
Road to SW corner of Tier II Landfill
Main Landfarm
Boundary of TPH Drainage Pathway (GPS Recorded)
Multiple Channels in Drainage Pathway
SP1
SP2
WP1
Settling Ponds and TPH Barrier Location
Road to the Beach
Direction of Flow
SP4
Cliff Edge
N
Scale
80 40 20 0m
Extent of PVC Liner
Sediment Trap
1st Boom
WP2
Direction of Flow
2nd Boom
Pond Dam
Pond Discharge Pipe
WP3
Extent HDPE Liner
WP4
WP5
SP3
Barrier and Filter Boxes
Liner Material Locations
Road

Gravel and charcoal (GAC) cassette filters form the final step of the pond and barrier system. The contents of the cassettes were replaced by clean gravel and GAC in 2005, 2006 (gravel only) and 2010. Measurable levels of TPH was found in two sections of the GAC filters in 2005 but this corresponded with only a small amount of TPH (0.75 g) and none has been detected since. This was likely due to upstream remediation activities but it does show that the barrier is capable of trapping TPH. Samples from the boom material were collected each year but interference from the material precluded analysis for TPH. Inspection of the whole system each year showed no problems with erosion or clogging. However by 2008 the PVC liner forming the first pond was showing damage above the water line but the seal on the pond was intact. This was not entirely unexpected since the pond liner is subject to uv-degradation and is much thinner than the HDPE liners used on the second barrier and the PCB barriers.

D. In Situ Landfarm Experiment

An ideal way to remediate fuel contaminated soil in the Arctic would be to add fertilizer on top of the affected area. The fertiliser might then percolate into the contaminated zone and promote bioremediation. Such an in situ scheme would be extremely cost effective and would result in no physical disturbance of the tundra. Such an in situ bioremediation might be successful in that most TPH contamination is in the surface active layer. On the negative side, the soil temperatures are low, particularly at the base of the active layer where contamination might be greatest, oxygen may be limited and the added nutrients may not reach the contaminated zone.

In order to investigate the performance of bioremediation in an in situ study in the Arctic one needs to add nutrients to a fuel contaminated area and observe changes in TPH concentration. At the same time TPH levels in an associated control plot in which no nutrients are added, needs to be followed. The main problem with this concept is that TPH levels in soil from a spill are extremely heterogeneous. Therefore, in order to carry out the study at Resolution Island it was necessary to excavate some TPH contaminated soil and homogenize it and then place it back in the ground. It was further decided that in this study the soil should be compacted into plots formed by excavation of pits in the ground in order to simulate undisturbed soil. Four holes measuring 5 m by 5 m and with a depth of 0.6 m (15 m^3 each) were excavated in the ground in the barrel cache valley.

Excavated, screened and mixed TPH contaminated soil was then placed in each hole and compacted.

The four plots were treated as follows::

- CP1 control plot – no fertilizer added
- FAS2 – no fertilizer added until the soil had settled for 2 years – fertilizer was added to this plot in 2007
- FAS1 - fertilizer added in 2005 and 2006 to the surface
- FAM - Fertilizer mixed with the soil in 2005 and added to the surface in 2006

Figures IV-5 and IV-6 show the changes in TPH and C_{17}/Pr ratio with time for the 4 plots. The two plots to which fertilizer was added in 2005 and 2006 now have reduced TPH levels and much reduced C_{17}/Pr ratios and therefore significant bioremediation must have occurred here. The control plot has no significant change to the TPH level or the C_{17}/Pr ratio. Surprisingly neither has the FAS2 plot to which fertilizer was added after a two year settling period. Therefore either the fertilizer failed to permeate the ground or there was not enough oxygen to support bioremediation. Laboratory experiments in 2010 confirmed these deductions. For the FAS1 and FAM plots TPH was lost from soil with or without added fertilizer showing that there was sufficient fertilizer present to support bioremediation. For CP1 and FAS2 plots , bioremediation only occurred in the samples to which fertilizer was added.

Data on Nutrients (Table VII-20), hydrocarbon degraders (Table VII-21 and chemical composition from CCME tests (Table VII-22) have also been obtained as a function of time for all four plots.

Figure IV-5: Change of TPH with Time at the In Situ Landfarm

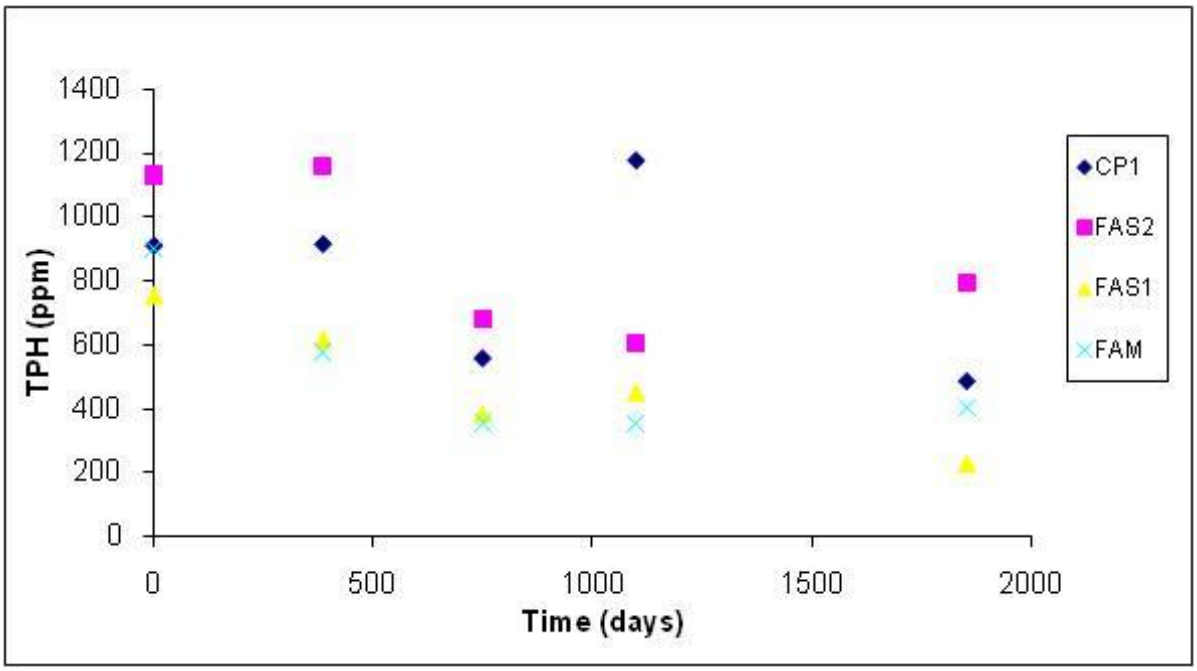
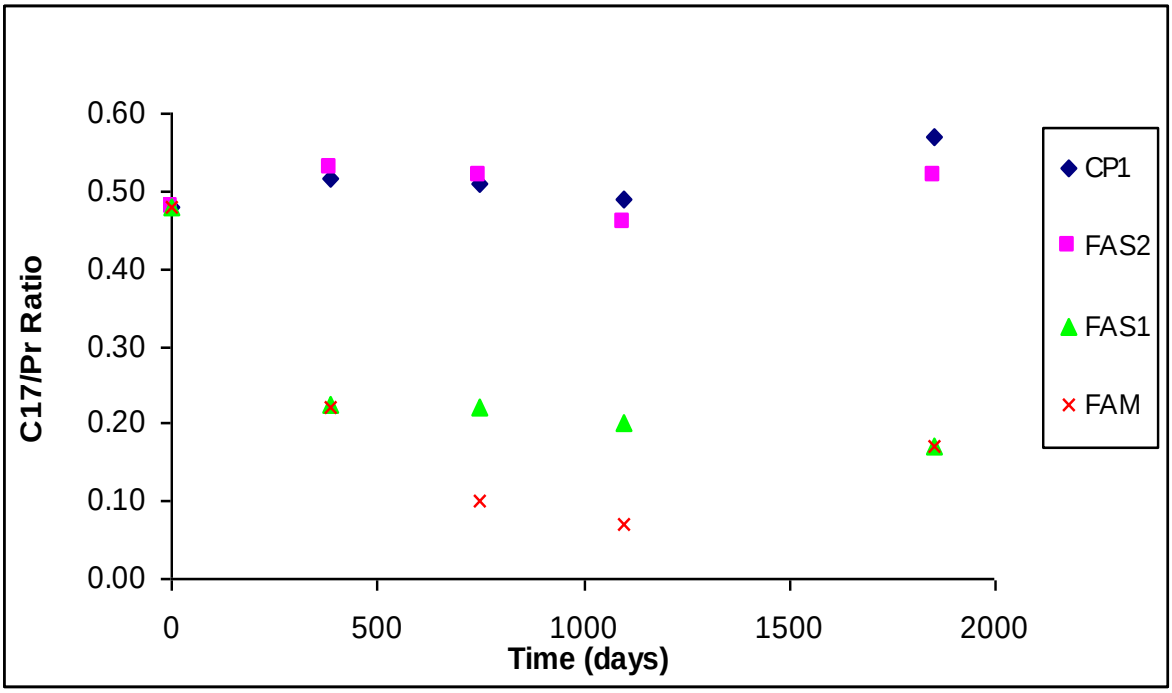


Figure IV-6: Change of C_{17}/Pr Ratios with Time at the In Situ Landfarm



E. Conclusions

The TPH levels at the main landfarm and the drainage pathway are all much below the cleanup criteria of 8000 ppm. The pond and barrier system is still functional and probably working well to stop migration of residual TPH but it has been difficult to get tangible monitoring results to prove this.

Results from the in situ landfarm experiment are interesting. Those plots to which fertilizer was added shortly after their construction show decreases in TPH and the C_{17}/Pr ratio but the control plot or the plot to which fertilizer was added in 2008 do not. This was expected for the contol plot but not the one to which fertilizer was added in 2008. It is unclear whether this was due to the fertilizer not penetrating the ground or other factors such as lack of oxygen below the surface.

F. Recommendations

It is recommended that no further monitoring of the main landfarm is needed. The pond/barrier system should remain in place since it is probably helping to reduce TPH migration and TPH levels.

The in situ landfarm plots have produced interesting results and their study should to continue. Addition of fertilizer into the ground at depth should be undertaken to ascertain whether bioremediation can be initiated by this method on a stable unaerated diesel fuel contaminated soil.

V. OTHER MONITORING ACTIVITIES

A. PCB Transportation Routes

There are three pathways by which PCBs can move in the environment. These are by leaching, through run off, or through the atmosphere. PCBs are not readily volatilized and it is generally accepted that, even for atmospheric pathways, they move on water or soil particles to which they are attached. Leachate tests have been carried out on Resolution Island soils and these have shown that the PCBs are not leachable to any significant degree[11]. The barriers discussed in Chapter II are designed to control the movement of PCBs through run off at the two major areas from which PCBs were found at high concentrations, namely the S1/S4 pathway and the furniture dump drainage area. In this chapter, the next section involves further monitoring of runoff at locations around the site where there are active water courses. This is followed by a study of atmospheric transport through the analysis of plant samples.

B. Surface Water

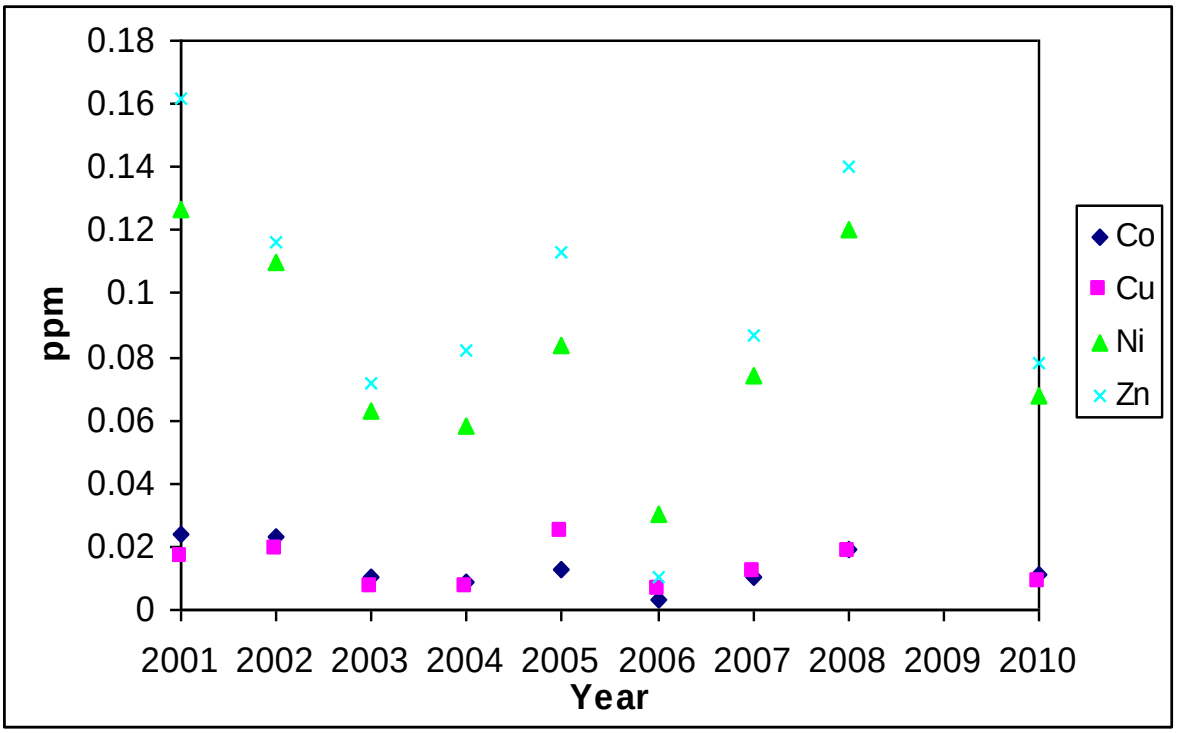
In order to establish background data, water samples were collected from several locations and analysed for PCBs, and the eight elements of the DEW Line Clean Up Criteria. This surface water monitoring was only conducted in 2005 and 2010 with the exception of the water flowing by the old officer's mess which was also analysed in 2006, 2007 and 2008. Metals are for the dissolved fraction.

For arsenic, cadmium, chromium and lead all are less than the method detection limits. For the other four elements the results in 2010 are between the minimum and maximum values that have been found for each location over the period 2001-2009. The results are presented in Table VII-23. Result vary quite a lot for nickel and zinc as is illustrated by Figure V-1 which shows the variation of the four metals with time for the water flowing near the Officer's mess. For most locations, as mentioned above, there is no data for 2006-2009. Lake water was collected from the old water lake in 2006 and 2010 and from the new water lake beyond the barrel cache valley from 2001-2005. The levels of all metals are higher in the old water lake. These levels are in the same range as those of the S1/S4 beach stream which flows from the lake but again levels vary quite a

[11] Analytical Services Unit (1998). Resolution Island 1997 Scientific Investigations. Prepared for Indian and Northern Affairs Canada

lot for nickel and zinc. PCB levels in the water are all very low but are measureable on occasion when the detection limit is 0.020 ppb. This is to be expected at this site were there was widespread PCB contamination of the ground.

Figure V-1: Levels of Cobalt, Copper, Nickel and Zinc in Water Collected from Near the Old Officer's Mess as a Function of Time.



C. Plants

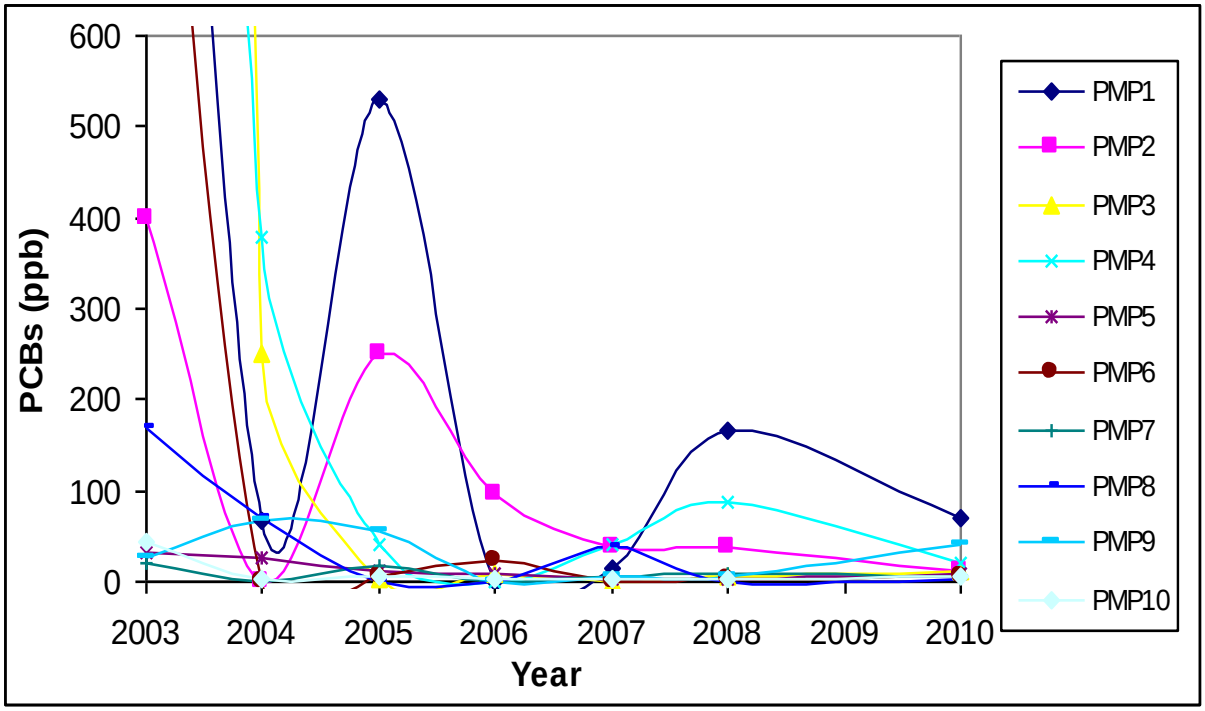
Results have now been obtained for seven years at the plant monitoring points. During the first three years (2003-2005) there was considerable remediation activity at the site particularly in 2003 when CEPA soil was being excavated. In 2007, 2008 and 2010, the last three years that this monitoring was undertaken, there was minimal soil disturbance. Table V-1 and Figure V-2 show the change in PCB levels at the ten monitoring points with time. The level of PCBs in the plants in the areas removed from remediation action had already dropped in 2005 presumably due to the removal of the high level CEPA soil. The results may show that vehicular traffic, which produces considerable dust, was still important up to 2006. These results indicate that the removal of the PCB contaminated soils has greatly reduced the airborne transport of PCBs. They also show that plant analysis is a good way to determine aerial transport of contaminants.

Plant samples were analysed as part of the environmental assessment in 1993. Results of these determinations are shown as ranges for various areas on Map V-1; results were for various Arctic plants, as opposed to Willow (Salix Polaris) used in this study; remote background plant samples from > 1.5 km from the site all contained < 4 ppb PCBs. At this time some plants would have been growing in PCB-contaminated soils and might therefore reflect uptake as well as aerial transport. Map V-2 shows the location of the ten monitoring points and gives the average PCB concentration found in 2007, 2008 and 2010. As can be seen there has been a large decrease in the level of PCBs in plants between Maps V-1 and V-2 which reflects the significant reduction in aerial transport of PCBs as a result of the site remediation.

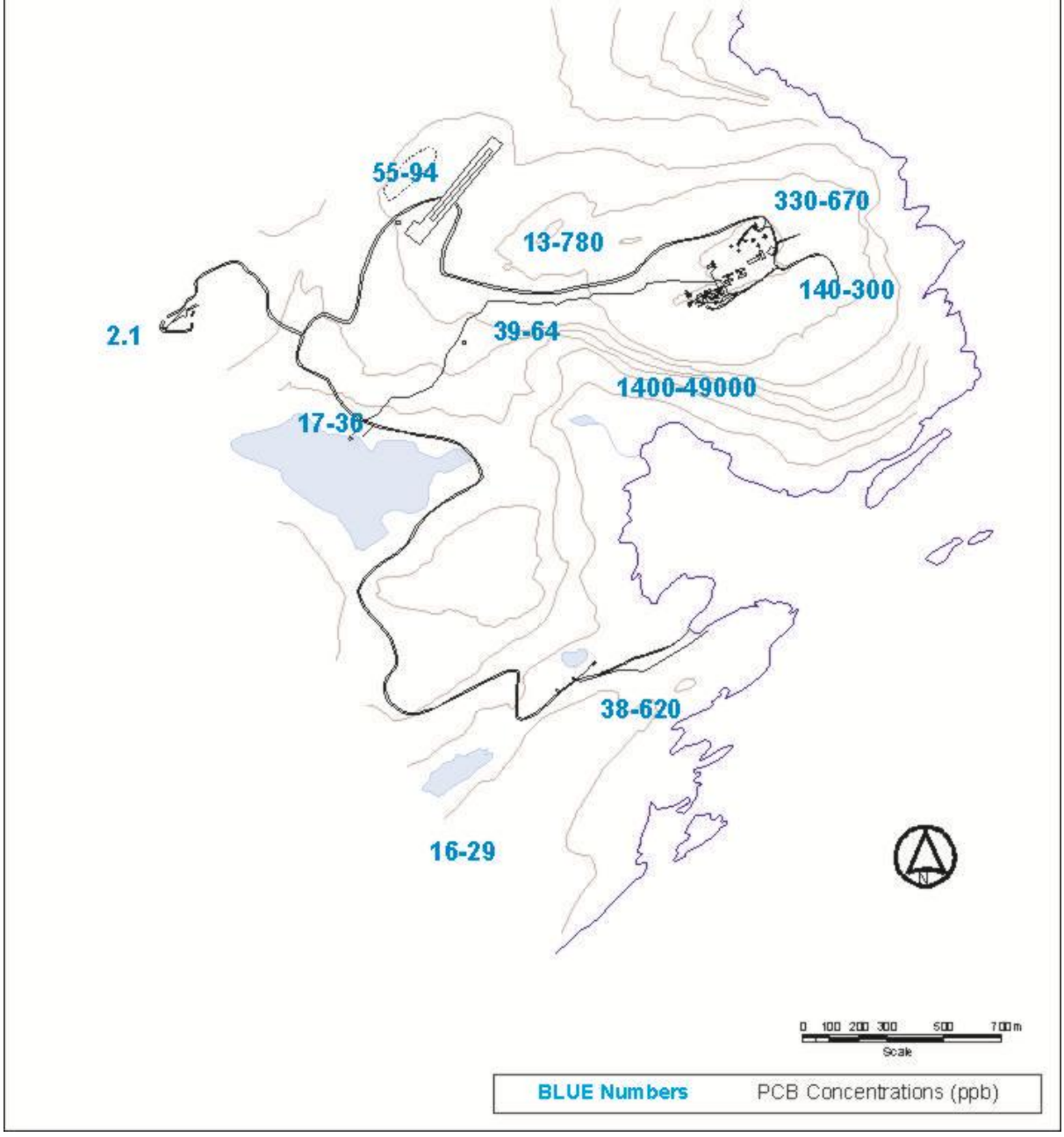
Table V-2: Results of Analyses of Background Plant Samples in ppb (2003-2010)

Point		2003	2004	2005	2006	2007	2008	2010
PMP1	Camp – old officer's mess	1700	66	530	-	15.5	166	71
PMP2	NE of Tier II landfill	400	<3.0	250	97	38	37	10.8
PMP3	Airstrip drainage pathway	11000	250	4.3	8.0	<3.0	6.0	12.9
PMP4	Near imploded tank	3300	380	42	-	40	87	20
PMP5	1000m NE of airstrip	33	25	11.3	7.9	4.0	3.8	9.4
PMP6	Radio Hill	1090	<3.0	5.8	22	<3.0	3.1	7.1
PMP7	S1/S4 Beach	21	<3.0	18	-	6.6	7.7	6.4
PMP8	Beaching area	170	70	-	-	38	-	4.0
PMP9	S of barrel cache valley	26	67	54	-	6.1	6.9	41
PMP10	New water lake	43	<3.0	4.5	<3.0	3.4	4.5	6.4

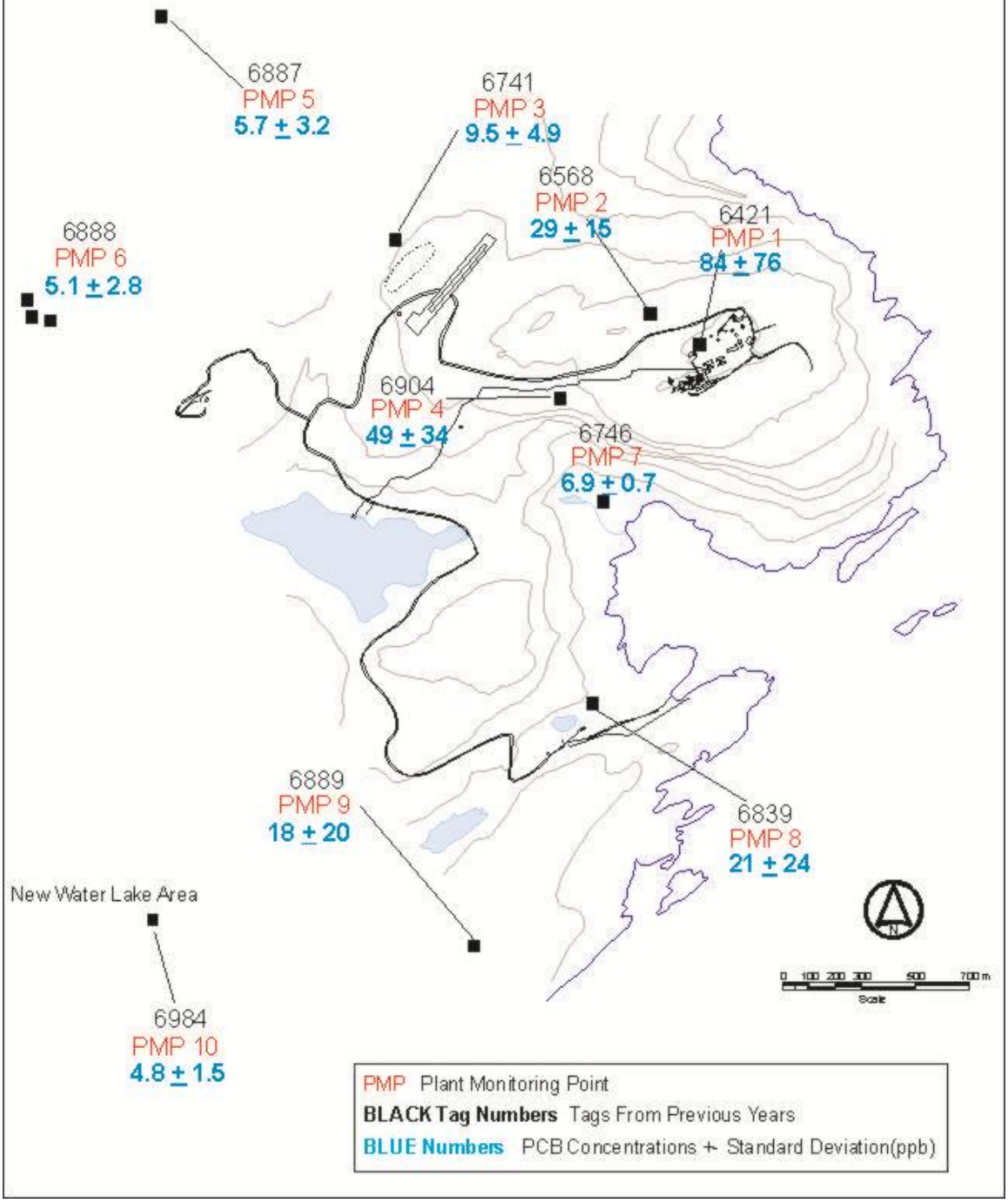
Figure V-2: PCB Levels in Plants From Various Locations at the Site With Time



Map V-1: Locations and PCB Concentrations of Background Plant Samples Collected in 1993



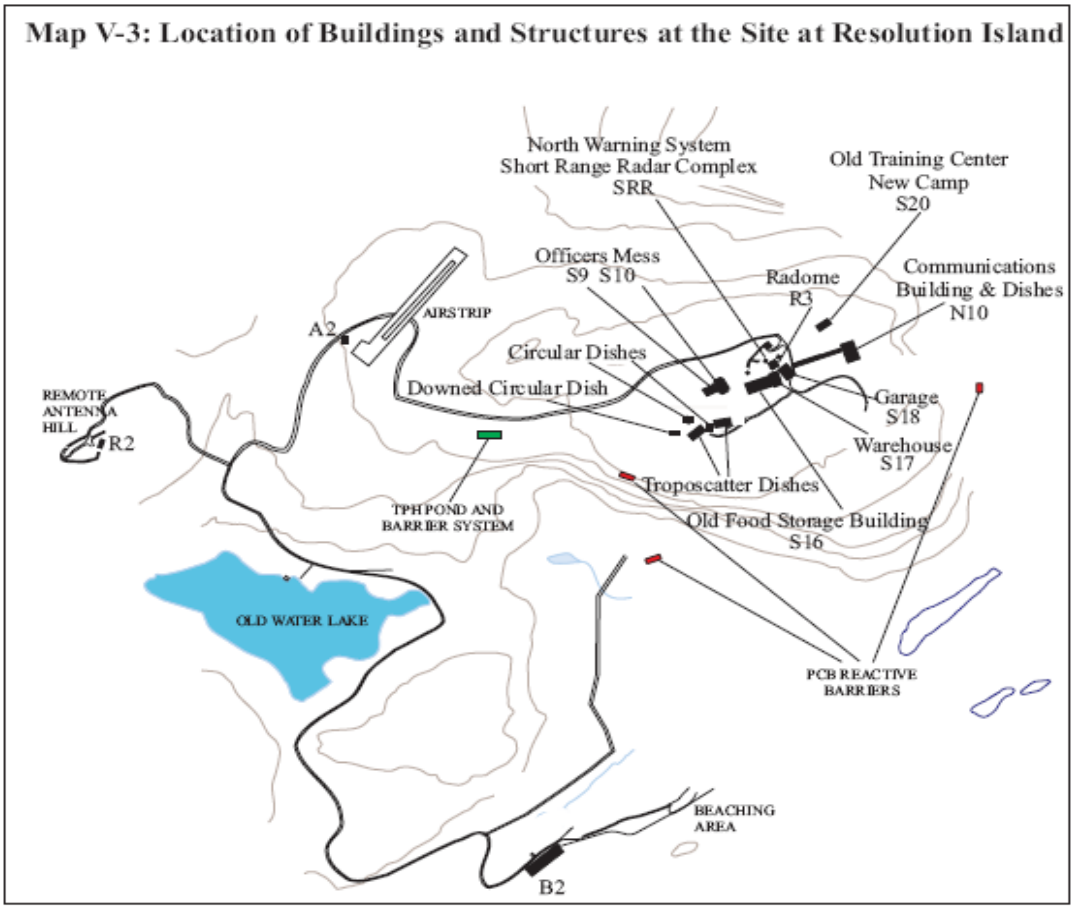
Map V-2: Locations of the Monitoring Points and Average PCB Concentrations of Background Plant Samples Collected in 2007, 2008 and 2010



D. Buildings and Debris

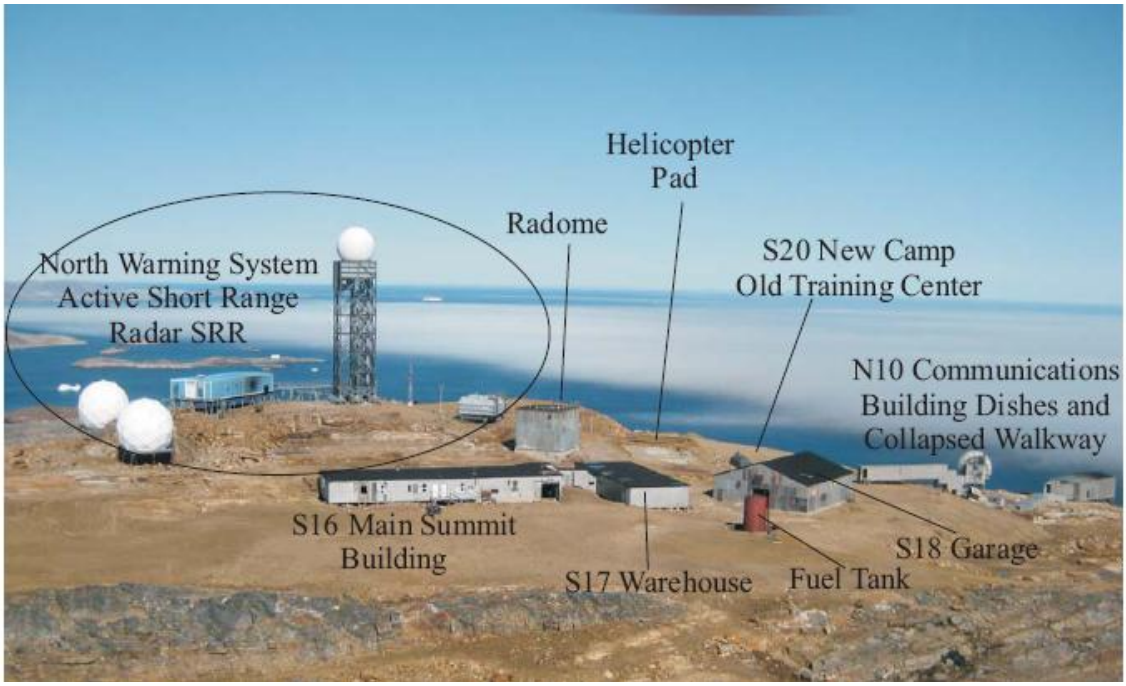
At the request of INAC all remaining structures and major debris at the site were photographed in 2010. Map V-3 shows the locations of all the structures and Photographs V-1 and V-2 show some of the structures at the summit. The location and description of the structures and debris are given in Table V-3 along with a key to Photographs 22 to 65 which is given in the 2010 Resolution Island report[12]. Most of the buildings and structures are in reasonable shape but some are losing pieces of sheet metal while a few have polar bear damage. The beach building, B2, is particularly prone to perennial winter damage which is unfortunate in that it is useful for storage for off-site shipment. There is very little debris present other than inside buildings; as part of the remediation program pieces of wood and metal on the ground were collected and buried in the non-hazardous landfills.

Map V-3: Location of Buildings and Structures at the Site at Resolution Island



[12] Analytical Services Unit (2011). Resolution Island 2010 Monitoring and Research. Section V. Prepared for Indian and Northern Affairs Canada

Photograph V-1: Some of the Structures Remaining at the Summit



Photograph V-2: The South East Part of the Summit

Table V-3: List of Remaining Buildings and Physical Debris at Resolution Island

Building Number and Name	Comments	Photograph Number[12] and Location
R3: Radome	Inside of building is wet but it provides useful storage for the Kubota loader and GAC	Photograph 22: North side Photograph 23: Inside radome
Troposcatter Dishes	Are in stable and good condition but with some sheet metal loss. Probably contains asbestos	Photograph 24: Troposcatter dishes and circular dish between
Circular metal dishes	One dish was taken down to recycle aluminum but this was not carried out and it remains on the ground at original site. The other is still standing and in excellent condition	Photograph 25: Circular dish dismantled on ground
S9 and S10: Officer's Mess and Officer's Living Quarters	Building exteriors is stable and in good condition but there is wood and metal debris on the ground surrounding the building. The interior is full of debris. At one time this was to be a museum on site. All the artifacts have disappeared	Photograph 26: East side and exterior entrance Photograph 27: South side view of S9, S10 Photograph 28: Interior view of bar area Photograph 29: Interior view of corridor
S16: Old Food Storage Building Remediation Project Dining Room and Office Areas	Building is solid with exterior in good condition. Interior is wet and debris in several rooms particularly camp kitchen and old supervisors office. Building has many unsecured entrances	Photograph 30: South side Photograph 31: Entrance to main room Photograph 32: Main room Photograph 33: 2009 camp kitchen and bear debris Photograph 34: Electrician's workshop Photograph 35: Electrical panels at north entrance Photograph 36: Corridor sbetween S17 from S16
S17: Warehouse	Building is solid with exterior in good condition. Interior is dry and entrances are secured.	Photograph 37: Warehouse Photograph 38: Entrance to S17 and S16 Photograph 39: Warehouse interior Photograph 40: Carpenter's garage

Building Number and Name	Comments	Photograph Number[12] and Location
S18: Garage	The building is in good condition but the garage doors at both ends were blown in the winter of 2007. There is some debris remaining inside. The concrete floor is in good condition but extremely wet	Photograph 41: Garage Photograph 42: West side entrance with missing door Photograph 43: East side garage door entrance Photograph 44: Interior debris on north side Photograph 45: Interior of S18 on the south side
New POL	Brought on site for NWSO installation in about 1989. Empty and in good shape	Photograph 46: Fuel tank
S20: New Camp (Old Training Centre)	Interior of S20 was renovated in 2010. The generator (old genset) was moved to present location in 2006. The seacan is in good condition and the interior is dry. It contains ASU supplies	Photograph 47: West side view of S20 including kitchen trailer, seacan, and generator trailer Photograph 48: Generator Photograph 49: Seacan
N10: Communication Building with Two Dishes and enclosed fallen walkway and stairs	The exterior is in good condition but missing doors. The interior is full of electrical and other debris. All PCB containing components were removed in the 1980s and 2004. Cables to enclosed walkway were cut in 2006 and it fell over during the following winter It remains on the ground in the original location	Photograph 50: Communications building and crumpled walkway Photograph 51: N10 with two dishes Photograph 52: Inside N10 showing electrical equipment Photograph 53: Fallen walkway
A2: Airstrip Building	It has deteriorated in last 2-3 years primarily due to bear damage. ATVs have been stored here since 2006. Both doors can be secured	Photograph 54: Main entrance showing bear damage on walls Photograph 55: Rear double door entrance
R2: Remote Antennae Hill Building	Only one building remains. Exterior walls are solid with many holes It was used as a fire training building and much debris (some burned) remains within the building. There is no debris outside on rest of the antenna hill area.	Photograph 56: Main entrance (south side) Photograph 57: Rear entrance (north side) Photograph 58: Interior with burned debris Photograph 59: Interior showing more debris

Building Number and Name	Comments	Photograph Number[12] and Location
B2: Beach Building PCB Storage	The building is gradually disintegrating. Both garage doors have blown in, the west side in 2008 and the east side in 2009. Some sheet metal panels are missing from the sides and the roof.	Photograph 60: Northeast view of B2 with blown-in walls and garage door Photograph 61: Southwest view of B2 Photograph 62: B2 interior Photograph 63: View of west side entrance and PCB storage facility
Other debris	Most debris outside of the buildings was cleaned up during main remediation project	Photograph 64: Area beyond furniture dump which was previously strewn with physical debris and downed tower. Photograph 65:

E. Conclusions

The monitoring of plants has been useful is demonstrating the positive effects of the site remediation on the aerial transport of PCBs while surface water monitoring has shown no changes in contaminant levels as a result of site activity and no sources of contaminant leaching. The photographic record of the current buildings will permit the future tendering of a contract to remove them if required.

F. Recommendations

No further monitoring of water or plants is recommended.

It is recommended that demolition of the remaining buildings should take place if heavy equipment is brought on site for other activities.

VI. RECOMMENDATIONS FOR LONG TERM MONITORING

Recommendation for the various contamination problems and the associated monitoring programs have been itemized at the end of each chapter above. They are reviewed in the following two sections. However, anyone who has ever worked in the Canadian Arctic knows that logistics are a great challenge and a great deal of planning is required for a successful project and for a cost effective one. Section D below outlines the recommended tasks as part of a multiyear program. One general recommendation is that if heavy equipment is to be taken on site then it should only be undertaken when all the tasks have been fully defined and that all remaining cleanup should be done during the visit. Also, the original monitoring program suggested years 7 (2012) and 10 (2015) for the next monitoring visits. These dates should not be written in stone and could be moved a year or two to fit in with an overall logistics plan.

A. PCBs

Main Problem is still PCBs – CEPA soils and the furniture dump which continues to generate them.

1. PCB Excavated Soils

The five drums of CEPA sediment and barrier material need to be dealt with by taking them off site, either in 2011 or later when such material is no longer being generated at the furniture dump. Tier I and Tier II soils should also be taken off site though the Tier I soils could be used as intermediate fill in a non-hazardous landfill if the remaining on site buildings were demolished.

2. Furniture Dump

This area continues to produce CEPA soil. Each year the ASU has excavated 1-3 drums of material from in front of the silt fence, in front of the barrier and within the barrier, including the barrier filter materials. It had been anticipated after the first few years that the volume of sediment would decrease and also the PCB concentration. Unfortunately this has not happened despite the fact that a very thorough cleanup of the area was done and there appears to be very little material in the drainage pathway. The main part of the drainage pathway between the dump itself and the current barrier was washed with water and vacuumed. The furniture dump was excavated to bedrock but a

large hole remained which was excavated as well as possible by the heavy equipment available. Remediation of the area started in 1999 and was completed in 2000.

The current source of the CEPA soil should be investigated by taking soil samples from within and around the drainage pathway. If the source can be identified then it may be possible to excavated it. Until the PCB levels in sediments at the barrier drop, the barrier should be monitored and shoveled out annually. The barrier should be inspected and geosynthetics monitored.

3. S1/S4 Valley and Beach

The drainage pathway is known to contain CEPA soil and soil contamination at lower levels where this soil cannot be excavated. The level of contamination of the material trapped by the barrier in the valley has been at the Tier I level for the last three years whereas it was at the Tier II level in 2005-2006. The mass of PCBs trapped in the filter box is very low particularly at the beach barrier.

One solution would be to carry on as for the past five years with monitoring and maintenance but at a reduced level; the filters could be left for a few years without changing and only the sediment within the barrier would need testing. The barriers would require shoveling out every year or two depending on the volume of sediment which would ultimately reduce monitoring requirements.

A more permanent solution is recommended. This would include

a) The construction of more Curlex and gabion type barriers to halt the flow of material in the drainage pathway, and

b) The stabilizing of the soil within the drainage pathway by revegetation.

Prior to the remediation of the site in the late 1990s, the soil in the S1/S4 valley was likely not eroding to any great extent because most of the area was covered in mosses and lichens. These would not have been present in these areas in the 1960s and therefore this revegetation took place over a period of about 30-40 years. Moss started growing on the side of the Curlex material by 2005: this geosynthetic is primarily used for hydroseeding embankments. It should be possible to speed up this by transplanting plants and mosses from nearby areas to the disturbed areas within the drainage pathway. If successful, the amount of sediment, and therefore the mass of PCBs, migrating down

the S1/S4 drainage pathway would be substantially reduced. This would permit the barriers to be left unattended. The filter boxes could be filled with stones and gravel and the facility would then provide a permanent barrier to prevent PCBs reaching the sea.

B. Landfills

The Tier II landfill is stable. The only minor concern is the apparent increase in zinc and nickel levels. This increase could be related to the demolition of the galvanized maintenance building prior to construction of the landfill, it could be an analytical artifact or it could be leakage from the landfill itself. Periodic testing of the groundwater at wells MW3, MW4, MW5A and MW5B and MW6 for metals is recommended. At the same time it would be good to test for PCBs in these wells since they are primarily what the landfill contains. The airstrip dump has visible debris especially near the toe which also shows some erosion. Neither of these represents an environmental problem at present but if heavy equipment were to be on site, then more fills should be added and the toe stabilized. It is recommended that monitoring the airstrip dump be continued but only for PCBs. No further testing is recommended for the other landfills. Monitoring should occur in 2012 and 2015 or thereabouts.

C. Other Monitoring

1. Hydrocarbon Contamination

It is recommended that no further monitoring of the main landfarm is done. The pond and barrier system can be left in place but needs not be monitored. The In Situ landfarm plots have produced interesting results and continued treatments and monitoring are recommended.

2. Plants and Waters

It is recommended that monitoring of plants and surface waters is no longer needed.

3. Buildings and Physical Debris

The remaining buildings are obviously going to deteriorate with time and are currently in poor shape. They do not pose much of a hazard as there are virtually no visitors to this remote spot and hence do not represent an environmental risk. The site could be posted to deter visitors. In order to demolish the buildings, a major project

involving the bringing in of heavy equipment to the site would be required. This project would require the extension of the upper site non-hazardous landfill and the production of gravel for this purpose. The fuel tanks and their fuel, which are situated near the beach, require attention. The fuel storage systems at the beaching area, camp and upper site helicopter pad will require inspections annually as required by regulation.

D. Logistical Considerations

The monitoring program for the next few years will depend on results of investigations into the source of CEPA soil at the furniture dump. The plan below assumes no excavation by heavy equipment is required. If a source of PCBs is found at the furniture dump and can be excavated, the logistics will change depending on the scale of the excavation required. In addition to the tasks listed below, monitoring of the landfills in 2012 and 2015 is required.

For 2011

- 2-3 days on site.
- Containerise sediment at furniture dump.
- Delineate PCB soil contamination in furniture dump pathway.
- Replace 1200R filters in furniture dump barrier
- Sample soil monitoring points at all barriers (not beach if time limited)
- Conduct revegetation experiments

For 2012 -2015

- 1-5 days on site.
- Containerise sediment at furniture dump. Determine its PCB level.

- Replace all filters in furniture dump barrier every 2-3 years
- Sample soil monitoring points at all barriers (not beach if time limited)
- If initial experiments are successful, revegetate large areas of the S1/S4 drainage pathway where soils and sediments are found.
- Add additional sediment traps above the S1/S4 valley barrier.
- If sediment volumes drop and PCB levels remain at the Tier I level, replace the barrier filters at the S1/S4 valley and beach barriers with stones and gravel and possibly add a gabion. Shovelling out of the barriers may be required if the amount of sediment in the barriers is too large or if the PCB concentration in the sediment rises.
- Helicopter transport will be required to remove containers of PCB contaminated sediments which currently reside at the barriers. This transport should be coordinated with other activities such as re-positioning of CEPA soil containers or personnel transport to the site for monitoring or a pre-monitoring visit recce.

VII. APPENDIX

A. The 2005 Monitoring Plan

A long term post-remediation monitoring program (LTMP) formed part of the three year final remediation plan for Resolution Island. This plan is concerned primarily with the landfills, former dumps and the permanent interceptor barriers. The remediation plan was based largely on the agreement between NTI and DND for the cleanup and restoration of DEW line sites within the Nunavut settlement area (Environmental Provisions, 1998). The ASU has been requested to up date this plan in light of the current conditions that now exist at the site.

1. Landfills

Three new landfills for non-hazardous wastes were constructed as part of the cleanup, two near the camp and the other near the barrel cache valley. Their construction will be completed in 2006. As part of the LTMP these will be inspected visually for stability only. This visual inspection will look for any major settling, ponding, erosion or frost action that may have occurred. If there are signs of instability at these landfills such that buried material becomes exposed, then remedial action may be required. Monitoring samples will be taken from the Tier II landfill, the airstrip dump and the maintenance dump. All other remaining dumps on site have never been observed to leach. These dumps are therefore are considered low risk and will only be monitored visually.

For the Tier II landfill, visual, water and soil monitoring are proposed as well as the recording of temperatures with thermisters buried in the landfill. Nine monitoring wells and six associated soil monitoring points have been established. Monitoring of these locations started in 2004. Soil points were sampled twice a year while the wells were sampled on a weekly basis. It is proposed that they be sampled twice in 2006 and once a year on the subsequent annual visit. Water from the wells should be tested for the 8 elements of the DCC (As, Cd, Cr, Co, Cu, Pb, Ni and Zn), TPH and PCBs. Soil collected from the six locations close to the monitoring wells will be analysed for the same set of parameters. Remediation steps may be required if the analytical results show a significant increase in contamination over a period of three or more years. Three thermister strings were placed at the landfill during 2005. Temperatures should be recorded several times in 2006 but once during the subsequent annual site visits. This landfill is designed to ensure that all the buried Tier II material should remain frozen.

This steady state should be reached within 3-4 years. Remedial action could be required if all the buried material is not frozen permanently.

The airstrip and maintenance dumps should be visually monitored for stability and have a water and soil sampling program similar to the Tier II landfill. Four monitoring points have been established at the airstrip dump and two at the maintenance dump. Soil and water samples will be taken annually for the 8 DCC metals, TPH and PCBs.

2. PCB Barriers

The three permanent PCB interceptor barriers should be inspected and repaired, if necessary, at each monitoring visit. Any silt collected by the barriers should be excavated into suitable containers and sub-samples collected for PCB analysis. In addition, soil samples should be collected from the clean cells which will be established beyond barriers in order to assess their performance. Water flowing through the barriers and materials in the filter box system should also be collected and analysed for PCBs. The nature of the materials in the filter box are expected to be changed with time due to decreased sediment loading and also as a result of laboratory research findings. Initially all filter materials will be sampled and replaced each year. As PCB levels decrease and sediment stabilizes, filter materials may not need to be replaced annually.

3. Landfarms and TPH Barrier System

The TPH level in the landfarm is already below the cleanup criterion of 8000 ppm diesel fuel. The main landfarm at the site will be aerated several times in 2006 in order to reduce the TPH level, to take advantage of the heavy equipment on site and to be proactive. All other activities related to TPH are associated with research. At the main landfarm, a section has been left undisturbed since its construction. It is proposed that a small area of the landfarm will be rototilled each year. The levels in these two sub-plots will compared to the landfarm as a whole in order to gain insight into landfarming in the Arctic. The barrier system established below the landfarm will be maintained and monitored so as to assess its performance and to judge its usefulness in this type of application and for excavations in general in cold climates.

Work at the experimental plots established in 2003 is now complete. New experimental plots were established in 2005 in order to study the potential use of in situ bioremediation. Annual sampling and maintenance of these plots will be undertaken.

4. Background PCB in Plants

Plant samples have been collected from various locations at the site for the past four years. Plants are good biological indicators of airborne PCBs. It is therefore expected that a decrease in PCB levels should now be seen since both the PCB levels and the level of physical activity at the site have been reduced. Thus one would expect, particularly by 2007, substantially lower PCB levels than during in the period 2002-2005.

5. Monitoring Frequency

Monitoring at the landfills should initially be conducted once a year in early to mid-August from 2006 onwards. The frequency of the program should be each year for 5 years. Then year 7, 10, 15 and 25 if no problems are encountered and approval is obtained from the Nunavut Water Board. Some modifications to the program may be undertaken during the initial 5 years. Such modifications may be to reduce the analytical suite or the number of wells being analysed at the Tier II landfill. These modifications would be contingent on obtaining similar results from the wells for at least two more years. Also, for example, the maintenance dump was leaching cobalt only; if no PCBs, TPH or other metals are found these additional parameters could be removed from the list of analyses required for the two wells at the maintenance dump. The frequency of all other activities should be the same as for the landfills. The level of these other activities will likely be reduced during the first 5 years. Much of the landfarm research activities, for example, are expected to be completed before the end of the five year period.

A full review of all the data is proposed after 5 years in 2010.

6. Infrastructure and Logistics

Logistics are often the most difficult part of environmental remediation planning in the Canadian Arctic and one can never over-plan for such activities. For the LTMP at Resolution Island these comments are particularly relevant given the climate, terrain and the uncertainty of the scope of the work. This latter statement particularly refers to the amount of sediment in the PCB barrier traps and the PCB level in this material.

Infrastructure has been put in place for the LTMP. The old training center building, which has its own generator, will be able to accommodate up to 10 people. In an emergency the NWSO module can be used. For 2006, the remediation of the site will

be completed and most of the equipment shipped off site. It is expected that the ASU will send a team on site for about 2 weeks to complete its work this year. It is expected that QC will be on site with helicopter support for about 4 weeks. The remainder of this section deals with 2007 and subsequent years.

Transportation to the Site

Helicopter support was used for the remediation of the site from 1997-2005. It is expected that a helicopter will be required to move containers of sediment from the barrier sites, at least for the first few years. Prior to 1997 all work was done using Twin Otter transportation. Once the sediment volume in the barriers is reduced it may be possible to use Twin Otter aircraft for the LTMP work. It also may be possible to approach NWSO regarding the use of their helicopter at the site for a day each year to move the containers of sediment.

Barrier Sediment

The volume of sediment in the S1/S4 barriers at the valley and beach areas is expected to be several cubic meters (2-10 m^3 for each location) at least for 2007 and 2008. This material needs to be placed in either barrels or waste wranglers and their PCB levels established. The plan is to transport this sediment off site by Twin Otter or helicopter. A Twin Otter can transport approximately 0.6 m^3 of sediment. Waste wranglers are light weight and many can be transported on site in a single Twin Otter flight. However once they are filled with sediment they may be more difficult to handle on site than barrels.

If the volumes of sediment are large it may be useful to consider alternatives to transporting the soil off site by air. If the sediment contains < 5 ppm PCBs (Tier I), then it could be placed at a suitable location on site and subsequently buried. A stockpile of gravel may be useful to have on site in an appropriate location if this option is being considered. If the level is between 5 and 50 ppm PCBs (Tier II), then the sediment needs to be isolated from the Arctic environment in accordance with the DLCU protocol. Containers filled with Tier II sediment could be stored at building B2 and ultimately removed by barge. Tier I soil could also be removed by barge rather than be buried on site. A few 205 L overpack barrels (UN approved) should be placed on site in case sediment or barrier material containing > 50 ppm PCBs is found.

The annual site visit would take place in early August each year. The sediment would be placed in containers adjacent to the barriers. At the S1/S4 valley barrier the Kabota can be used to excavate much of the soil from the barrier. Some shoveling will be necessary in the two settling ponds to ensure the liner is not breached. Filled containers can be transported on site using the Kabota and/or ATVs and trailers. At the S1/S4 beach barrier, all containers will be filled manually because the barrier is not accessible by the Kabota or ATVs. Once filled, the containers will be moved by helicopter. In subsequent years, if the sediment volume is reduced to less than 1 m^3, it may be possible to move the sediment without the use of a helicopter.

If possible sediment samples would be sent to the laboratory and analyzed before the end of the site visit. Sediment could be sampled in place on day one of the visit and the samples sent to the laboratory the same day. The containers could then be labeled as either Tier I or Tier II before the site visit is complete.

Ground Transportation and Equipment

A Kubota 310 loader plus 2-4 ATVs and trailers should be left at the site to assist in the monitoring which would be expected to take 4-7 days. The Kubota would be used for transporting materials, water and fuel. The ATVs and trailers would be needed for personnel, supplies and barrier sediment. Ideally two would be stored at B2 and two at the upper station site. It is hoped that the road linking the beach with the camp would be open in early August, but the large snow field above the old water lake may pose a problem and erosion at this location may make the road impassable.

Personnel

It is proposed that the ASU conduct the LTMP at least for the first 5 years. The ASU can collect the monitoring samples and inspect and maintain the barriers in one site visit. The ASU would employ at least 2 workers from the Arctic as part of the team. The workers would be needed to run the camp (food, water, generator etc), keep the ATVs and Kubota running and to act as bear monitors. In year 5 an engineer would also be brought on site for a complete appraisal of the landfills. The ASU would have 3-4 of its personnel on site for the 4-7 day visit and would produce a check list prior to the site visit outlining all the monitoring requirements. A monitoring report on the visit would be produced by December 31 each year.

B. Further Discussions Related to the Monitoring Plan in 2008

The long term monitoring plan recommends continuing annual monitoring for 5 years followed by monitoring in year 7, 10, 15 and 25. These time intervals were the same as those used by DND on their DEW Line sites and are based on the premise that after five years trends in the monitoring results should have been established. Clearly if any problems were noted the frequency of future visits might be increased. For the program described in this report, some measurements have become stable and predictable while others are no longer required.

There were some minor logistical difficulties this year and there are perceived problems for next year, in particular with regard to accommodation and on site transport. It would be very beneficial if conditions at the site were known before the site visit so that appropriate adjustments to the program could be made. To that end it is suggested that INAC contact the NWSO to see if it is possible to get a visit to the site on a scheduled NWSO visit prior to mid-July. Such a visit could enable an inspection of sediment levels in the barriers, an assessment on the status of the ATVs and the Kubota loader and of the road system. Depending on the length of this "recce" visit, other activities could be initiated. The old training center is no longer suitable for accommodation. Alternative accommodation could be at the NWSO module or possibly in the old cold storage building occupied by INAC personnel during the remediation program. Given the required changes a detailed logistics plan needs to be developed for next year's visit regarding, fuel, electricity generation, heating, food, sewage disposal etc.

It is getting harder to conduct the monitoring program as the roads, accommodation and ATVs have deteriorated. The status of the Kubota loader is unknown as it has not been operated for two or three years. As a result the monitoring program is getting more difficult to run. Since, as mentioned above, some of the elements of the monitoring program are now less important than in the past, and some produce predictable results, it would make operating the program more manageable if its scope were reduced. The following suggestions are therefore presented below regarding changes to the scope of the monitoring program for 2009; these are presented in the same order as they appear in this report.

- The monitoring of all landfills should remain unchanged. Batteries should be replaced in the 4 thermister units at the Tier II landfill.

- Sampling and analysis of drinking water should be dropped from the program. The same results have been obtained for over ten years. The most important parameters, those regarding bacteria levels cannot be undertaken due to the time delay between collection and analysis. The levels of these have not been a problem in the past.

- Sampling and analyses of the water near the Officer's mess should continue as it relates to possible leaching from the upper site and its non-hazardous landfill.

- Background plant sampling should be dropped from the list for one or two years.

- Sampling and analysis of the main landfarm should be suspended for two years. Levels have now become stable or are dropping slowly. One aspect of the operation of this landfarm which is particularly interesting relates to the periodic or annual addition of fertilizer. After the initial addition of fertilizer it was found by laboratory experimentation that a further addition would be beneficial and this proved to be the case. It is not known whether the fertilizer that has previously been added is available to the bacteria for the promotion of bioremediation. It is therefore proposed to test this in a cold room in the laboratory. If fertilizer is beneficial it would be added in 2010. One way to test this would be to add fertilizer to part of the landfarm for the next two years and then see if this results in a significant increase in diesel fuel decomposition relative to the untreated portion. Unfortunately the C_{17}/Pr ratios can no longer be used to test this as both compounds are now present at levels below the method detection limit. The current diesel fuel level of 1250 ppm is below the remediation criterion of 2500 ppm but the proposed tests would add to our knowledge for the operation of landfarms and also be environmentally beneficial

- Sampling and analysis of the in situ landfarm research experiment should continue as predictable levels have not yet been established .

- Sampling of the TPH ponding and barrier system should be stopped for two years. It has been difficult to assess whether the system is beneficial even though

logistically it seems very likely to be. If it is left in place for a longer time, results may show that the barrier is indeed preventing down stream migration.

- Maintenance and monitoring of the PCB barriers should continue. However, the sampling and analysis of gravel and GAC in the S1/S4 valley and beach systems should be reduced to a single composite sample. If only a little sediment was found in these two barriers it could be left in place for another year. The sampling of the geotextile filters should be also reduced.

- It is suggested the timing of the site monitoring visit be at the start of August rather than mid-July. It is possible that some results this year were different due to the earlier sampling date and also several wells were frozen.

C. Further Discussions Related to the Monitoring Plan in 2009

The long term monitoring plan recommends continuing annual monitoring for 5 years followed by monitoring in year 7, 10, 15 and 25. These time intervals were the same as those used by DND on their DEW Line sites and are based on the premise that after five years trends in the monitoring results should have been established. Clearly if any problems were noted the frequency of future visits might be increased. Conversely some measurements have become stable and predictable while others are no longer required and were therefore dropped this year. There were logistical difficulties this year but some progress was made in terms of future accommodation and transport at the site. Unfortunately the new camp area and any supplies have been compromised by the open window and bear damage. All functional ATVs were removed from the Island to overwinter in Iqaluit. ATVs will not be left on site and gasoline will be brought in from Iqaluit. Next year is year 5 of the monitoring program. Therefore the following points outline some steps that might be taken in regard to the 2010 monitoring program.

- The Recce undertaken this year was extremely valuable in planning and executing the monitoring program and should be repeated in some form in 2010.

- The use of daily transport to and from the site is not recommended because too much time is lost in transport and in securing bear monitors. The working time during the day is therefore too short.

- Part of the Recce must be to ensure that the camp is usable for accommodation. Fuel, electricity generation, heating, food, water, sewage disposal and transport must be adequate for the length of the site visit. The first day of the monitoring visit should be devoted to ensuring this is so and in establishing the camp. A thorough check of all health and safety related equipment (including heaters and generators) should be conducted prior to arrival on site.

- The scope of the monitoring visit should be clearly defined in terms of the overall monitoring plan given that 2010 represents year 5 of the plan. This is a milestone year when the program's first 5 years should be reviewed and future year's activities determined.

D. Additional Tables of Data

Table VII-1: Details of the Four Drums in the PCB Storage Facility and One Drum at the Furniture Dump Each Containing PCBs at Concentration Above 50 ppm

Year Excavated	Labelling on Drum	Location	Drum Contents	PCB (ppm)
2008	Furniture dump barrel #1	inside B2	Soil/sediment	78*
2008	Furniture dump barrel #2	inside B2	Soil/sediment	78*
2008	Furniture dump barrel #3	inside B2	Soil/sediment	78*
2008	Furniture dump barrel #4	inside B2	Soil/sediment and filter material	78*
2010	tag 5502	furniture dump	filters and ponding sediment	58

*Average level of contamination of source

Table VII-2: Details of PCB Concentrations in Sediment in the Drums from the Barriers Now Stored Adjacent to Building B2 or Beside the Barriers

Tag	Old Labelling on Drum	Location	Drum Contents	PCBs (ppm)
5512	valley #1 PCBs 2007	near B2	soil/sediment	3.0
5513	valley #2 PCBs 2007	near B2	soil/sediment	3.0
5514	valley #3 PCBs 2007	near B2	soil/sediment	3.3
5515	valley #4 PCBs 2007	near B2	soil/sediment	2.8
5516	valley #5 PCBs 2007	near B2	soil/sediment	5.9
5517	valley #6 PCBs 2007	near B2	soil/sediment	4.3
5518	valley #7 PCBs 2007	near B2	soil/sediment	3.7
5519	valley #8 PCBs 2007	near B2	soil/sediment	15.7
5520	valley #9 PCBs 2007	near B2	gravel	5.1
5521	beach #1 PCBs 2007	near B2	soil/sediment	0.6
5522	beach #2 PCBs 2007	near B2	soil/sediment	0.5

Tag	Old Labelling on Drum	Location	Drum Contents	PCBs (ppm)
5523	beach #3 PCBs 2007	near B2	soil/sediment	0.5
5524	beach #4 PCBs 2007	near B2	soil/sediment	0.7
5525	beach #5 PCBs 2007	near B2	soil/sediment	0.6
5526	beach #6 PCBs 2007	near B2	filter material & soil/sediment	0.6
5527	furniture dump #1 PCBs 2007	near B2	soil/sediment	30
5528	furniture dump #1 PCBs 2007	near B2	soil/sediment	1.1
5529	furniture dump #3 PCBs 2007	near B2	soil/sediment	26
5530	valley #1 PCBs 2008	near B2	soil/sediment	3.3
5531	valley #2 PCBs 2008	near B2	soil/sediment	2.5
5532	valley #3 PCBs 2008	near B2	soil/sediment	1.3
5533	valley #4 PCBs 2008	near B2	soil/sediment	1.9
5534	valley #5 PCBs 2008	near B2	soil/sediment	3.3
5535	valley #6 PCBs 2008	near B2	soil/sediment	2.7
5536	valley #7 PCBs 2008	near B2	soil/sediment	3.8
5537	valley #8 PCBs 2008	near B2	soil/sediment	2.8
5538	valley #9 PCBs 2008	near B2	soil/sediment	2.3
5539	valley #10 PCBs 2008	near B2	filter material & soil/sediment	1.4
5540	valley #11 PCBs 2007	near B2	soil/sediment	5.6
5541	valley #12 PCBs 2007	near B2	garbage and soil/sediment	5.5
5542	valley #13 PCBs 2007	near B2	soil/sediment	2.4
5543	beach #1 PCBs 2008	near B2	soil/sediment	0.8
5544	beach #2 PCBs 2008	near B2	filter material & soil/sediment	1.0
5545	beach #3 PCBs 2008	near B2	soil/sediment	0.7
5546	beach #4 PCBs 2008	near B2	soil/sediment	2.5
5554	tag 5554 (2010)	S1/S4 valley	filters and sediment	nr

Tag	Old Labelling on Drum	Location	Drum Contents	PCBs (ppm)
5555	tag 5555 (2010)	S1/S4 valley	soil/sediment	3.6
5556	tag 5556 (2010)	S1/S4 valley	soil/sediment	3.4
5557	tag 5557 (2010)	S1/S4 valley	soil/sediment	2.2
5558	tag 5558 (2010)	S1/S4 valley	soil/sediment	1.8
5559	tag 5559 (2010)	S1/S4 valley	soil/sediment	5.7
5560	tag 5560 (2010)	S1/S4 valley	soil/sediment	3.7
5504	Tag 5504 (2010)	S1/S4 beach	filters and sediment	0.4
5505	Tag 5505 (2010)	S1/S4 beach	soil/sediment	4.3
5506	Tag 5506 (2010)	S1/S4 beach	soil/sediment	1.5
5507	Tag 5507 (2010)	S1/S4 beach	soil/sediment	0.9
5508	Tag 5508 (2010)	S1/S4 beach	soil/sediment	0.5
5510	Tag 5510 (2010)	S1/S4 beach	soil/sediment	1.7
5511	Tag 5511 (2010)	S1/S4 beach	soil/sediment	2.4
5503	tag 5503	furniture dump	soil/sediment from in front of silt fence	35

nr no result but likely Tier I level

Table VII-3: PCB Concentrations in Sediment in the Waste Wranglers from the Barriers and Now Stored Adjacent to Building B2 or Beside the Barriers

Tag	Old Labeling on Waste Wrangler	Location	Waste Wrangler Contents	PCBs (ppm)
5547	beach waste wrangler #1 2008	near B2	soil/sediment	8.6
5548	beach waste wrangler #2 2008	near B2	soil/sediment	1.1
5549	beach waste wrangler #3 2008	near B2	soil/sediment	2.1
5550	beach waste wrangler #4 2008	near B2	soil/sediment	2.9
5551	beach waste wrangler #5 2008	near B2	soil/sediment	0.4
5552	beach waste wrangler #6 2008	near B2	soil/sediment	3.9
5553	beach waste wrangler #7 2008	near B2	soil/sediment	1.6
5561	tag 5561	S1/S4 valley	soil/sediment	5.3
5509	tag 5509	S1/S4 beach	soil/sediment	2.4

Table VII-4: Results of Analyses of Soil Samples Taken From Close to Three of the Monitoring Wells at the Tier II Landfill Site in 2005

Location	Unit	MW 4		MW 5		MW 6	
Arsenic	ppm	1.0	<1.0	1.3	1.6	1.3	1.0
Cadmium	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	ppm	43	37	70	50	36	44
Cobalt	ppm	14	13.8	25	18.8	6.1	6.9
Copper	ppm	52	56	118	93	63	72
Lead	ppm	10	<10	20	35	<10	<10
Nickel	ppm	58	61	106	80	30	31
Zinc	ppm	57	57	103	83	37	41
PCBs	ppb	12	15	132	63	27	<3
TPH (lube)	ppm	<40	<40	180	175	<40	<40
TPH (fuel)	ppm	1230	500	90	90	50	70

Table VII-5: Results of Analyses of Water Samples Taken From MW-2 in 2005

Date Sampled		9July05	19July05	27Jul05	8Aug05	13Aug05	21Aug05	26Aug05
As	ppm	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cd	ppm	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Co	ppm	0.007	<0.003	0.041	0.058	0.048	0.032	0.033
Cr	ppm	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cu	ppm	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005
Ni	ppm	0.038	0.018	0.191	0.266	0.220	0.147	0.142
Pb	ppm	<0.010	<0.010	<0.010	<0.010	0.019	<0.010	<0.010
Zn	ppm	0.012	0.016	0.060	0.138	0.125	0.084	0.088
PCBs	ppb	<0.020	0.021	0.031	0.368	0.90	<0.020	<0.020
TPH (lube)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (fuel)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table VII-6: Results of Analyses of Water Samples Taken From MW-5B in 2005

Date Sampled		9Jul05	19Jul05	27Jul05	8Aug05	13Aug05	21Aug05	26Aug05
As	ppm	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cd	ppm	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Co	ppm	0.058	<0.003	0.019	0.019	0.018	0.022	0.013
Cr	ppm	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cu	ppm	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005
Ni	ppm	0.132	0.010	0.051	0.038	0.037	0.047	0.035
Pb	ppm	<0.010	<0.010	<0.010	<0.010	0.014	0.011	<0.010
Zn	ppm	0.048	<0.010	0.035	0.051	0.071	0.038	<0.010
PCBs	ppb	0.051	0.11	0.17	0.146	<0.020	<0.020	0.14
TPH (lube)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (fuel)	ppm	<1.0	2.0	<1.0	1.5	1.1	<1.0	1.2

Table VII-7: Average Levels of Metals, PCBs and TPH in the Soil Monitoring Points at the Tier II Landfill from 2005 to 2010

		2005	2006	2007	2008	2009	2010
Arsenic	ppm	1.1	1.8	1.1	1.1	1.1	1.7
Cadmium	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	ppm	41	48	40	48	43	43
Cobalt	ppm	11.9	16.4	11.6	15.7	13.4	13.6
Copper	ppm	66	87	60	84	70	63
Lead	ppm	16.4	18.3	16.0	14.4	14.8	16.2
Nickel	ppm	55	72	52	70	58	55
Zinc	ppm	60	76	59	74	60	62
PCBs	ppb	48	85	78	46	79	84
TPH (lube)	ppm	135	191	443	<40	<40	168
TPH (fuel	ppm	270	65	255	88	<40	116

Table VII-8: Average Levels of Metals, PCBs and TPH in the Water Monitoring Points at the Tier II Landfill from 2005 to 2010

		2005	2006	2007	2008	2009	2010
Arsenic	ppm	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cadmium	ppm	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	ppm	0.028	0.007	<0.005	<0.005	<0.005	<0.005
Cobalt	ppm	0.014	0.030	0.015	0.019	0.024	0.030
Copper	ppm	0.006	0.017	0.008	<0.005	0.011	0.008
Lead	ppm	0.064	<0.010	<0.010	<0.010	<0.010	<0.010
Nickel	ppm	0.011	0.068	0.034	0.060	0.086	0.088
Zinc	ppm	0.046	0.047	0.024	0.057	0.081	0.081
PCBs	ppb	0.071	0.086	0.023	0.057	0.065	0.022
TPH (lube)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	1.1
TPH (fuel)	ppm	1.1	<1.0	1.1	1.2	7.4	<1.0

Table VII-9: Summary of Baseline Results for Elemental Levels in Soil Samples Collected From the Tier II Landfill Soil Monitoring Points in 2004 and 2005 (ppm)

	Arsenic	Cadmium	Chromium	Cobalt
Mean	1.1	<1.0	40.0	11.1
Standard Deviation	0.4	0.0	9.4	4.9
Range	<1.0-2.0	<1.0	32-70	5.6-25
# samples > det limit	22	0	28	28
	Copper	Lead	Nickel	Zinc
Mean	61	13.4	48	57
Standard Deviation	19	14.0	19	18
Range	35-118	<10-63	24-106	33-103
# samples > det limit	28	11	28	28

Table VII-10: Baseline Summary of Elemental Levels in the 86 Water Samples Collected From the Tier II Landfill Monitoring Wells in 2004 and 2005 (ppm)

	Arsenic	Cadmium	Chromium	Cobalt
Mean*	<0.003	<0.001	<0.005	0.017
Standard Deviation*	0.000	0.000	0.000	0.019
Range	<0.003-0.05	<0.001	<0.005-0.367	<0.003-0.073
# samples > det limit	1	0	2	51
	Copper	Lead	Nickel	Zinc
Mean	0.006	0.006	0.037	0.021
Standard Deviation	0.006	0.003	0.042	0.027
Range	<0.005-0.033	<0.010-0.022	<0.010-0.091	<0.010-0.286
# samples > det limit	26	7	71	41

* Excluding outliers

Table VII-11: Average Levels of Metals, PCBs and TPH in the Soil Monitoring Points at the Airstrip Landfill from 2005 to 2010

		2005	2006	2007	2008	2009	2010
Arsenic	ppm	1.5	2.4	1.3	1.2	1.5	1.5
Cadmium	ppm	<1.0	<1.0	<1.0	1.1	<1.0	<1.0
Chromium	ppm	45	51	46	49	48	42
Cobalt	ppm	16.6	17.3	15.9	23	15.4	15.0
Copper	ppm	75	82	75	98	78	67
Lead	ppm	12.5	13.6	15.3	31.3	15.3	22.6
Nickel	ppm	76	83	76	94	78	69
Zinc	ppm	125	125	128	176	148	140
PCBs	ppb	23	42	46	84	24	71
TPH (lube)	ppm	1471	550	840	1128	150	538
TPH (fuel)	ppm	<40	<40	<40	<40	<40	<40

Table VII-12: Average Levels of Metals, PCBs and TPH in the Water Monitoring Points at the Airstrip Landfill from 2005 to 2010

		2005	2006	2007	2008	2009	2010
Arsenic	ppm	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cadmium	ppm	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	ppm	<0.003	0.024	0.006	0.008	0.005	0.005
Cobalt	ppm	0.005	<0.003	<0.003	0.004	<0.003	<0.003
Copper	ppm	<0.005	0.012	<0.005	0.011	0.007	<0.005
Lead	ppm	<0.010	<0.010	<0.010	0.012	<0.010	<0.010
Nickel	ppm	0.014	0.021	0.010	0.014	0.011	0.009
Zinc	ppm	0.016	0.014	0.020	0.030	0.013	<0.010
PCBs	ppb	<0.020	0.026	0.040	0.079	<0.020	0.039
TPH (lube)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (fuel)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table VII-13: Average Levels of Metals, PCBs and TPH in the Soil Monitoring Points at the Maintenance Dump from 2005 to 2010

		2005	2006	2007	2008	2009	2010
Arsenic	ppm	1.1	1.9	<1.0	1.1	<1.0	1.3
Cadmium	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chromium	ppm	44	41	45	46	47	41
Cobalt	ppm	19.0	21	14.5	31	26	22
Copper	ppm	68	74	66	73	78	63
Lead	ppm	11.5	11.0	10.0	10.5	12.0	10.0
Nickel	ppm	76	74	69	85	85	70
Zinc	ppm	158	142	97	157	155	148
PCBs	ppb	24	33	78	30	7.5	33
TPH (lube)	ppm	<40	<40	<40	<40	<40	100
TPH (fuel)	ppm	<40	<40	<40	<40	<40	<40

Table VII-14: Average Levels of Metals, PCBs and TPH in the Water Monitoring Points at the Maintenance Dump from 2005 to 2010

		2005	2006	2007	2008	2009	2010
Arsenic	ppm	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cadmium	ppm	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	ppm	<0.003	0.068	0.006	0.005	0.005	0.005
Cobalt	ppm	0.005	<0.003	0.004	<0.003	<0.003	<0.003
Copper	ppm	<0.005	0.008	<0.005	<0.005	<0.005	<0.005
Lead	ppm	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nickel	ppm	<0.005	0.173	0.007	<0.005	<0.005	<0.005
Zinc	ppm	<0.010	0.020	0.020	<0.010	<0.010	<0.010
PCBs	ppb	<0.020	0.021	0.031	0.024	0.079	<0.020
TPH (lube)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (fuel)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table VII-15: Results of Analyses of Samples for CCME-TPH from the Main Landfarm (ppm)

Samples	Location	F1 (C6-C10)	F2 (C10-C16)	F3 (C16-C34)	F4 (C34-C50)
27 Jul 2006	Main Area	32	1800	820	69
27 Jul 2006	Main Area	21	1100	750	35
5 Aug 2006	Main Area	21	960	520	17
5 Aug 2006	Main Area	12	1400	620	62
9 Aug 2010	Main Area	<40	1680	590	<10
9 Aug 2010	Main Area	<40	1210	520	<10
9 Aug 2010	Main Area	<40	1495	560	<10
9 Aug 2010	Control Plot	<40	1930	650	<10

Table VII-16: Extractable Ammonia and Nitrate and Phosphorus Levels at the Main Landfarm as a Function of Time (ppm)

Date	Ext. Ammonia	Ext. Nitrate	Ext P
4 Sep 2004	6.5, 29, 11	<4	7, 4, 4
31 Jul 2005	7, 7, <5, 25	<1	na
4 Sep 2005	<0.25	<4	4, 4, 4, 3, 2
26 Jul 2006	270, 485, 412, 78	<2	279, 23, 14, 21
5 Aug 2006	5, 140,	<2	11, 15
31 Jul 2007	64	11	279
18 Jul 2008	138 , <5.0	57, <2.0	20, 20
9 Aug 2010	2.2, 19.6, <2.0	<2.0, 3.1, <2.0	<20, <20, 20

Table VII-17: Levels of Hydrocarbon Degraders at the Main Landfarm as a Function of Time

Date	Unit	Hydrocarbon Degraders $\times 10^4$
2 Sep 2004	cfu/g	9.6, 4.8, 6.2, 41, 28, 27
4 Sep 2005	cfu/g	53, 43, 26
31 Jul 2007	cfu/g	31, 68, <0.1
18 Jul 2008	cfu/g	7.3, 18
9 Aug 2010	cfu/g	2.0, 25, 0.2

Table VII-18: Extractable Ammonia and Nitrate and Phosphorus Levels (ppm) at the TPH Barrier as a Function of Time

Date	Ext. Ammonia	Ext. Nitrate	Ext P
4 Sep 2004	<0.3	<4	3, 3, 4
31 Jul 2005	<0.3	<4	4, 3, 2
6 Aug 2006	5, 3, 2, 3	<2, <2, <2, 4	26, 8, 14, 29
31 Jul 2007	<5	<2	<10
18 Jul 2008	<5, <5, <5, 6	<2.0	<10, <10, 10, <10
9 Aug 2010	<2.0, <2.0, <2.0, <2.0, <2.0	<2.0, <2.0, <2.0, <2.0, <2.0	<20, <20, <20, <20, <20

Table VII-19: Levels of Hydrocarbon Degraders at the TPH Barrier as a Function of Time

Date	Unit	Hydrocarbon Degraders $\times 10^4$
31 Jul 2007	cfu/g	4.5, 0.42, 0.22
18 Jul 2008	cfu/g	0.45, 0.22, 3.9, 0.34
9 Aug 2010	cfu/g	0.01, 0.055, 0.06, 2.0, 0.01

Table VII-20: Extractable Ammonia and Nitrate and Phosphorus Levels (ppm) at the In Situ Landfarm as a Function of Time

Date	Plot	Ext. Ammonia	Ext. Nitrate	Ext P
14 Aug 2005	CP1	<0.2	<4	3
6 Aug 2006	CP1	<2	<2	24
31 Jul 2007	CP1	<5	<2	<10
18 Jul 2008	CP1	<5	<2	20
9 Aug2010	CP1	<2.0	<2.0	<20
27 Jul 2006	FAM	210	<2	22
6 Aug 2006	FAM	100	<2	23
31 Jul 2007	FAM	7	<2	<10
18 Jul 2008	FAM	6	5	30
9 Aug 2010	FAM	<2.0	<2.0	<20

27 Jul 2006	FAS1	46	<2	26
6 Aug 2006	FAS1	55	<2	26
31 Jul 2007	FAS1	22	<2	<10
18 Jul 2008	FAS1	<5	<2	20
9 Aug 2010	FAS1	<2.0	<2.0	<20
27 Jul 2006	FAS2	<2	<2	28
6 Aug 2006	FAS2	<2	<2	23
31 Jul 2007	FAS2	<5	<2	<10
18 Jul 2008	FAS2	<5	<2	20
9 Aug2010	FAS2	2.4	<2.0	<20

Table VII-21: Levels of Hydrocarbon Degraders at the In Situ Landfarm as a Function of Time

Date		Unit	Hydrocarbon Degraders × 10^4
31 Jul 2007	CP1	cfu/g	0.11
31 Jul 2007	FAM	cfu/g	5.0
31 Jul 2007	FAS2	cfu/g	0.09
31 Jul 2007	FAS1	cfu/g	1.7
18 Jul 2008	CP1	cfu/g	<0.01
18 Jul 2008	FAM	cfu/g	7.3
18 Jul 2008	FAS2	cfu/g	9.0
18 Jul 2008	FAS1	cfu/g	5.0
9 Aug 2010	CP1	cfu/g	4.0
9 Aug 2010	FAM	cfu/g	6.5
9 Aug 2010	FAS2	cfu/g	0.04
9 Aug 2010	FAS1	cfu/g	4.0

Table VII-22: Results of Analyses of Samples for CCME-TPH (ppm) from the In Situ Landfarm Plots

Samples	Plot	F1 (C6-C10)	F2 (C10-C16)	F3 (C16-C34)	F4 (C34-C50)
9 Aug 2010	CP1	<40	805	143	<10
9 Aug 2010	FAM	<40	1000	160	<10
9 Aug 2010	FAS2	<40	666	146	<10
9 Aug 2010	FAS1	<40	284	72	<10

Table VII-23: Results of Analyses of Surface Water Samples at Various Locations for Four Metals and PCBs

Location	Year	Co	Cu	Ni	Zn	PCBs
		ppm	ppm	ppm	ppm	ppb
Officer's Mess	2005	0.013	0.025	0.084	0.113	<0.020
	2006	<0.003	<0.006	<0.030	<0.010	-
	2007	0.010	0.012	0.074	0.087	<3
	2008	0.019	0.018	0.120	0.14	<3
	2010	0.011	0.009	0.068	0.078	0.023
Old Water Lake	2006	0.019	0.014	0.078	0.053	-
	2007	0.032	0.046	0.160	0.100	<3
	2008	0.032	0.053	0.160	0.088	<3
	2010	0.029	0.047	0.14	0.095	-
Imploded Tank	2005	0.022	0.032	0.051	0.077	<0.020
	2010	0.017	0.014	0.038	0.047	<0.020
Maintenance Dump	2005	0.005	0.034	0.013	0.06	<0.020
	2010	0.010	0.005	0.033	0.028	<0.020
Beach Dump	2005	0.018	0.021	0.062	0.042	<0.020
	2010	0.037	0.023	0.130	0.062	<0.020
S1/S4 Beach Stream	2005	0.032	0.053	0.147	0.087	0.040
	2010	0.030	0.048	0.015	0.096	<0.020

Appendix B: Queen's University Resolution Island Monitoring and Research Report 2010

Resolution Island 2010

Monitoring and Research

Analytical Services Unit
Queen's University

Indian and Northern Affairs Canada
Affaires indiennes et du Nord Canada

Resolution Island 2010 Monitoring and Research

Prepared by

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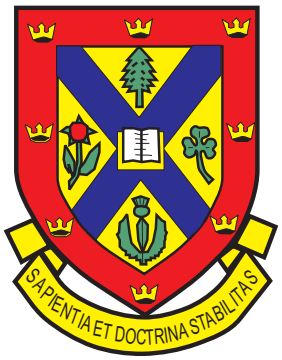

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Analytical Services Unit
March 2011

EXECUTIVE SUMMARY

This report describes this work undertaken by the Analytical Service Unit (ASU) at Queen's University in 2010 for Indian and Northern Affairs Canada. This is the fifth year of long term monitoring at the site after the completion of the remediation program in 2005. As such a more complete set of tests were carried out this year. Overall results were as expected.

Water, soil and filter materials from the three reactive polychlorinated biphenyl (PCB) barriers were sampled and analysed. Concentrations of PCBs found in the various components were similar to previous years. The furniture dump barrier contained sediment with a PCB content higher than either of the barriers in the S1/S4 drainage system as has been the case in previous years. The volume of sediment in the barriers was similar to previous years except 2008 when larger volumes were found. The liners in the barriers were examined to evaluate performance over-time under cold-weather conditions. Evaluations of the performance of the PCB barriers is planned to continue.

The condition of main and beach hydrocarbon landfarms was also monitored. Hydrocarbon concentrations have been relatively stable for the last few years. Laboratory experiments were conducted to see whether more fertilizer would increase the rate breakdown of the hydrocarbon. Results for the main landfarm showed that the addition of more fertilizer had little or no effect and that bioremediation was now very slow. However the actual hydrocarbon levels are much lower than when the landfarm was constructed. Results from the in situ landfarm plots showed that the two plots fertilized in 2005 had enough fertilizer present for bioremediation to continue. However, the control plot and the plot which was allowed to stabilize for two years before fertilizer was added behaved similarly in that they both responded to the addition of extra fertilizer in the laboratory experiment. It is unclear whether the fertilizer failed to penetrate the soil and was therefore unavailable or whether other factors such as depleted oxygen availability was a limiting factor.

The conditions of the landfills on the site were assessed through visual inspection, soil, water, and groundwater sampling. Results indicated that the landfills were stable. Surface waters and plants were also collected and analysed. Results were consistent with those from previous years. Neither surface water nor plants had been monitored in 2009. Surface waters had not been fully monitored since 2005. The surface of the airstrip landfill, where some minor erosion was observed, was tested for PCBs but very little was found. A comprehensive photographic record of all remaining structures was taken.

ACKNOWLEDGMENTS

The work was supported by Indian and Northern Affairs Canada through its office in Iqaluit, Nunavut. Special thanks go to Stephen Hooey and Natalie Plato from the Iqaluit Office for their support and encouragement.

Allison Rutter of Queen's University directed the project. The on site team leader, Rebecca McWatters was ably assisted by Alex Gerber, Dan Jones, Sonja Koster and Ellen Woolfenden. Bear monitoring was provided by Johnny Qammaniq and Sheotiapik Peter. This report was written by John Poland and edited by Allison Rutter.

Laboratory analyses were conducted by Queen's University Analytical Services Unit, Kingston, Ontario. Thanks are due to Paula Whitley, Mary Andrews, Rhonda Kristensen, Kalam Mir and Mesha Thompson in addition to those listed above, who provided their usual high professional standards.

TABLE OF CONTENTS

I. Introduction 1

A. General 1

B. Previous Reports 1

C. On Site Scientific Investigations 2

D. Long Term Monitoring Plan 4

E. Other Activities 5

II. Methodology 9

A. Sampling 9

B. Chemical Analysis 9

1. Metals 9

2. Total TPH Analysis 10

3. C_{17}/Pristane and C_{18}/Phytane Ratios 10

4. CCME TPH Analysis 11

5. Nitrogen and Phosphorus 11

6. PCBs 11

7. Surface Water 12

8. Barrier Materials 13

a) Gravel 13

b) GAC 13

c) Geotextiles 13

d) Overpack Drums 13

9. Fertilizer Addition Experiments 13

III. Permeable Reactive Barriers 15

A. Background 15

B. PCB Analysis of Containerised Barrier Sediment 16

C. S1/S4 Valley Barrier 20
1. General 20
2. 2010 Field Work 20
3. Monitoring Results 21
a) Water 21
b) Sediment 21
c) Filters 22
d) Containers of Sediment 23
D. S1/S4 Beach Barrier 27
1. General 27
2. 2010 Field Work 27
3. Monitoring Results 28
a) Water 28
b) Sediment 28
c) Filters 29
d) Containers of Sediment 31
E. Furniture Dump Barrier 35
1. General 35
2. 2010 Field Work 35
3. Monitoring Results 36
a) Water 36
b) Sediment 36
c) Filters 37
d) Containers of Sediment 38
F. Summary of Barrier Results 41
IV. Hydrocarbon Remediation 45
A. Main Landfarm 45

1. Background 45
2. 2010 Field work 45
3. Results for 2010 46
B. In Situ Landfarm 51
1. Background 51
2. 2010 Field Activities 52
3. 2010 Results 53
C. Ponding and Barrier Research 57
1. General 57
2. 2010 Field Activity 57
3. Monitoring Results 58
V. Long Term Monitoring 63
A. Tier II Landfill Monitoring Program 63
1. Background 63
2. Water and Soil Monitoring 63
3. Discussion of Analytical Results 66
a) Metals 66
b) TPH 68
c) PCBs 68
B. Airstrip Landfill Monitoring Program 69
1. Background 69
2. Soil and Water Monitoring 69
C. Maintenance Dump Monitoring Program 72
1. Background 72
2. Water and Soil Monitoring 72
D. Background Water Samples 74
E. Background Plant Samples 77

F. Airstrip Landfill Eroded Surface Investigation 82
G. Wildlife Observations 84
1. Land 84
2. Sea 84
VI. On Site Buildings 85
VII. Geosynthetics 113
A. Introduction 113
B. Sampling 114
C. Testing Methodology 117
1. Oxidative Induction Time 117
2. Crystallinity 117
3. Tensile Test 117
4. Hydraulic Conductivity 118
5. Swell Index 118
6. Cation Exchange 119
7. Diffusion Tests 119
D. Results for PRB Geomembranes 120
1. Physical Testing 120
2. Functional Testing 121
E. Results for PRB Geosynthetic Clay Liners 124
F. Conclusions 126
G. Recommendations 127
H. References 127
VIII. Appendices 129
A. Appendix I – Quality Control/ Quality Assurance (QA/QC) 129
B. Appendix II: Field Report 140
C. Appendix III: Health and Safety Plan 143

I. INTRODUCTION

A. General

The remediation project at Resolution Island was completed in 2005. Research activities associated with the cleanup of this unique site have been on going throughout the project and have been supported by contribution agreements between Indian and Northern Affairs Canada (INAC) and the Analytical Services Unit (ASU) at Queen's University. During the last 4 years, various components at the site have been monitored by the ASU in conjunction with this research while personnel were on site. This is the fifth year of the monitoring program which was earmarked as a milestone in the site monitoring plan when an assessment of the monitoring program should undergo a thorough review.

There are three aspects to the research to be conducted by the ASU this year, all of which supported the remediation of the unique problems inherent on this site. These projects related to the PCB permeable reactive barriers (Chapter III and VII), hydrocarbon remediation (Chapter IV), and long term monitoring (Chapter V). The appendix (Chapter VIII) includes all QA/QC documentation. In addition the Analytical Services Unit at Queen's University continued to provide the scientific expertise for this project with Dr. Allison Rutter and Dr. John Poland acting as scientific advisors.

B. Previous Reports

Over the period 1993-1996, environmental work at the site was detailed in a set of reports entitled "Environmental Study of a Military Installation at Resolution Island, BAF-5". These reports[1] fully described items such as site characteristics, history, and previous investigations. Scientific investigations have continued and have been reported annually[2]. From 1997 onwards, work at the site was managed by the Qikiqtaaluk Corporation (QC) through a contribution agreement with INAC. This work started in

[1] Environmental Sciences Group (1994). Volume One, Analytical Services Unit (1995) Volume Two, Analytical Services Unit and Environmental Sciences Group (1996) Volume Three, and Analytical Services Unit (1997) Volume Four: Environmental Study of a Military Installation at Resolution Island. BAF-5. Prepared for Indian and Northern Affairs Canada.

[2] Analytical Services Unit (1998), (1999), (2000), (2001), (2002) (2003) (2004) (2005) and (2006) Resolution Island 1998: Scientific Investigations: Resolution Island 1999: Scientific Investigations, Resolution Island 2000: Scientific Investigations: Resolution Island 2001: Scientific Investigations: Resolution Island 2002: Scientific Investigations: Resolution Island 2003: Scientific Investigations and Research: Resolution Island 2004: Scientific Investigations and Research: Resolution Island 2005. Scientific Investigations and Research: Resolution Island 2006. Prepared for Indian and Northern Affairs Canada.

1997 with infrastructure improvements and expanded from 1998 onwards to include remediation activities and training. The three year plan to complete the work at the site was initiated in 2003[3] and was essentially completed in 2005. The site was demobilized in 2006 with the removal of the heavy equipment relating to the remediation project, and the mobile laboratory and demolition of the camp. Research and monitoring has been conducted annually by the ASU[4] up to the present time. Map 1 shows the location and general layout of the site at Resolution Island.

C. On Site Scientific Investigations

The Queen's University team composed of five Queens ASU personnel and a bear monitor, Johnny Qammaniq from Resolute Bay, were on site from 5 August to 13 August 2010. In addition, a bear monitor/field assistant, Siut Peter from Iqaluit joined the team on 11 August 2010. Accommodation was provided in the newly renovated training building (Photographs 1 to 3). All meals and camp operations were provided by Biogenie who were contracted by INAC for this purpose. Transport of the team and equipment to and from the island was by fixed wing aircraft. Three ATVs and two trailers were available for on site transport. The road by the old water lake was largely washed out at the culvert which was functional only over a small section (Photograph 4): some work was undertaken at this location to make crossing this area safer. The road to the beach barrier was completely removed in 2006 and is impassable to even ATVs due to the soft ground conditions and large boulders. This location was reached by walking from the beach area near to building B2. The weather was very poor for the first 4-6 days with thick fog and strong winds but the last 4 days were sunny.

The main tasks completed by the ASU this year are listed below:

[3] Analytical Services Unit (2003). Resolution Island Project Description and New Remediation Plan Revision 1 March 2003. Prepared for Indian and Northern Affairs Canada.

[4] Analytical Services Unit (2007a), (2008),(2009). Resolution Island 2007: Monitoring and Research. Prepared for Indian and Northern Affairs Canada. Resolution Island 2008: Monitoring and Research. Prepared for Indian and Northern Affairs Canada. Resolution Island 2009: Monitoring and Research. Prepared for Indian and Northern Affairs Canada.

General

- Provided scientific and engineering support for the project as required
- Organized the 7th International Conference on Contamination in Frozen Ground (CFG7) in May 2010 in Kingston.
- Acted and liaised with the Australian Antarctic Division. Provided training and supervision of an Australian PhD student on exchange from May to August 2010.

Permeable Reactive Barriers

- Thoroughly inspected the S1/S4 valley barrier, the furniture dump barrier and the S1/S4 beach barrier.
- Sampled and replaced all filters in each barrier.
- Sampled and analyzed the sediment trapped in all three barriers.
- Excavated all sediments from the barriers. Sediment was placed in barrels and waste wranglers for subsequent disposal.
- Sampled and analyzed water and soil monitoring points for all barriers.
- Sampled soil from all barrels and waste wranglers currently stored on site.
- Assessed the geomembranes used in the barriers for the effects of weathering and freeze thaw. This entailed taking membrane samples from the barriers and testing the materials for physical properties such as crystalinity, oxidative induction time (both standard and HP-OIT), tensile strength tear resistance and, as well as functional testing by determining the diffusive transport of BTEX through the geomembranes. Samples of the GCLS were taken from the field to assess the changes in hydraulic conductivity, swell index and cation exchange capacity. This work was done in collaboration with Dr R Kerry Rowe.
- Provided a long term plan for the monitoring of the barriers and prepare contingencies for phasing out of the barriers over the long term.

Hydrocarbon Remediation

- Monitored the main and in situ landfarm on site. Samples were analyzed for total hydrocarbons, nutrients, hydrocarbon degraders and for markers of bioremediation. Assessed the aeration and bioremediation occurring in the two landfarms. A subsection of the samples were analyzed for CCME hydrocarbons. The main landfarm was re-fertilized.
- Bulk samples were taken on site and laboratory experiments conducted to assess the fertilizer requirements of both the main and in situ landfarm soils.
- The barrier system and ponds were monitored. Water and soil sample monitoring points were analyzed for TPH. The barrier materials were sampled and analyzed for TPH. The filters were replaced.
- The ponds were inspected but sediment excavation was unnecessary.

Long Term Monitoring

- Sampled the Tier II landfill monitoring wells and associated soil points for PCBs, TPH and metals. Sampled the monitoring wells and associated soil points at the airstrip and maintenance dumps.
- Collected and analyzed ten background plant samples for PCB content.
- Collected and analyzed seven background water samples at the sites monitored during the period 2001 to 2005.
- Sampled and analyzed 10 samples for PCBs from the erosion channels starting to develop at the airstrip dump.
- Created a photographic record of the external and internal state of the buildings
- Recorded wildlife observations

D. Long Term Monitoring Plan

The original long term monitoring plan recommended continuing annual monitoring for 5 years followed by monitoring in year 7, 10, 15 and 25. These time

intervals were the same as those used by DND on their DEW Line sites and are based on the premise that after five years trends in the monitoring results should have been established. Clearly if any problems were noted, the frequency of future visits might be increased. Conversely, some measurements may have become stable and predictable while others may be no longer required.

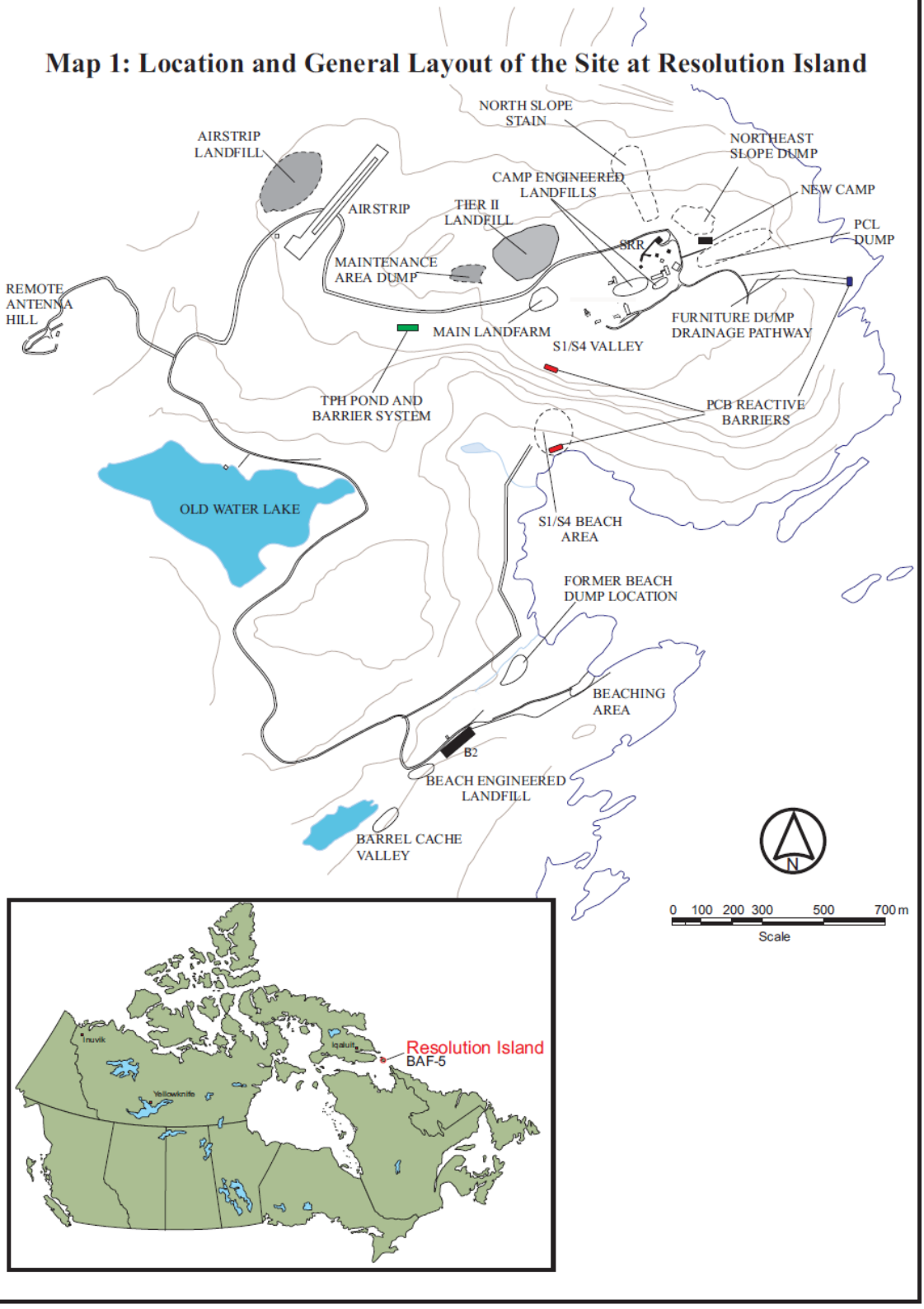
As part of the contribution agreement between INAC and ASU this year, the ASU was contracted to review the five years of monitoring data and to submit recommendations for the long term monitoring of the site. This work has been completed and has been reported as a separate document.

E. Other Activities

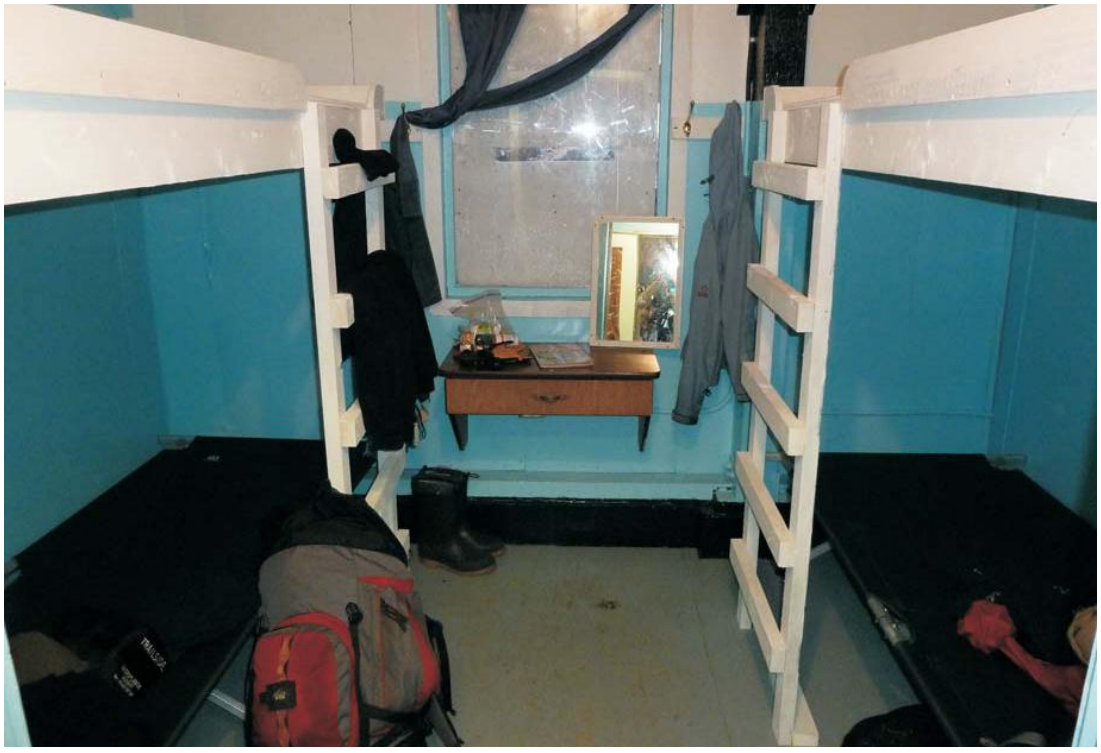
The 7th International Conference on Contaminants in Freezing Ground (CFG7) was organized by the ASU and held at the Biosciences Complex at Queen's University May 24-28, 2010. The conference brings together scientists, engineers, environmental managers, and companies who have a scientific or practical interest in contaminants in cold climate soils. The conference was well attended and provided an excellent forum for the discussion and development of new science and technology for remediation in the Arctic. Natalie Plato, Director Contaminated Sites in Nunavut was a panel member in an informative and lively discussion on Arctic development and sustainability.

Ellen Woolfenden, a PhD candidate in the Department of Earth and Planetary Sciences, Macquarie University, Australia was part of the Resolution Island team. This collaboration with Australians, who have worked in the Antarctic, facilitates an excellent exchange of ideas between Arctic and Antarctic researchers. Currently Dr Rebecca McWatters, part of the Resolution Island field team for several years, is working in Antarctica on hydrocarbon remediation.

Map 1: Location and General Layout of the Site at Resolution Island



Photograph 1: The Kitchen Area of the Newly Renovated Training Center



Photograph 2: A Bedroom Area in the Renovated Training Center

Photograph 3: The Training Center Building Used for Accommodation

Photograph 4: The Culvert Under the Road to the Beach by the Old Water Lake Was Only Intact for a Narrow Width That Barely Enabled ATV Passage

II. METHODOLOGY

A. Sampling

Soil samples for metals and PCBs were collected using plastic scoops and placed in WhirlPak bags. Soil samples for TPH were placed in 125 mL glass amber jars which were completely filled to allow no headspace. Water samples for PCBs were collected in 1 L Teflon bottles or 1 L glass bottles with teflon lined lids. Water samples for metals were collected in 250 mL plastic bottles and water samples for TPH in 250 mL glass amber bottles with Teflon lined lids. Soil and water samples were kept at 4 °C prior to analysis. Plant samples were wrapped in foil and placed in ziplock bags. Plant samples were not washed and were kept frozen prior to analysis.

Samples were shipped by air freight to Queen's University for testing. In order to conform with regulations regarding sample control, a rigorous chain of custody was maintained. Chain-of-custody forms were filled out and checked for each sample before shipment from the North, and the contents of shipments were verified upon receipt in the laboratory. The relevant documentation is available on request.

B. Chemical Analysis

1. Metals

Soil samples were air-dried and ground to a fine powder with a mortar and pestle; large stones were removed as they would not be expected to contain any anthropogenic environmental contamination. Approximately 0.5 g of this dried material was heated with 2 ml nitric acid and 6 ml hydrochloric acid overnight so that the volume was reduced to 1-2 ml. This solution was then made up to 25 ml, and analyzed by inductively coupled plasma atomic emission spectroscopy (ICP/AES). The ICP/AES analysis was conducted using a Varian Vista Pro Spectrophotometer with axial configuration. While it is recognized that the digestion procedure used may not bring all metals into solution (some metals may be locked into silicate minerals), it is felt that the metals released into solution are of greater environmental significance than true total metals.

Water samples were refluxed in acid and made up to 50 mL. The resulting solution was run on the ICP spectrometer equipped with an ultrasonic nebulizer. This is the method for total metals. For dissolved metals, the sample was filtered through a 0.45 um filter and the procedure for total metals carried out without refluxing with acid.

2. *Total TPH Analysis*

Soil samples were homogenized and sub-samples dried for moisture determination. A wet sample (10 g dry equivalent weight) was mixed with anhydrous sodium sulphate and Ottawa sand in an Erlenmeyer flask. Pesticide grade hexane (20 mL) was added, and the flask ultrasonically agitated. For wet samples additional hexane and sodium sulphate was added. A one mL aliquot of the hexane extract was pipetted from the flask in a manner ensuring no transfer of solid material, and sealed in a gas chromatography (GC) vial.

For water samples, 100 mL was accurately measured and transferred to a clean, 125 mL glass separatory funnel. Hexane, 10 mL, was added and the mixture shaken vigorously and then allowed to separate. If emulsions formed, the funnel was briefly sonicated to ensure adequate phase separation. An aliquot of the hexane phase was then transferred to a GC vial. For low level detection the samples were concentrated by blowing down with nitrogen gas to about 0.5 mL before transfer to a GC vial; the final volume was determined accurately with a syringe.

The hexane extracts were analysed by GC/FID using a Hewlett Packard gas chromatograph with flame ionization detector. TPH was quantified by comparing the chromatogram peak area of the sample with that of the standard; standards of fuel oil and lubricating oil were prepared in hexane. Compound identity was determined by comparing the sample chromatogram with those of known hydrocarbon mixtures.

3. *C_{17}/Pristane and C_{18}/Phytane Ratios*

Diesel fuel contains two pairs of compounds with very similar boiling points but for each pair, one is a straight chain alkane while the other is branched. Because the straight chain alkane is volatilized at the same rate as its branched counterpart but the straight chain hydrocarbon is bioremediated faster than the branched counterpart, these two pairs of compounds can be used to discriminate between the two remediation pathways of volatilization and bioremediation. The four compounds are the two straight chain alkanes, heptadecane ($C_{17}H_{36}$; C_{17}) and octadecane ($C_{18}H_{38}$; C_{18}), and the two branched alkanes 2,6,10,14 tetramethylpentadecane ($C_{19}H_{40}$; pristane Pr) and 2,6,10,14-tetramethylhexadecane ($C_{20}H_{42}$; phytane Ph). These branched alkanes are sometimes referred to as isoprenoids. The ratio of the masses of each pair in the hydrocarbon mixtures (equivalent to the ratio of the peak areas) are given as the mass of the straight chain alkane divided by the mass of the branched alkane; these are abbreviated as C_{17}/Pr and C_{18}/Ph in this report.

4. CCME TPH Analysis

Analysis was carried out according to the Canada-Wide standard for petroleum hydrocarbon in soil method.

For soil fraction F1, accurately weighed samples of wet soil (5 g) were extracted on a shaker for 1 hour with 10 mL of methanol. The methanol layer was then transferred into a vial and refrigerated until analysis by SPME GC/FID. A SPB-1 fused silica capillary column (30 m, 0.25 mm ID x 0.25 μm film thickness) was used. Retention time marking was done using nC6 and nC10 hydrocarbons and calibration using toluene. A wet/dry ratio for the sample was determined using a sub-sample and the final result was calculated using the dry weight of the sample.

For soil fractions F2-F4, samples were homogenized and sub-samples dried for moisture determination. Accurately weighed samples of wet soil (10 g) were extracted with hexane/acetone (1:1) using an ultrasonic bath. The extract was filtered through sodium sulphate and 3 mL of toluene was added. The extract was then concentrated by rotoevaporation and transferred to a 50 mL tube. Hexane/dichloromethane (1:1) was added to bring the volume up to 30 mL. Silica was added and the sample shaken for 5 minutes. Once the sample had settled, a GC vial was then filled and the sample analysed by GC/FID. Blanks, control samples and duplicates were run at a frequency of approximately 20%. Calibration and retention time marking was done using nC10, nC16 and nC34 hydrocarbons and the final result reported in ug/g for each fraction.

5. Nitrogen and Phosphorus

Total Kjeldahl nitrogen (TKN), total phosphorus and extractable phosphorus were analysed by RPC Laboratories Fredericton. The methods used were colorimetric (ALPH 4500-NH3 G), ICP (EPA 3050) and sodium citrate extraction followed by ICP analysis respectively. For extractable ammonia, nitrate and nitrite, a 2M KCl solution was used. Moisture content was first determined and then a 5 g of dry equivalent sample of the wet soil weighed out and 25 ml of KCl added. Vials containing the resultant mixture were shaken for 30 min at 200 rpm, then filtered through P5 filter paper and analyzed on Technicon Autoanalyzers for each analyte.

6. PCBs

The standard analytical procedure for the analysis of PCBs, namely gas chromatography with an electron capture detector (GC/ECD) was used. These analyses were performed at the Analytical Services Unit, Queen's University by one of the three

following procedures. For all procedures a separate sample (soil, gravel or GAC) was first taken for the determination of wet weight/dry weight ratio. Geotextiles were air dried before analysis as were samples extracted by ASE (accelerated solvent extraction). The samples were analyzed by using approximately 10 g (dry weight equivalent), spiking with an internal standard solution (decachlorobiphenyl) and extracting. The soxhlet method used approximately 250 mL dichloromethane in a soxhlet extractor for four hours. The DCM shaker method used 3 times 50 mL dichloromethane with agitation on a platform shaker for 20 minutes for each extract. The ASE method used 30 mL hexane: acetone to extract. Equivalency has been demonstrated for all three methods.

The shaker and ASE methods were used for most soil and gravel samples while the soxhlet method was generally used for other solid matrices. The solutions obtained from the soxhlet and DCM extraction methods were concentrated to 1-2 mL and the solvent exchanged for hexane. This concentrate was then applied to a Florisil column (Supelco SPE tube) and the resulting eluent analyzed using an Agilent 6890 chromatograph equipped with electron capture detector and a 30 m SPB-1 capillary column and calibrated with Aroclor 1260 standards.

Water was analyzed by using approximately 800 mL of sample, spiking with internal standard and extracting three times with dichloromethane. The extract was filtered through sodium sulphate and concentrated to 1-2 mL and the solvent exchanged for hexane. This concentrate was then applied to a Florisil column for cleanup of the extract and the resulting eluent analyzed by GC/ECD. For samples requiring a lower detection limit, extracts were concentrated to 0.5 mL before analysis on the GC.

For plants, a 1 - 5 g sample of dried material was accurately weighed and then ground in a mortar and pestle with sodium sulphate and Ottawa sand. The ground sample was transferred to a thimble, spiked with DCBP, and extracted by soxhlet for 6 hours at 4-6 cycles per hour using 250 mL of dichloromethane. The extract was then concentrated to 10 mL, and 5 mL of this extract was applied to a GPC column to separate the PCBs from the lipids. The PCB fraction was rotoevaporated, the solvent exchanged to hexane and the extract applied to a Florisil column for cleanup. This final extract was concentrated to 0.5 mL and run by GC/ECD. Values are reported on a dry weight basis.

7. Surface Water

Water samples were collected in 1 L polyethylene bottles for general water quality parameters and inorganic elements analysis, and in 1 L Teflon bottles for PCB analysis. Standard methods of analysis were employed.

8. Barrier Materials

a) Gravel

A pea gravel with a particle size of roughly 6.4 – 9.5 mm which was quarried locally near Kingston, Ontario and was distributed through Pyke Farms, was available on-site having been brought there by sea previously.

b) GAC

Granulated activated charcoal (CNS 612) which has a particle size range of 2.00 to 3.35 mm was obtained through A.C. Carbone, Saint-Jean-Sur-Richelieu, Quebec.

c) Geotextiles

A vertical non-woven needle-punched geotextile, 1200R, was used in the barriers. This was supplied by Terrafix, Toronto. The a pore size was between 0.05 and 0.15 mm.

d) Overpack Drums

Standard metal overpack drums were used as the receptacles for the PCB contaminated soil from the barriers at the S1/S4 valley, S1/S4 beach and furniture dump this year. Waste Wrangler containers purchased from Quatrex Inc. were also used.

9. Fertilizer Addition Experiments

In order to see whether the addition of fertilizer would be beneficial to the main and in situ landfarms, laboratory experiments were conducted. These were carried out as follows. Bulk soil samples were first sieved though a #4 sieve and the sample homogenized and analysed for TPH. This TPH value was then used to calculate the amount of urea and DAP to be added to achieve C:N:P ratios of 100 : 7.5 : 0.5. The water content of the sample was also determined at the same time and thus the amount of water required to raise the water content to 15% was determined. For each in situ landfarm sample 300 g or 350 g of material was added to 6 reactors. For the main landfarm 500 g was added to each of 10 reactors. Urea and DAP were then added to half of the reactor sets and water added to all the reactors. Each reactor was then shaken vigorously and a sample taken from each for TPH and water content determination. The reactors were then placed in a constant temperature cabinet for 47 days at 14 ºC. Each reactor was sampled and the TPH level determined. The temperature of the reactors was then raised to 20 ºC and resampled after a further 50 days. The water content was assessed several times during the experiment and extra water added as necessary to maintain a water content of 10 – 15 %.

III. PERMEABLE REACTIVE BARRIERS

A. Background

The excavation of PCB contaminated soils at Resolution Island was carried out in the same manner as would be done elsewhere in Canada. However, it was not possible to excavate all the PCB contaminated soil because some soil was trapped in fractured bedrock, or located on very steep terrain that could not be accessed for logistical and safety reasons. The soil surface prior to the cleanup was stabilized by lichens and dwarf plants or by compaction. The soil remaining after excavation was loose and subject to erosion, particularly during runoff. In order to control the PCB migration from these two factors, it was decided that permanent barrier systems were required as a long term solution. The ASU was contracted to conduct the necessary research, design and development of these barrier systems.

In 2003, the first barrier was installed at the top of the cliff in the S1/S4 valley. Laboratory studies were conducted by the ASU in order to support the design and construction of this barrier system. As a result of these studies and field observations, the barrier was modified and two others were constructed at the S1/S4 beach adjacent to the shore and at the end of the furniture dump drainage channel. The barriers consist of a lined funnel formed by rock gabions through which all drainage must flow and a gate which contains various filters. Coarse sediment is trapped in the funnel while finer material is collected by the filters in the gate which also may remove dissolved material.

The operation, effectiveness and efficiency of the barriers has varied from year to year. The main factor affecting the barriers is the amount of sediment migrating into the funnel and the amount of sediment removed from the trap each season. Another key factor is the particle size of the migrating sediment which varies with time and with each barrier. In addition the arrangement of the filters and their composition has also varied over the years of operation. Last year all the excavated material from the barriers that had been placed in containers was removed to the area around building B2 at the beach. However no sediment was excavated from the barriers and only the geotextile filters were renewed.

This year all three barrier systems were inspected, sampled and maintained as necessary. This maintenance involved excavating sediment from the "funnel" traps and replacing all the filters in the filter boxes. Only one geotextile, 1200R, was again used in the filter boxes this year along with gravel and GAC as outlined below for each barrier. All drums and waste wranglers filled in previous years (2007 and 2008) were re-sampled except the four drums comprising the PCB storage facility in building B2. In addition this year, the materials employed in the construction of the barriers were examined and is reported in Section VIII.

B. PCB Analysis of Containerised Barrier Sediment

All the overpack drums and waste wranglers containing the PCB-contaminated sediment from previous years were removed by helicopter to the beach area in 2009. Four drums from the furniture dump barrier, which contained > 50 ppm PCBs were placed in a corner of building B2 (Photograph 5). This new PCB storage facility was cordoned off with fencing and the drums and area appropriately signed. The contents and labeling of these 4 drums are as presented in Table 1.

Table 1: Details of the Four Drums in the PCB Storage Facility

Year Excavated	Labelling on Drum	Drum Contents	PCB (ppm)*
2008	Furniture dump barrel #1	Soil/sediment	78
2008	Furniture dump barrel #2	Soil/sediment	78
2008	Furniture dump barrel #3	Soil/sediment	78
2008	Furniture dump barrel #4	Soil/sediment and filter material	78

*Average level of contamination of source

The other containers of sediment from the barriers comprising 7 waste wranglers on pallets and 34 drums were placed adjacent to building B2 in 2009. This year the contents of all these containers were sampled (Photograph 6) and the containers resealed, and tagged with a metal tag and the tag number written on the outside of the containers both with spray paint and paint marker; the previous identification marks were worn and becoming difficult to decipher. The samples were analysed for PCBs and results are presented in Tables 2 and 3. These results are generally in line with those obtained from the sediment monitoring data and from previous sampling of some of the containers. There are no changes in the average levels for each set (Tier I and Tier II categories. Of

particular note are the 5 drums of sediment from the beach barrier in 2007. All contain < 1ppm PCBs and the corresponding sediment results in 2007 also gave < 1 ppm PCBs.

Table 2: PCB Concentrations in Sediment in the Drums from the Barriers Now Stored Adjacent to Building B2

Tag	Sample Number	Old Labelling on Drum	Drum Contents	PCBs (ppm)
5512	RI10-032	valley #1 PCBs 2007	soil/sediment	3.0
5513	RI10-047	valley #2 PCBs 2007	soil/sediment	3.0
5514	RI10-044	valley #3 PCBs 2007	soil/sediment	3.3
5515	RI10-042	valley #4 PCBs 2007	soil/sediment	2.8
5516	RI10-092	valley #5 PCBs 2007	soil/sediment	5.9
5517	RI10-128	valley #6 PCBs 2007	soil/sediment	4.3
5518	RI10-127	valley #7 PCBs 2007	soil/sediment	3.7
5519	RI10-082	valley #8 PCBs 2007	soil/sediment	15.7
5520	RI10-081	valley #9 PCBs 2007	gravel	5.1
5521	RI10-084	beach #1 PCBs 2007	soil/sediment	0.6
5522	RI10-033	beach #2 PCBs 2007	soil/sediment	0.5
5523	RI10-151	beach #3 PCBs 2007	soil/sediment	0.5
5524	RI10-129	beach #4 PCBs 2007	soil/sediment	0.7
5525	RI10-152	beach #5 PCBs 2007	soil/sediment	0.6
5526	RI10-091	beach #6 PCBs 2007	filter material & soil/sediment	0.6
5527	RI10-161	furniture dump #1 PCBs 2007	soil/sediment	30
5528	RI10-159	furniture dump #1 PCBs 2007	soil/sediment	1.1
5529	RI10-160	furniture dump #3 PCBs 2007	soil/sediment	26
5530	RI10-049	valley #1 PCBs 2008	soil/sediment	3.3
5531	RI10-045	valley #2 PCBs 2008	soil/sediment	2.5
5532	RI10-096	valley #3 PCBs 2008	soil/sediment	1.3
5533	RI10-097	valley #4 PCBs 2008	soil/sediment	1.9
5534	RI10-030	valley #5 PCBs 2008	soil/sediment	3.3

Tag	Sample Number	Old Labelling on Drum	Drum Contents	PCBs (ppm)
5535	RI10-031	valley #6 PCBs 2008	soil/sediment	2.7
5536	RI10-093	valley #7 PCBs 2008	soil/sediment	3.8
5537	RI10-080	valley #8 PCBs 2008	soil/sediment	2.8
5538	RI10-046	valley #9 PCBs 2008	soil/sediment	2.3
5539	RI10-099	valley #10 PCBs 2008	filter material & soil/sediment	1.4
5540	RI10-094	valley #11 PCBs 2007	soil/sediment	5.6
5541	RI10-095	valley #12 PCBs 2007	garbage and soil/sediment	5.5
5542	RI10-048	valley #13 PCBs 2007	soil/sediment	2.4
5543	RI10-083	beach #1 PCBs 2008	soil/sediment	0.8
5544	RI10-029	beach #2 PCBs 2008	filter material & soil/sediment	1.0
5545	RI10-090	beach #3 PCBs 2008	soil/sediment	0.7
5546	RI10-098	beach #4 PCBs 2008	soil/sediment	2.5

Table 3: PCB Concentrations in Sediment in the Waste Wranglers from the Barriers and Now Stored Adjacent to Building B2

Tag	Sample Number	Old Labeling on Waste Wrangler	Waste Wrangler Contents	PCBs (ppm)
5547	RI10-158	beach waste wrangler #1 2008	soil/sediment	8.6
5548	RI10-156	beach waste wrangler #2 2008	soil/sediment	1.1
5549	RI10-162	beach waste wrangler #3 2008	soil/sediment	2.1
5550	RI10-154	beach waste wrangler #4 2008	soil/sediment	2.9
5551	RI10-155	beach waste wrangler #5 2008	soil/sediment	0.4
5552	RI10-157	beach waste wrangler #6 2008	soil/sediment	3.9
5553	RI10-153	beach waste wrangler #7 2008	soil/sediment	1.6

Photograph 5: The Interior of Building B2: In the Corner are the Four Drums Comprising the PCB Storage Facility

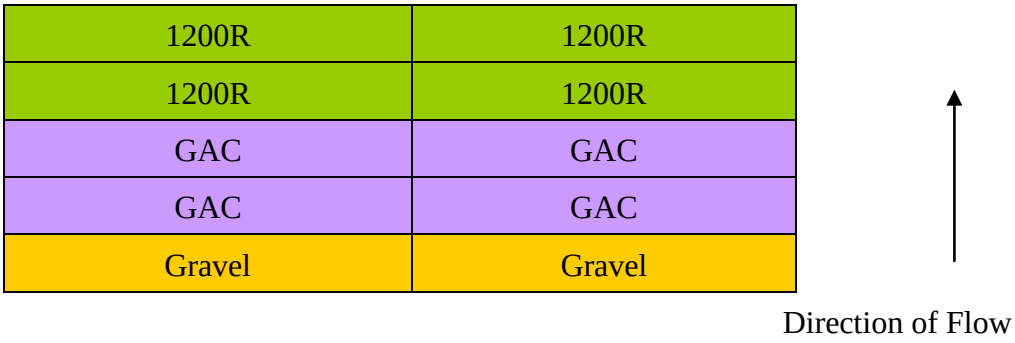
Photograph 6: The Drums Filled with Sediment From the PCB Barriers in Previous Years Are Outside Building B2. This Year They Were Numbered With Metal Tags and these Numbers also Written on Them

C. S1/S4 Valley Barrier

1. General

Filters containing gravel and GAC placed in the filter box in 2008 and new 1200R geotextile placed in the filter box in 2009 were arranged as shown in Figure 1.

Figure 1: Arrangement of Filters and Sorbents in the S1/S4 Valley Filter Box at the End of the 2009 Field Season

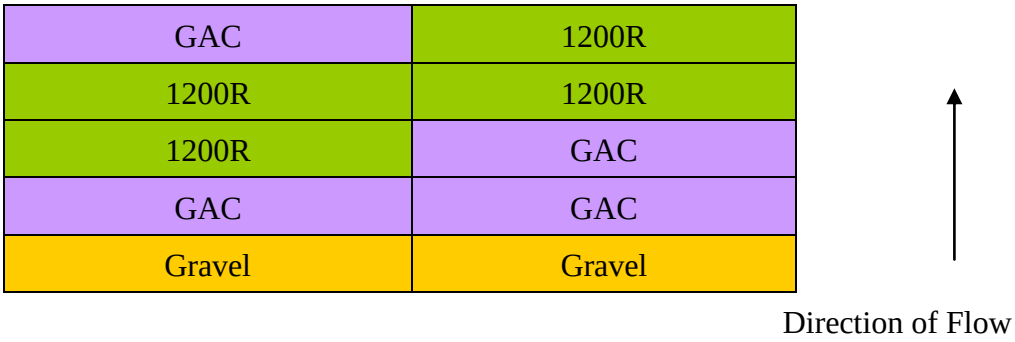


2. 2010 Field Work

On arrival at the barrier it was observed to be full of water and sediment was present in both the upper and lower sections of the trap. Water was flowing through but it was partially clogged (Photograph 7) with the water being stopped by the first two GAC filters. Plant growth was clearly visible on the curlex trap (Photograph 8). No repairs were necessary.

Sediment and water samples were taken from the various monitoring points around the barrier. Sediment was then shoveled out of the catchment areas within the barrier system into overpack drums and an waste wrangler. Seven drums were filled with sediment and tagged. One waste wrangler was filled ¾ full and also tagged. Each of the eight containers was sampled. Filters were sampled and material from the old filters was placed into one of the overpack drums. The filter cassettes were filled with new gravel, GAC and geotextile 1200R. The valley barrier was charged with 2 gravel filters, 4 GAC filters and 4 geotextile filters as shown in Figure 2: one of the GAC filter had to go into the last position on the left side as it could not fit in the second filter space.

Figure 2: Arrangement of Filters and Sorbents in the S1/S4 Valley Box at the End of the 2010 Field Season



3. Monitoring Results

a) Water

Water was collected from 5 locations in the valley. Their locations and PCB concentrations are given in Table 4 and Map 2. These results are at similar levels to those obtained in 2009. The levels in these two years are generally lower than in the previous years where levels from 0.02 - 0.25 ppm PCBs were found.

Table 4: PCB Concentration in Water from the S1/S4 Valley

Monitoring Point	PCB (ppb)	Location
VWP1	0.024	In front of chevrons
VWP2	0.042	In front of filter box
VWP3	<0.020	After filter box
VWP4	0.036	20 m downstream of barrier
VWP5	0.036	Near cliff

b) Sediment

Results of the analysis for PCBs from sediment collected from within the barrier are shown in Table 5 and Map 2. The average PCB level within the barrier was 2.9 ppm (Tier I). This was more than in 2009 (1.6) but the same as 2008. These three values are significantly lower than the average concentrations (4.8 ppm and 5.0 ppm) found in 2007 and 2006 respectively. Total amount of soil removed from the funnel this year was 2.5 m^3; there was an estimated 0.75 m^3 in the trap last year, so an estimated 1.75 m^3 was

collected in the trap over this last winter. Last year the volume of soil was estimated as 0.75 m^3 but this was not removed. This year the total sediment collected and removed was 2.5 m^3 with an average concentration of 2.9 ppm. Thus the calculated amount of pure PCB trapped by the barrier in front of the filter box between 17 July 2008 and 8 August 2010 was 13.1 g as compared to 13.6 g for 2008 and 8.5 g for 2007. That is two years worth as compared to single years.

Table 5: PCB Concentration of Sediment from the S1/S4 Valley Barrier

Monitoring Point	PCB (ppm)	Location
VSP1	1.2	In front of chevrons
VSP2	1.4	Between chevrons and first gabion fence
VSP3	6.2	Between first gabion fence and filter box
VSP4	3.0	In front of filter box
VSP5	3.3	First clean cell
VSP6	4.2	Between the two clean cells
VSP7	7.8	Second clean cell
VSP8	9.9	20 m downstream

c) Filters

The filters were removed from the filter box on 8 August 2010. Samples were collected from each filter as in previous years and analysed for PCBs. Results of analysis are presented in Tables 6 and 7, which also gives the location from which the sample was taken. The PCB concentration found in the gravel and GAC filters was lower than levels found in 2008 and 2007. The amount of PCB trapped by the gravel and GAC filters was calculated to be 4 mg and 36 mg respectively for a total of 40 mg. This compares to 148 mg in 2008, 289 mg in 2007, and 128 mg in 2006. This large decrease is even more impressive if one takes into account that it was for a two year duration. Two layers of 1200R geotextile filters were placed in the box last year and results of analysis of these is given in Table 7. The levels found were higher than in previous years and higher than those for the gravel and GAC. The average concentration was 3.5 ppm this year as opposed to 1.7 ppm in 2008 and 1.5 in 2007. The amount of pure PCBs trapped by the

geotextile filters was 17 mg. The amount trapped in 2009 was 14 mg and in 2008 was 8 mg.

Table 6: PCB Concentration of Filter Box Materials from the S1/S4 Valley Barrier System in Operation from 16 July 2008 to 8 August 2010

Sample No	Medium	Location	PCB (ppm)
RI10-139	Gravel	Left first filter	0.1
RI10-138	Gravel	Right first filter	0.2
RI10-140	GAC	Left second filter	0.5
RI10-142	GAC	Right second filter	0.6
RI10-131	GAC	Left third filter	0.9
RI10-130	GAC	Right third filter	1.0

Table 7: PCB Concentration of the Geotextile Materials from the S1/S4 Valley Barrier System in Operation from 25 August 2009 to 8 August 2010

Sample No	Medium	Location	PCB (ppm)
RI10-136	1200R	Left first filter	1.6
RI10-132, 133, 134	1200R	Right first filter (top, middle, bottom)	2.8, 1.8, 4.8
RI10-137	1200R	Left second filter	1.6
RI10-135	1200R	Right second filter	7.0

d) Containers of Sediment

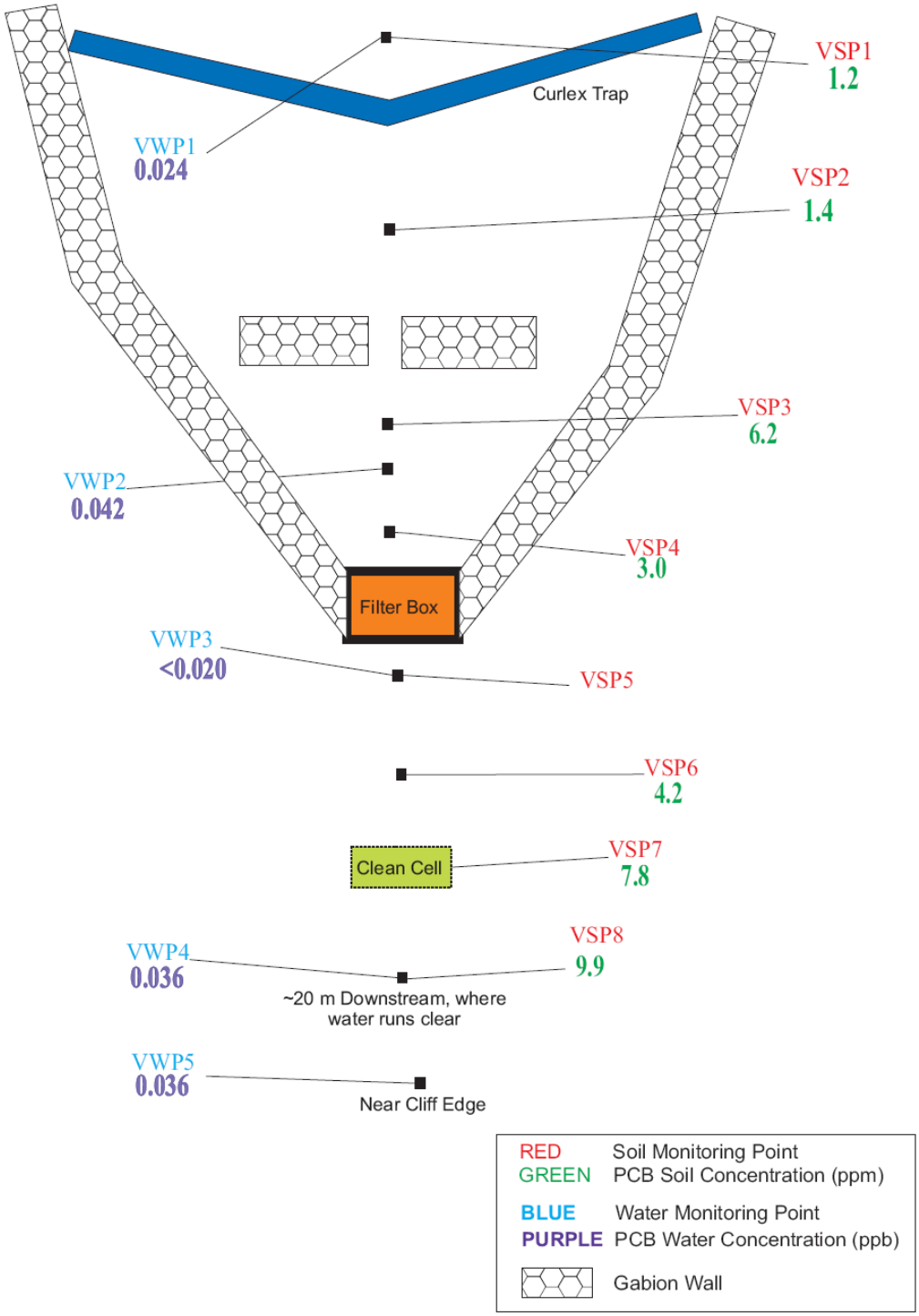
Each of the eight containers was sampled and tagged. The containers were left by the barrier as helicopter support was not available. The results of analysis for PCBs of these samples is given in Table 8. The average PCB level is 3.7 ppm which compares well with the value of 2.9 ppm from the sediment monitoring results.

Table 8: PCB Concentrations in Sediment in the Containers from the S1/S4 Valley Barrier in 2010

Tag	Sample Number	Labeling on Drums*	Drum Contents	PCBs (ppm)
5554	RI10-164	tag 5554	filters and sediment	Lit#
5555	RI10-170	tag 5555	soil/sediment	3.6
5556	RI10-165	tag 5556	soil/sediment	3.4
5557	RI10-169	tag 5557	soil/sediment	2.2
5558	RI10-166	tag 5558	soil/sediment	1.8
5559	RI10-163	tag 5559	soil/sediment	5.7
5560	RI10-168	tag 5560	soil/sediment	3.7
5561	RI10-167	tag 5561	soil/sediment	5.3

* All containers were overpack drums except the one tagged 5561 which was a waste wrangler III: # lit – Lost in transit

Map 2: Locations and PCB Concentrations of Soil and Water Samples at the S1/S4 Valley Barrier in 2010



Photograph 7: The S1/S4 Valley Barrier Was Partially Clogged by the GAC Filters

Photograph 8: Vegetation Has Established Itself on the Curlex Trap

D. S1/S4 Beach Barrier

1. General

An interceptor barrier was designed and constructed at the bottom edge of this area adjacent to the sea in 2005. Figure 3 shows the arrangement of filters in the filter box at the end of the 2009 field season. The same arrangement of filters was used this year.

Figure 3: Arrangement of Filters and Sorbents in the S1/S4 Beach Filter Box at the End of the 2009 and 2010 Field Seasons

1200R	1200R	1200R
1200R	1200R	1200R
1200R	1200R	1200R
1200R	1200R	1200R
GAC	GAC	GAC
GAC	GAC	GAC
¾ full Gravel	¾ full Gravel	¾ full Gravel

Direction of Flow

2. 2010 Field Work

The S1/S4 beach barrier was found to be in good condition upon arrival with ponded water (Photograph 9). The water was not overflowing and water was flowing readily through the filter box (Photograph 10). After sampling the monitoring points and filters, shoveling of the sediment out of the trap commenced. It was not possible to completely clean the area due to residual water (Photograph 11) but most of the sediment was removed. Seven drums and one waste wrangler (3/4 full) were generated. These were tagged and left beside the barrier. The filters were replaced with new material (Photograph 12).

3. Monitoring Results

a) Water

Water was collected from 3 locations in the beach area. Their locations and PCB concentrations are given in Table 9 and Map 3. These values are generally lower than in the previous years. It is particularly encouraging to find that the level of PCBs in the water entering the sea was below the method detection limit.

Table 9: PCB Concentration (ug/L) in Water From the S1/S4 Beach Area

Monitoring Point	PCB Concentration	Location
BWP1	<0.020	Water in the barrier trap
BWP2	0.093	Effluent from barrier filter box
BWP3	<0.020	Below cliff at the sea edge

b) Sediment

Six sediment samples were collected in and around the barrier. Results of analysis of these for PCBs and their locations are given in Table 10, and Map 3. The volume of sediment removed was 2.25 m^3; the trap was not emptied last year so this amount represents the volume of sediment collected over the last two seasons. In 2008, 5.3 m^3 of sediment was collected by the trap and removed to waste wrangler containers whereas 1.2 m^3 and 2.0 m^3 was removed from the barrier in 2007 and 2006 respectively. The average PCB level in the sediment removed from the barrier was 1.4 ppm. This compares to 1.6 ppm in 2008 and 0.6 ppm in 2007. The amount of pure PCBs removed in the sediment from the barrier was calculated to be 5.7 g PCB.

Table 10: PCB Concentration of Sediment from the S1/S4 Beach Barrier

Monitoring Point	PCB Concentration (ppm)	Location
BSP1	0.5	Between top gabions and Curlex trap
BSP2	0.3	In front of Curlex trap
BSP3	3.1	Between edge of liner and central gabion
BSP4	1.7	In front of filter box
BSP5	0.9	Clean cell
BSP6	2.8	Between filters

c) Filters

The filters were removed from the filter box on 10 August 2010. Samples were collected from each filter and analysed for PCBs. Results of analysis are presented in Table 11 for GAC and gravel and Table 12 for the geotextile 1200R, which also give the location from which the samples were taken. Very low concentrations of PCBs were found again this year in the gravel and GAC filters. The amount of PCBs collected were 14 mg on the gravel and 51 mg on the GAC for a total of 65 mg or 33 mg per year for 2009 and 2010. These values compare with 71 mg on these filters in 2008, 64 mg in 2007 and 45 mg in 2006. The 2009 and 2010 amounts therefore show a decrease from the values in previous years

Table 11: PCB Concentration of Filter Box Materials from the S1/S4 Beach Barrier System in Operation from 17 July 2008 to 10 August 2010

Sample No	Medium	Location	PCB (ppm)
RI10-062	Gravel	Left first filter	0.4
RI10-061	Gravel	Center first filter	0.5
RI10-060	Gravel	Right first filter	0.3
RI10-065	GAC	Left second filter	0.7
RI10-064	GAC	Center second filter	0.9
RI10-063	GAC	Right second filter	0.8
RI10-066	GAC	Left third filter	0.4
RI10-067	GAC	Center third filter	0.7
RI10-069	GAC	Right third filter	0.7

The average concentration of PCBs found on the geocomposite filters was 0.6 ppm. The average concentration was 1.9 ppm in 2009, 3.2 in 2008 and 0.2 in 2007. The total mass of PCBs collected by the geotextile filters was 8 mg which was slightly less than in the previous years.

Table12: PCB Concentration of the Geotextile Materials from the S1/S4 Beach Barrier System in Operation from 25 August 2009 to 10 August 2010

Sample No	Medium	Location	PCB (ppm)
RI10-068, 70, 71	1200R	Left first filter (top, middle, bottom)	1.3, 1.2, 1.5
RI10-078	1200R	Center first filter	0.2
RI10-087	1200R	Right first filter	0.1
RI10-072	1200R	Left second filter	1.6
RI10-077	1200R	Center second filter	0.1
RI10-086	1200R	Right second filter	0.1
RI10-073	1200R	Left third filter	0.6
RI10-076	1200R	Center third filter	0.2
RI10-085	1200R	Right third filter	0.2
RI10-074	1200R	Left fourth filter	0.9
RI10-075	1200R	Center fourth filter	0.1
RI10-079	1200R	Right fourth filter	0.2

d) Containers of Sediment

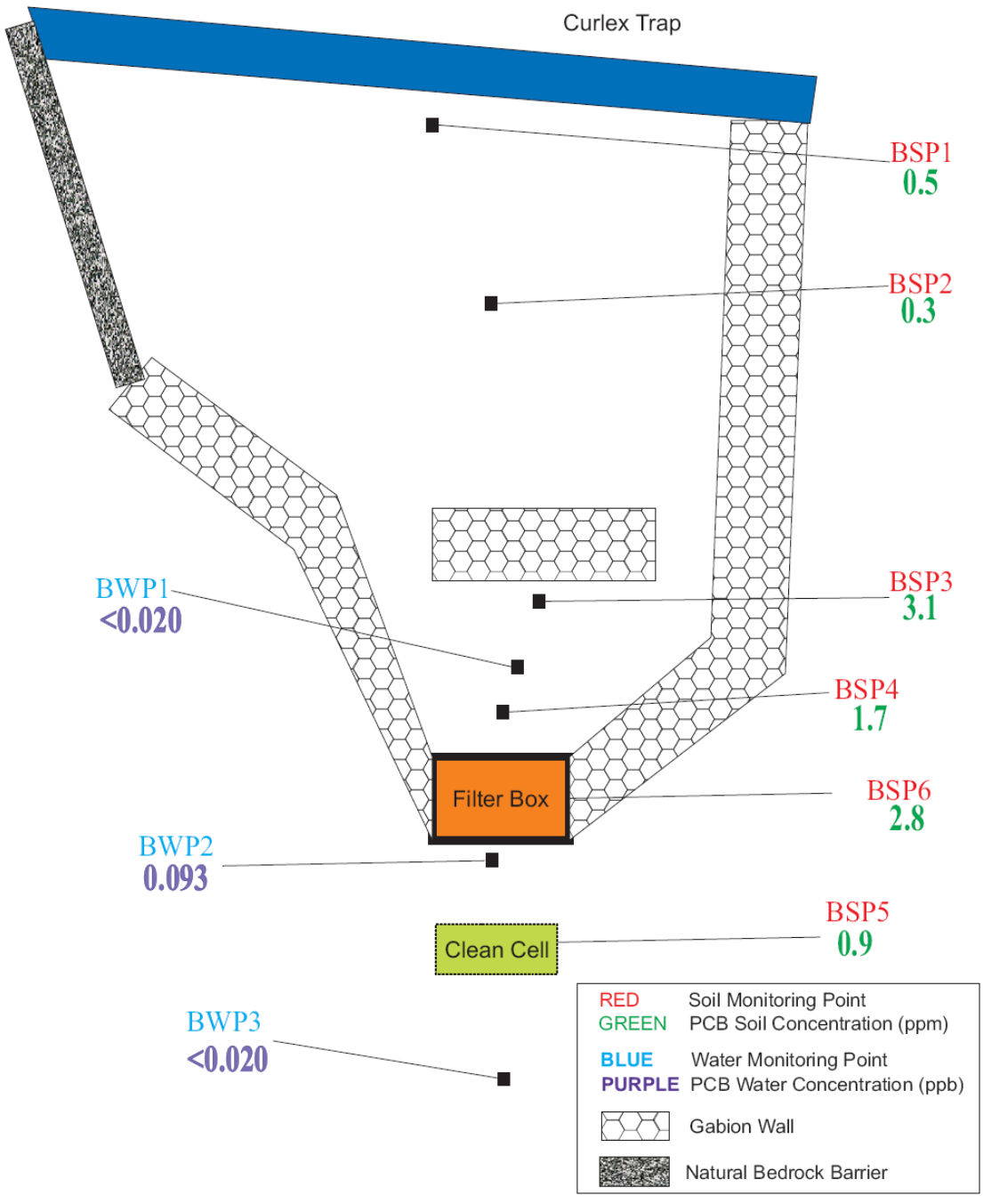
Each of the eight containers was sampled and tagged. The containers were left by the barrier as helicopter support was not available. The results of analysis for PCBs is given in Table 13. The average level of 1.8 ppm PCBs is similar to the average of 1.4 ppm PCBs obtained from the sediment monitoring data.

Table 13: PCB Concentrations in Sediment in the Containers from the S1/S4 Beach Barrier in 2010

Tag	Sample Number	Labeling on Drums*	Drum Contents	PCBs (ppm)
5504	RI10-021	Tag 5504	filters and sediment	0.4
5505	RI10-123	Tag 5505	soil/sediment	4.3
5506	RI10-121	Tag 5506	soil/sediment	1.5
5507	RI10-122	Tag 5507	soil/sediment	0.9
5508	RI10-124	Tag 5508	soil/sediment	0.5
5509	RI10-109	Tag 5509	soil/sediment	2.4
5510	RI10-125	Tag 5510	soil/sediment	1.7
5511	RI10-126	Tag 5511	soil/sediment	2.4

* All containers were overpack drums except the one tagged 5509 which was a Waste Wrangler.

Map 3: Locations and PCB Concentrations of Soil and Water Samples at the S1/S4 Beach Barrier in 2010



Photograph 9: Water Was Ponded Behind the Filter Box at the S1/S4 Beach Barrier

Photograph 10: Water was Flowing Smoothly Through the Filter Box When the Team Arrived at the S1/S4 Beach Barrier: Note the Staked Clean Cell in the Water Channel

Photograph 11: The S1/S4 Beach Barrier After Shoveling Sediment From the Trap: Not All the Sediment Could be Removed Because of the Water Present

Photograph 12: Sampling the Geotextile 1200R at the Beach Barrier

E. Furniture Dump Barrier

1. General

The furniture dump and its drainage pathway were excavated in 1999. Transformers containing nearly pure PCBs were removed from the dump. All soil containing > 1 ppm PCB was removed from the original dump and its drainage pathway and large areas of exposed boulders were washed and vacuum cleaned. In 2003, a wooden experimental barrier was designed and constructed. This was replaced by a stainless steel one in 2005. Results of analyses of barrier sediment and filters in the period 2004-2006 showed that PCBs were being transported in the drainage pathway and were still present in the area previously occupied by the furniture dump and in the drainage pathway leading from it. This was the case despite considerable effort to remove any soil found to contain > 1 ppm PCBs with the vacuum truck; normally vacuuming was only undertaken for CEPA areas. Figure 4 shows the arrangement of filters in the filter box at the end of the 2009 field season. This same arrangement of filters was used this year.

Figure 4: Arrangement of Filters in the Furniture Dump Filter Box at the End of the 2009 and 2010 Field Seasons

1200R	1200R
1200R	1200R
1200R	1200R
1200R	1200R
GAC	GAC
GAC	GAC
¾ full Gravel	¾ full Gravel

Direction of Flow

2. 2010 Field Work

On arriving at the barrier it was observed that both stainless steel covers over the filter box had been blown off by the wind but were still attached to the barrier. Inspection of the barrier revealed that there was again relatively little sediment in the furniture dump barrier. Water was flowing very slowing through the system with some

ponded water in the trap. A water sample was collected from the ponded area in the barrier. Five soil samples were collected from in and around the barrier. Approximately 0.48 m^3 of material was then removed from above the silt fence (Photograph 13) up gradient from the barrier and from just in front of the barrier funnel. This was done by shoveling into a cooler (Photograph 14), which was then taken to an overpack drum and emptied into it. This was placed in two overpack drums which were sealed and tagged. Soil from between the filters and within the filter box was collected in 7 sample bags which were taken to Queens and composited to form one sample. The filters were sampled and replaced.

3. Monitoring Results

a) Water

A level of 0.99 ppb PCBs was found in water (sample FWP1) above barrier this year. This is higher than the previous levels of 0.125 ppb found in 2008, 0.535 ppb found in 2007 and 0.89 ppb found in 2005; in other years water has been absent during the summer sampling season.

b) Sediment

Five sediment samples were collected and analysed from the locations given in Table 14 and Map 4. One of these samples comprised all the sediment collected from within the barrier. The high values found paint a similar picture to the results obtained in previous years, that is, that there are relatively small quantities of sediment contaminated at much higher concentrations than found in the S1/S4 valley or S1/S4 beach areas. This is likely due to the very highly contaminated soils that were found within the furniture dump. This year, the total amount of pure PCBs removed with the sediment was 36 g in 0.48 m^3 of sediment. This is less than the 76 g in 2008 but higher than the 16.9 g removed in 2007 and 15.4 g in 2006. However, the barrier was not shoveled out in 2009 so that the 36 g represents the amount collected for two years. The levels of PCBs beyond the barrier however did not increase showing that the barrier is performing well and preventing PCBs from reaching the ocean. The level of 78 ppm PCBs that was found in the small volume of soil between the filter cartridges in the box indicates that this finer material contains higher PCB concentrations than in the sediment as a whole.

Table 14: PCB Concentration of Sediment Samples from the Furniture Dump Barrier System After Spring Runoff

Monitoring Point	PCB Concentration (ppm)	Location
FSP1	31	In front of silt fence
FSP2	53	In funnel of barrier
FSP3	13.8	Between the barrier and the cliff
FSP4	13.6	Near cliff edge to the south of the barrier
FSP5	76	Between the filters in the box and from within the box

c) Filters

Results of analyses of the contents of the gravel and GAC filters are given in Table 15. The levels in the gravel are similar to those found in 2008 and higher than those for 2007 and 2006. The total mass of PCBs collected by the gravel and GAC filters was 109 mg and 1094 mg respectively. The filters were not replaced in 2009 so the actual amounts of PCBs collected by the gravel and GAC in 2009 and 2010 averaged 601 mg per year. The filters were not replaced in 2007 so a similar double year collection resulted. The average mass of PCBs collected for 2007 and 2008 averaged 1004 mg per year. In 2006 the total amount of PCBs collected on the gravel and GAC filters was 730 mg.

Table 15: PCB Concentration of Filter Box Materials from the Furniture Dump Barrier System in Operation from 15 July 2008 to

Sample No	Medium	Location	PCB (ppm)
RI10-148	Gravel	Left first filter	3.5
RI10-149	Gravel	Right first filter	5.5
RI10-145	GAC	Left second filter	23
RI10-146	GAC	Right second filter	38
RI10-143	GAC	Left third filter	15.0
RI10-144	GAC	Right third filter	14.2

The PCB levels found in the geotextile filters are presented in Table 16. The average level of 42 ppm is lower than the average level of 81 ppm found in 2009 and 190 ppm found in 2008. The total amount of PCBs collected by the eight filters was 204 mg. The mass collected in 2009 was 320 mg and in 2008 was 540 mg. The mass collected is decreasing with time and could be as a result of the stabilization of sediment in the drainage pathway. However, this may be as a result of less water flow rather than a steady decrease in the amount of PCBs remaining in the catchment area.

Table 16: PCB Concentration of the Geotextile Materials from the Furniture Dump Barrier System in Operation from 25 August 2009 to

Sample No	Medium	Location	PCB (ppm)
RI10-053	1200R	Left first filter	30
RI10-050, 051, 052	1200R	Right first filter (top, middle, bottom)	65, 51, 39
RI10-055	1200R	Left second filter	44
RI10-054	1200R	Right second filter	83
RI10-057	1200R	Left third filter	13
RI10-056	1200R	Right third tilter	60
RI10-059	1200R	Left fourth filter	21
RI10-058	1200R	Right fourth filter	30

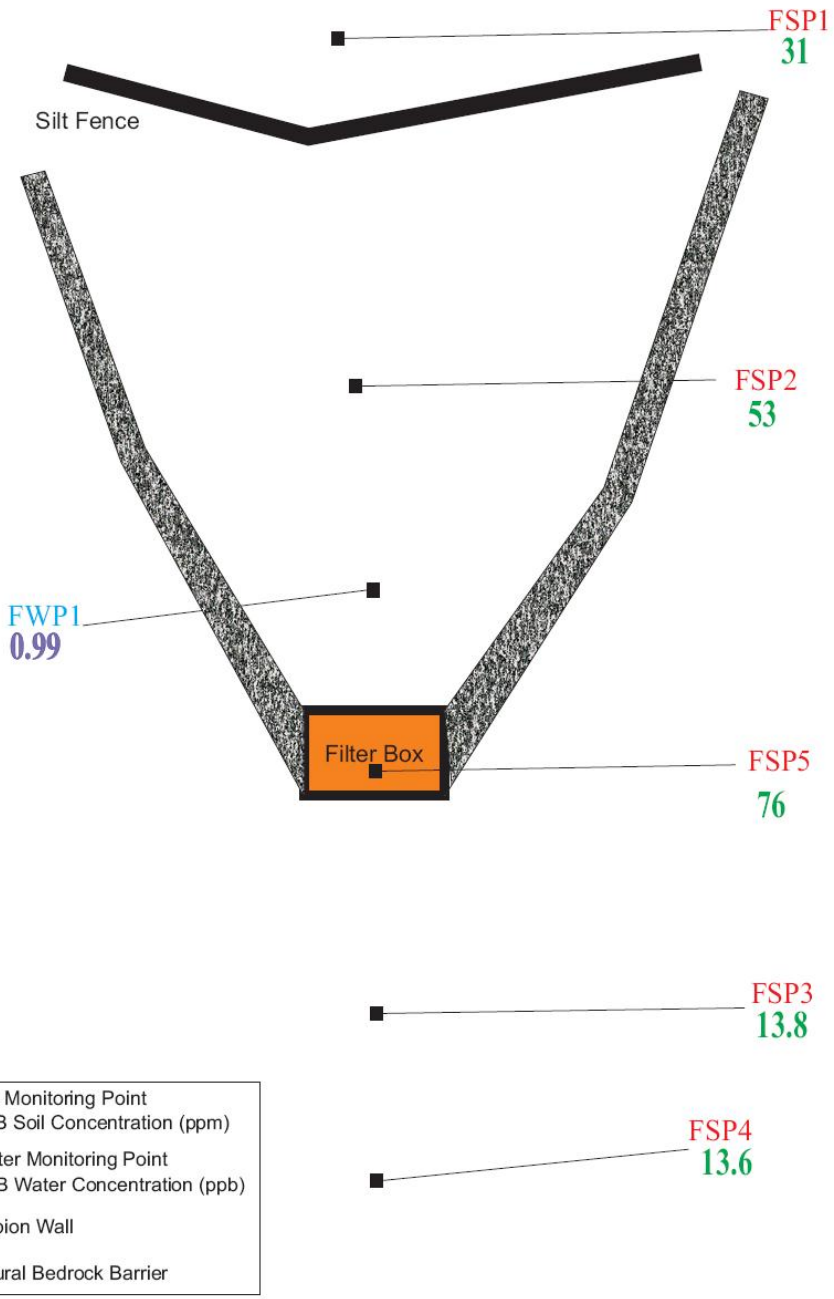
d) Containers of Sediment

The two containers were sampled and tagged and were left by the furniture dump barrier. The results of analysis for PCBs is given in Table 17. The average value of 46 ppm compares well with the 42 ppm from the sediment results given in Table 14.

Table 17: PCB Concentrations in Sediment in the Containers From the Furniture Dump Barrier in 2010

Tag	Sample Number	Labeling on Drums	Drum Contents	PCBs (ppm)
5502	RI10-027	tag 5502	filters and ponding sediment	58
5503	RI10-028	tag 5503	soil/sediment from in front of silt fence	35

Map 4: Locations and PCB Concentrations of Soil and Water Samples at the Furniture Dump Barrier in 2010



Photograph 13: Shoveling the Sediment From Above the Silt Fence at the Furniture Dump Barrier

Photograph 14: Shoveling Sediment From Within the Lined Trap Immediately in Front of the Filter Box at the Furniture Dump Barrier

F. Summary of Barrier Results

Figures 5, 6 and 7 summarise the masses of pure PCBs in mg collected on each filter type in the barriers at the S1/S4 valley barrier, S1/S4 beach barrier and furniture dump barrier respectively. Trends are similar to previous years though there is quite a variation in the mass of PCBs collected on the 1200R geotextile from the left, right and centre filters which has not been particularly noticeable before.

Figure 7: Mass of Pure PCBs (mg) Found in the Various Sections of the S1/S4 Valley Barrier Filter Box in 2010

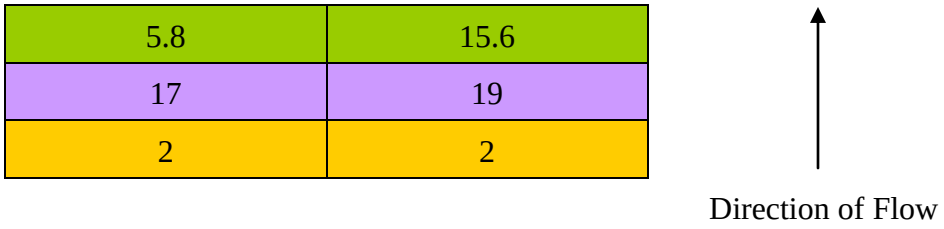


Figure 8: Mass of Pure PCBs (mg) Found in the Various Sections of the S1/S4 Beach Barrier Filter Box in 2010

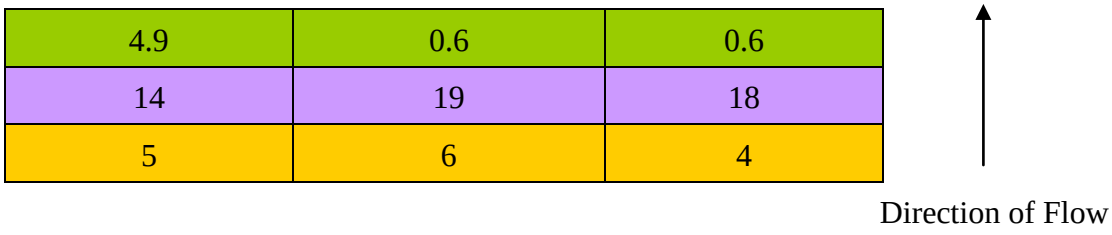
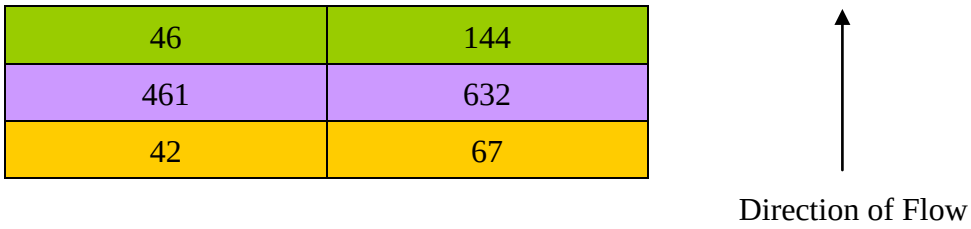


Figure 9: Mass of Pure PCBs (mg) Found in the Various Sections of the Furniture Dump Barrier Filter Box in 2010



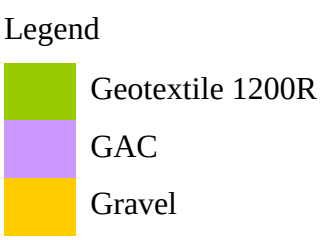


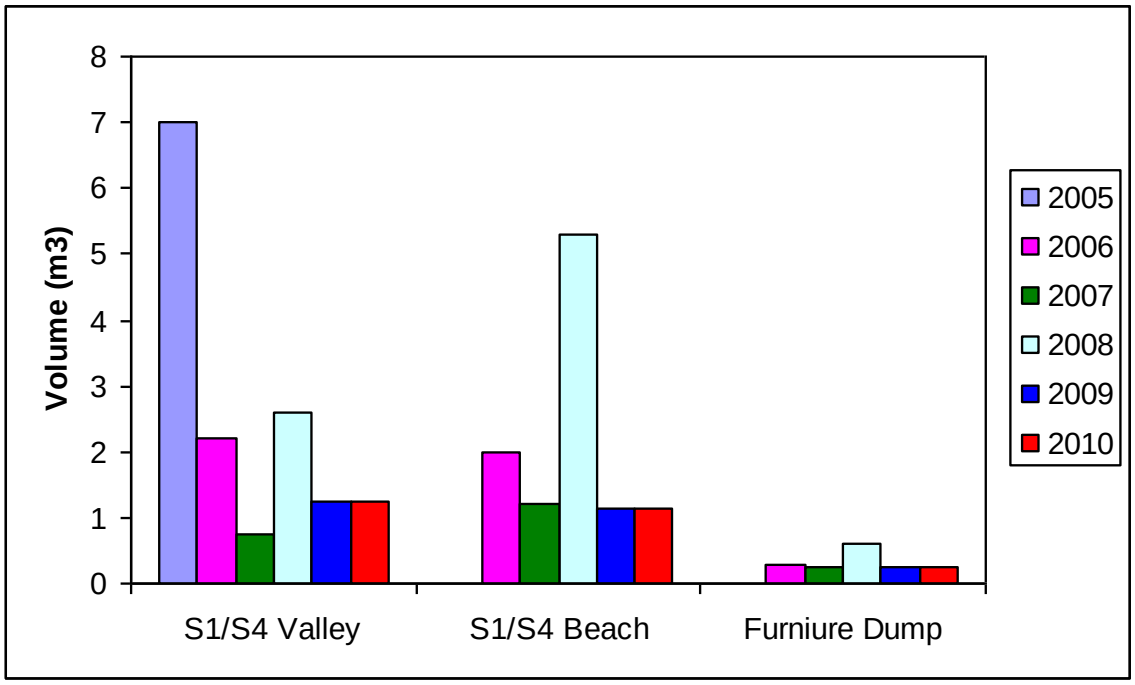
Table 18 summarizes the PCB levels in the components of the barrier systems at the three locations this year. As usual the furniture dump PCB levels are much higher than those in the S1/S4 drainage pathway. The relative levels in the media at each location vary but the trends each year are generally similar. Thus, at the S1/S4 beach area the levels in the three filter box components are all low and similar while at the other two barriers the levels in the gravel are generally lower than in the other two media. The levels in the sediment trapped between the layers of 1200R geotextile are always higher than elsewhere as this material is composed of the finer particles of sediment from the drainage pathways.

Table 18: PCB Levels in Components of the Barrier Systems in 2010

Barrier	PCB Concentration (ppm)			
	Sediment	Gravel	GAC	1200R
S1/S4 Valley	2.9	0.1	0.7	3.5
S1/S4 Beach	1.4	0.4	0.7	0.6
Furniture Dump	42	4.5	23	42

Figure 8 illustrates the change in sediment loading at the barriers with time: the values for 2009 and 2010 are identical as they have been calculated as equal to half the two year total. In general the loading in the two S1/S4 barriers is generally slightly more than One cubic meter whereas the amount in the furniture dump is around a quarter of this amount. However the amount is likely to vary from year to year depending on the rate of snow melt and the occurrence of summer storms. It is difficult to say whether any soil stabilization by settling or by plant and moss establishment has occurred.

Figure 8: Change in Volume of Sediment Collected at the Three Barriers With Time



IV. HYDROCARBON REMEDIATION

A. Main Landfarm

1. Background

A major landfarm was set up in 2004 in order to remediate soil contaminated with > 2500 ppm fuel at the site. The approximate size of the landfarm was 76 m by 21 m with a depth of about 0.6 m. The area was therefore 1390 m^2 and a volume of 700 m^3. Fertilizer was then added at a rate of 117 g urea and 1.8 g diammonium phosphate (DAP) per m^2 in 2004 and the whole area was then rototilled and 39 representative samples taken on 3 September 2004 and analysed. The concentration of the TPH in the landfarm was found to be 3320 ± 970 ppm. In 2005, one quadrant was marked off and designated as a control plot. This control plot was not fertilized or aerated. Analytical results obtained from three samplings of the main landfarm in 2005 showed that the mean TPH concentration was 2450 ± 1150 ppm The C_{17}/Pr ratios showed little change also indicating that TPH losses due to bioremediation were very low. Laboratory experiments in the winter of 2005 showed that more fertilizer was required and therefore urea and MAP were added at the rate of 252 g Urea and 19 g MAP per m^2 on 24 July 2006. The main landfarm (excluding the control plot) was thoroughly mixed three times in 2006. Analytical results obtained from the landfarm in 2006 gave results of 2140 ± 690 and 1510 ± 560 from the two samplings. The C_{17}/Pr ratios showed a significant reduction in 2006 indicating that TPH losses due to bioremediation were occurring. Results for the control plot show higher TPH levels for the two samplings of 2280 ppm and 3000 ppm and an average C_{17}/Pr ratio of 0.28. The ratio was not statistically different from the starting value of 0.36. In 2007, the TPH level in the main landfarm was 810 ± 410 ppm while that of the untilled plot was 1690 ± 650 ppm. Also the value of the C_{17}/Pr ratio for the control plot was 0.27 ± 0.06 which was still not significantly different from the value obtained when the landfarm was constructed whereas, for the main landfarm, the ratio could not be determined since the two peaks involved were at concentrations below the method detection limit. By 2008 the TPH level in the main plot was determined to be 1250 ± 570 ppm while no sampling was undertaken in 2009 due to bad weather.

2. 2010 Field work

This year soil samples were collected from the main area of the landfarm and from the control plot on 9 August 2010. The main area was divided into 9 zones (Photograph 15) and holes were excavated in each along with 2 locations from the control plot. Sampling locations were marked with rock cairns. Four of the 11 sample locations

produced two samples each as depth samples from 0-30 cm and 30-60 cm were taken; all other samples were from 0-60 cm.

Fertilizer was applied to the landfill excluding the control plot (Photograph 16). The amount added was 170 kg of urea and 10 kg of diammonium phosphate (DAP). This corresponds to an application of N and P based on a C:N:P ratio of 100:7.5:0.5 assuming a TPH content of 1000 ppm; the level of TPH was determined to be 810 ± 410 ppm in 2007 and 1260 ± 570 ppm in 2008.

3. Results for 2010

Results of analyses for diesel fuel are given in Table 19. Data for the fertilized main portion of the landfarm and the unfertilized small control plot is shown graphically along with data from previous years in Figure 9. The average soil fuel level of 1670 ± 640 was higher than last year but the results were not significantly different. TPH was lower in the top 30 cm as compared to 30 to 60 cm possibly indicating relatively greater bioremediation or aeration in the warmer top layer. For the control plot to which no fertilizer had been added, the fuel levels were higher than the main landfarm (3160 ppm versus 1670 ppm). Average C_{17}/Pr ratios obtained from the main landfarm gave a value of 0.16 in contrast to the value of 0.30 for the control plot. The C_{17}/Pr ratios show that bioremediation was essentially absent when no fertilizer was added.

Table 19: Results of Analyses of Soil Samples for TPH from the Main Landfarm

Quadrant type	Depth (cm)	Sample Numbers (RI10-)	TPH diesel fuel (ppm)
Main Landfarm	0-30	508; 512; 519	950; 1800; 1360
	30-60	509; 513; 520	1600; 2530; 3940
	0-60	506; 507; 510; 511; 514; 518	1610; 1080; 1080; 2600; 1160; 1420
		Mean Concentration ± sd	**1670 ± 640**
Control plot	0-30	515	2420
	30-60	516	6270
	0-60	517	1970
		Mean Concentration ± sd	**3160 ± 1680**

sd = standard deviation

Figure 9: Change of TPH with Time at the Main Landfarm

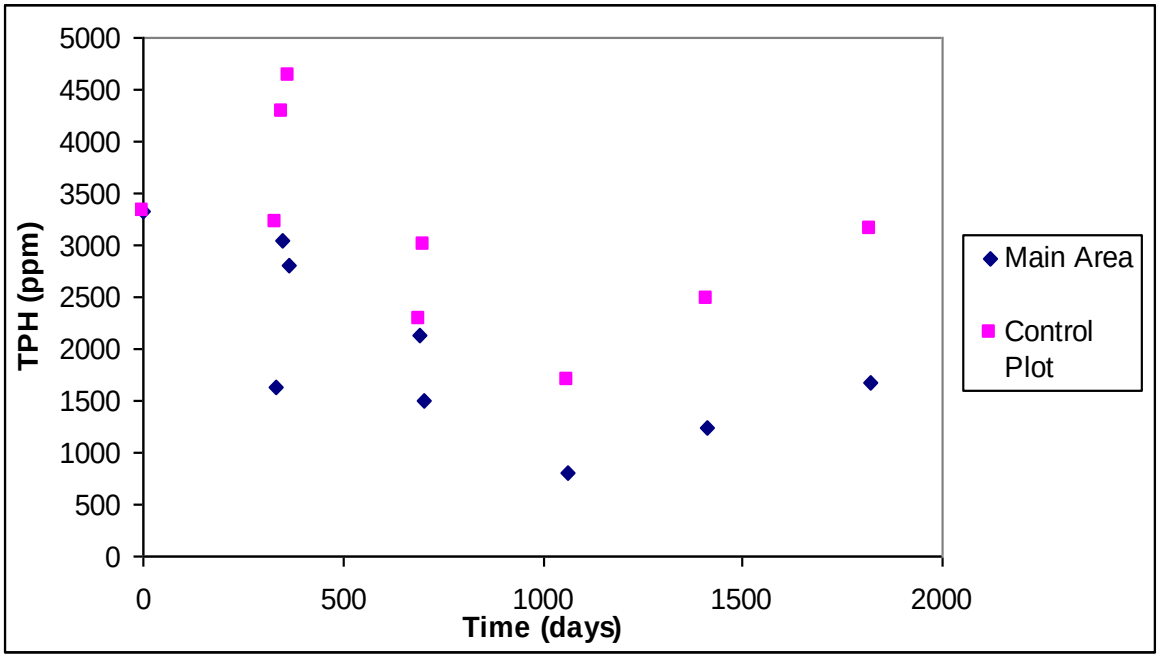
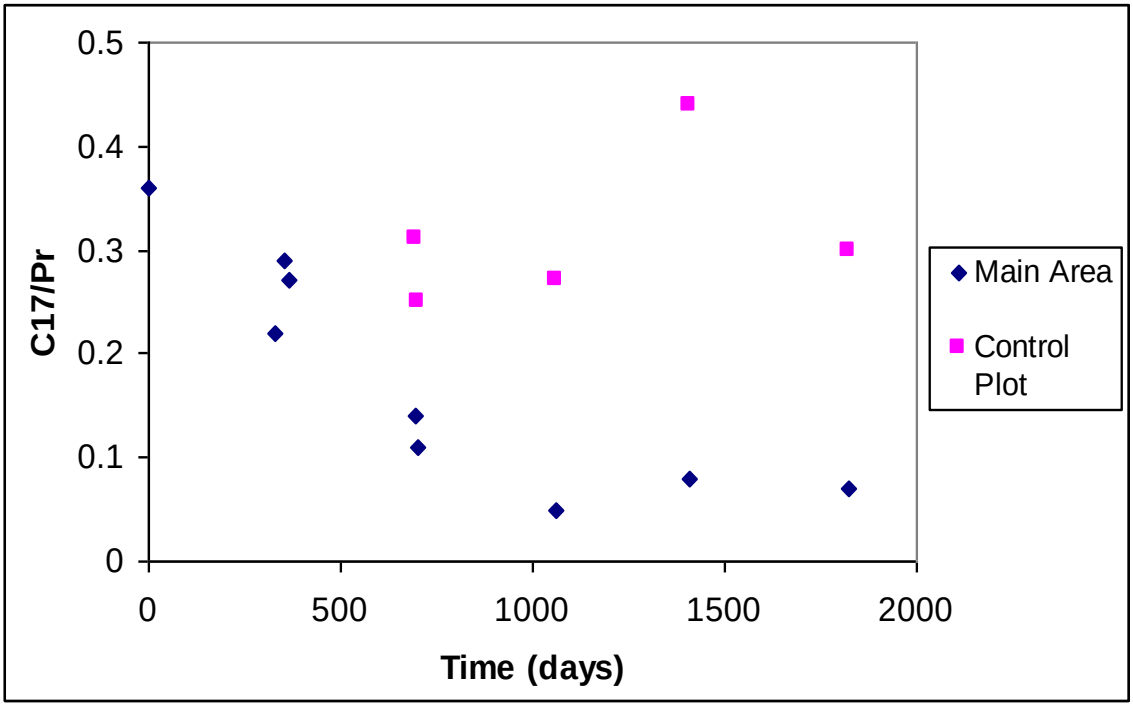


Figure 10: Change of C_{17}/Pr Ratios with Time at the Main Landfarm



Four soil samples were analysed by the CCME-TPH method to give the results shown in Table 20. These show that the major fraction is F2 with lesser amounts of F3 which is consistent with the diesel fuel GC pattern. The ratio of F2/F3 however is higher for the control plot as expected.

Table 20: Results of Analyses of Soil Samples for CCME-TPH from the Main Landfarm (ppm)

Sample location	Sample (RI10-)	F1 (C6-C10)	F2 (C10-C16)	F3 (C16-C34)	F4 (C34-C50)
Control plot	526	<40	1930	650	<10
Main landfarm	523 524 525	<40 <40 <40	1680 1210 1495	590 520 560	<10 <10 <10

Soil nitrogen and phosphorus data for the main landfarm are presented in Table 21. The data for total nitrogen and total and extractable phosphorus are in line with previous determinations. However the presence of extractable ammonia and nitrate in some of the samples from the main landfarm was unexpected. As with the hydrocarbon degrader data presented below, it suggests considerable heterogeneity within the landfarm with, maybe, pockets of trapped fertilizer.

Table 21: Soil Nitrogen and Phosphorus Levels (ppm) at the Main Landfarm

Sample location	Sample (RI10-)	Unit	TKN	Ext. Ammonia	Ext. Nitrate	Ext. Nitrite	Total P	Ext P
Control plot	N003	ppm	240	<2.0	<2.0	<2.0	170	<20
Main landfarm	N001 N002 N004	ppm ppm ppm	370 440 410	2.2 19.6 <2.0	<2.0 3.1 <2.0	<2.0 <2.0 <2.0	150 150 170	<20 <20 20

The hydrocarbon degraders level for the control plot was found to be 1.7×10^3 while the three samples from the main landfarm gave values of 2.0×10^4 , 2.5×10^5 and 2.0×10^3. These results show that there are considerable differences in biological activity within the soils of the landfarm which are quite heterogeneous from this point of view.

Three bulk samples were taken from the main landfarm and homogenized in the laboratory. Laboratory experiments were then conducted to determine if the addition of more fertilizer would aid in the depletion of hydrocarbon content as described in the methods section. The average initial TPH concentration of the soil in the ten reactors was 546 ± 178 ppm. After 47 days at 14 ºC the average level in the five fertilized reactors was 376 ± 78 ppm while in the 5 control reactors the level was 454 ± 238 ppm. After a further 50 days at 20 ºC, the corresponding levels were 619 ± 147 ppm for the fertilized reactors and 540 ± 94 ppm for the control reactors. These results are highly variable and no conclusions can be drawn. The C_{17}/Pr ratios were 0.24 ± 0.06 for the fertilized reactors and 0.24 ± 0.04 for the five control reactors. These results are more convincing in that they are much more precise. They show that the addition of more fertilizer had no effect on the rate of degradation of TPH. In fact there was no evidence of further degradation which tends to indicate that the readily biodegradable fraction has been removed and the remaining hydrocarbon are less easily degraded. It should, however, be pointed out that the sample used had a much lower concentration and higher C_{17}/Pr ratio than the samples collected from the nine locations as reported in Table 19 and was therefore not very representative.

Photograph 15: The Main Landfarm was Divided into Nine Zones for Sampling

Photograph 16: Fertilizer was Applied to the Surface of the Main Landfarm in the Form of Urea and Diammonium Phosphate

B. In Situ Landfarm

1. Background

An ideal way to remediate fuel contaminated soil in the Arctic would be to add fertilizer on top of the affected area. The fertilizer might then percolate into the contaminated zone and promote bioremediation. Such an in situ scheme would be extremely cost effective and would result in no physical disturbance of the tundra. Such an in situ bioremediation might be successful in that most TPH contamination is in the surface active layer. On the negative side, the soil temperatures are low, particularly at the base of the active layer where contamination might be greatest, oxygen may be limited and the added nutrients may not reach the contaminated zone.

In order to investigate the performance of bioremediation in an in situ study in the Arctic, one needs to add nutrients to a fuel contaminated area and observe changes in TPH concentration. At the same time, TPH levels in an associated control plot in which no nutrients are added, needs to be followed. The main problem with this concept is that TPH levels in soil from a spill are extremely heterogeneous. Therefore, in order to carry out the study at Resolution Island, it was necessary to excavate some TPH contaminated soil and homogenize it and then place it back in the ground. It was further decided that in this study the soil should be compacted into plots formed by excavation of pits in the ground in order to simulate undisturbed soil. One trial plot would be left for two years before nutrients were added so that the soil would be more settled and oxygen levels stabilized.

Four holes measuring 5 m by 5 m and with a depth of 0.6 m were excavated in the ground in the barrel cache valley. Excavated, screened and mixed TPH contaminated soil was then placed in each hole and compacted. For one plot, fertilizer was mixed with the soil prior to filling the hole. At another plot fertilizer was sprinkled on top. The amount of fertilizer added was 124 g of urea and 21 g of DAP per plot. Thus the four plots were as follows:

- Control Plot 1 (CP1) – no fertilizer added
- Control Plot 2 (FAS2) – no fertilizer added until the soil had settled for 2 years – fertilizer was added to this plot in 2007
- Fertilizer added to the surface (FAS1)
- Fertilizer mixed with the soil (FAM)

The four plots were then sampled twice in August 2005. The average concentrations from the two samplings was 918 ± 250 ppm and 926 ± 340 ppm. Examination of the data showed no significant difference of TPH with depth or between plots. The C_{17}/Pr ratios in the TPH from the plots was found to be 0.48 ± 0.04 ppm, again with no difference between plots as would be expected at the start of the experiment. In 2006, more fertilizer was sprinkled on the top of the FAS1 and FAM plots in the form of urea (1.6 kg) and DAP (0.25 kg) on 27 July 2006. More fertilizer was added to both plots because much less fertilizer was added in 2005 than required. Essentially both plots were then the same. Average TPH levels in the 4 plots in 2006 were found to be 910, 1150, 620 and 670 ppm for CP1, FAS2, FAS1 and FAM respectively. The C_{17}/Pr ratios in the FAS1 and FAM plots had been reduced to 0.20 while for the CP1, FAS2 plots, they remained unchanged at 0.50, indicating that bioremediation was taking place in the two fertilized plots. Average soil temperatures were 7.9 to 8.9 ºC in the top 30 cm but 6.1 – 7.3 ºC at depths between 40-80 cm. In 2007, fertilizer was added to plot FAS2 in the form of urea (1600 g) and DAP (250 g). Analytical results for the 4 plots showed a decrease with time for the fertilized plots but these were not statistically different. The C_{17}/Pr ratios however exhibited a significant difference between the plots fertilized in 2005/2006 and the unfertilized plots. In 2008 the analytical results gave data that were consistent with results and trends from previous years. In 2007, fertilizer was added to FAS2 which was previously left for two years in order to give it time to stabilize. TPH levels found in 2007 were anomalously low for both CP1 and FAS 2. In 2008 however the CP1 level was virtually unchanged from that in 2005 whereas the FAS2 level had fallen to roughly half the initial value. The C_{17}/Pr ratio for the CP1 plot was not significantly different from the 2005 value. The C_{17}/Pr ratio for the FAS2 was slightly less but not significantly different from the control plot. This was surprising given the apparent lowering of the TPH level. The C_{17}/Pr ratio for FAS1 and FAM plots are much lower showing that a significant amount of bioremediation had taken place. No sampling was undertaken in 2009 due to logistical problems.

2. 2010 Field Activities

All four plots were sampled on 6 August 2010 with 3 holes excavated per plot. All samples were taken by hand excavation as it was found to be very wet at depth. For one of the three holes, two samples were taken, one from 0-30 cm and one from below 30 cm. Soil was returned to the sampling location and this was marked so that the location would not be sampled in subsequent years.

3. 2010 Results

Analytical results obtained from the four landfarm plots in 2010 are given in Table 22 and Figure 11. C_{17}/Pr ratios were determined again this year and are shown in Figure 12 together with results from the previous year; C_{18}/Ph ratios showed a similar result. There is, as usual, considerable heterogeneity in the soil from the plots with the resulting poor precision within the TPH data sets. Figure 12 shows clearly the difference between the two plots (FAS1 and FAM) which were fertilized in 2005 and 2006 and the control plot (CP1) and the FAS2 plot which was fertilized in 2007. Clearly little or no bioremediation is taking place at the CP1 and FAS2 plots. This data may, in fact, indicate that with a plot such as FAS2 which was left to stabilize for 2 years, that bioremediation will not take place unless the earth is aerated as well as fertilized. A very important result if this result is confirmed in subsequent years. It could also be argued that the fertilizer did not penetrate the ground and therefore was not available.

Table 22: Results of Analyses of Soil Samples for TPH From the In Situ Landfarm

Plot Regime	Sample Number	Depth (cm)	TPH (ppm)
CP1	RI10-527	0-30	500
CP1	RI10-528	30-60	390
CP1	RI10-529; 530	0-60	280; 770
Control plot 1 average ± sd			**485 ± 210**
FAS2	RI10-534	0-30	650
FAS2	RI10-532	30-60	1300
FAS2	RI10-533; 531	0-60	620; 610
FAS 2 plot average ± sd			**795 ± 340**
FAS1	RI10-535	0-30	220
FAS1	RI10-536	30-60	190
FAS1	RI10-537; 538	0-60	360; 140
FAS 1 plot average ± sd			**227 ± 94**
FAM	RI10-539	0-30	460
FAM	RI10-540	30-60	510
FAM	RI10-541; 542	0-60	260; 380
FAM plot average ± sd			**402 ± 110**

Figure 11 Change of TPH with Time at the In Situ Landfarm

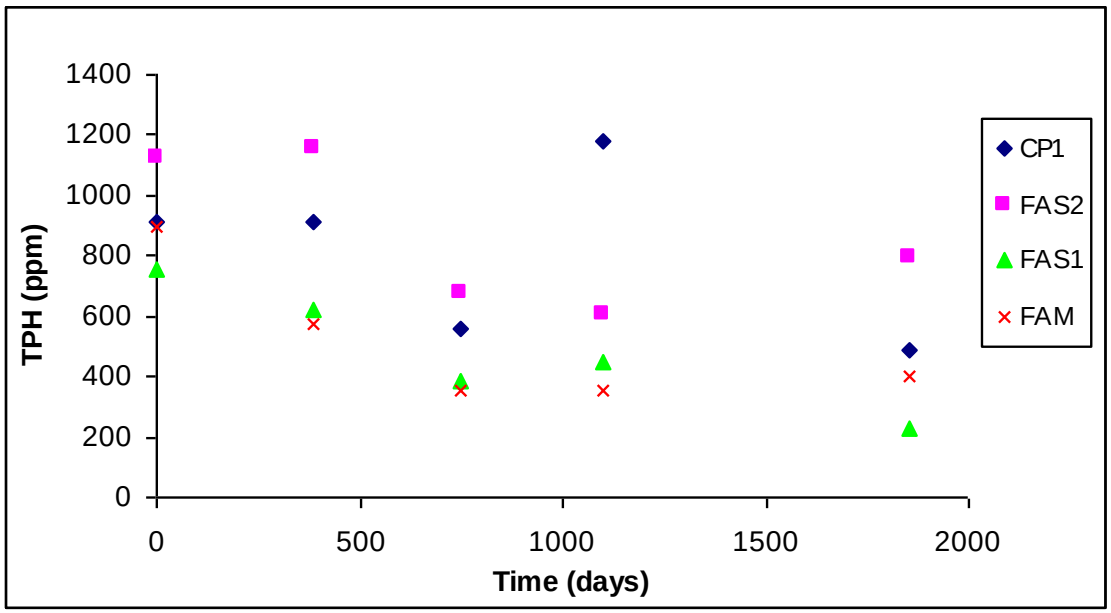
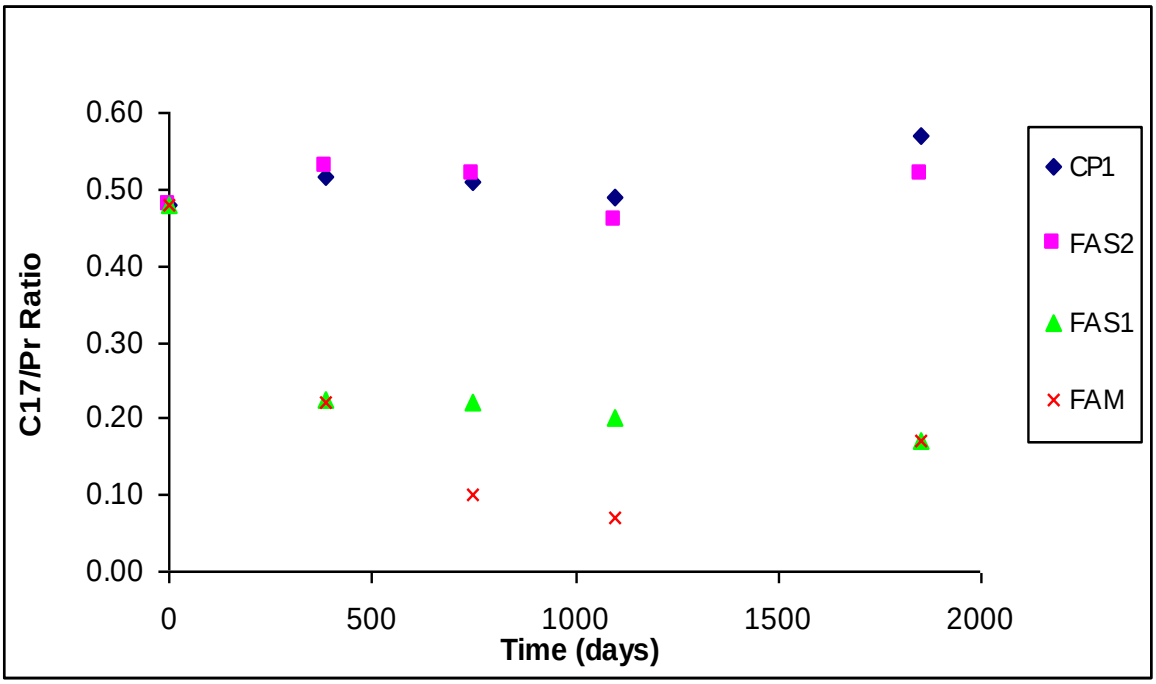


Figure 12: Change of C_{17}/Pr Ratios with Time at the In Situ Landfarm



Four soil samples were analysed by the CCME-TPH method to give the results shown in Table 23. These show that the major fraction is F2 with lesser amounts of F3 which is consistent with the diesel fuel GC pattern. Samples from this area had not previously been subjected to the CCME test. The F2/F3 ratio are much larger than for the Main Landfarm indicating a light fuel mixture.

Table 23: Results of Analyses of Soil Samples for CCME TPH from the In Situ Landfarm

Sample	Plot	F1 (C6-C10)	F2 (C10-C16)	F3 (C16-C34)	F4 (C34-C50)
RI10-529	CP1	<40	805	143	<10
RI10-533	FAS2	<40	1000	160	<10
RI10-537	FAS1	<40	666	146	<10
RI10-541	FAM	<40	284	72	<10

Nutrient analysis results are presented in Table 24. For the FAM plot a trace of ammonia was found. Nutrients were added to this plot in 2006 and extractable ammonia was found in 2007 and 2008. However the FAS1 was treated similarly and fertilizer was added to FAS2 in 2007 yet no extractable material was observed at these two plots.

Table 24: Soil Nitrogen and Phosphorus Levels (ppm) at the In Situ Landfarm

Sample	Plot	TKN	Ext. Ammonia	Ext. Nitrate	Ext. Nitrite	Total P	Ext P
RI10-N008	CP1	280	<2.0	<2.0	<2.0	210	<20
RI10-N007	FAS2	220	<2.0	<2.0	<2.0	180	<20
RI10-N006	FAS1	400	<2.0	<2.0	<2.0	190	<20
RI10-N005	FAM	360	2.4	<2.0	<2.0	220	<20

Hydrocarbon degraders levels in the four samples CP1, FAS2, FAS1 and FAM were 4.0×10^4, 4.0×10^2, 4.0×10^4, and 6.5×10^4 respectively. In 2007 and 2008 the CP1 plot gave values of 1.1×10^3 and 100 respectively which were less than the results for the treated plots. However this year a much higher value was obtained.

One bulk samples was collected from each plot and subjected to the same laboratory fertilizer experiment as for the main landfarm as described in the methods section. Results are shown in Table 25 and are quite interesting.

For the two plots FAS1 and FAM which were first fertilized in 2005 both show identical behavior. For both the fertilized and unfertilized plots there is a significant and parallel reduction in TPH with time. Their C_{17}/Pr ratios were low and did not change significantly with time This suggests that there is sufficient nutrient present for the degradation of hydrocarbons in these two plots.

For the CP1 and FAS2 the TPH levels did not change in the unfertilized reactors whereas a sharp reduction was seen in the fertilized reactors. Also there was a large reduction in C_{17}/Pr ratios in the fertilized reactors which was not observed in the unfertilized plots. This was, of course, expected for the control plot. The fact that the same behaviour was obtained for the FAS2 plot confirms the results found during the routine monitoring. That is, that for this plot which was left for two years to stabilize, no bioremediation is taking place.

Table 25: TPH levels (ppm) and (C_{17}/Pr Ratios) from the Laboratory Fertilizer Addition Experiments for Four Soils From the In Situ Plots

	Type	Initial	After 47 days at 14 ºC	After an additional 50 days at 20 ºC
CP1	unfertilized	520 ± 84 (0.49)	748 ± 82 (0.52)	812 ± 336 (0.51)
	fertilized	619 ± 18 (0.53)	446 ± 115 (0.26)	354 ± 94 (0.23)
FAS2	unfertilized	812 ± 24 (0.48)	1207 ± 240 (0.47)	780 ± 50 (0.44)
	fertilized	664 ± 71 (0.48)	706 ± 31 (0.23)	495 ± 208 (0.19)
FAS1	unfertilized	668 ± 164 (0.26)	501 ± 19 (0.12)	177 ± 54 (0.21)
	fertilized	542 ± 20 (0.25)	342 ± 91 (0.16)	104 ± 39 (0.22)
FAM	unfertilized	465 ± 79 (0.12)	347 ± 120 (0.12)	136 ± 41 (0.15)
	fertilized	332 ± 247 (0.14)	247 ± 11 (0.16)	156 ± 47 (0.16)

C. Ponding and Barrier Research

1. General

A pond and barrier system was constructed in 2004. This novel system was installed to examine its effectiveness in removing TPH from a drainage pathway under Arctic conditions. It was reasoned that a pond would help in the removal of volatile TPH by adding a large surface area for evaporation and an oil absorbent boom on the surface of the pond would remove any hydrocarbon on the water surface. Additionally, the placement of a barrier system incorporating absorbent materials would remove any TPH from the water or entrapped particles.

In 2005 and 2006, the various components of the barrier system were sampled and analysed and the filter materials and booms replaced. This required the testing of soil and water monitoring points and the components of the system (sand, GAC and boom material) to determine whether TPH was being removed. The soil and water monitoring points were established at locations upstream, downstream and within the system reservoirs in 2004 as shown on Map 5. Results of analyses of the soil and water samples probably reflected upstream remediation activity rather than barrier performance. Measurable levels of TPH were found in two sections of the GAC filters but this corresponded with only a small amount of TPH (0.75 g). Samples from the boom material were collected each year but interference from the material precluded analysis for TPH. Nitrogen and phosphorus levels determined in soil samples from monitoring points in 2004, 2005 and 2006 suggested that there had been little or no leaching of fertilizer from the main landfarm. Inspection of the whole system in each year showed no deterioration as a result of erosion or ultraviolet light. In 2007 and 2008 both water and soil samples were collected and analysed. The system was generally found to be in good repair but by 2008 the PVC liner forming the first pond was damaged above the water line but the seal on the pond was intact. This was not entirely unexpected since the pond liner is subject to uv-degradation and is much thinner than the HDPE liners used on the second barrier and the PCB barriers. No sampling was undertaken in 2009.

2. 2010 Field Activity

No major repairs were needed on the system again this year. Build up of sediment found at the PCB barriers was not found at this barrier probably due to the smaller catchment area involved and therefore these did not need to be shoveled out; the first pond has a PVC liner and the sediment protects this from sunlight. The second boom had been washed to the top of the dam but was still functional. Water was flowing smoothly

though the underground system and was half way up the filter box in the second pond (Photograph 17). Monitoring samples were taken for both soil and water at the established monitoring points along the pathway, both upstream and downstream from the barrier at locations indicated on Map 5. The filter box system was in good condition. This year the filters were sampled and the gravel and GAC replaced (Photograph 18). Boom material was also sampled but not replaced. The integrity and performance of pond liners was investigated and results of this work presented along with that of the liners in the PCB barriers in Section VII.

3. Monitoring Results

Results of analyses of soil samples collected this year are shown in Table 26 along with those for some previous years. The results are generally consistent with the exception of those for SP2 and SP4 in 2008; the variability of TPH levels found in field samples is well known. The results show no obvious trends.

Table 26: Results of Soil Analyses for TPH at the Imploded Tank Drainage Area Ponds and Barriers

Soil Monitoring Point/ Sample	Location	TPH (ppm)				
		2005	2006	2007	2008	2010
SP1/RI10-505	Below waterfall	710	310	370	430	280
SP2/RI10-504	Between waterfall and barrier	<40	<40	<40	400	<40
SP3/RI10-501	Just beyond barrier	600	182	290	310	860
SP4/RI10-500	Between barrier and cliff	100	<40	100	850	190
SP5/RI10-503	Sediment in Dammed Pond	-	-	-	-	<40
SP6/RI10-502	Sediment in Pond with filter box	-	-	-	-	<40

Water samples taken in the imploded tank drainage channel during the assessment phase all gave results of <1.0 mg/L TPH. Water samples were collected in 2004 from four points within the barrier system to determine low-level concentrations of TPH in water. Results given in Table 27 show that TPH levels were in the range from

0.09 - 0.11 ppm. In 2005 one additional monitoring point was added. Results of the analysis for TPH in water from these five points gave values in the range 0.16 – 0.31 ppm TPH. In both 2004 and 2005 there was considerable disturbance of the surface soil and water interface in and around the imploded tank area. The results for these years may therefore represent elevated background levels associated with this activity. The samples collected this year were analysed with a detection limit of 0.10 ppm and no TPH was detected as was the case in 2007 and 2008.

Table 27: Results of Water Analyses for TPH at the Imploded Tank Drainage Area Ponds and Barriers

Monitoring Point	Location	TPH (ppm)				
		2005	2006	2007	2008	2010
WP1	Small Waterfall Upstream of Pond	0.19	<0.20	<0.10	<0.10	<0.10
WP2	Pond #1	0.31	<0.20	<0.10	<0.10	<0.10
WP3	Pond #1 Discharge Pipe	0.16	<0.20	<0.10	<0.10	<0.10
WP4	Pond #2	0.29	<0.20	<0.10	<0.10	<0.10
WP5	Filter System Discharge	0.23	<0.20	<0.10	<0.10	<0.10

Nutrient levels at the four soil sampling points are given in Table 28. Total N and P levels are similar to those from previous years. In previous years the levels of extractable ammonia, nitrate and nitrite were all below the method detection limits therefore showing no leaching of extractable nutrients from the main landfarm.

Table 28: Results of Analyses for Nutrient in Soil at the Imploded Tank Drainage Area Ponds and Barriers (ppm)

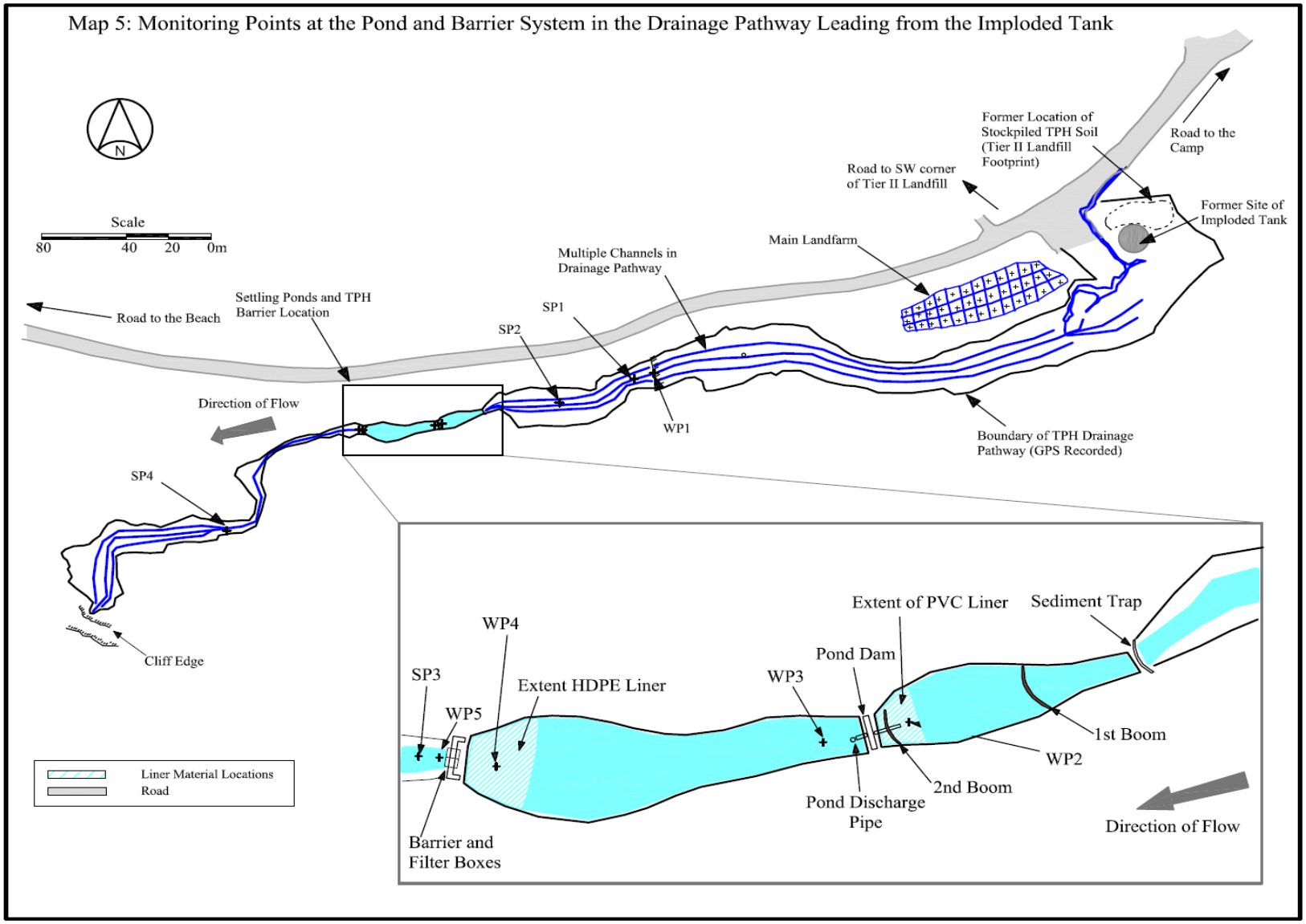
Sample	Location	TKN	Ext. Ammonia	Ext. Nitrate	Ext. Nitrite	Total P	Ext P
RI10-N014	SP1	300	<2.0	<2.0	<2.0	120	<20
RI10-N013	SP2	110	<2.0	<2.0	<2.0	105	<20
RI10-N010	SP3	230	<2.0	<2.0	<2.0	90	<20
RI10-N009	SP4	150	<2.0	<2.0	<2.0	80	<20
RI10-N011	SP5	310	<2.0	<2.0	<2.0	150	<20
RI10-N012	SP6	70	<2.0	<2.0	<2.0	100	<20

Hydrocarbon degrader levels in the 6 soil samples from SP1, SP2, SP3 SP4, SP5 and SP6 were found to be 1.0×10^2, 5.5×10^2, 6.0×10^2, 2.0×10^4, 1.0×10^2, and 1.8×10^3 respectively. These are typical of levels found at the site on previous occasions.

Results given in Table 29 show that no diesel fuel was detected in samples of gravel or GAC from the filter box.

Table 29: TPH Concentration of Filter Box Materials From 2005. to 18 July 2008

Sample No	Medium	Location	TPH (ppm)
RI10-548	Gravel	Left first filter	<40
RI10-549	Gravel	Right first filter	<40
RI10-546	GAC	Left second filter	<40
RI10-547	GAC	Right second filter	<40
RI10-544	GAC	Left third filter	<40
RI10-545	GAC	Right third filter	<40


Map 5: Monitoring Points at the Pond and Barrier System in the Drainage Pathway Leading from the Imploded Tank
N
Scale
80 40 20 0m
Former Location of Stockpiled TPH Soil (Tier II Landfill Footprint)
Road to the Camp
Road to SW corner of Tier II Landfill
Former Site of Imploded Tank
Main Landfarm
Multiple Channels in Drainage Pathway
Settling Ponds and TPH Barrier Location
Road to the Beach
SP1
SP2
WP1
Direction of Flow
Boundary of TPH Drainage Pathway (GPS Recorded)
SP4
Cliff Edge
Extent of PVC Liner
Sediment Trap
WP4
Pond Dam
SP3
Extent HDPE Liner
WP3
WP5
1st Boom
WP2
2nd Boom
Pond Discharge Pipe
Barrier and Filter Boxes
Direction of Flow
Liner Material Locations
Road

Photograph 17: Water in the Second Pond of the Hydrocarbon Barrier System

Photograph 18: Water was Gushing Through the Filter Box of the hydrocarbon Barrier System After Replacement of the Filter Media

V. LONG TERM MONITORING

A. Tier II Landfill Monitoring Program

1. Background

The long-term, post-remediation monitoring program contained provisions for monitoring wells and associated soil points at the Tier II landfill. The landfill was constructed over the period 2003-2005 at a somewhat contaminated location as was evidenced by the discovery of TPH in the sub-surface soils at the site location. Four monitoring wells and associated soil monitoring points were established in 2003 and 5 additional monitoring wells added in 2004. These were sampled up to seven times during the 2004 and 2005 seasons in order to establish baseline data. No water could be obtained from the two wells, 1B and 3B, and thus the Tier II monitoring well system was comprised of 7 wells and 6 associated soil monitoring points: soil monitoring point 5 is adjacent to both wells 5A and 5B. Sampling of soil from MW#4 was omitted in error this year. Analytical results for the water and soil samples collected this year are presented in the next section in two tables which are followed by a discussion of these results including a comparison to the results obtained in previous years.

2. Water and Soil Monitoring

The position of the monitoring wells and their associated soil monitoring locations is given in Map 6. Wells were all purged to dryness on the day prior to sampling. After sampling, the Waterra tubing was removed from the wells and discarded. Well caps and lids were replaced and secured with zip ties. Water was present in all seven wells this year; well MW1B and MW3B yielded no water as in the past. Soil and water samples were collected on 7-8 August 2010. Water samples are filtered for metals but not for TPH and PCBs due to the potential loss of analytes to the filter. Results of the analysis of the soil and water soil samples are given in Tables 30 and 31 respectively.

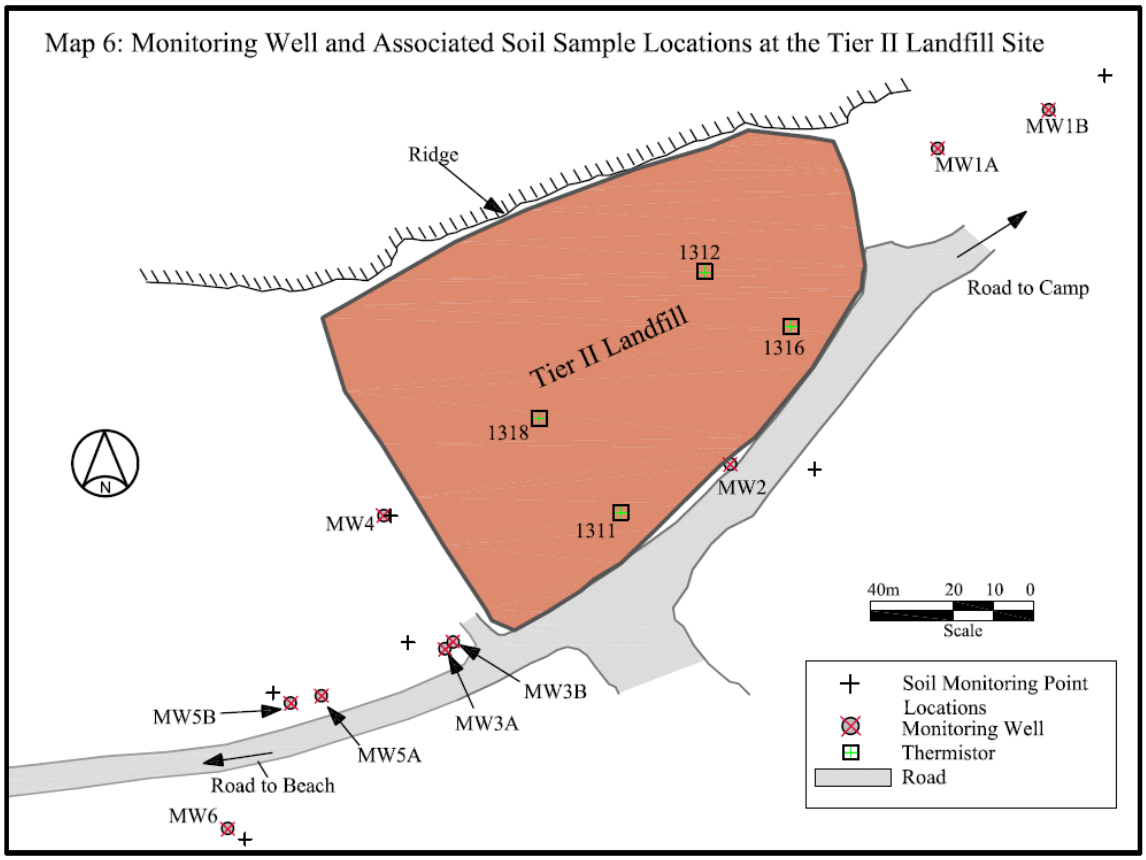

Map 6: Monitoring Well and Associated Soil Sample Locations at the Tier II Landfill Site
Ridge
MW1B
MW1A
1312
Road to Camp
Tier II Landfill
1316
1318
N
MW2
MW4
1311
40m 20 10 0
Scale
MW3B
MW5B
MW3A
MW5A
Road to Beach
MW6
Soil Monitoring Point Locations
Monitoring Well
Thermistor
Road

Table 30: Results of Analyses of Soil Samples Taken From Close to the Monitoring Wells at the Tier II Landfill Site

Location		MW1	MW2	MW3	MW4	MW5	MW6
Prefix RI10-		005	001	002	-	003	004
Arsenic	ppm	1.2	1.9	2.0	-	2.0	1.4
Cadmium	ppm	<1.0	<1.0	<1.0	-	<1.0	<1.0
Chromium	ppm	33	48	40	-	62	34
Cobalt	ppm	8.2	9.5	13.5	-	30	6.7
Copper	ppm	45	58	48	-	115	50
Lead	ppm	<10	<10	30	-	21	<10
Nickel	ppm	48	33	51	-	118	26
Zinc	ppm	44	45	77	-	109	35
PCBs	ppb	6.0	33	231	-	144	8.2
TPH (lube)	ppm	<40	680	<40	-	<40	<40
TPH (fuel)	ppm	<40	420	<40	-	<40	<40

Table 31: Results of Analyses of Water Samples Taken From the Monitoring Wells at the Tier II Landfill Site

Location	Unit	MW1A	MW2	MW3A	MW4	MW5A	MW5B	MW6
Arsenic	ppm	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cadmium	ppm	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	ppm	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cobalt	ppm	0.010	0.068	0.025	0.039	0.024	0.015	0.029
Copper	ppm	<0.005	0.008	<0.005	<0.005	0.023	0.005	<0.005
Lead	ppm	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nickel	ppm	0.020	0.277	0.070	0.051	0.047	0.052	0.098
Zinc	ppm	0.019	0.170	0.041	<0.010	0.051	0.149	0.126
PCBs	ppb	0.032	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020
TPH (lube)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TPH (fuel)	ppm	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

3. Discussion of Analytical Results

The objective of the monitoring wells and associated soils program was to initially establish baseline values for levels of parameters in the soil and water and thus any increases in the levels of these parameters in time might then be attributed to failure of the landfill to have contained the contaminants placed within it. Unfortunately the Tier II landfill site was situated on a site contaminated at levels that one might expect at an industrial site and the variability of some of the initial baseline levels was larger and more variable than desired.

a) Metals

Table 32 summarizes the soil baseline sample data obtained in previous years while Table 33 summarizes the results for this year. Elements for all samples were within the baseline ranges developed in 2004 and 2005 except for three metals in MW5. These metals (cobalt, nickel and zinc) were all slightly higher than the established range. In addition copper and chromium levels both exceeded the DCC II criteria in this sample. Generally the levels of metals in soil from MW5 have been similar to the other soil monitoring points during the last 5 years though results similar to the ones obtained this year were found in 2005 for MW5.

Table 32: Summary of Baseline Results for Elemental Levels in Soil Samples Collected From the Tier II Landfill Soil Monitoring Points in 2004 and 2005 (ppm)

	Arsenic	Cadmium	Chromium	Cobalt
Mean	1.1	<1.0	40.0	11.1
Standard Deviation	0.4	0.0	9.4	4.9
Range	<1.0-2.0	<1.0	32-70	5.6-25
# samples > det limit	22	0	28	28
	Copper	Lead	Nickel	Zinc
Mean	61	13.4	48	57
Standard Deviation	19	14.0	19	18
Range	35-118	<10-63	24-106	33-103
# samples > det limit	28	11	28	28

Table 33: Summary of Elemental Levels Found in Soil Samples Collected From the Tier II Landfill Soil Monitoring Points in 2010 (ppm)

	Arsenic	Cadmium	Chromium	Cobalt
Mean	1.7	<1.0	43	13.6
Range	1.2-2.0	<1.0	34-62	6.7-30
	Copper	Lead	Nickel	Zinc
Mean	63	16.2	55	62
Range	45-115	<10-30	33-118	35-109

Table 34 summarizes the water baseline sample data obtained in previous years. No arsenic, chromium, or lead were detected in any samples but a trace of cadmium was found in MW2. Copper was detected in 3 wells but within the established range. Cobalt and zinc were detected in all wells but again within the established ranges. Only nickel in MW2 and MW6 was outside the normal range (0.277 ppm and 0.098 ppm respectively as compared to (<0.010 – 0.091 ppm). Both these wells have exhibited high levels of nickel spasmodically during the past 5 years of monitoring.

Table 34: Baseline Summary of Elemental Levels in the 86 Water Samples Collected From the Tier II Landfill Monitoring Wells in 2004 and 2005 (ppm)

	Arsenic	Cadmium	Chromium	Cobalt
Mean*	<0.003	<0.001	<0.005	0.017
Standard Deviation*	0.000	0.000	0.000	0.019
Range	<0.003-0.05	<0.001	<0.005-0.367	<0.003-0.073
# samples > det limit	1	0	2	51
	Copper	Lead	Nickel	Zinc
Mean	0.006	0.006	0.037	0.021
Standard Deviation	0.006	0.003	0.042	0.027
Range	<0.005-0.033	<0.010-0.022	<0.010-0.091	<0.010-0.286
# samples > det limit	26	7	71	41

* Excluding outliers

b) TPH

TPH was detected as both fuel and lubricating oil and grease in soil from MW2 this year. Generally none has been found at this location in the past. However no TPH was found in any other soils. Fuel has sporadically been found in soil samples from other locations over the past years particularly from MW3 and MW4. TPH was not detected in any of the water from the wells this year.

c) PCBs

PCB levels in the soil samples at the monitoring points ranged from 6 to 230 ppb which is consistent with results obtained in previous years. MW3 and MW5 again exhibited the highest results. The average value found this year from the 5 samples was 84 ppb as compared to 46 ppb in 2009 and 78 ppb in 2008.

This year PCBs were only detected in one of the six water samples. The value of 0.032 ppb found in MW1A is low as compared to the detection limit of 0.020 ppb. Over the last 5 years levels of PCBs found in the well water have varied considerably. Given the level of PCBs in the nearby soil, any soil contamination in the water is likely to give measurable PCB levels in the water. The water cannot be filtered since this process would remove the PCBs from the water. In the laboratory, the samples were allowed to stand for at least 24 hours and then the water to be analysed was carefully decanted. However several samples in the past contained soil particles floating on the surface and, in others, colloidal material was present. Thus, the results where PCBs were found in the water may well have been a measure of the soil contamination rather than actual levels in the water. This is particularly likely since PCB molecules tend to partition on to solid surfaces and to absorb on to particles rather than to dissolve in water.

B. Airstrip Landfill Monitoring Program

1. Background

The remediation of the airstrip dump was completed in 2003. Four monitoring wells were placed around it, one above and three in the leachate channel leading away from it (Map 7). However, it should be noted that the drainage channel for MW12, MW13 and MW14 is extremely narrow and the staked area for the soil samples straddles the channel. For the first time water samples were obtained from all four wells.

2. Soil and Water Monitoring

Results of the analyses are shown in Table 35 and Table 36 for soil and water respectively.

Elemental results in the soil samples were consistent with results found in previous years. All the results are within the levels given in Table 32 for the Tier II landfill with the exception of zinc levels which have been generally higher over the last 5 years especially from soil adjacent to MW13 and MW14. The metal levels in water were consistent with results from previous years and all within the normal ranges given in Table 34. Nickel was detected in all samples but at low levels. The only other metal found was lead at the detection limit at MW11from which water has not been obtained in the past.

For the soil samples this year, TPH (lubricating oil and grease) was high in MW 12 as usual and also a low amount was found in MW13. In contrast no TPH was found in the other soil samples and no TPH was found in the water samples. These results are consistent with results from previous years.

PCB levels in the soil samples were generally higher this year. Similar levels were found in 2008 while generally lower levels were found in 2009 and in prior years. However there is considerable variation from year to year. For instance the PCB level in soil at MW13 was 106 ppb this year as opposed to 12 ppb in 2009, 38 ppb in 2008, 48 ppb in 2007 and 24 ppb in 2006. For water samples, the PCB results levels ranged from <0.020 ppb to 0.062 ppb.

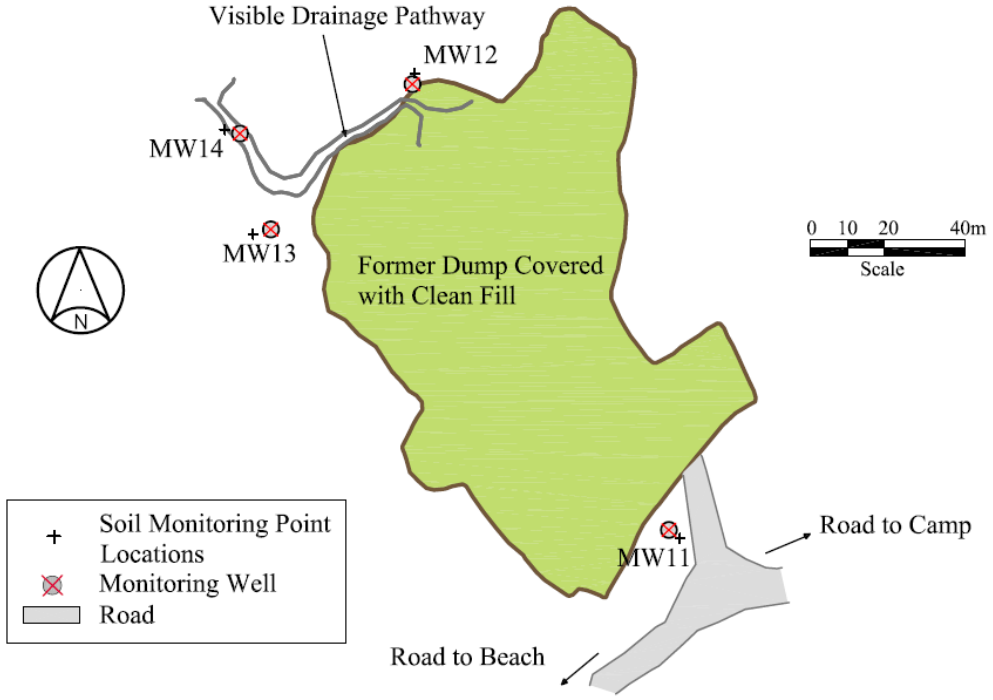
Table 35: Results of Analyses of Soil Samples Taken From the Monitoring Wells at the Airstrip Landfill

		MW11	MW12	MW13	MW14
Prefix RI10-		008	009	043	010
Arsenic	ppm	1.2	1.1	2.0	1.7
Cadmium	ppm	<1.0	<1.0	<1.0	<1.0
Chromium	ppm	45	37	42	45
Cobalt	ppm	15.1	15.5	13.5	15.7
Copper	ppm	65	60	78	66
Lead	ppm	31	14.2	35	10.3
Nickel	ppm	59	77	63	75
Zinc	ppm	93	97	233	135
PCBs	ppb	108	61	106	10.5
TPH (lube)	ppm	<40	1970	100	<40
TPH (fuel)	ppm	<40	<40	<40	<40

Table 36: Results of Analyses of Water Samples Taken From Close to the Monitoring Wells at the Airstrip Landfill

		MW11	MW12	MW13	MW14
Arsenic	ppm	<0.003	<0.003	<0.003	<0.003
Cadmium	ppm	<0.001	<0.001	<0.001	<0.001
Chromium	ppm	<0.005	<0.005	<0.005	<0.005
Cobalt	ppm	<0.003	<0.003	<0.003	<0.003
Copper	ppm	<0.005	<0.005	<0.005	<0.005
Lead	ppm	<0.010	<0.010	<0.010	<0.010
Nickel	ppm	0.010	0.005	0.012	0.007
Zinc	ppm	0.010	<0.010	<0.010	<0.010
PCBs	ppb	0.062	0.054	<0.020	0.020
TPH (lube)	ppm	<1.0	<1.0	<1.0	<1.0
TPH (fuel)	ppm	<1.0	<1.0	<1.0	<1.0

Map 7: Monitoring Well and Soil Monitoring Sample Locations at the Airstrip Landfill



C. Maintenance Dump Monitoring Program

1. Background

The remediation of the maintenance dump was completed in 2005 and two monitoring wells and two soil monitoring points established (Map 8).

2. Water and Soil Monitoring

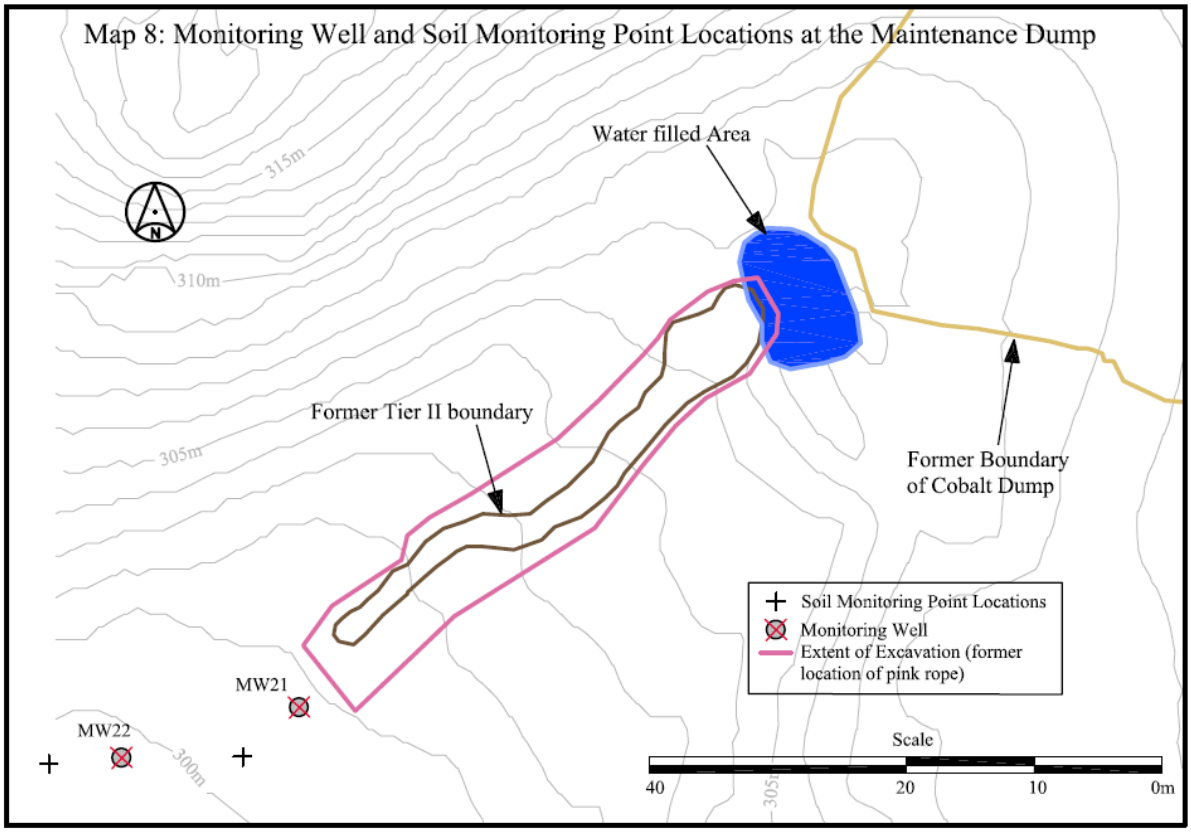
Water and soil samples were collected this year and results of their analyses are shown in Table 37. Water in MW21 was frozen and therefore no sample was available.

Elemental results from soil samples were consistent with those obtained in previous years. For the water samples, all metal results were below the method detection limit. Again these results are consistent with the results from the previous two years.

Lubricating oil was detected for the first time in soil from MW21 this year. No hydrocarbons were detected in soil from MW22 or in the two water samples. The PCB levels in the two soils were consistent with results from previous years. No PCBs were detected in water from MW22 this year. Levels have varied from <0.020 to 0.079 over the last 5 years.

Table 37: Results of Analyses of Water and Soil Samples Taken From the Monitoring Well Locations at the Maintenance Dump

Location	Units	Water		Soil	
		MW21	MW22	MW21	MW22
Prefix RI10-		frozen		007	006
Arsenic	ppm	-	<0.003	1.0	1.5
Cadmium	ppm	-	<0.001	<1.0	<1.0
Chromium	ppm	-	<0.005	39	43
Cobalt	ppm	-	<0.003	16.0	27
Copper	ppm	-	<0.005	54	72
Lead	ppm	-	<0.010	<10	<10
Nickel	ppm	-	<0.005	67	73
Zinc	ppm	-	<0.010	116	180
PCBs	ppb	-	<0.020	11.3	55
TPH (lube)	ppm	-	<1.0	160	<40
TPH (fuel)	ppm	-	<1.0	<40	<40


Map 8: Monitoring Well and Soil Monitoring Point Locations at the Maintenance Dump
Water filled Area
315m
310m
305m
300m
Former Tier II boundary
Former Boundary of Cobalt Dump
MW21
MW22
Soil Monitoring Point Locations
Monitoring Well
Extent of Excavation (former location of pink rope)
Scale
40
20
10
0m

D. Background Water Samples

In order to establish background data, water samples were collected from several locations and analysed for PCBs, and the eight elements of the DEW Line Clean Up Criteria. This surface water monitoring was last conducted in 2005 with the exception of the water flowing by the old officer's mess which was also analysed in 2006, 2007 and 2008. Analytical procedures were used to give low detection limits; metals are for the dissolved fraction.

Seven samples were collected from six locations this year; one was a field duplicate. Sample numbers and locations are given in Table 38 and results of analyses are presented in Table 39. For arsenic, cadmium, chromium and lead all are less than the method detection limits. For the other four elements the results are in line with previous data. That is to say that all results are between the minimum and maximum values that have been found for each location over the period 2001-2009. Result vary quite a lot for nickel and zinc as is illustrated by Figure 13 which shows the variation of the four metals with time for the water flowing near the Officer's mess. For most locations there is no data for 2006-2009. PCB results were all very low. Lake water was collected from the old water lake in 2006 and 2010 and from the new water lake beyond the barrel cache valley from 2001-2005. The levels of all metals are higher in the old water lake. These levels are in the same range as those of the S1/S4 beach stream which run from the lake but again levels vary quite a lot for nickel and zinc. The old water lake sample was also analysed for other analytes and results given in Table 40.

Table 38: Sampling Locations of Background Water Samples

Sample Number	Sample Description and Location
RI10-W035	Water flowing in stream below the S1/S4 Beach, now crossed by road
RI10-W014	Water flowing by the old officer's mess
RI10-W020	Water flowing behind imploded tank
RI10-W058	Water flowing from the maintenance dump
RI10-W022	Water flowing in the beach dump stream
RI10-W100	Old water lake

Table 39: Analytical Results Obtained from Background Water Samples

Element	Unit	Stream by S1/S4 beach	Officer's mess	Imploded tank
PCBs	ppb	<0.020	0.023	<0.020
As	ppm	<0.003	<0.003	<0.003
Cd	ppm	<0.001	<0.001	<0.001
Cr	ppm	<0.005	<0.005	<0.005
Co	ppm	0.030	0.011	0.017
Cu	ppm	0.048	0.009	0.014
Pb	ppm	<0.010	<0.010	<0.010
Ni	ppm	0.15	0.068	0.038
Zn	ppm	0.096	0.078	0.047

Element	Unit	Maint. dump	Beach dump	Old water lake
PCBs	ppb	<0.020	<0.020	
As	ppm	<0.003	<0.003	<0.003
Cd	ppm	<0.001	<0.001	<0.001
Cr	ppm	<0.005	<0.005	<0.005
Co	ppm	0.01	0.037	0.029
Cu	ppm	<0.005	0.023	0.047
Pb	ppm	<0.010	<0.010	<0.010
Ni	ppm	0.033	0.13	0.14
Zn	ppm	0.028	0.062	0.095

Figure 13: Levels of Cobalt, Copper, Nickel and Zinc in Water Collected from Near the Old Officer's Mess as a Function of Time.

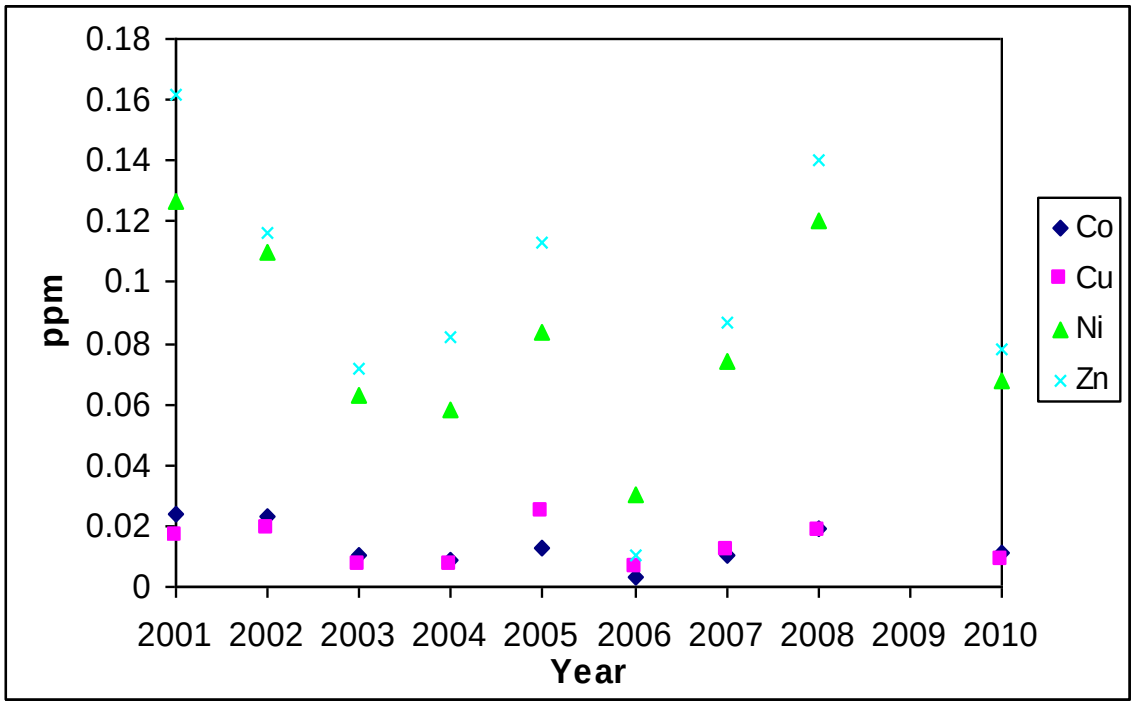


Table 40: Results of Analysis of the Old Water Lake Sample for Other Parameters

	Units	Old Water Lake
Chloride	ppm	6.4
Nitrate	ppm	<0.05
Nitrite	ppm	<0.05
Sulphate	ppm	41
Sodium	ppm	4.0
Potassium	ppm	0.59
Calcium	ppm	4.5
Magnesium	ppm	2.6
Iron	ppm	<0.05
Manganese	ppm	0.06
pH	-	4.2
Conductivity	uS/cm	110

E. Background Plant Samples

Eleven background plant samples were collected this year; one was a field duplicate. The results are presented in Table 41 and Map 9. Plants were collected but not washed and therefore dust and water droplets transferred to new growth, and which may contain PCBs, were analysed in the sample. Therefore results of these analyses are an indication of airborne PCB levels. All PCBs showed the Aroclor 1260 pattern.

Table 41: Results of Analyses of Background Plant Samples

Monitoring Point	Tag	PCBs (ppb)	Location
PMP1	6421	71	Camp – old officer's mess
PMP2	6568	10.8	NE of Tier II landfill
PMP3	6741	12.9	Airstrip drainage pathway
PMP4	6746	20	Imploded tank
PMP5	6887	9.4	1000m NE of airstrip
PMP6	6888	7.1	Radio Hill
PMP7	6746	6.4	S1/S4 Beach
PMP8	-	4.0	Beaching area
PMP9	6889	41	1000m S of barrel cache valley
PMP10	6984	6.4	New water lake

During the first three years of monitoring (2003-2005) there was considerable remediation activity at the site particularly in 2003 when CEPA soil was being excavated whereas in 2007 and 2008 there was minimal soil disturbance. Table 41 and Figure 12 show the change in levels at the PMPs with time. The level of PCBs in the plants in the areas removed from remediation action had already dropped in 2005 presumably due to the removal of the high level CEPA soil. The results may show that vehicular traffic, which produces considerable dust, was still important up to 2006. Also not just the new growth was analysed in the samples but some older woody material which would reflect levels from previous year's activity. These results indicate that the removal of the PCB contaminated soils has greatly reduced the airborne transport of PCBs.

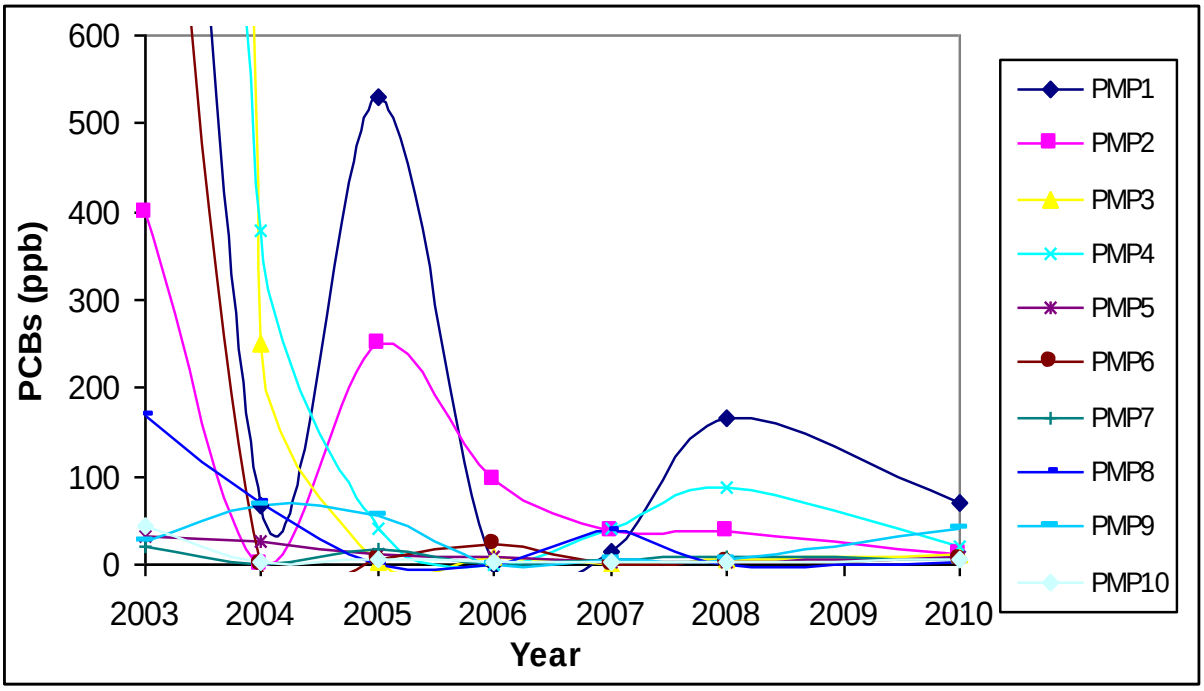
Plant samples were analysed as part of the environmental assessment in 1993. Results of these determinations are shown as ranges for various areas on Map 10; remote background plant samples from > 1.5 km from the site all contained < 4 ppb PCBs. At this time some plants would have been growing in PCB-contaminated soils and might therefore reflect uptake as well as aerial transport.

As can be seen by comparison to the data in Table 42, Figure 14 and Map 9, there has been a large decrease in the level of PCBs in plants which reflects the significant reduction in aerial transport of PCBs as a result of the site remediation. Generally the levels around the summit have dropped from values of 1000s of ppb to < 100 ppb PCBs whereas at other locations values have dropped from in the range of 50-1000 ppb to < 10 ppb PCBs.

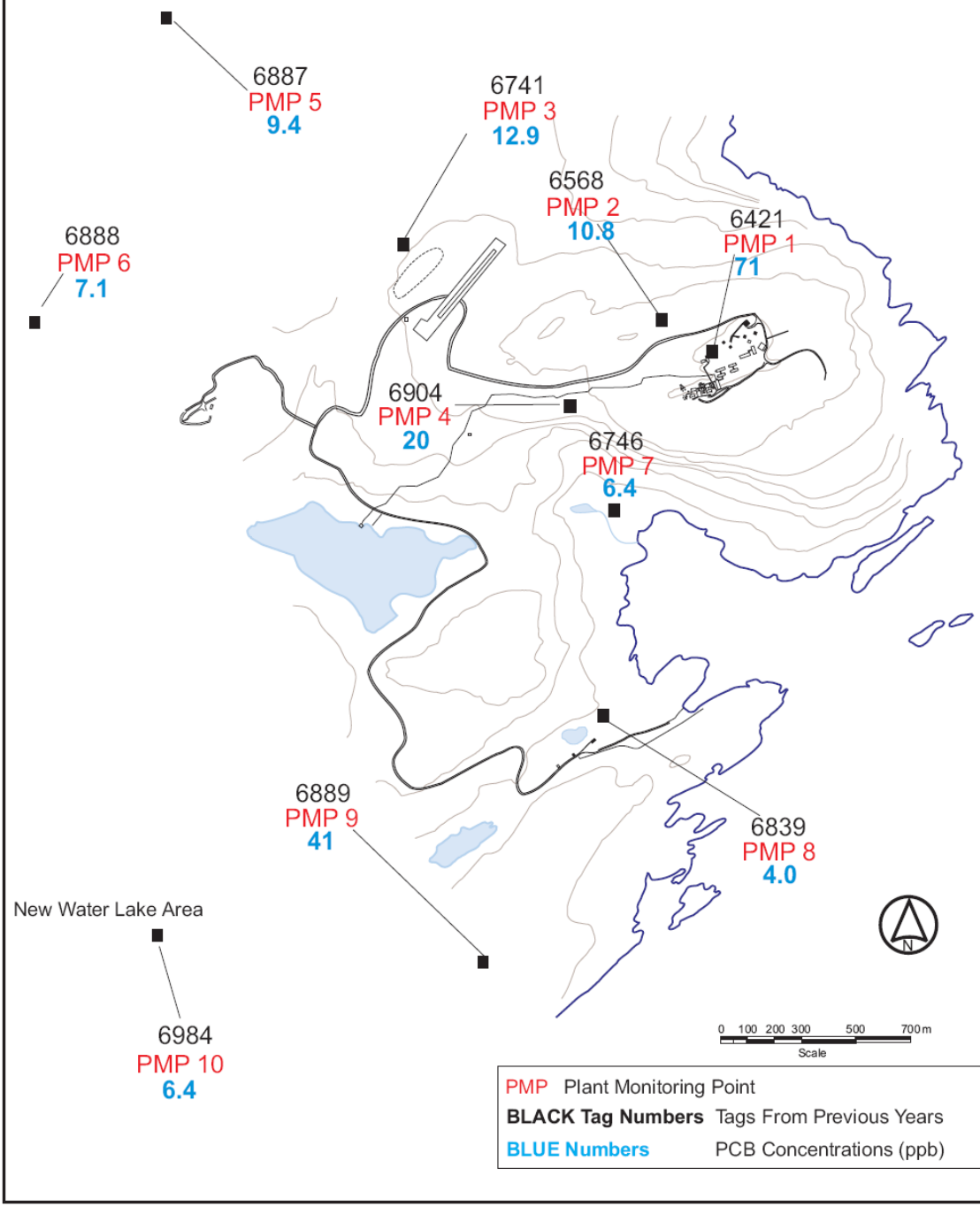
Table 42: Results of Analyses of Background Plant Samples (2003-2010)

		2003	2004	2005	2006	2007	2008	2010
PMP1	Camp – old officer's mess	1700	66	530	-	15.5	166	71
PMP2	NE of Tier II landfill	400	<3.0	250	97	38	37	10.8
PMP3	Airstrip drainage pathway	11000	250	4.3	8.0	<3.0	6.0	12.9
PMP4	Near imploded tank	3300	380	42	-	40	87	20
PMP5	1000m NE of airstrip	33	25	11.3	7.9	4.0	3.8	9.4
PMP6	Radio Hill	1090	<3.0	5.8	22	<3.0	3.1	7.1
PMP7	S1/S4 Beach	21	<3.0	18	-	6.6	7.7	6.4
PMP8	Beaching area	170	70	-	-	38	-	4.0
PMP9	S of barrel cache valley	26	67	54	-	6.1	6.9	41
PMP10	New water lake	43	<3.0	4.5	<3.0	3.4	4.5	6.4

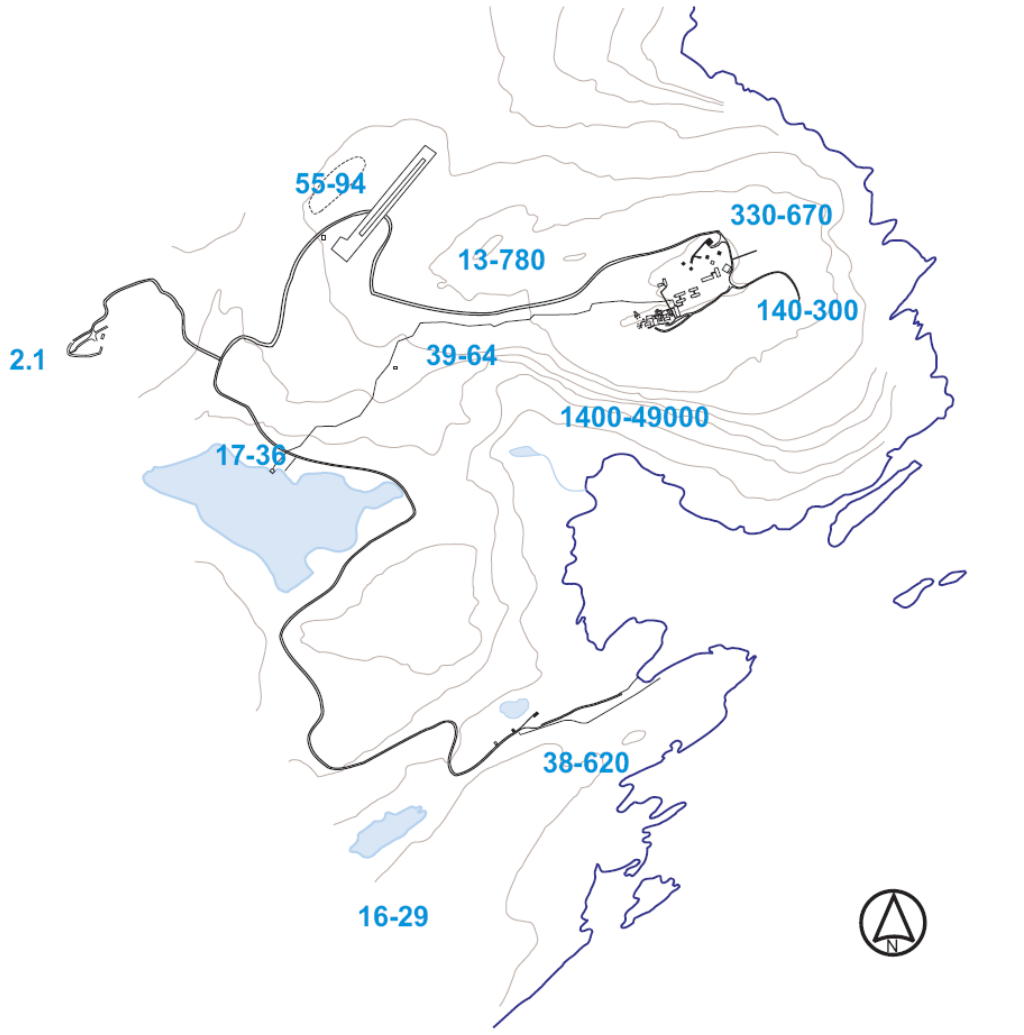
Figure 14: PCB Levels in Plants From Various Locations at the Site With Time



Map 9: Locations and PCB Concentrations of Background Plant Samples Collected in 2010



Map10: Locations and PCB Concentrations of Background Plant Samples Collected in 1993



F. Airstrip Landfill Eroded Surface Investigation

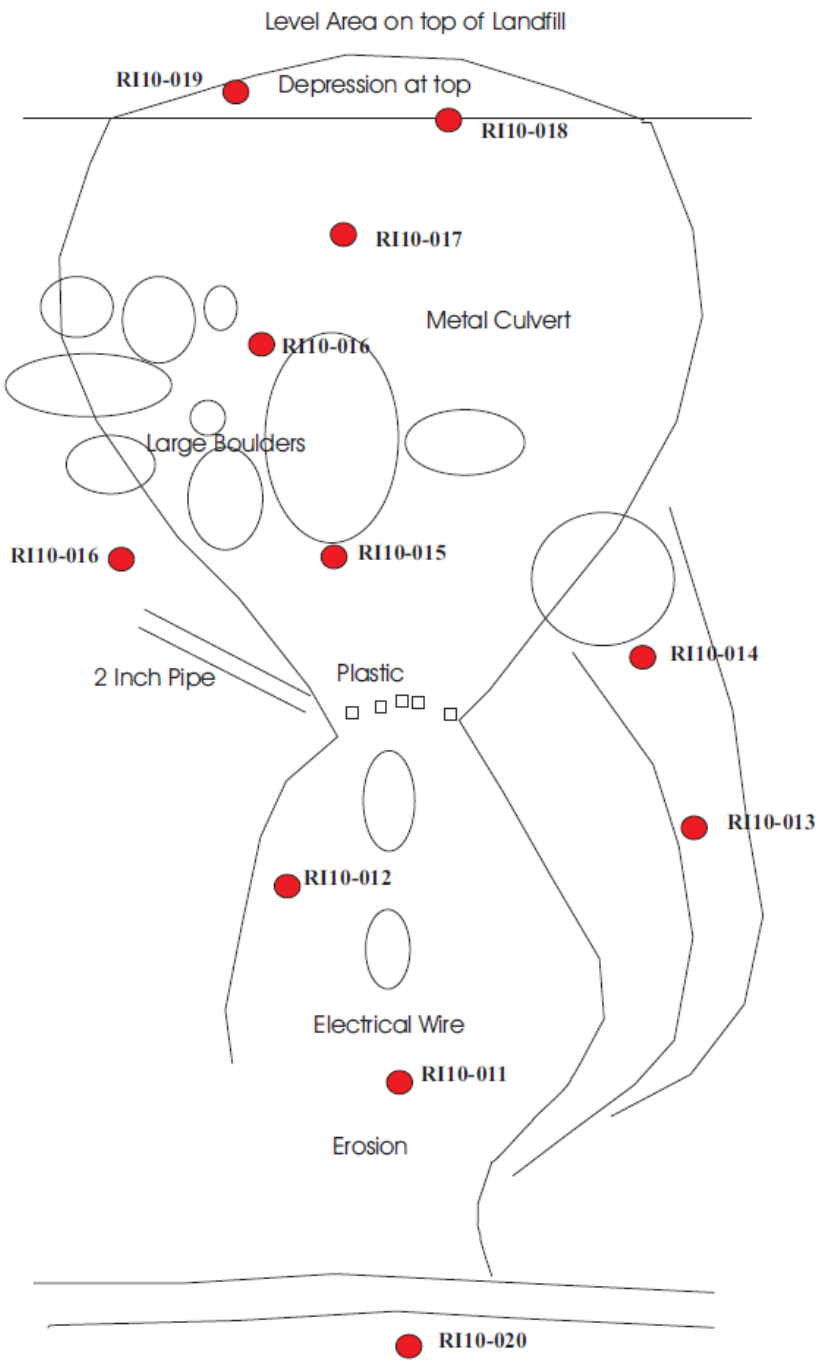
The remediation of the airstrip dump involved removal of PCB contaminated soil and covering with clean fill. The coverage with fill was not complete and as a result some physical debris was still visible. While the engineering assessment of the landfill in 2009 showed it was in good condition there was evidence of erosion on the north west berm. The berm was constructed with large boulders and some of these had migrated down the slope. Gravel was also moving down the slope and shallow gullies had formed. As a result it was decided to analyse the surface soil in this area to determine PCB levels.

Eleven samples from ten locations were collected from locations shown on Map 11. Results of analyses of the samples are given in Table 43. These show that essentially all soil from this area contained less than the Tier I level for PCBs with one sample containing 1.1 ppm PCBs.

Table 43: PCB Concentration in Soil Samples From the Airstrip Landfill

Sample No	PCB Concentration (ppm)
RI10-011	<0.1
RI10-012	<0.1
RI10-013	0.1
RI10-014	0.1
RI10-015	1.1
RI10-016	<0.1
RI10-017	0.2
RI10-018	0.2
RI10-019	<0.1
RI10-020	<0.1

Map 11: Sampling Locations and PCB Concentrations of Soil Samplesfrom the North West Berm of the Airstrip Landfill



G. Wildlife Observations

The following wildlife were observed at the site during the summer's filed season.

1. *Land*

The following wildlife was observed on land: ptarmigan and ravens. Polar bear paw prints were also seen at the beach.

2. *Sea*

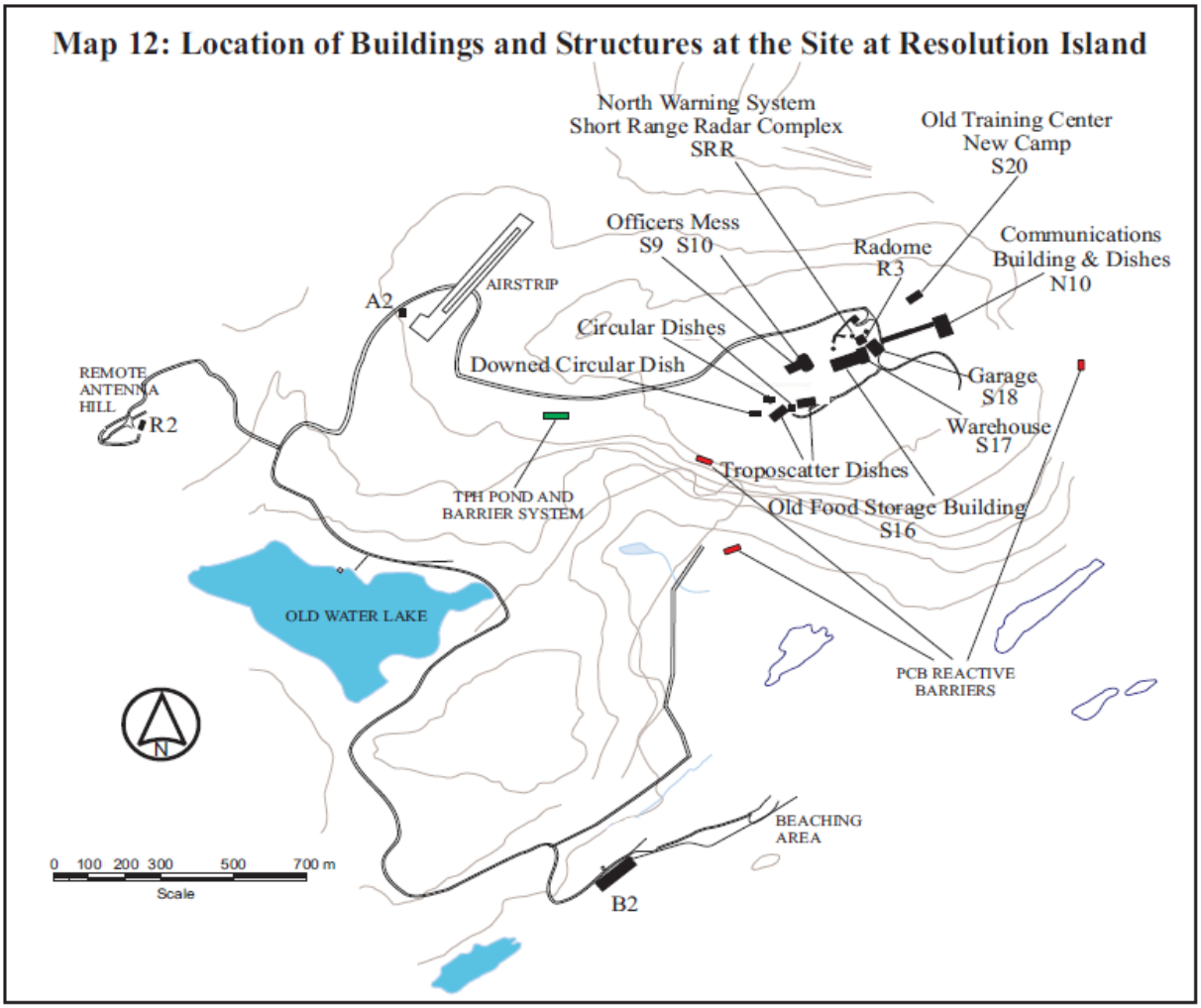
The following were observed on and in the water: beluga whale and black guillemot.

Photograph 19: An Arctic Fox at the Site in 2006

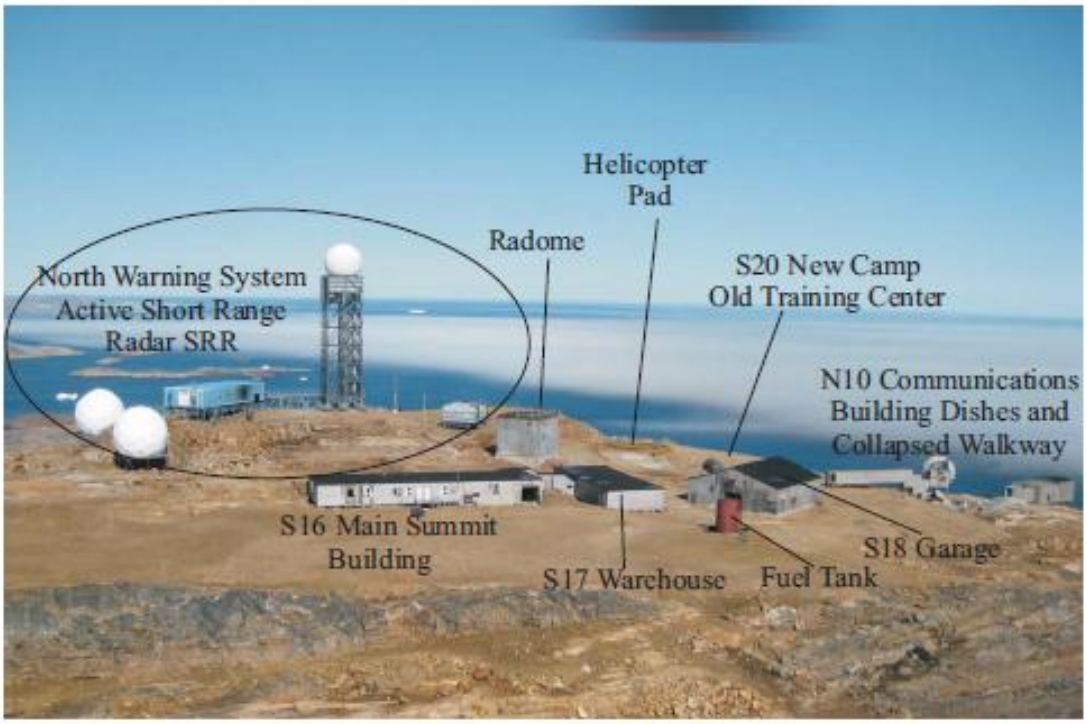
VI. ON SITE BUILDINGS

At the request of INAC all remaining structures and major debris at the site were photographed in 2010. Map 12 shows the locations of all the structures and Photographs 20 and 21 show some of the structures at the summit. The location and description of the structures and debris are given in Table 44 along with a key to Photographs 22 to 64 which follow. Most of the buildings and structures are in reasonable shape but some are losing pieces of sheet metal while a few have polar bear damage. The beach building, B2, is particularly prone to perennial winter damage which is unfortunate in that it is useful for storage for off-site shipment. There is very little debris present other than inside buildings; as part of the remediation program pieces of wood and metal on the ground were collected and buried in the non-hazardous landfills.

Map 12: Location of Buildings and Structures at the Site at Resolution Island



Photograph 20: Some of the Structures Remaining at the Summit



Photograph 21: The South East Part of the Summit

Table 44: List of Remaining Buildings and Physical Debris at Resolution Island

Building Number and Name	Comments	Photograph Number and Location
R3: Radome	Inside of building is wet but it provides useful storage for the Kubota loader and GAC	Photograph 22: North side Photograph 23: Inside radome
Troposcatter Dishes	Are in stable and good condition but with some sheet metal loss. Probably contains asbestos	Photograph 24: Troposcatter dishes and circular dish between
Circular metal dishes	One dish was taken down to recycle aluminum but this was not carried out and it remains on the ground at original site. The other is still standing and in excellent condition	Photograph 25: Circular dish dismantled on ground
S9 and S10: Officer's Mess and Officer's Living Quarters	Building exteriors is stable and in good condition but there is wood and metal debris on the ground surrounding the building. The interior is full of debris. At one time this was to be a museum on site. All the artifacts have disappeared	Photograph 26: East side and exterior entrance Photograph 27: South side view of S9, S10 Photograph 28: Interior view of bar area Photograph 29: Interior view of corridor
S16: Old Food Storage Building Remediation Project Dining Room and Office Areas	Building is solid with exterior in good condition. Interior is wet and debris in several rooms particularly camp kitchen and old supervisors office. Building has many unsecured entrances	Photograph 30: South side Photograph 31: Entrance to main room Photograph 32: Main room Photograph 33: 2009 camp kitchen and bear debris Photograph 34: Electrician's workshop Photograph 35: Electrical panels at north entrance Photograph 36: Corridor sbetween S17 from S16
S17: Warehouse	Building is solid with exterior in good condition. Interior is dry and entrances are secured.	Photograph 37: Warehouse Photograph 38: Entrance to S17 and S16 Photograph 39: Warehouse interior Photograph 40: Carpenter's garage

Building Number and Name	Comments	Photograph Number and Location
S18: Garage	The building is in good condition but the garage doors at both ends were blown in the winter of 2007. There is some debris remaining inside. The concrete floor is in good condition but extremely wet	Photograph 41: Garage Photograph 42: West side entrance with missing door Photograph 43: East side garage door entrance Photograph 44: Interior debris on north side Photograph 45: Interior of S18 on the south side
New POL	Brought on site for NWSO installation in about 1989. Empty and in good shape	Photograph 46: Fuel tank
S20: New Camp (Old Training Centre)	Interior of S20 was renovated in 2010. The generator (old genset) was moved to present location in 2006. The seacan is in good condition and the interior is dry. It contains ASU supplies	Photograph 47: West side view of S20 including kitchen trailer, seacan, and generator trailer Photograph 48: Generator Photograph 49: Seacan
N10: Communication Building with Two Dishes and enclosed fallen walkway and stairs	The exterior is in good condition but missing doors. The interior is full of electrical and other debris. All PCB containing components were removed in the 1980s and 2004. Cables to enclosed walkway were cut in 2006 and it fell over during the following winter It remains on the ground in the original location	Photograph 50: Communications building and crumpled walkway Photograph 51: N10 with two dishes Photograph 52: Inside N10 showing electrical equipment Photograph 53: Fallen walkway
A2: Airstrip Building	It has deteriorated in last 2-3 years primarily due to bear damage. ATVs have been stored here since 2006. Both doors can be secured	Photograph 54: Main entrance showing bear damage on walls Photograph 55: Rear double door entrance
R2: Remote Antennae Hill Building	Only one building remains. Exterior walls are solid with many holes It was used as a fire training building and much debris (some burned) remains within the building. There is no debris outside on rest of the antenna hill area.	Photograph 56: Main entrance (south side) Photograph 57: Rear entrance (north side) Photograph 58: Interior with burned debris Photograph 59: Interior showing more debris

Building Number and Name	Comments	Photograph Number and Location
B2: Beach Building PCB Storage	The building is gradually disintegrating. Both garage doors have blown in, the west side in 2008 and the east side in 2009. Some sheet metal panels are missing from the sides and the roof.	Photograph 60: Northeast view of B2 with blown-in walls and garage door Photograph 61: Southwest view of B2 Photograph 62: B2 interior Photograph 63: View of west side entrance and PCB storage facility
Other debris	Most debris outside of the buildings was cleaned up during main remediation project	Photograph 64: Area beyond furniture dump which was previously strewn with physical debris and downed tower.

Photograph 22: North Side of the Radome Showing the Entrance and the SRR Tower Behind

Photograph 23: The Interior of the Radome. The floor was Wet but the Building Provides Useful Storage for the Kubota Loader and Other Equipment

Photograph 24: The Two Very Large Troposcatter Dishes with a Circular Dish Between. The Other Standing Circular Dish is Behind the Nearer Troposcatter Dish

Photograph 25: The Collapsed Circular Dish DW1. The Circular Dishes are Made of Aluminum

Photograph 26: East Side and Entrance of the Old Officer's Mess

Photograph 27: The Old Officer's Mess Surrounded by Lots of Debris and the Conduit for Electrical Cables

Photograph 28: The Interior of the Officer's Mess Bar Area. The Inside of Both S9 and S10 Were Full of Debris

Photograph 29: The Inside of the Corridor Linking the Two Parts of the Officer's Mess

Photograph 30: South Side of Building S16

Photograph 31: Side of Building S16 Showing the Former Entrance to the Remediation Project Large Dining Area

Photograph 32: Main Room of Building S16. This Was Used as the Dining Room/Games Room for the Remediation Project but Was Formerly the Main Food Storage Area for the Base

Photograph 33: Building S16 Showing the Evidence of Bear Intrusion into the Camp Kitchen in 2009

Photograph 34: Building S16 – Electricians Workshop

Photograph 35: Building S16 – Electrical Panels in Corridor

Photograph 36: Corridor Leading From S16 to the Warehouse S17

Photograph 37: Building Number S17 – The Warehouse with S16 Behind

Photograph 38: Ramp Entrance to S16 and S17

Photograph 39: The Interior of the Warehouse

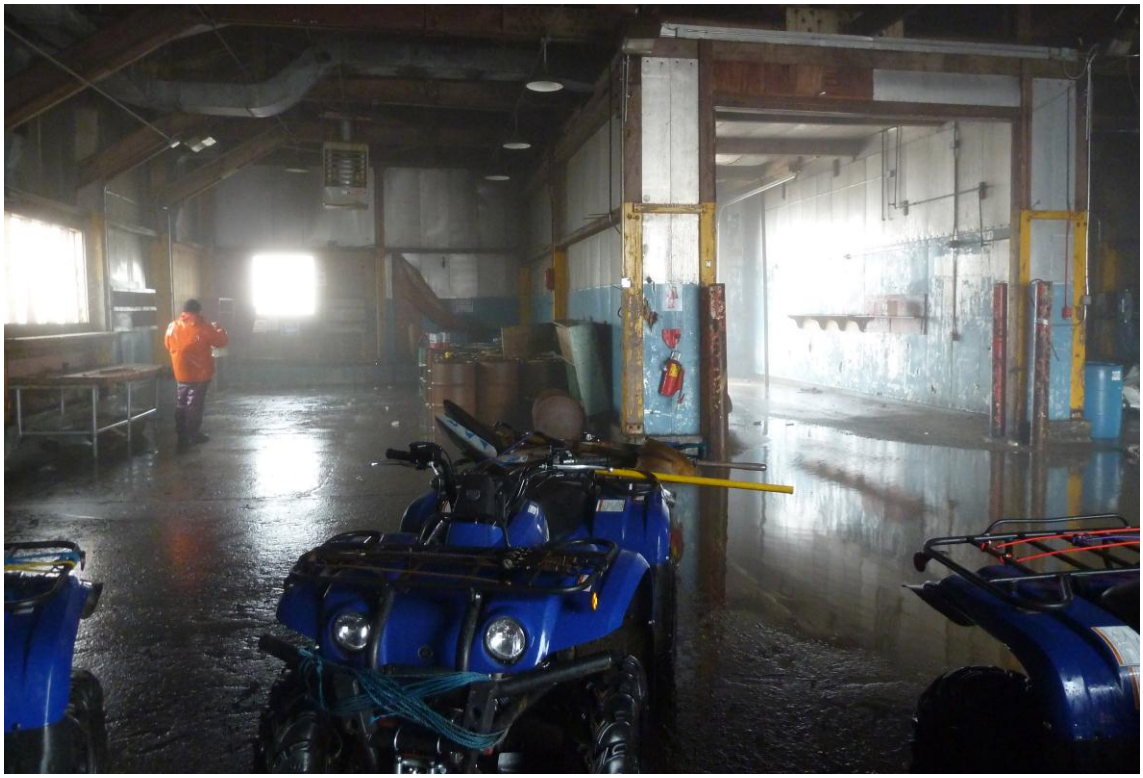
Photograph 40: The Carpenter's Garage at the End of the Warehouse

Photograph 41: The North Side of the Garage, Building S18

Photograph 42: The West Side of the Garage Showing the Blown in Garage Door and the Bear Door

Photograph 43: East Side of the Garage with Blown in Door and Some New Metal Panels

Photograph 44: The Interior of the North Side of the Garage



Photograph 45: The Interior of the South Side of the Garage

Photograph 46: Old Fuel Tank For the Camp With Garage Behind

Photograph 47: Building S20 – The Training Center for the Remediation Project with the Generator and Seacan Behind – It has Been Renovated and is Now the New Living Quarters at the Site

Photograph 48: The Old Genset is Now the Generator for the Renovated Camp, S20

Photograph 49: The Storage Seacan Next to Building S20

Photograph 50: Building N10, the Communications Building with Collapsed Corridor From the Summit Camp and Building S20 Behind

Photograph 51: The Communications Building N10 With its Two Dishes

Photograph 52: The Electrical Equipment and Panels Inside N10: All PCB Containing Components Have Been Removed, Though Some PCB Labels Remain

Photograph 53: The Enclosed Walkway From the Summit to N10 Collapsed When the Support Cables Were Cut

Photograph 54: The Airstrip Building Shows Some Bear Damage But is Secure

Photograph 55: The Rear Double Doors of the Airstrip Building Which is Used to Store an ATV for Convenience on Arrival

Photograph 56: The Remaining Building Atop the Antennae Hill

Photograph 57: The Rear of the Antennae Hill Building Has Several Entrances

Photograph 58: The Interior of the Antennae Hill Building Contains Burned Debris From Fire Training Exercises

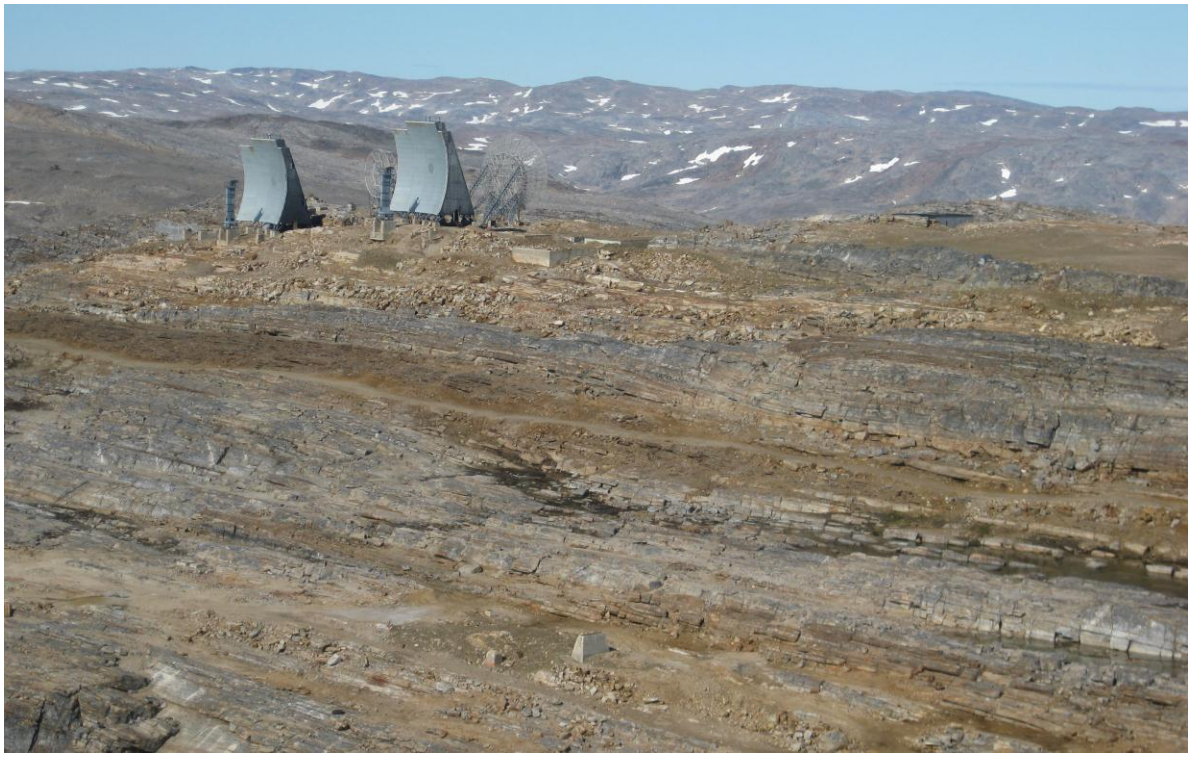
Photograph 59: Debris in the Antennae Hill Building

Photograph 60: The Beach Building B2 Has Lost Many Panels and Both Doors

Photograph 61: The Blown in Door and Other Structural Damage at the South West End of Beach Building B2

Photograph 62: The Interior of Beach Building B2

Photograph 63: One Corner of the Beach Building B2 Contains the Temperory PCB Storage Area Comprising of Four Drums of Soil With PCB Concentrations in the Range 50-200 ppm



Photograph 64: The Area Beyond the Furniture Dump Was Prevoiously Strewn With Debris and a Downed Antenna. This Photograph Shows Minimal Remaining Loose Material

VII. GEOSYNTHETICS

A. Introduction

As described in Chapter III, the first permeable reactive barrier was installed at the top of the cliff in the S1/S4 valley in 2003. Laboratory studies were conducted by the ASU in order to support the design and construction of this barrier system. As a result of these studies and field observations, the barrier was modified and two others were constructed in 2005 at the S1/S4 beach adjacent to the shore and at the end of the furniture dump drainage channel. All three barriers consist of a lined funnel formed by rock gabions through which all drainage must flow and a gate which contains various filters. Water is contained in the funnel by two layers of geocomposite clay liner (GCL) on top of which was placed a black composite synthetic liner (composite XR-5 8130 geomembrane). In addition a textured high density polyethylene (HDPE) liner was placed on top of the composite liner. This was not used as a hydraulic barrier but to protect the composite liner when sediment was shoveled out.

For the barriers to continue functioning as settling ponds, the geosynthetic liners must remain intact, hence it is important to assess the viability of these membranes over time. Exposure to UV radiation, cold climates and freeze-thaw cycles can all affect the performance of these materials. Physical and functional testing was conducted in order to assess the integrity and performance of samples from the barriers. There are many tests which can be done on geosynthetics to assess their serviceability and integrity. For geomembranes these include; OIT (oxidative induction time), HP-OIT (high pressure oxidation induction time), stress crack tear resistance, tensile strength and crystalinity. The geocomposite liners can be tested for hydraulic conductivity, cation exchange capacity and swell index.

Liners at all three barriers were sampled during the field visit and analysis of a small subsection of these is described in this section. The geosynthetics being discussed in this section include composite geomembranes, high density polyethylene (HDPE) geomembranes and geosynthetic clay liners (GCLs). Testing was limited to the valley and beach liners. Samples of unused material, referred to as virgin, were used for comparison. Only samples from the S1/S4 valley and beach barriers were tested this year.

B. Sampling

Samples were taken from site in August 2010. They were taken such as not to disturb the barrier. This means that many samples had no direct contact with the contaminants (as a sample from there would have opened up a hole allowing contaminants to escape freely). Samples were cut out in approximately 8 inch squares, triple bagged, and then stored in a cold room to minimize water loss and slow aging. Sampled materials are shown in Photographs 65 and 66. Two samples were taken at all sites, and where possible, samples were taken as both inside and outside the contaminant pathway. Starred samples were those analyzed and discussed below. Lists of the samples taken are given in Tables 45 to 49.

Table 45: Geomembrane Samples Taken from the S1/S4 Valley Barrier in 2010

Sample Type	Sample Name	Conditions
GCL	Location A	exposed to air, dry, not in PCB flow path
GCL	Location B*	beneath HDPE, wet, not in PCB flow path
HDPE	Location A*	exposed to PCB flow path, direct contact with water
HDPE	Location B	exposed to PCB flow path, direct contact with water
Composite	Location A	air exposed, not in PCB flow path
Composite	Location B*	exposed to PCB flow path, direct contact with water
Upper HDPE	Location A	exposed to PCB flow path, direct contact with water
Upper HDPE	Location B	exposed to PCB flow path, direct contact with water

Table 46: Geomembrane Samples Taken from the S1/S4 Beach Barrier in 2010

GCL	Location A*	exposed to air, dry
GCL	Location B	covered by GM, should be wet
HDPE	Location A*	exposed to PCB flow path, direct contact with water
HDPE	Location B	exposed to PCB flow path, direct contact with water
Composite	Location A	air exposed, potential water contact, not in PCB flow path
Composite	Location B*	exposed to PCB flow path, direct contact with water

Table 47: Geomembrane Samples Taken From the Furniture Dump Barrier in 2010

GCL	Location A	exposed to air, no direct flow path contact, dry
GCL	Location B	underneath GM, no direct PCB flow path contact, dry
Composite	Location A	no direct PCB flow path contact, air exposed
Composite	Location B	no direct PCB flow path contact, air exposed

Table 48: Geomembrane Samples Taken at the TPH Ponds and Barriers in 2010

GT	Location A	air exposed, outside of PCB flow path
GT	Location B	covered by GM, outside of PCB flow path
GCL	Location A	underneath GM, outside flow path, semi dry
GCL	Location B	underneath GM, outside flow path, semi dry
PVC	Location A	air exposed, outside of PCB flow path
PVC	Location B	air exposed, minimal contact with PCB flow path

Table 49: Geomembrane Samples Taken from the Tier II Landfill in 2010

HDPE	Tier II Landfill location A buried	buried, exposed to water
HDPE	Tier II Landfill location A air exposed	air exposed, no contaminant content
HDPE	Tier II Landfill location B	air exposed, no contaminant content

Photograph 65: Sampling of GCL at the Valley Barrier: In Order not to Destroy the Integrity of the Barrier Samples Were Taken From the Exposed GLC

Photograph 66: Sampling of Composite Geomembrane From the Valley Barrier

C. Testing Methodology

1. Oxidative Induction Time

There are two methods of OIT measurement; standard OIT (ST-OIT) and high pressure OIT (HP-OIT) measured as per ASTM D3895 and ASTM D5885, respectively. These values are measured using a Differential Scanning Calorimeter (DSC). The ST-OIT test is performed by heating a small piece of geomembrane specimen from room temperature to 200 °C at a rate of 20 °C/min in a nitrogen environment with a gas flow rate of 50 ml/min. The gas flow is then changed from nitrogen to oxygen under isothermal conditions at 35 kPa pressure. The HP-OIT test follows a similar procedure; however it is conducted at temperature and pressure of 150 °C and 3500 kPa, respectively. The main objective of conducting HP-OIT test is to verify that the higher temperature in the ST-OIT test does not volatilize some of the antioxidants such as thiosynergists or hindered amines (Hsuan and Koerner, 1998).

2. Crystallinity

The crystallinity of a polymer controls some of its physical and mechanical properties, e.g., yield stress, modulus of elasticity, impact resistance, dimensional stability, density, and permeability (Fann et al. 1998; Sperling 1992; Kong and Hay 2002). The degree of crystallinity of the HDPE GMs was measured in accordance with ASTM E794 (ASTM 2008d5) using the same DSC as used for the Std-OIT tests.

The crystallinity of a geomembrane has been known to affect other physical characteristics, such as yield stress, density, permeability, impact resistance and the modulus of elasticity (Hsuan et al 2009). Crystallinity is measured using the same apparatus as for Standard OIT. Testing procedures are done according to ASTM E794 (ASTM 2008d).

3. Tensile Test

Tensile tests were performed using a Zwick Roell tensile testing machine (Model Z020) equipped with 20 kN load cell and self aligning wedge grips in accordance with ASTM D6693 (ASTM 2008h9) (Type IV) at a strain rate of 50 mm min^{-1}. For any specific sampling event, 10 specimens were tested: five along the machine direction and five along the cross-machine direction, and the average and standard deviation in each direction are reported. Tensile tests will be completed in accordance to ASTM D6693 (ASTM 2008h), and strained at a rate of 50 mm min^{-1}. Samples are tested both along the machine direction and again in the cross machine direction. Values reported are the

average of these two values. A sample of a yielded geomembrane can be seen in Photograph 67.

Photograph 67: Tensile Strength Clamping Device with Failed Sample.

4. Hydraulic Conductivity

The hydraulic conductivity was measured using a flexible wall permeameter under falling head/rising tail conditions according to ASTM (D5084-03). Hydraulic conductivity is an important characteristic to know because it is the main condition that governs that rate of diffusion through the barrier. It should be noted that samples were taken from exposed sides of the barrier (as can be seen in Photograph 65) which can lead to lower hydraulic conductivity than one from the centre of the roll. It should be noted that the Virgin and Beach samples are the same GCL, made of Bentofix NWL, whereas the Valley is a Bentofix CNSL.

5. Swell Index

The swell index of a GCL is a measure of the bentonite's ability to swell, after a period of drying. The bentonite is extracted from the liner, ground and dried overnight at

105 °C. The next day, 2.00 g of the clay powder is added, periodically, in 0.10 g increments to 90 mL of tap water. The increase in swelling (or the new water level) is measured, and reported as a mL per 2g. This test is completed in accordance with ASTM D5890.

6. Cation Exchange

Soluble salts are washed off with de-ionized water and the concentration of soluble salts in the extract is measured. The bound cations are measured using ammonium acetate to force the existing cations in the bound layer into solution. The total bound and soluble cations in this solution are measured. The cation exchange is measured by displacing the ammonium acetate with potassium chloride. Sodium, calcium, magnesium and postassium salts are measured by ICP/OES.

7. Diffusion Tests

In the diffusion tests, a stainless steel double compartment cell (source and receptor, 250 mL and 110 mL, respectively), Photograph 67, was divided by a geomembrane sample. Diffusion tests were run in triplicate for each geomembrane type. The receptor cell was filled with double deionized water. BTEX compounds were injected into the source water for an initial concentration of 25 μg mL^{-1}. Diffusion cells were agitated on a magnetic stirrer at a constant temperature of 24 ± 1 ^{o}C. Samples were taken from the source and receptor at regular time intervals. Sampling continued for 10 days beyond equilibrium, which is defined as no change in concentration.

Samples were analyzed by Purge & Trap Gas Chromatography/Mass Spectrometer (P&T)-GC/MS. The procedure used a Hewlett Packard 5890 GC with a P&T unit and 5972 mass selective detector (MS). VOCs were purged from the samples for 11 minutes with helium. The temperature was then raised to 225 ^{o}C for the baking step. VOCs were desorbed off the VOCARB trap inside the Purge & Trap apparatus for 4 minutes. Desorbed compounds travel to the VOCOL column (60 m x 0.32 mm x 2.0 μm thickness) in the GC. Chromatographs were quantified using selective ion monitoring (SIM). This method is based on EPA method 8240 (USEPA 1996).

In the diffusion tests, normalized concentrations in the source and receptor were plotted relative to the initial concentration in the source. Theoretical curves will be obtained from POLLUTE v7 and fitted to the experimental data to generate S_{gf} and D_g values.

Photograph 67: Double Compartment Diffusion Cells, Used for Functional Testing

D. Results for PRB Geomembranes

There are many tests which can be done on geomembranes to give clues towards their serviceability and integrity. These include; OIT (oxidative induction time), HP-OIT (high pressure oxidation induction time), stress crack tear resistance, tensile strength and crystalinity. Each of these tests was completed on the samples from the S1/S4 valley and beach barriers as well as a virgin sample. There were two geomembranes, the composite XR-5 8130 geomembrane used as the liner in the ponds, as well as a textured high density polyethylene (HDPE) geomembrane used on the top of the composite for serviceability. Functional testing can show the performance of the liner with respect to its diffusive properties.

1. Physical Testing

Depletion of OIT has been shown to be a function of antioxidant concentration (Mueller and Jakob, 2003). Thus the level of OIT in a geomembrane sample could be employed as an indicator of remaining antioxidant concentration. Since the exact composition of antioxidants is generally unknown to users, OIT values are measured to evaluate the antioxidant depletion rate (Hsuan et al., 2004).

The results which have been obtained from the physical testing of the geomembranes are the standard OIT, which can be seen in Table 50. The HDPE and the composite geomembrane do not appear to be indicating any changes due to weathering at either location. The crystallinity results do show an increase in crystallinity in the valley geomembrane. The valley PRB was installed in 2003 and the beach in 2005 and so the change in the valley may be due to aging. Tensile strength results show some reduction in tensile strength in the HDPE as compared to the virgin HDPE.

Table 50: Standard Oxidative Induction Time for Geomembrane Samples

Sample ID	Average ± standard deviation
Composite Virgin	9.4 ± 2.7
Composite Beach	9.9 ± 0.5
Composite Valley	8.6 ± 5.8
HDPE Virgin	134 ± 27
HDPE Beach	103 ± 3.3
HDPE Valley	125 ± 11

Table 51: % Crystallinity Results for the Geomembrane Samples

	Average (n=3) ± standard deviation
Composite Virgin	0.8 ± 0.8
Composite Beach	1.0 ± 0.6
Composite Valley	12.0 ± 3.8
HDPE Virgin	50.5 ± 7.8
HDPE Beach	57.8 ± 3.6
HDPE Valley	36.7 ± 3.0

2. Functional Testing

Intact geomembranes are a good advective barrier to the migration of contaminants and diffusion becomes the dominant mode of contaminant migration through the geomembrane (Rowe et al. 2004). Understanding the diffusive properties of a geomembrane is essential to predicting contaminant migration. These properties include

the partitioning coefficient, S_{gf}, diffusion coefficient, D_g, and the permeation coefficient, P_g (Sangam and Rowe 2001). Samples of the geomembrane, from the S1/S4 valley and beach barriers as well as virgin samples, were analyzed for their diffusive properties with respect to benzene, toluene, ethylbenzene and xylenes (BTEX). These VOCs commonly are found in landfill gas and leachate in both municipal and hazardous waste landfills. Due to their mobility they are often some of the first contaminants to diffuse through a geomembrane (Park and Nibras 1993; Rowe et al. 1995; Rowe 1998, 2005; Sangam and Rowe 2001). The diffusive parameters, S_{gf}, D_g, and P_g, with respect to BTEX contaminants have been studied extensively for HDPE geomembranes (Park and Nibras 1993; Sangam and Rowe 2001; Joo et al. 2004, 2005; Islam and Rowe 2009).

Results for the diffusion experiments are shown in Figures 15 and 16. For the composite liner, equilibrium has been reached and there are no significant differences between the liners used in the PRB versus the virgin geomembrane. The higher crystallinity value for the valley composite liner would have been expected to decrease diffusion through the membrane but thus far this cannot be seen in the data. Diffusion tests for the HDPE are currently in progress, and are expected to take several more months to reach equilibrium for the HDPE geomembrane. So far no differences can be seen between the virgin HDPE and the samples taken from the PRBs.

Figure 15: Source Depletion in the Valley HDPE Diffusion Cell Using Benzene

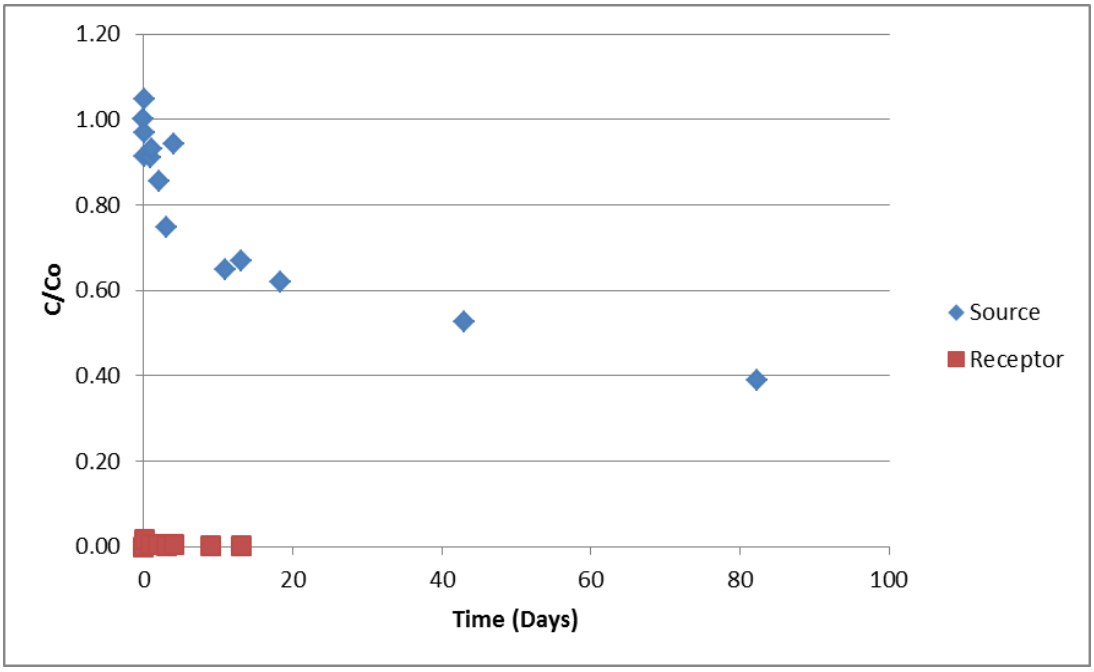
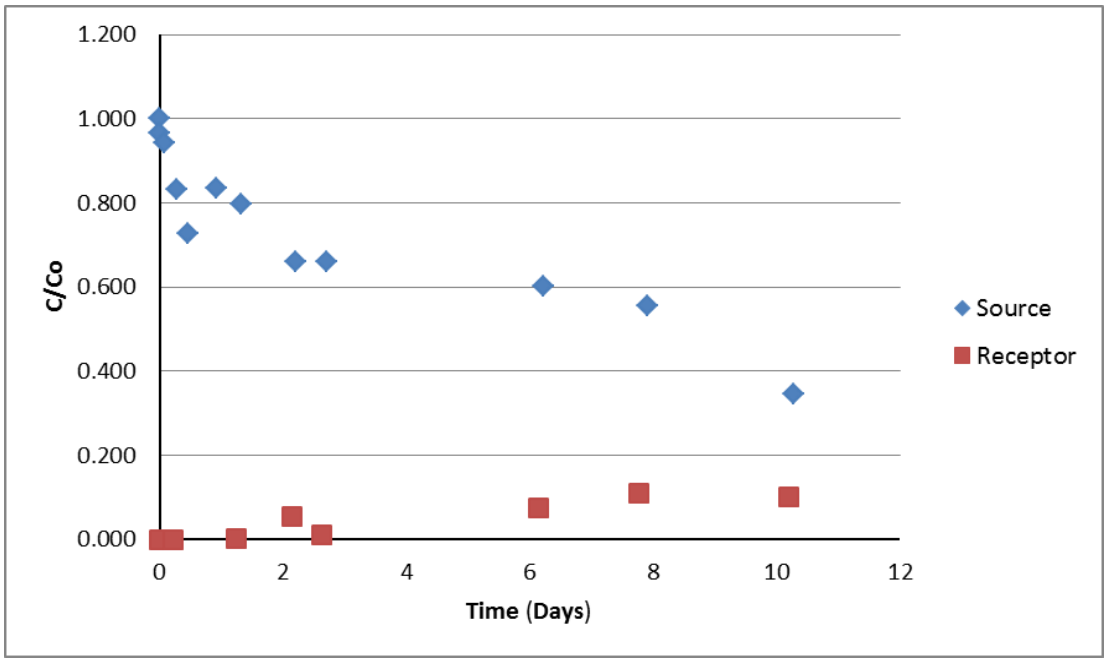


Figure 16: Diffusion of Benzene Through a Composite Geomembrane (Virgin)



E. Results for PRB Geosynthetic Clay Liners

GCLs are the main diffusive barrier against contaminant transport into the environment in the barriers at Resolution Island and can make a good barrier when combined with a geomembrane to minimize against advective transport. A Geosynthetic Clay Liner (GCL) is comprised of a thin layer of bentonite sewn between two geotextiles, and when properly wetted and swelled, can achieve very low hydraulic conductivities and minimize contaminant transport. GCLs are being used on Resolution Island in the barriers at the S1/S4 valley, S1/S4 beach and the furniture dump. Tests conducted include: swell index, hydraulic conductivity and cation exchange capacity. Samples were taken from the furniture dump although, most likely due to dry conditions and high winds, there was no bentonite found in the samples. Only dry geotextiles remained, hence no samples were analysed.

Results for hydraulic conductivity and swell index are shown in Table 52 and Figure 17. The hydraulic conductivity of the GCL in the beach PRB is higher than the virgin GCL. Freeze thaw cycles have previously been demonstrated to increase hydraulic conductivity and so this is not unexpected (Rowe et al, 2006). The increase has been attributed to the creation of macropores due to the freezing. A small and likely insignificant increase was seen in the valley PRB. A more significant change in the beach GCL is likely due to the fact that a dry exposed sample from the beach was tested as compared to a wet covered sample from the valley (Tables 45 and 46). The swell index of the virgin GCL was higher than both the beach and valley GCL. The data indicates that the GCL has been somewhat impacted, however, the hydraulic conductivity is still very low. The sampled GCL at the beach is expected to represent the worst case scenario since it has been exposed whereas the majority of the GCL is protected underneath the composite liner and has not been subjected to drying. Soluble cation results are shown in Table 53 and indicate some exchange of sodium for calcium in the valley and beach GCLs as compared to the virgin GCL. The large variability in the virgin GCL is likely due to sample heterogeneity.

Table 52: GCL Results for the Swell Index and Hydraulic Conductivity

GCL[(a)]	Effective stress	$M_{bentonite}$	w_{ci}	w_{cf}	H_i[(b)]	H_f[(b)]	e_{Bi}	e_{Bf}	k	Average Swell Index ± sd
	kPa	g m^{-2}	%	%	mm	mm			m s^{-1}	mL $2g^{-1}$
Virgin	3	4100	140	143	8.0	8.3	3.3	3.2	$4.7x10^{-11}$	23 ± 0.6 (n =3)[(c)]
Beach	3	4800	100	175	9.1	11.3	3.1	4.2	$6.2x10^{-11}$	20 ± 1.0 (n =3)[(c)]
Valley	4	5200	83	157	8.8	10.3	2.8	3.5	$4.9x10^{-11}$	19 ± 1.0 (n =3)[(c)]

where: $M_{bentonite}$: bentonite mass per unit area; w_{ci} : initial water content; w_{cf} : final water content; H_i : initial thickness; H_f : thickness after k test; e_{Bi} : initial bulk void ratio; e_{Bf} : bulk void ratio after k test; k : hydraulic conductivity; Permeant used for the test is tap water; k tests conducted under a hydraulic gradient of 67, 45, and 39 for virgin, beach, and valley samples, respectively;[(a)] Virgin and beach GCL samples are bentofix NWL. Valley GCL sample is bentofix CNSL; [(b)] Thickness value is an average for at least 150 readings measure by laser machine. The standard deviation for the thickness varies between 0.28mm to 0.64mm; [(c)] SD: standard deviation, n: number of tested samples

Figure 17 Plot of Pore Volume Versus Hydraulic Conductivity Using Tap Water for the Virgin GCL

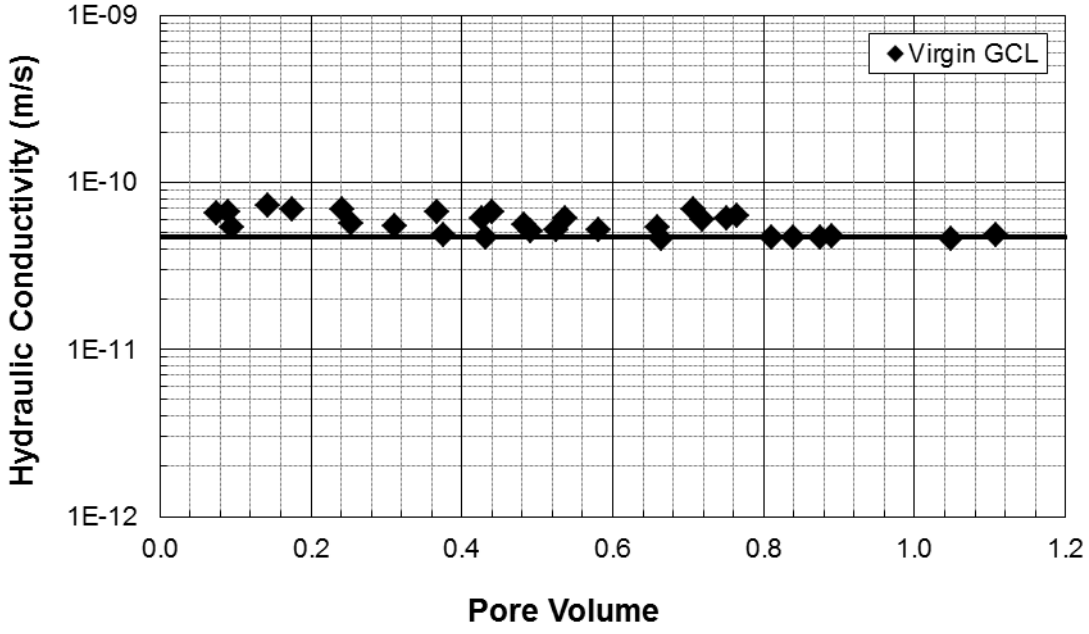


Table 53: Soluble Cations in the GCLs

	Na	Ca	Mg	K	Ion Conc.	Concentration
	mg L^{-1}	mg L^{-1}	mg L^{-1}	mg L^{-1}	cmol L^{-1}	cmol kg^{-1}
Valley	33.7	34.9	11	2.7	0.29	14.5
Beach	39.3	34.3	7.8	2.3	0.30	14.8
Virgin	59	14.2	5.7	1.7	0.32	16.2
Virgin (dup)	114	27.4	9.4	2.9	0.61	31.0

F. Conclusions

Overall results from the PRB geomembranes and GCLs from the site have relatively comparable results to those of the virgin samples, with some evidence of weathering. In particular, increased crystallinity is evident in the valley composite liner

and increased hydraulic conductivity has been demonstrated in the beach GCL. Of these only the increased conductivity would be expected to have a negative impact on the functionality of the PRBs.

G. Recommendations

As described in Chapter III, the furniture PRB continues to trap sediment contaminated with PCB concentrations in the 20 - 200 ppm range. Levels at the valley and beach barriers are lower and hence ensuring functionality at these two barriers is less critical. Given that some parameters such as hydraulic conductivity do show some degradation, continued long term monitoring of the PRB geosynthetics is recommended. The main recommendation is to test the GCL and composite liner at the furniture dump. UV exposure is a major factor in the loss of antioxidants in geomembranes, which are typically designed for use when covered with soil. Most sections at the furniture dump are not generally covered with soil or water and, therefore, have a very significant UV exposure. It will be necessary to resample the GCL at the furniture dump and investigate the GCL underneath the composite liner to ensure its integrity.

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VIII. APPENDICES

A. Appendix I – Quality Control/ Quality Assurance (QA/QC)

The ASU is accredited by the Canadian Association for Laboratory Accreditation (CALA), for specific tests listed in the scope of accreditation. Quality control was maintained through the analysis of standards, duplicates, and blanks.

Most of the tables given below are self explanatory and show good quality of the results. The number of results for each parameter in most cases are small so no average numbers have been calculated.

Table A-1: PCB Concentrations in Blank and Spiked QA/QC Soil and Other Solid Samples

Sample	Units	PCB Concentrations
Blank	ppm	<0.1, <0.1,<0.1, <0.1<0.1, <0.1,<0.1, <0.1,<0.1, <0.1,<0.1, <0.1,<0.1, <0.1, <0.1, <0.1, <0.1, <0.1, <0.1, <0.1, <0.1, <0.1, , <0.1, <0.1, <0.1, <0.1
Control	ppm	4.1; 4.1, 3.8, 4.3, 4.8, 4.5, 5.4, 4.1, 4.1, 5.0, 4.7, 4.2, 4.7, 4.2, 4.7, 4.3, 4.3, 4.1, 4.1, 4.2, 4.7, 3.8, 4.1, 4.1, 4.5,4.6, 4.2, 5.1,
Control Target	ppm	5.0

Table A-2: PCB Concentrations in Laboratory Duplicate Soil & Other Solid Analysis

Sample Number	PCB Concentrations (ppm)	Standard Deviation	Relative Standard Deviation (RSD) (%)
RI10-020	<0.10; <0.10	0	0
RI10-047	3.1; 2.8	0.21	7
RI10-081	5.1; 5.1	0.00	0
RI10-160	22.9; 29.5	4.67	18
RI10-162	2.4; 2.2; 1.6	0.42	20
RI10-163	5.1; 6.2	0.78	14
RI10-166	1.7; 1.8	0.07	4
RI10-VSP3	6.7; 5.7	0.71	11
RI10-VSP6	4.2; 4.2	0.00	0

Sample Number	PCB Concentrations (ppm)	Standard Deviation	Relative Standard Deviation (RSD) (%)
RI10-021	0.3; 0.4	0.07	20
RI10-109D	2.1; 2.6	0.35	15
RI10-126	2.2; 2.5	0.21	9
RI10-062	0.3; 0.2	0.07	28
RI10-BSP2	0.3; 0.3	0.00	0
RI10-BSP3	3.3; 2.8	0.35	12
RI10-FSP5	77.3; 75.3	1.41	2
RI10-011	<0.1; <0.1	0.00	0
RI10-012	<0.1; <0.1	0.00	0
RI10-013	0.1; 0.1	0.00	0
RI10-014	0.1; <0.1	0.00	0
RI10-015	0.7; 1.7; 0.9; 1.2	0.43	39
RI10-016	<0.1; <0.1	0.00	0
RI10-017	0.2; 0.1	0.07	47
RI10-018	0.2; 0.2	0.00	0
RI10-020	<0.1; <0.1	0.00	0
RI10-146	26.3;49.2	16.19	43
RI10-062	0.3;0.2	0.07	28
Average RSD			12

Table A-3: PCB Concentrations in Field Duplicate Soil and Other Solid Analysis

Sample Number	PCB Concentrations (ppm)	Standard Deviation	Relative Standard Deviation (RSD) (%)
RI10-019	<0.10; <0.10	0	0
RI10-029	1.2; 0.7	0.35	37
RI10-032	3.0; 3.1	0.07	2
RI10-049	2.7; 3.8	0.78	24
RI10-084	0.5; 0.6	0.07	13
RI10-129	0.5; 0.9	0.28	40
RI10-159	0.9; 1.2	0.21	20

Sample Number	PCB Concentrations (ppm)	Standard Deviation	Relative Standard Deviation (RSD) (%)
RI10-170	3.5; 3.7	0.14	4
RI10-139	0.1; 0.1	0.00	0
RI10-VSP5	3.7; 2.9	0.57	17
RI10-149	4.8; 6.3	1.06	19
RI10-140	0.5;0.5	0.00	0
RI10-069	0.7;0.7	0.00	0
RI10-059	10.2; 32	15.41	73
RI10-079	0.2; 0.3	0.07	28
Average RSD			18

Table A-4: PCB Concentrations in Blank and Spiked Low Level Soil Analyses

Sample	Units	PCB Concentrations (ppb)
Blank	ppb	<3.0; <3.0
Control	ppb	7.7; 8.9
Control Target	ppb	10.0

Table A-5: PCB Concentrations in Low Level Field and Laboratory Duplicate Soil Analysis

Sample Number	Type	PCB Concentrations (ppb)
RI10-001	field	24.4; 42.6
RI10-006	field	57; 54
RI10-007	laboratory	18.7; 3.9
RI10-043	laboratory	124; 88

Table A-6: PCB Concentrations in Blank and Spiked QA/QC Water Samples

Blank	<0.020	<0.020	<0.020	<0.020	<0.020
Control	0.051	0.055	0.071	0.059	0.051
Control Target	0.063	0.063	0.063	0.063	0.063

Table A-7: PCB Concentrations in Field Duplicate Water Samples

Sample Number	Type	PCB Concentrations (ppb)
RI10-3A	field	<0.020; <0.020
RI10-5B	field	<0.020; <0.020
RI10-35	field	<0.020; <0.020
RI10-VWP4	field	<0.020; <0.020

Table A-8: PCB Concentrations in Blank and Spiked QA/QC Plant Samples

Sample	Unit	PCB Concentrations
Blank	ppb	<3.0; <3.0; <3.0
Control	ppb	8.6; 10.5; 9.3
Control Target	ppb	10.0

Table A-9: PCB Concentrations in Laboratory Duplicate Plant Samples

Sample Number	Unit	PCB Concentrations
RI10-PMP5	ppb	15.5; 3.2
RI10-PMP7	ppb	7.5; 5.3
RI10-PMP8	ppb	3.3; 4.7
RI10-PMP9	ppb	10.7; 70.7
RI10-PMP10	ppb	7.0; 5.8

Table A-10: TPH Concentrations in Blank and Spiked QA/QC Soil Samples

Sample	Unit	TPH Concentration								
Blank	ppm	<40	<40	<40	<40	<40	<40	<40	<40	<40
Control	ppm	341	293	308	430	274	146	130	256	341
Control Target	ppm	487	487	487	487	425	150	150	297	487

Table A-11: TPH (Fuel) Soil Concentrations in Laboratory and Field Duplicates

Sample Number	Type	TPH Concentrations (ppm)	Standard Deviation	Relative Standard Deviation (RSD) (%)
RI10-001	field	<40; <40	0	0
RI10-006	field	<40; <40	0	0
RI10-508	field	830; 1080	177	19
RI10-518	field	1450; 1400	35	2
RI10-534	field	606; 696	64	10
RI10-549	field	<40; <40	0	0
RI10-010	laboratory	<40; <40	0	0
RI10-043	laboratory	<40; <40	0	0
RI10-507	laboratory	1107; 1048	42	4
RI10-518	laboratory	6555; 5982	405	6
RI10-530	laboratory	833; 699	95	12
RI10-538	laboratory	151; 134	12	8
RI10-544	laboratory	<40; <40	0	0
RI10-548	laboratory	<40; <40	0	0

Table A-12: TPH (Lube) Soil Concentrations in Laboratory and Field Duplicates

Sample Number	Type	TPH Concentrations (ppm)	Standard Deviation	Relative Standard Deviation (RSD) (%)
RI10-001	field	<40; <40	0	0
RI10-006	field	<40; <40	0	0
RI10-518	field	<40; <40	0	0
RI10-534	field	<40; <40	0	0

Sample Number	Type	TPH Concentrations (ppm)	Standard Deviation	Relative Standard Deviation (RSD) (%)
RI10-549	field	<40; <40	0	0
RI10-010	laboratory	<40; <40	0	0
RI10-043	laboratory	78; 121	30	31
RI10-507	laboratory	<40; <40	0	0
RI10-518	laboratory	<40; <40	0	0
RI10-530	laboratory	<40; <40	0	0
RI10-538	laboratory	<40; <40	0	0
RI10-544	laboratory	<40; <40	0	0
RI10-548	laboratory	<40; <40	0	0

Table A-13: TPH Concentrations in Blank and Spiked QA/QC Water Samples

Sample	TPH Concentrations (ppm)		
Blank	<1.0	<1.0	<0.1
Control	17.0	14.7	5.9
Control Target	13.3	13.3	10.0

Table A-14: TPH (Fuel) Water Concentrations in Field Duplicate Analysis

Sample Number	TPH Concentrations (ppm)
RI10-MW3A	<1.0; <1.0
RI10-MW5B	<1.0; <1.0
RI10-WP5	<0.10; <0.10

Table A-15: TPH (Lube) Water Concentrations in Field Duplicate Analysis

Sample Number	TPH Concentrations (ppm)
RI10-MW3A	<1.0; <1.0
RI10-MW5B	<1.0; <1.0

Table A-16: TPH Concentrations in Blank and Spiked Samples for CCME TPH Analyses (ppm)

Sample	F1 C6-C10	F2 C10-C16	F3 C16-C34	F4 C34-C50
Blank	<40	<10	<10	<10
Control	138	123		
Control Target	150	150		

Table A-17: TPH Concentrations in Field and Laboratory Duplicates for CCME TPH Analyses (ppm)

Sample	Type	F1 C6-C10	F2 C10-C16	F3 C16-C34	F4 C34-C50
RI10-537	laboratory	<40, <40	-	-	-
RI10-541	laboratory	-	261 ; 306	63 ; 80	<10 ; <10
RI10-525	field	<40, <40	1560, 1430	564, 556	<10, <10

Table A-18: Metal Water Concentrations in Laboratory Blank Determinations and QC Control Samples

		Blank	Blank	Control	QC Target	Control	QC Target
Arsenic	mg/L	<0.003	<0.003	0.76	0.80	0.74	0.80
Cadmium	mg/L	<0.001	<0.001	0.80	0.80	0.78	0.80
Chromium	mg/L	<0.005	<0.005	0.82	0.80	0.78	0.80
Cobalt	mg/L	<0.003	<0.003	1.61	1.60	1.57	1.60
Copper	mg/L	<0.005	<0.005	1.44	1.60	1.42	1.60
Lead	mg/L	<0.010	<0.010	8.06	8.00	7.86	8.00
Nickel	mg/L	<0.005	<0.005	1.62	1.60	1.57	1.60
Zinc	mg/L	<0.010	<0.010	3.00	3.00	2.96	3.00

Table A-19: Metal Water Concentrations in Laboratory Duplicate (ppm)

	RI10-MW022W		RI10-058	
Arsenic	<0.003	<0.003	<0.003	<0.003
Cadmium	<0.001	<0.001	<0.001	<0.001
Chromium	<0.005	<0.005	<0.005	<0.005
Cobalt	<0.003	<0.003	0.01	0.01
Copper	<0.005	<0.005	<0.005	<0.005
Lead	<0.010	<0.010	<0.010	<0.010
Nickel	<0.005	<0.005	0.033	0.033
Zinc	<0.010	<0.010	0.028	0.028

Table A-20: Metal Water Concentrations in Field Duplicates (ppm)

	RI10-MW3A		RI10-MW5B		RI10-35	
Arsenic	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cobalt	0.025	0.024	0.015	0.016	0.03	0.029
Copper	<0.005	<0.005	0.005	0.006	0.048	0.048
Lead	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nickel	0.072	0.069	0.049	0.054	0.15	0.15
Zinc	0.034	0.048	0.138	0.161	0.096	0.095

Table A-21: Metal Soil Concentrations in Blank and Reference Material (ppm)

	Blank	Mess-3	QC Control
Arsenic	<1.0	16.0	13.9-17.3
Cadmium	<1.0	<1.0	-
Chromium	<20	44	31-49
Cobalt	<5.0	12.3	10.7-13.7
Copper	<5.0	28	29.8-37.4
Lead	<10	17.3	16.6-20.5
Nickel	<5.0	34	35.0-40.8
Zinc	<15	125	125-147

Table A-22: Metal Soil Concentrations in Laboratory Duplicate Analysis (ppm)

Parameter	RI10-003		RI10-009	
Arsenic	2.0	2.0	1.0	1.1
Cadmium	<1.0	<1.0	<1.0	<1.0
Chromium	59	66	37	38
Cobalt	28	31	15.5	15.5
Copper	107	123	60	60
Lead	19.9	22.5	14.4	14.0
Nickel	113	123	65	89
Zinc	102	115	97	98

Table A-23: Metal Soil Concentrations in Field Duplicate Analysis (ppm)

Parameter	RI10-001		RI10-006	
Arsenic	2.4	1.4	1.5	1.5
Cadmium	<1.0	<1.0	<1.0	<1.0
Chromium	47	48	41	45
Cobalt	8.2	10.7	28	25
Copper	51	64	68	76
Lead	10.2	<10	<10	<10
Nickel	29	38	71	76
Zinc	40	49	181	179

Table A-24: Nutrient Concentrations in Field Duplicate Analysis (ppm)

Sample	RI10-N013		RI10-N005	
TKN	100	120	380	340
Ext. Ammonia	<2.0	<2.0	2.9	<2.0
Ext. Nitrate	<2.0	<2.0	<2.0	<2.0
Ext. Nitrite	<2.0	<2.0	<2.0	<2.0
Total P	110	100	200	240
Ext P	<20	<20	<20	<20

Table A-25: Nutrient Concentrations in Laboratory Duplicate Analysis (ppm)

Sample	RI10-N011	
TKN	-	-
Ext. Ammonia	<2.0	<2.0
Ext. Nitrate	<2.0	<2.0
Ext. Nitrite	<2.0	<2.0
Total P	-	-
Ext P	-	-

Table A-26: Nutrient Concentrations in Blank and Spiked QA/QC Samples (ppm)

Sample	Blank	Control	Control Target
TKN	<20	-	-
Ext. Ammonia	<2.0	9.7	10.0
Ext. Nitrate	<2.0	5.7	5.0
Ext. Nitrite	<2.0	5.6	5.0
Total P	<20	600	688
Ext P	<20	-	-

Table A-27: QA/QC Data for the Potable Water Analysis of RI10-100

	Units	RI10-W100	RI10-W100	Blank	Control	Control Target
Chloride	mg/L	6.4	6.4	<0.05	3.0	3.0
Nitrate	mg/L	<0.05	<0.05	<0.05	1.5	1.5
Nitrite	mg/L	<0.05	<0.05	<0.05	0.71	0.75
Sulphate	mg/L	42.5	39.7	<0.10	2.9	3.0
Sodium	mg/L	4.1	3.8	<1.0	14.1	15.0
Potassium	mg/L	0.59	0.58	<0.2	15.6	15.0
Calcium	mg/L	4.7	4.3	<0.05	5.8	6.0
Magnesium	mg/L	2.7	2.5	<0.05	6.1	6.0
Iron	mg/L	<0.05	<0.05	<0.05	15.5	16.0
Manganese	mg/L	0.063	0.059	<0.05	16.0	16.0

B. Appendix II: Field Report

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4 December 2010

Stephen Hooey,
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Iqaluit, Nunavut
X0A 0H0

Resolution Island 2010 – Field Report

Dear Stephen,

The Analytical Services Unit team was onsite at Resolution Island from August 5th until August 13th 2010. Several days of strong winds and poor visibility due to fog prevented incoming flights and food supplies. However all intended monitoring was successfully completed with the able and generous assistance of Stephen Hooey from INAC, and Nicolas Audet from Biogenie.

LOGISTICS

The team stayed at the main camp, which had been refurbished in July/August 2010 by Biogenie. During the eight day stay, the plumbing and fridge were still not working; these were slated to be fixed upon the team's departure. The three ATVs onsite were working properly and the two trailers were in good condition. One ATV suffered a broken trailer hitch while the team was onsite due to rough terrain.

TIER II LANDFILL, AIRSTRIP LANDFILL, MAINTENANCE DUMP AND TWO NON-HAZARDOUS LANDFILLS

At the landfills, the monitoring wells were purged and 42 water samples were taken the following day. Three monitoring wells were unable to be sampled, as they were frozen. Thirty nine soil samples were taken congruently with water samples and an additional eleven soil samples were collected from the airstrip landfill. The sampling methods and locations were disseminated to the engineer from Biogenie, Nicolas Audet. Additionally, geosynthetic samples were taken from next to the Tier II landfill for possible future assessment of structural and functional integrity with respect to time.

DIESEL FUEL REMEDIATION

The In-situ Landfarm 17 TPH soil samples and 4 nutrient samples were collected at various depth profiles. 3 large bulk soil samples were also taken for future in-laboratory nutrient experiments. The Large Landfarm was similarly sampled with an additional 5 soil samples taken for CCME analysis, and the remaining urea and DAP that had been stored in the seacan were applied superficially on the last day of monitoring activities. The imploded tank drainage pathway was sampled for soil (x13) and water (x6) at the identified monitoring points both upstream and downstream of the TPH pond barrier. The filters were removed from the barrier and the water was left to drain from the TPH pond for a day. The geotextile filters were then replaced along with the GAC and gravel; the old material was sampled (x11) and placed into barrels. The barrels were well labeled, and composite samples of the contents of the waste barrels were taken for analysis. Geosynthetic material was also taken from the drainage pathway for potential future assessment.

PCB BARRIERS

The sediment loading in the drainage pathways of the PCB barriers was high, as they were not shoveled out last year. This year, all barriers had their respective geotextile filters replaced and GAC and gravel refilled. Geosynthetic materials were sampled at all three PCB barriers drainage pathways for possible future analysis.

S1/S4 VALLEY

The S1/S4 Valley Barrier was sampled at six water and nine soil monitoring points along the drainage pathway. Upstream from the barrier, the sediment loading was very heavy; as much sediment as possible was shoveled into nine barrels and waste wranglers, which were subsequently labeled and sampled. The filter boxes had once again grown moss, and the geotextile filters were sampled (x13) and replaced. The filters were refilled with GAC and gravel and replaced in the barrier gate.

S1/S4 BEACH

Monitoring of the beach barrier encompassed the majority of one day. Six soil and three water monitoring points were sampled, old barrier material was sampled (x23) and filters were replaced and filled with new GAC and gravel. The sediment levels upstream from the barrier were quite high; as much sediment as was possible - given the time constraints in a day - was removed and shoveled into barrels. Eight barrels and waste wranglers were filled and labeled, and composite samples of the waste material were taken.

FURNITURE DUMP

One water and eleven soil samples were taken from the monitoring points at the Furniture Dump barrier. The sediment loading at this site was low as usual and was easily shoveled into two existing barrels. The filters and barrier material were sampled (x17) and replaced.

OTHER ACTIVITIES

Several other monitoring activities were able to be conducted during the short field week: the buildings at the Main Camp and Remote Antenna Hill were toured and an inventory of photos was created, 47 barrels and waste wranglers at the beach building were sampled and tagged, eleven plant samples were taken from various remote locations on the island for background PCB analysis, and 14 water samples were taken from the drinking water lake and from around the main camp to ensure no new contamination has occurred.

Sincerely,

Allison Rutter and Alexandra Gerber

C. Appendix III: Health and Safety Plan

Health and Safety Plan

for the

Resolution Island Project

By

Analytical Services Unit

Queen's University

2010

Table of Contents

1. Introduction 4

1.1 Purpose 4

1.2. Application 4

1.3 Dry Camp Policy 4

1.4. Scope of Work 4

1.5 General Safety Rules 5

2.0 Hazard Characterization 6

2.1 Helicopter Safety 6

2.1.1 Passengers and ground personnel shall follow the guidelines outlined below in order to minimize risks associated with riding and approaching a helicopter: 6

2.1.2 General safety practices and guidelines are detailed below which apply to helicopter operations with particular attention to abating hazards associated with transport of materials by an externally-loaded helicopter: 6

2.2 Contaminated Site Hazards & Procedures 7

2.2.1 During excavation of barriers, Soil/Water are anticipated to contain: 7

2.2.2 The hazards associated with waste removal, sorting and excavation may include: 7

2.2.3 Exposure routes relevant to this project include: 7

2.3 Polar Bear Safety 8

2.4 General Working Hazards & Procedures 9

2.5 Hazardous Products Used on Site 9

2.5.1 Flammable/Combustible Liquids 9

2.6 ATV Safety 10

3. Personal Protection 10

4. Medical Emergencies and Program 10

4.1 Emergency Response Procedures 10

Appendices

Appendix A: Iqaluit Emergency Contact Phone Numbers

Appendix B of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix D of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix F of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix G of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix H of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix I Additional Polar Bear Safety Information

Appendix J Queen's Health and Safety Forms

1.0 Introduction

1.1 Purpose

The purpose of this Health and Safety Plan (HASP) is to minimize the risk of occupationally related exposures and accidents to personnel during the performance of their work associated with the monitoring of the cleaned-up abandoned military site on Resolution Island. The objective is to ensure that an effective occupational health and safety management system is available and that this plan is effectively communicated to all site staff. This plan will assist in the creation of a working environment where risks and potential hazards are properly identified and mitigated.

The Project's Health and Safety Plan is an amendable document that may evolve as the project is progressing. The Project Management Team may have to face unpredictable situations that will require new operating procedures. The new procedures will be reviewed to ensure standards are met or exceeded to prevent work-related accidents in the future.

1.2. Application

This plan applies to the abandoned military site at Resolution Island, Nunavut, and all personnel involved with the project on-site, whether it be for the entire duration of the project or for intermittent work on-site.

1.3 Dry Camp Policy

With the utmost priority of ensuring the safety of camp personnel, it has been determined that the possession, importation, consumption and/or usage of alcohol is prohibited at Resolution Island. The policy established is Zero Tolerance and any person that violates this policy can be removed from the Resolution Island site and can be terminated from company service.

1.4. Scope of Work

Environmental monitoring of the abandoned site will be conducted over a 14 day period in July/August of 2010. Work at the site will be conducted in cooperation with Biogenie who will be providing logistical and engineering technical support. ASU-Queen's University activities and responsibilities will include:

a) Monitoring and maintenance of all three permeable reactive barriers as well as a thorough assessment of the GCLs and geomembranes' viability over time

b) A detailed analysis of all filter materials and filter replacement at the permeable reactive barriers
c) Monitoring and sampling at the main and in situ landfarms as well as an analysis and replacing of the filters in the ponding and barrier system.
d) Long-term monitoring including background plant sampling at pre-determined points, sampling the monitoring wells at the airstrip and maintenance dumps, creating a photographic record and recording wildlife sitings.

1.5 General Safety Rules

a) Report all work injuries and illnesses immediately
b) Report all unsafe acts or unsafe conditions to your supervisor
c) Use, possession or sale of alcohol is not permitted on site. Misuse of prescription and non-prescription drugs is not permitted on site.
d) Only authorized and trained employees may repair or adjust machinery and equipment.
e) Only authorized and trained employees may work on or near exposed energized electrical parts or electrical equipment. Follow Electrical Safety Rules when working with electrically powered machinery and equipment.
f) Only authorized and trained employees may dispense or use chemicals. It is your responsibility to know where Material Safety Data Sheet (MSDS) are located and that they are available for your use and review.
g) Wear and use the prescribed personal protective safety equipment. This includes foot protection, head protection, gloves, etc.
h) Only authorized individuals may enter a PCB storage facility. Only authorized and trained individuals may enter contaminated or restricted site areas.
i) Failure to follow the above rules may cause serious injury and/or illness. Please use common sense and think before you act. If you are not sure how to complete a job or task safely or have any questions, ask your supervisor.
j) There shall be no eating, drinking or smoking inside contaminated work areas or while working with or near other hazardous materials and personnel will wash-up prior to any eating, drinking or smoking, which is to be conducted away from these areas.
k) There shall be no work conducted on a steep incline where there is a risk of a fall that could result in serious bodily injury.
l) Personnel shall take every reasonable precaution to protect against sun exposure. (See Appendix E, Ultraviolet Radiation)
m) Drinking water shall be obtained from Old Water Lake.
n) Drums are to be handled and opened in a manner consistent with the guidelines for Handling Drums and Other Containers published in the Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities (NIOSH, 1985).
o) Waste currently packed in drums will be identified and prepared for movement.

2.0 Hazard Characterization

The most significant hazards will be those associated with ATV operation, work with or near heavy equipment and vehicles such as helicopters, polar bears and exposure to hazardous materials.

2.1 Helicopter Safety

2.1.1 Passengers and ground personnel shall follow the guidelines outlined below in order to minimize risks associated with riding and approaching a helicopter:

a) Secure any loose articles of clothing before approaching or departing a helicopter
b) On level terrain approach and depart the helicopter from the front (avoiding the rear rotor) and always within view of the pilot.
c) On uneven terrain, wait for instructions from the pilot. Never approach or leave a helicopter on the uphill side
d) Always walk in a crouched position and keep you head down. (If your hands are free, hold the front of your knees).
e) Exercise extreme caution when loading and unloading equipment from a running helicopter. Wear impact resistant safety glasses or goggles. The equipment to be loaded/unloaded must be carried horizontally below waist level in a secure manner (must not be adversely susceptible to the rotor downwash).
f) Fasten seat belt and secure doors before take off.
g) Be equipped with a life jacket when operating over water.
h) Smoking is not permitted in or around the helicopter
i) Never throw anything from the helicopter
j) Keep clear of the landing area when a helicopter is landing or taking off
k) Remove any object from the landing area that may be swept up by the helicopter downwash air stream.

2.1.2 General safety practices and guidelines are detailed below which apply to helicopter operations with particular attention to abating hazards associated with transport of materials by an externally-loaded helicopter:

a) The pilot of a helicopter that is hoisting materials shall be competent to fly an externally-loaded helicopter.
b) The pilot shall be in charge of hoisting operation and shall determine the size and weight of loads to be hoisted and the method by which they are attached to the helicopter.
c) Ground personnel including signalers for a helicopter being used to hoist materials shall

be competent workers

d) While transporting an external load, the helicopter pilot shall follow a flight path that minimizes the risk to ground personnel and structures.
e) The Site Leader or his/her designate shall take precautions against hazards caused by helicopter rotor downwash.

2.2 Contaminated Site Hazards & Procedures

2.2.1 During excavation of barriers, Soil/Water are anticipated to contain:

a) soils contaminated with up to 100 ppm PCBs.
b) there may be also methane, carbon dioxide, hydrogen sulphide and other gases produced by bacteria, however, it is assumed that significant quantities of biodegradable materials are not present based on former remediation/clean-up practices at the site and site characterization studies.

2.2.2 The hazards associated with waste removal, sorting and excavation may include:

a) Immediately Dangerous to Life and Health (IDLH)/ acute toxicity conditions should not exist with sampling/ soil excavation from barriers, as high levels of contamination have been removed from the site during the clean-up procedure (PCBs of levels, metals of levels, hydrocarbons of levels)
b) chronic toxicity associated with exposure to high airborne dust levels or volatile chemicals (e.g. repeated and/or continuous overexposure to soils contaminated with hydrocarbons or PCBs)
c) other physical/chemical injury such as cuts from sharp objects, contact with corrosive material
d) Injury from helicopter slinging/moving of materials to and from barrier/waste locations.

2.2.3 Exposure routes relevant to this project include:

a) Inhalation

Airborne contaminant levels are not anticipated to be hazardous to personnel unless standing in the path of significant dust clouds or other direct downwind plume during heavy excavation of PCB-contaminated soil. It is assumed that outdoors and above grade any contaminant gases and vapours will be adequately diluted. The average dust levels from soil excavations can be maintained well below 10 mg/m3 (total particulate, or 3 mg/m3 respirable particulate) based on damp soil and/or that excavation will be by hand. Based on peak PCB contamination levels of PCB in soil concentrations can be expected to be no more than 100 ppm in soil (and likely much lower following remediation of the site. Average airborne PCB levels based on typical PCB-soil levels would be much lower. Metal contaminated soils are likely to only be encountered in the

Maintenance dump drainage Monitoring Wells, where peak soil levels of 0.038% cobalt are found. Based on similar values for dust, and the fact that excavation will not be occurring in this area, it is not anticipated to be of any hazard.

b) Ingestion

Hand to mouth conveyance can result in ingestion of chemical and biological contaminants. This will be controlled with appropriate protective clothing and hygiene practices. Proper labeling and the training of personnel in accordance with WHMIS regulations will also minimize the risk of accidental ingestion of chemicals brought to, or stored at, the site.

c) Skin Contact PCBs (associated with soil contamination) can be absorbed through intact skin. Diesel, gasoline and Jet fuel, as well as other solvents will defat the skin and may cause dermatitis. Any corrosive material that may be discovered or stored at the site (e.g. acid or alkali) may irritate or burn the skin, depending on the type and concentration of chemical and degree of exposure. Skin exposure is to be minimized with the prescribed protective clothing.

d) Eye Contact

A splash of corrosive liquid to the eye may permanently damage eye tissue. A splash of diesel, gasoline or Jet fuel, as well as many other solvents (e.g. methanol) to the eye may cause slight to severe irritation. Eye protection is required within designated work areas of this project.

2.3 Polar Bear Safety

The site has been identified as potentially inhabited/visited by polar bears. An armed bear monitor, bear deterring procedures and bear deterring devices are intended to minimize this risk.

a) Armed and experienced bear monitors shall oversee the outdoor activities. Bear monitors will also inspect the site, including all work areas, immediately prior to the regular day's activities.
b) At least one person in every group will wear an appropriate bear deterring device while outdoors, and all site personnel will be familiar with bear deterring tactics.

For further bear safety, refer to Appendix B of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc. (attached) and the following two documents (attached and also available on line)

http://www.pc.gc.ca/~/media/pn-np/nu/auyuittuq/pdf/PolarBearEnglish2007final.ashx
http://www.nunavutparks.com/english/parks-special-places/katannilik-territorial-park/documents/PolarBearSafety.pdf

2.4 General Working Hazards & Procedures

Shoveling, digging and manual materials handling shall be conducted in a manner that minimize the risk of injury (Ergonomics: Appendix H of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.(attached)).

a) There are steep, rocky sloped areas, including sections of road connecting the beach to the upper site, where the shoulder drops off abruptly to a cliff. Strict adherence to ATV safety rules and speed limits will be necessary to minimize the risk of fatal accidents. Anyone working at the base of rocky sloped terrain will be at risk of injury from falling rock. Work will not be performed where there is a significant risk of rock slides (including freeze thaw periods).
b) Most, if not all of the work will be outdoors. There are risks of heat stress, cold stress and exposure to ultraviolet radiation from the sun (Appendix D and F of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.(attached)).
c) Where vehicles are driven on uneven terrain, there is a risk of roll-over accidents.
d) Personnel will operate All Terrain Vehicles (ATVs) and be exposed to the associated physical hazards

2.5 Hazardous Products Used on Site

a) Diesel

b) Gasoline

d) Oil

2.5.1 Flammable/Combustible Liquids

a) Flammable and combustible liquid storage vessels and areas, as well as the dispensing activities and usage of these liquids, shall also be in accordance with the National Fire Code of Canada and the N.W.T. Fire Prevention Act and regulations
b) Suitable equipment and materials shall be used wherever there may be flammable liquid/vapour.
c) Fuel for vehicles and generators, etc. and any other flammable liquid shall be stored, handled and dispensed in a manner appropriate for flammable liquids. Fuelling and flammable liquid handling shall be done in a place where the vapours are readily dissipated and in the absence of ignition sources (including engines off and no smoking).
d) Flammable liquid containers will be opened slowly at the appropriate access port or bung,

allowing for a controlled release of any pressure.

e) Flammable liquids (flash point less than 37.8^{o}C) shall not be used for decontamination or other types of cleaning.

2.6 ATV Safety

ATV riders shall read and understand the vehicle operators' manual, as well as Tips for the ATV Rider (Appendix G). Helmets (as provided) are to be worn when riding an ATV. If the helmets are not equipped with visors, then impact resistance safety glasses are also to be worn by the riders(s). Personnel will ideally have completed the Canada Safety Council's ATV rider course.

For further ATV safety, refer to Appendix G of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc. (attached)

3. Personal Protection

Personnel shall be equipped with clothing appropriate for the time of year and the remote Arctic location. Exposure is a significant hazard, not just for cold, but for UV exposure and heat stress.

For further safety on cold and heat stress, refer to Appendix D, E and F of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc. (attached)

4. Medical Emergencies and Program

4.1 Emergency Response Procedures

Emergency response procedures will be planned in advance of the work activities. Methods and routes of evacuation and liaisons with off-site medical rescue personnel will be pre-established. In the event of an emergency the following procedures will be implemented:

a) Work in affected area will stop.
b) In the case of a bear, the bear monitor will respond. All other personnel will act in a manner consistent with bear avoidance tactics (Appendix B), including moving to a safe location if this can be accomplished without aggravating the situation.
c) Emergency response/treatment personnel will evaluate the incident and implement the necessary action.
d) A predetermined person (e.g. Site Leader) will coordinate site control which may include: moving personnel to a safe location, preparing for extrication and/or evacuation, contacting off-

site resources

e) Fires that can be easily controlled will be extinguished immediately by the nearest trained person(s). Spills may be similarly controlled by the nearest trained person(s), if feasible.
f) Where the fire (or other emergency) produces a serious and imminent danger (e.g. where there is a risk of explosion) everyone will be evacuated to a safe location and if appropriate, off-site resource personnel will be contacted.

Following an emergency and prior to recommencement of work, there shall be:

a) notification of regulatory authorities as required
b) an incident investigation including documentation of the event
c) review of work procedures for the purpose of preventing similar events
d) review of emergency response plan for the purpose of improvement, and
e) replacement of emergency equipment and supplies where necessary

Appendix A contains a list of phone numbers for off-site resources.

If the satellite phone is not working (RI is on the fringe of the service area) ASU team members have permission to use the direct line to North Warning Station Operations (NWSO) center in North Bay. A team member will be dispatched to use this emergency line located within the unlocked vestibule of the North Warning Station on site—the big blue building.

In the unlikely event the emergency line to NWSO in North Bay cannot be physically reached, it is to be understood by all team members that the NWS installation is equipped with motion sensors and constant video surveillance. A distress signal could thus be communicated to the NWSO by approaching the building and gesturing, NWSO has the ability to broadcast voice over loudspeakers fixed to the building.

Appendices

Appendix A: Iqaluit Emergency Contact Phone Numbers

Appendix B of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix D of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix F of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix G of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix H of Project Health and Safety Plan: Clean Up of the Abandoned Military Site on Resolution Island, June 1998, Phoenix OHC, Inc.

Appendix I Additional Polar Bear Safety Information

Appendix J Queen's Health and Safety Forms

EMERGENCY CONTACT LIST

RESOURCE	CONTACT/LOCATION	PHONE NUMBER
Site Phones		
	Sat Phone	**TBC**
Air Transportation		
Air Nunavut **(MEDEVAC)**	Air Ambulance Iqaluit	**867-979-4018**
Kenn Borek Air **(MEDEVAC)**	Iqaluit	**867-979-0040**
Canadian Helicopter	Iqaluit	**709-686-2095**
North Warning System Operations (Iqaluit)	Operation manager	**867-979-4818**
Fire		
Local Fire Department	Iqaluit – Fire or medical emergencies	**867-979-4422**
Police		
Police Department	Iqaluit	**867-979-0123**
	Kimmirut	**867-939-0123**
Hospitals		
Baffin Regional Hospital	Iqaluit	**867-979-7300**
Kimmirut Health Center	Kimmirut	**867-979-2217**
Environmental Emergency		
24-hour Spill Line	NWT/Nunavut	**867-920-8130**
Canadian Transport Emergency Centre (CANUTEC)	24 hour service	**613-996-6666**
Department of sustainable development, Gov't of Nunavut	Robert Eno Manager Pollution Control and Air Quality Environmental Protection Service	**867-975-5907**
Qikiqtani Inuit Association	Officers available 24 hours	**867-975-8419**
INAC Water Resources	Iqaluit	**Tel.: 867-975-4550**

EMERGENCY CONTACT LIST

RESOURCE	CONTACT/LOCATION	PHONE NUMBER
Health and Safety		
Workers' Compensation Board 24-hour Accident Reporting Line	Barron Building/1091 Box 669 Iqaluit, NU X0A 0H0	**1-877-404-4407**
Department of Human Resources	Qikiqtaaluk Region	**1-800-682-9033**
Wildlife Management		
Nunavut Wildlife Management Board	P.O. Box 1379, Lot 924 Parnaivik Building Iqaluit, NU X0A 0H0	**867-975-7300**
Hunters and trappers association	Iqaluit	**867-979-6848**
	Kimmirut	**867-939-2355**
Heritage Resources		
Inuit Heritage Trust Incorporated	P.O. Box 2080 Iqaluit, NU X0A 0H0	**867-979-0731**
Management		
INAC	Stephen Hooey, Project Manager	**867-975-4731**
QUEEN'S		**418-653-4422 Ext 5431**

APPENDIX B

EXCERPTS FROM SAFETY IN BEAR COUNTRY

Chapter 4. Avoiding Bear Problems
Chapter 5. Camp Design and Maintenance
Chapter 6. Bear Deterrent Methods
(Including Bear Monitor Program)

From: Safety in Bear Country, a Reference Manual. Department of Renewable Resources, Government of the Northwest Territories 1992

AVOIDING BEAR PROBLEMS

CHAPTER 4

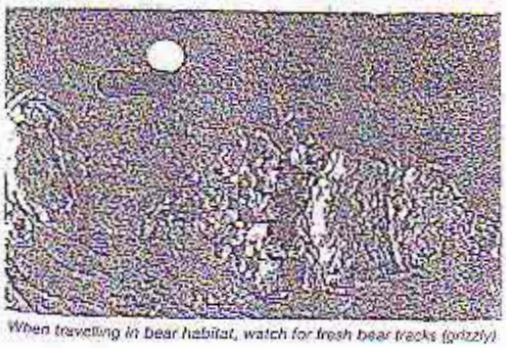
The best defense against bears is to avoid encountering them. Bears are encountered by chance, or because they are attracted to you. You can reduce the chances of attracting a bear to camp by following the guidelines in Chapter 5. The sudden encounter is the most common situation associated with grizzly bear inflicted injury. You can help prevent a chance encounter by taking the following precautions.

Precautions While Travelling

Know the areas and habitat bears use at different times of the year (Chap. 2). This information is available at your local Renewable Resource office. Try to avoid these areas or habitats or be especially cautious when travelling through them.

If you are in bear habitat, there is always the chance you may encounter a bear. Always be alert and aware of your surroundings. Think ahead and be prepared. Watch for bear signs, such as:

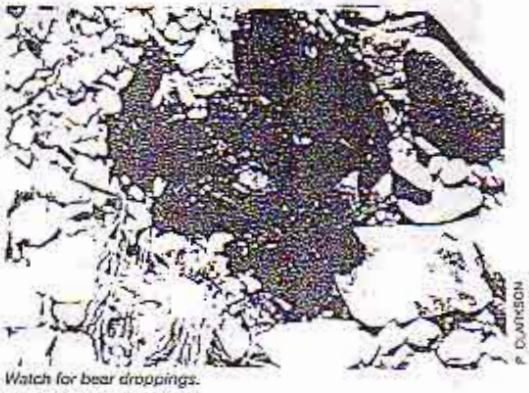
- fresh tracks,
- droppings which contain vegetation, berries, or hair, or have a tarlike appearance,
- animal carcasses, sometimes covered with dirt,
- seal kills,
- torn up stumps or rotten logs, digging, especially near ground squirrel holes,
- matted vegetation in berry patches, or
- claw marks on trees.



F. CLARKSON

When travelling in bear habitat, watch for fresh bear tracks (grizzly).

Pay attention to the behaviour of other animals. A flock of ravens may indicate an animal carcass, and possibly a bear, which should be avoided. Alarm calls of birds or squirrels could mean a bear is near.



F. CLARKSON

Watch for bear droppings.

In open terrain, use binoculars to look ahead for bears in the areas where you intend to travel. If you notice a bear at a distance, take action to avoid surprising it. Never approach a bear knowingly.

Travel in daylight and avoid areas of restricted visibility. Make noise as you travel, especially where visibility is limited. Announcing your presence may prevent an encounter by giving a bear a chance to leave before you approach too close. You can sing, shout, or talk loudly. Some people carry portable airhorns or cans of rocks; others wear bells.

The effectiveness of bells and other noise-makers is debatable. A bear may stay away if it has associated bells or another noise with the presence of people. However, if a bear has never heard the noise before it may approach out of curiosity. This may be particularly true in remote areas with few human travellers. Keep in mind that in some cases noise will be masked by natural sounds such as wind or water, or may go unnoticed by a bear who is resting or whose attention is on feeding. The use of noise-makers should not make people over confident.

Travelling in groups reduces your chances of meeting a bear, as groups tend to make a lot of noise. If you encounter a bear a larger group may appear more intimidating that a single person. No grizzly attack has ever been reported on a group of six or more people.

Do not take a pet dog when travelling in bear country. If you must take a dog, keep it on a leash at all times. A roaming dog may attract or aggravate a bear and run back to you with the bear in pursuit.

Grizzly bears hunt ground squirrels by digging up their holes.

Avoid using odorous products, such as cologne, deodorant, perfume, or cosmetics, as they may attract bears.

It has been suggested that bears may be attracted to odours associated with menstruation; however, this is a controversial subject. Menstruating women need not avoid travelling in bear country. They should, however, be especially cautious and try to minimize odours through careful personal hygiene, use of tampons rather than external sanitary protection, and by burning sanitary materials.

Carry deterrent devices (e.g. bird scaring/flare cartridges or cracker shells, capsicin spray)(Chap. 7) and a firearm (Chap. 8). Make sure that you are familiar with the use of the deterrents that you are carrying. Carry them in easily accessible locations and be prepared to use them. A firearm can be used to fire warning shots or to protect yourself from an aggressive bear. People who are inexperienced with firearms, can hire a local guide who has experience with deterrents and firearms, and is familiar with bear behaviour and ecology.

Special Precautions

Field Workers

- Fly over the work area and check for bears from the aircraft before landing.
- Work in pairs and stay alert. Alternate responsibilities so one person is watching for bears. If both people are busy working, a bear may approach unnoticed.
- Every field crew should carry bear deterrents (e.g. a flare gun or 12-gauge shotgun and cracker shells) (Chap. 7). Each pair of workers should also carry a loaded 12-gauge shotgun (no shell in chamber) (Chap. 8) for personal protection. Partners should stay close together.
- Field workers should have a portable hand-held radio for communication with the aircraft or base camp.
- If possible, carry odourless food or keep food in bear resistant containers (Appendix D). Carry all garbage back to camp and dispose of it properly (Chap. 5).

Work in pairs and alternate watching for bears.

Camp Workers

- If you leave the camp or worksite tell someone where you are going and when you plan to return.
- Take a 12-gauge shotgun and a partner with you.
- If you plan to go far, take a portable two-way radio.

Researchers Using Blinds

- Make sure every side of the blind has a viewing hole and regularly look from each one.
- Have another person with you to watch for bears, or have a person responsible for "guarding" the blind by frequently checking on it from a distance and scouting the surrounding area for bears.
- Establish a signal to warn the person in the blind if a bear is approaching, and another to indicate distress from the person in the blind.
- Always keep a deterrent device (Chap. 7) and a loaded 12-gauge shotgun (no shell in chamber) in the blind.

Researchers Working With Bears

- All researchers involved with the capture and immobilization of bears should be knowledgeable about immobilization drugs and handling procedures (Chap. 9).
- Work with a minimum of three people. One person should be responsible for the safety of personnel.
- Be equipped with a loaded 12-gauge shotgun (no shell in the chamber) and deterrent device (Chap. 7) in the event that a bear revives unexpectedly from an immobilizing drug.

Hunters

- Be alert for bears when dressing a kill or packing meat.
- Always have a loaded 12-gauge shotgun (no shell in chamber) with you.
- While packing meat, stay in the open as much as possible so you can see a bear approaching.
- Check behind you frequently.
- If a bear is following you while you are packing meat out, try to deter the bear. Firing a few warning shots may scare it off. If you are without a gun or other deterrent, you can drop enough meat to delay the bear. Use this as a last resort as you do not want to reward a bear and create problems for other hunters or hikers. If a bear becomes aggressive and threatens your safety, it may have to be shot.

Fishermen

- Be cautious when travelling stream banks or lake shores. Bears often use the same travel ways.
- When venturing into new fishing territory, do so with caution as a bear may consider the area its private fishing grounds.
- Keep fish already caught in the water to reduce fish odours.
- Refer to Chapter 5 for guidelines on handling fish in camp.

How to React to a Bear Encounter

If a bear detects you in time, it will usually flee to avoid an encounter. However, despite precautions, there is always a chance you may surprise a bear at close range or meet a bear which is not afraid of people. There is no guaranteed formula for reacting to a bear encounter because every encounter is unique. There are, however, guidelines which may help. Most are based on good judgement, common sense, and familiarity with bear behaviour (Chap. 3).

General Recommendations

- Assess the situation and think about your surroundings before you act.
- Try to stay calm, even though it may be difficult.
- Try to keep the bear in sight at all times; even a polar bear can hide in what appears to be open habitat.
- If travelling with a group, move close together.
- Do not run unless you are sure you can reach a safe place before the bear catches up. Running away may invite pursuit, and a bear is faster than you are. More appropriate responses are suggested in the following sections.

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Bears often travel along stream banks and lake shores.

Responding to a Bear in Camp

1) A bear is sighted at a distance, approaching camp.

- Walk to the nearest safe shelter.
- Make sure everyone in the area is aware of the bear.
- Try to drive the bear away using an appropriate deterrent method (Chap. 7). Keep a loaded firearm ready as a back-up. Continue using the deterrent until the bear is out of sight.

- If the bear continues to approach, and time permits, try a different deterrent. Fire warning shots.
- Give the bear a chance. It may leave after its curiosity is satisfied. Shooting the bear should be considered a last resort.

2) A bear is in camp.

- If camp occupants are not in immediate danger, try to scare the bear away with deterrents.
- You may have to act quickly if a bear is attempting to enter an occupied tent or building. If people are in immediate danger, shooting the bear may be your only option.
- Flashing a strong light back and forth across a window rapidly may coax a polar bear out of an unoccupied cabin or building at night. The bear can then be deterred or, if necessary, shot.

Assess why the bear came into (or near) camp. Was it attracted to something or was it curious or hungry? Remove any possible attractants. Make an appraisal of camp design and maintenance. Determine if any changes are necessary and make them.

Report the incident to the local Renewable Resource Officer.

Reacting t^ a Chance Encounter Away From Camp

1) The bear is unaware of you and feeding.

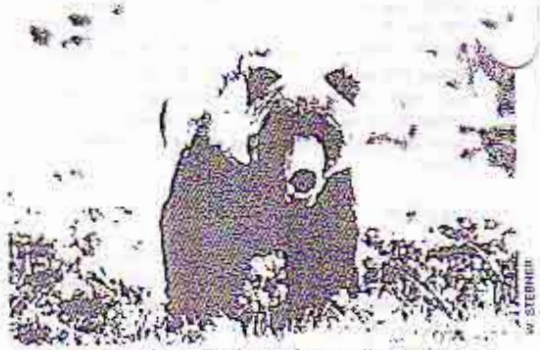
- If you can do so undetected, leave the area. Quietly go back the way you came. Move only when the bear's head is down. Stop when it lifts its head to look around. Stay downwind. When you are a safe distance away, wait until the bear leaves or make a wide detour around it.
- If you cannot leave undetected, let the bear sense you by smell first. Quietly move upwind. If possible, keep the bear in sight. The bear may leave when it smells a person nearby.

2) The bear is unaware of you, but approaching.

- Give the bear the right-of-way.
- Try to get out of the way without being noticed. If that is not possible, announce your presence by shouting. Bears should be able to determine that you are a human by the time they are 100-150 m (300-450 ft) away.
- Give the bear a chance to leave.

3) The bear is aware of you, but distant.

- Stay calm.
- Continue walking slowly, but head away from the bear.
- Do not run unless you are sure you can reach safety. A bear is fast and can outdistance you in a short time if so inclined.
- If the bear follows, leave behind a hat or scarf to distract it and allow it to identify you as a person from your scent.
- If you are dealing with a grizzly bear, climb a tree if a large one is available. Remember black bears climb trees and grizzlies can reach 3-4 m (10-13 ft) and may climb if the spacing of limbs permits.
- If there is a bird colony nearby, or something else which could be a distraction to the bear, you could head in that direction.



In close confrontations with a bear, act as non-threatening as possible by avoiding sudden movements and direct eye-contact.

4) The bear is aware of you and close.

- In close confrontations, the bear is likely to feel threatened. Its natural tendency is to reduce or remove the threat. Help it by acting as non-threatening as possible, particularly if it is an adult bear or a female with young. Do not make sudden movements. Monitor the bear's movements but avoid direct eye contact. If the bear is young and possibly curious, it may be best to yell or in so

way be more aggressive to drive it away. To help you act appropriately, assess the situation and try to determine why the bear is acting the way it is.

- Help the bear identify you as a person. It may leave. Stay upwind if possible. Talk in low tones and slowly wave your arms.
- Give the bear the opportunity to leave. Make sure it has an open escape route.
- Back away slowly and/or climb a tree if appropriate.
- Try to deter the bear (Chap. 7) if you are in a safe position.

5) The bear is close to you and threatening.

- Try to scare the bear off with an appropriate deterrent (Chap. 7) if you are equipped to do so.
- If you have no deterrent, or if the attempt is unsuccessful, act as non-threatening as possible (however, see the note regarding young, curious bears above).
- Talk in a calm, but authoritative voice.
- Do not make fast or sudden movements which might startle or provoke the bear.
- Do not imitate a bear's aggressive sounds, signals, or postures.
- Back off slowly and drop a hat, scarf or other article to distract the bear. Do not drop your pack - it can help protect the spine and back if the bear charges (Refer to the section on "Playing Dead"). Drop food only as a last resort because the bear may continue to approach you, or others, for more food.

6) The bear is very close (less than 50 m (160 ft) in open areas, closer in forests) and approaching.

- If the bear does not respond to a deterrent, stand your ground.
- If you are unarmed do not play dead unless bear charges and is close (see 7b). Standing will enable you to dodge an attack, distract the bear by dropping something or by flashing clothing, and allow you to monitor the bear's actions.
- If you are armed and the bear continues to approach and act aggressively be prepared to shoot. Once the bear comes within 20 m (65 ft) you will have little time to react should the bear suddenly charge.

7) The bear charges.

- A bear charges at high speed, on all four legs, often crouched low to the ground. It does not charge on its hind legs.
- Many charges made by grizzlies and black bears are bluffs. These bears often stop or veer to the side at the last minute. However, it may be difficult to know if a charge is a bluff until the bear is very close.
- If you are faced with a charging bear, you have two options: shoot to kill if you have a gun, or play dead (7b) if you are unarmed.
- Bluff charges are rarely observed in polar bears. If a polar bear charges it should be interpreted as an attack and you should not play dead. Polar bears occasionally stand on their hind legs before initiating a charge.

a) Shooting a bear

When to shoot - The decision to shoot a bear is a personal decision, and has to be made quickly. The "right" moment for you to squeeze the trigger depends on your experience and confidence with a gun, how fast the bear is approaching, and your nerves. Everyone has a different threshold, or imaginary line, at which they shoot. People often shoot too far away - a charging bear can appear bigger and closer than it actually is. It is good to set your own personal limit before the bear charges to avoid shooting in a panic. Many experts recommend waiting until the bear is within 20 m (65 ft) before shooting, and, depending on the circumstances, as close as 3-10 m (10-30 ft) if you are using a 12-gauge shotgun. Some people may feel confident waiting to see if the charge is a bluff. The decision can be made only by the person facing the bear. Remember that an accurate shot fired at close range has a greater chance of killing a bear than one fired from further away.

Where to shoot - Try to kill the bear cleanly and quickly. The first shot is the most important. Aim for 1) the low neck if the bear is broadside, 2) low centre neck between the shoulders if the bear is facing you, or 3) the front shoulder area to knock the bear down and disable it (Fig. 5). Avoid head shots, as they often do not kill a bear. Do not stop to check the results of your shot. If the bear goes down, keep shooting vital areas until it is still. Make sure it is dead.

If you wound a bear - A wounded bear is dangerous. If you injure a bear, it is your responsibility to find and k'" it, or report the incident to the nearest Renewable Resources office. At least two armed and organized people are needed to track a bear. Stay together, keep guns ready, and communicate. Be prepared for a close encounter with an angry bear.

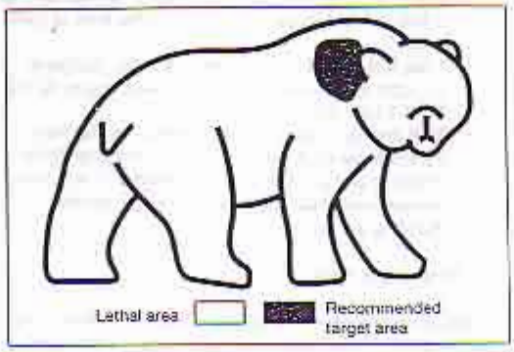


Figure 5. Area of instant kill or disabling shot.

Regulations - Generally stated, in the Northwest Territories, Yukon Territory, and Alaska it is legal to shoot a bear to preserve your, or another person's life, or to protect property. (Contact your local wildlife agency for a precise definition of regulations that deal with bear-people conflicts in your area.) Shooting a bear should be a last resort. You must report the kill to the nearest Renewable Resource Officer as soon as possible. Appendix F explains what to do if an officer is not immediately available to come to the kill site.

b) Playing dead

Playing dead may prevent serious injury if a surprise encounter brings on an attack, and you are unable to kill the bear. Playing dead may reduce the threat you represent to the bear. If you appear harmless, the bear may leave. However, do not play dead too soon (i.e., only play dead if an attack is imminent). A curious bear may approach and investigate you if you suddenly fall to the ground, rather than leave. Do not play dead if the bear appears to consider you prey (see No. 8 below).

- Your body position should minimize exposure of vital areas (neck, face, abdomen). Lie on your side, curled into a ball with your legs drawn to your chest and your head buried in your knees ("fetal position"). Clasp your hands behind your neck with your fingers interlocked. Use your forearms and elbows to protect your face as best as possible. Keep your legs tightly together. Try to stay in this position even if moved.
- Try not to resist, struggle, or call out as it may intensify the attack.
- Look cautiously and be sure the bear is gone before moving.

8) The bear is hunting.

- If the bear is treating you as potential food (Chap. 3) and you do not have a gun, do not play dead.
- Act aggressively and defend yourself with whatever means available.
- You want to appear dominant and frighten the bear. Jump up and down, shout, wave your arms. Fight back. It may help to raise your jacket or pack to make you look bigger.

An unarmed person presents little opposition to a bear, however, fighting may frighten the bear into leaving, or at least, provide valuable time for someone nearby to assist you.

Remember, fighting back does not apply in situations when you have surprised a bear at close range. Fighting back applies when a bear is stalking you and shows signs that it considers you prey.

Emergency Situations

Responding to a Bear Attack

Bear attacks are rare but some forethought on the matter could save a life. When a bear attacks one member of a group the actions of other members may help determine the outcome of the incident. Suggestions for witnesses of an attack are listed below. However, each incident will be unique and not all suggestions will apply to your situation.

Do not hesitate to use deterrent devices or weapons, if you have them, when one member of a party is in the process of being attacked, mauled, or carried off by a bear; or, a bear has entered an inhabited dwelling or tent. The risk of injury to a victim from a deterrent or a misplaced shot are less, at this point, than the injury c

possible death that could result from an attack.

It is dangerous to aim a deterrent in the direction of a person or use a firearm in an inhabited dwelling, so you must do so with care. Discuss the scenario with your group beforehand and determine who is the most capable person to handle a firearm in a tense situation. Not everyone can remain composed during an emergency or is mentally prepared to kill a bear. If the situation arises, try to remain calm. Look beyond the bear and know where the bullet or deterrent is going to end up.

In the event that a bear attacks a member of an unarmed group everyone should try to remain calm and silent (however, see the note below regarding shouting at a bear).

- If you are in a close group, and a bear attacks, do not scatter. Sporadic, panicked activity may increase the bear's perception of threat and prolong or increase the severity of the attack.
- Increase the distance between you and any attacking bear. Slowly back away from the bear. Do not run, as this could entice the bear to chase you.
- Move towards a safe location, such as a large tree or inside a building or vehicle, if you can do so without drawing attention to yourself.

Shouting at a bear by a second person may cause it to break its attack on a victim but usually serves to redirect the attack to the other person. Ideally, you should attempt to draw the attention of an attacking bear only if you are in a safe location, i.e., up a high tree or inside a vehicle or building. A group of people shouting could frighten an attacking black or grizzly bear, however females with cubs have been known to charge even small groups. In the case of polar bear attacks, once a mauling has begun the bear is extremely difficult to deter. Chasing the polar bear with a vehicle or hazing it with a helicopter may cause it to leave its victim.

Injuries

Injuries inflicted by bears range from scratches or light bites to major injuries requiring hospitalization. The face and skull commonly receive injuries during a bear attack.

People could be accidentally injured by a deterrent while attempting to repel a bear. You should be fully aware of the safety precautions necessary to operate the deterrent device(s) that you have selected. To minimize the risk of injury, read all information supplied by the manufacturer and practice with the device before you have to use it in an emergency situation. Injuries may include: rifle or shotgun wounds, impact injuries (from rubber bullets or plastic slugs), burns (from flares), and chemical irritation (from capsicin sprays). Always carry first aid products suitable for the type of deterrent that you plan to use.

First aid and medical treatment is beyond the scope of this manual. Include the following general steps in an emergency plan.

- Remain calm.
- Do not approach an injured person until it is safe to do so, i.e., the bear has left.
- Administer first aid.
- Contact others with a two-way radio, or send someone for help.
- Call for a helicopter or other means of transport, depending on the severity of the injuries.
- Evacuate the victim(s) and other people from the area.
- If possible, do not leave an injured person alone, especially if the bear is still in the area or its whereabouts is unknown.
- Inform the nearest Renewable Resource Officer or RCMP of the incident.

It is important to inform local Renewable Resource Officers about any bear incident. Even non-injurious incidents without property damage should be reported so that wildlife managers can gain insight into why human-bear incidents occur and how best to prevent them. In the Northwest Territories, be prepared to provide the information requested on the Occurrence Record/Nuisance Bear Report form (Appendix E). Other wildlife agencies have similar forms that people are required to fill out in the event of a bear incident.

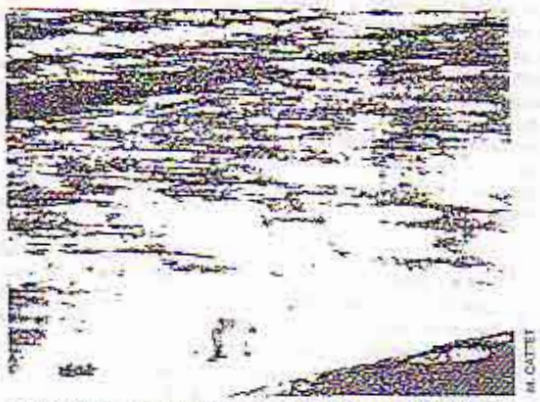
CAMP DESIGN AND MAINTENANCE

CHAPTER 5

The most effective way to deal with bear problems is to prevent them by discouraging bears from visiting your camp. Careful planning and attention to details of camp design and maintenance will decrease your camp's attractiveness to bears.

A little time and effort spent on precautions can reduce the chances of expensive property damage, increase the safety of camp workers, discourage the habits of problem bears, and prevent unnecessary bear kills.

You must determine which guidelines apply to your situation based on the size, permanence, function, and location of your camp, the chances of encountering bears in the area, and the bear species likely to be encountered. Remember that each precaution you take reduces the chances of a bear visiting your camp. Completing a Site Operation Plan (discussed in this chapter) will help you prepare for any encounters that may occur and enable you to handle them better.



M. CATTET

Avoid placing camps in areas used by bears, such as shorelines.

General Precautions

The following precautions apply to all camps in bear country.

Camp Location

In bear habitat, camp location is important. You can reduce the risk of bear visits by avoiding the following areas when setting up:

- bear feeding areas: near the floe edge, leads, open water areas, and heavily pressured near shore ice (polar bears); along floodplains, near berry patches, burns, and areas rich in horsetails or Eskimo potato (Appendix C) (grizzly and black bears),
- bear travel lanes and trails: along shorelines, points of land, pressure ridges on sea ice (polar bears); trails along streams and ridges or near berry patches (grizzly and black bears),
- den sites: especially known polar bear or grizzly denning areas,
- polar bear summer retreats: coastlines and off-shore islands,
- locations with previous bear problems,
- locations where bear signs (e.g. tracks, fresh droppings) are evident, locations where vegetation or terrain limit visibility and might hide a bear, and
- locations where loud noise (e.g. a river) would drown out the sound of an approaching bear.

Avoid placing camps in locations where bear tracks are evident.

Consult the local Renewable Resource Officer for advice on camp placement. Before going to the field, ask the officer to identify specific locations of high bear use and past bear problems in the area where you intend to camp. Familiarity with bear biology (Chap. 2) will also help you determine areas to avoid because of their use by bears.

Before going to the field, ask the local Renewable Resource Officer for advice on camp placement.

Camp Layout

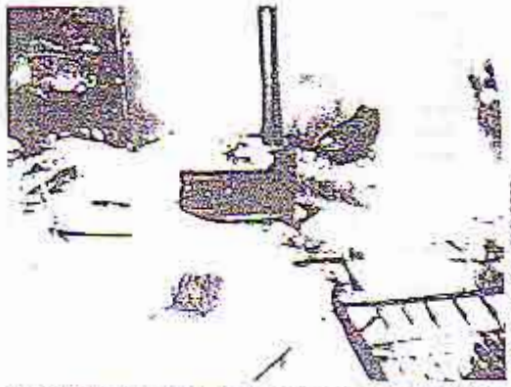
Proper arrangement of tents, buildings, and other facilities makes your camp safer for workers if a bear does come to investigate. Several guidelines can be followed when setting up camp.

- Do not sleep in the open (without a tent).
- In polar bear country, consider placing windows in your tent so that you can check for bears without sticking your head out of the tent - which may resemble a seal sticking its head out of a breathing hole.
- A few big tents/buildings are better than several small ones. It is best to sacrifice individual privacy for safety. A bear surrounded by structures may feel trapped and confused and may charge.
- For the same reason, keep tents or buildings well-spaced but not scattered, and place them in a line or semi-circle, not a circle. This gives the bear an avenue of escape and allows deterrents or firearms to be used more safely.
- Cooking, food storage, and latrine facilities should be in the open, at least 50 m (160 ft) from, but in view of, sleeping quarters.
- Garbage should be burned well away from camp (at least 200 m (650 ft)), but in an area visible from camp.
- Sleeping quarters should be upwind (based on prevailing wind direction) from cooking and waste disposal areas.

Food Preparation and Storage

Special care is needed for food preparation and storage. Do not underestimate the power of a bear's nose for finding carelessly stored food. Keep a clean camp. The following general rules apply to all situations in bear country.

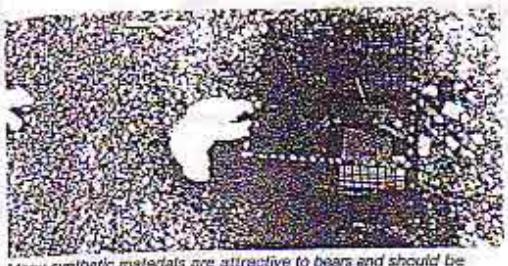
- Produce few food wastes.
- Eliminate or reduce food odours.
- Maintain special areas for cooking and food storage (preferably separate), away from sleeping quarters. Restrict food to those areas. Do not keep food in sleeping or working areas, vehicles, or helicopters (except odourless canned or dried food kept in aircraft for emergency use).
- Use up leftovers as soon as possible. If necessary, store them for a short time in sealed, airtight containers.
- Grease is especially attractive to bears. Cook non-greasy foods as much as possible. Burn excess grease in a hot fire or reuse it right away. Store grease in an airtight container.



Bears attracted to poorly-stored food can cause considerable damage.

Other Bear Attractants

Bears are often attracted to synthetic materials and have been known to eat or chew on inflatable boats, plastic gas cans, rubber gas lines, sleeping bags, snowmachine seats, nylon tents, motor oil, and insulation on wires. If possible, objects such as these should be stored in a bear-proof location when not in use. Salt used in diamond drilling operations should also be made inaccessible to bears.



M. CATTET

Many synthetic materials are attractive to bears and should be stored in a bear-proof location.

Waste Disposal

Careless handling of garbage is a major cause of bear problems at most sites. Bears make no distinction between the dump and the kitchen tent, and will seek meals from either. Because bears are initially attracted by odours, it is odours which must be eliminated.

- Incinerate all garbage on a daily basis, or remove garbage from the camp. Pack garbage out in a plastic bag if you are continually moving camp, or send it out by supply vehicle.
- Burying garbage does not eliminate smells. Bears have dug pits 4 m (13 ft) in diameter and 2 m (6 ft) deep to find garbage.
- Greasy dishwater should be dumped in a pit away from camp and treated with disinfectant or lye.
- Latrine facilities should be covered with lime and earth on a regular basis. Tampons and sanitary napkins should be burned.

Camp Security

Following bear safety guidelines and precautions should reduce the chances of a bear visiting your camp. However, even the cleanest camp may be investigated by a bear. If a bear comes to your camp, you should be prepared.

- Have a plan for dealing with bears and make sure every person in camp knows it.
- Every camp should be equipped with:
  - a dependable flashlight or spot light,
  - an appropriate detection method (Chap. 6),
  - an appropriate deterrent technique (Chap. 7)
  - one or more firearms capable of killing a bear (Chap. 8).
- One person should be responsible for maintaining firearms and deterrents so that they are in good working condition. Make sure these items are accessible and that everyone knows where they are located and when and how to use them.
- Consider taking along a VHF radio for use in an emergency.

R. LETHEMAN

Remove bear attractants or store them in an inaccessible location when you leave a tent camp.

Bear-proofing Camp While Away

You can take a few precautions to reduce the chance of a bear entering tents or buildings and causing damage while you are away.

- Remove all attractants. If you are leaving for an extended period, store food in an inaccessible location. This is especially important for tents, which cannot be physically bear-proofed.
- Remove equipment that may be easily damaged by bears (e.g. plastic, rubber, canvas, nylon), or store these items in a location that is inaccessible to bears.
- Ensure that all windows and doors are securely locked. Windows can be equipped with solid wood shutters for extra protection.
- When leaving for long periods, some people place "bear boards" on steps and window sills. These can be made by driving lots of nails through a sturdy board so the points protrude on the outside. Bear boards may give added protection, but do not work for all bears.

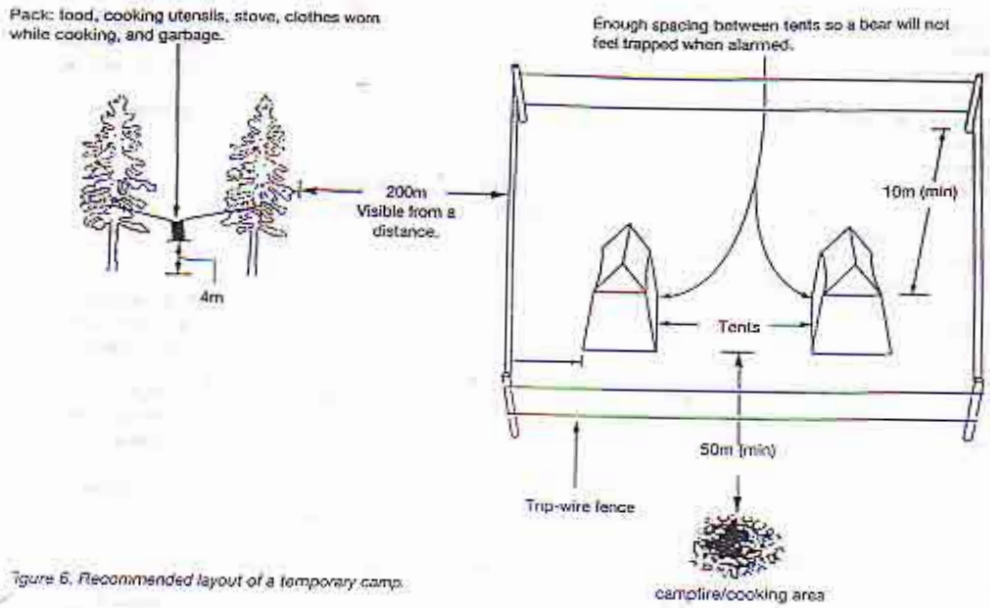


Figure 6. Recommended layout of a temporary camp.

- Some people claim moth balls keep bears away, however, most reports indicate that moth balls do not repel bears.
- An electric fence may be effective protection in some cases (Chap. 7). Keep in mind that electric fences require regular maintenance and may not be reliable for long periods.

Site Operation Plans

Camps should have a plan of action - or site operation plan - for dealing safely with bear problems. Site operation plans are drafted specifically for each camp, rig, community, etc. by the site supervisor, following a general outline developed by the N.W.T. Department of Renewable Resources (Appendix M). Each plan includes:

- identification of key contact personnel on site and in nearby communities,
- a site description and map identifying locations of possible bear attractants, bear use of the area, travel paths used by workers, and danger areas such as locations accessible to bears,
- guidelines for movement of personnel in the area, and,
- steps to be taken on sighting a bear.

Specific Camp Precautions

In addition to general precautions, there are several design guidelines for specific types of camps.

Temporary Camps with Few Tents

1) Food Preparation and Storage

- Use odourless foods as much as possible (dry and freeze-dried foods).
- Avoid cooking foods with strong smells (bacon, fish).
- Keep your pack, sleeping bag, tent, and clothes, free of food smells.
- Wear a hat or kerchief while cooking so your hair does not pick up food smells.
- If possible do not sleep in clothes worn while cooking, and store them away from your tent.
- Clean kitchen utensils immediately after use.

B12

- Store all food, including leftovers and wastes, in bear resistant containers. Several types of containers have proven effective against black and grizzly bears, and are being used in National Parks in the United States (especially Alaska and California) (Appendix D). Special containers may be expensive, however, a bear attempting to get poorly-stored food can damage tents, packs and other gear which may be expensive to replace.
- If you do not have bear resistant containers, seal the articles in a plastic bag or plastic-lined duffle bag and (in order of preference):
  - suspend the bag on a rope, cable or pole between two trees at least 4 m (13 ft) off the ground and 1.5 m (5 ft) from trees or other vertical surfaces,
  - hang the bag from the limb of a tree at least 4 m (13 ft) off the ground - remember that black bears and young grizzlies can climb trees,
  - place the bag in a cooler, bury, and cover with moss, or
  - when there are no trees and you do not have a cooler, make sure the bag is airtight and bury it or place it on the ground downwind from camp.
- Cache food, cooking utensils (including stove), clothes worn while cooking, and garbage at least 200 m (650 ft) downwind from camp (Fig. 6). Place the cache where it is visible from camp so you do not surprise a bear when you return to your cache.

2) Waste Disposal

- Completely burn all flamable garbage.
- Garbage which cannot be completely burned can be stored in airtight containers and cached with food away from camp. Cans, bottles, and other containers should be washed first.
- Pack garbage with you when you move to a new location. Leave nothing behind. Garbage left at campsites creates problems for other camps as bears in the area will associate people with a food source.

3) Camp Security

- Keep a dependable flashlight handy. It can be kept warm in your sleeping bag.
- A trip-wire fence is an appropriate detection system for small camps (Chap. 6). If this option is not available and you are in an area where there is a high probability of encountering a polar bear you should maintain a night watch.
- Camps should have appropriate deterrent equipment (Chap. 7).

Long-Term Camps with Several Tents/Buildings

1) Food Preparation and Storage

- Food should be stored inside locking steel containers (e.g. sturdy trunks), in metal drums with locking lids, or in bear resistant food containers (Appendix D).
- If the camp has refrigerators and/or freezers, these should be fitted with locks and secured at night.
- Keep the kitchen area clean. Do not leave dirty dishes, utensils, or pans sitting around.
- Make sure grease is regularly wiped off the stove, counters, tables, walls, etc.

2) Waste Disposal

Camps which receive regular supply shipments can send garbage out if shipments are frequent. Garbage should not accumulate for more than a few days and should be stored in airtight, bear-proof containers (e.g. metal drums with sealed lids).

Camps without the transportation option should burn garbage at least once a day, or more often if accumulation is excessive. Complete incineration (i.e., to ash) is essential so that odours will be eliminated.

A forced-air solid waste incinerator is the most effective and preferred method of burning garbage. Compact, economical forced-air incinerators can be rented or purchased. These can be mounted on skids for easier moving. Another option is to make a small incinerator from a 45 gallon drum which has openings for air circulation (Fig. 8). The Yukon Department of Renewable Resources has produced a pamphlet that describes design considerations and lists materials required to construct an incinerator (Appendix B).

When an incinerator is impractical, garbage can be soaked with diesel fuel, thrown in a pit, and burned completely. Ashes should be buried at least one m (3 ft) deep and at least 200 m 650 ft) from camp (Fig. 7).

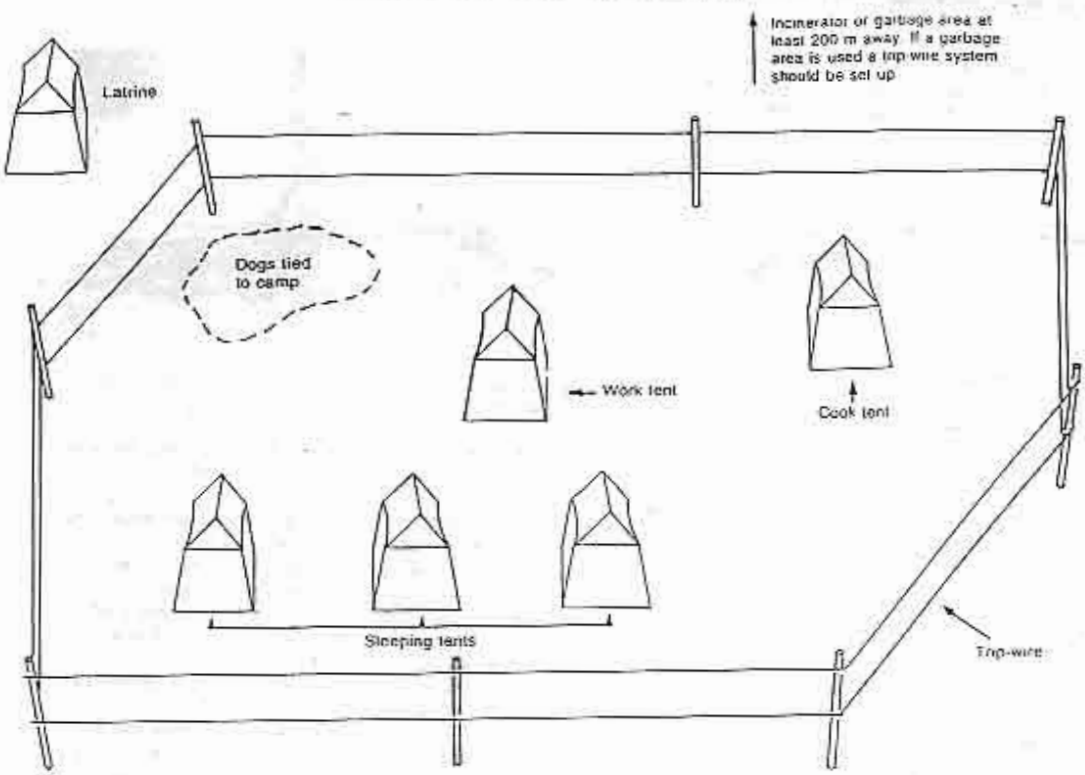


Figure 7. Recommended layout of a long-term camp.

Unburnables should be thoroughly scorched and buried only when they cannot be taken to a dump or stored in secure containers such as drums with lids.

If your camp will be incinerating or burning garbage, following the precautions listed below will increase the safety of personnel.

- Where possible, burn and/or bury garbage on islands.
- Burn garbage in the morning and/or immediately after supper. Burning garbage right before bedtime should be avoided as it may attract bears to camp while people are asleep.
- Position garbage handling areas so they are visibly from the main camp.
- Take garbage directly from the kitchen to the incinerator or burning area.
- Keep the camp and surrounding area litter-free. Even small wastes such as carelessly-tossed wrappers or drink containers attract bears.

3) Camp Security

- Camps should have appropriate detection and deterrent-equipment (Chap. 6 and 7).
- Where practical, larger living units should have two doors so that occupants can get out if a bear gets in. Always keep doors latched.
- If possible, a loaded firearm should be kept in each tent/building (shells in magazine not chamber). A firearm in the cook tent is useless if a bear tries to enter your sleeping tent during the night.

B 14

- One person should be responsible for firearm maintenance, but everyone should be able to shoot camp guns and know where they are located.

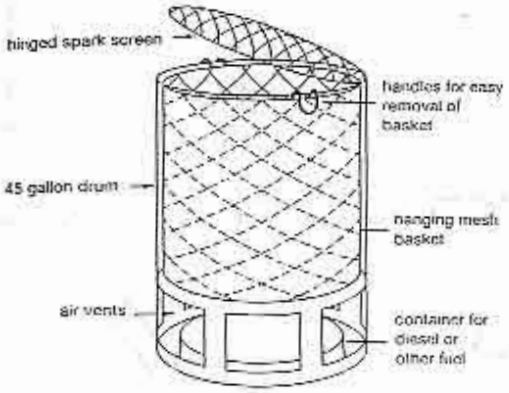


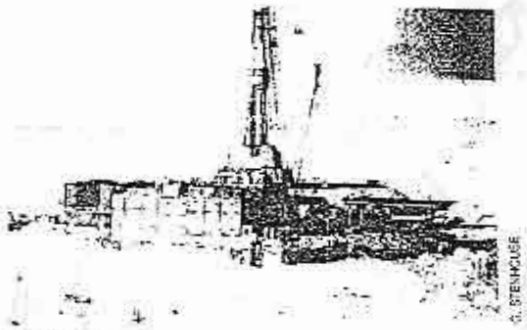
Figure 8. Incinerator made from a 45 gallon drum

Large, Permanent Industrial Sites

1) Camp Layout

Large camps should be planned and constructed to reduce the chance of conflicts with bears and increase personnel safety. On the sea ice and arctic islands, where polar bears are common, the details of camp layout are especially important. Large sites should be designed to minimize unnecessary outdoor activity by personnel, especially during long periods of darkness (Fig. 9). This can be accomplished by:

- connecting buildings by covered, lighted walkways, or
- providing vehicles to transport people between buildings and to outdoor work areas.



Large camps should be planned and constructed to reduce the chance of conflicts with bears.

In areas where outdoor activity is necessary, several precautions can be taken to increase safety.

- Eliminate "ambush" areas where bears might hide, such as blind corners and snow banks.
- Place skirting around buildings and steps to prevent bears from crawling underneath.
- Provide enough lighting for good visibility in all areas, especially at building exits, outdoor work areas, and along outdoor walkways.
- Install windows near doors so people can check for bears before going out.
- Use an appropriate detection system (Chap. 6) and/or an electric fence (Chap. 7) around outdoor work areas which are away from the main camp.
- Remove drifted snow from the camp area, especially where it might provide an access ramp for bears to reach elevated work areas.
- Regularly monitor ramps and other means of access which cannot be eliminated.

2) Food Preparation and Storage

Large camps should follow the guidelines described in the section on "General Precautions". Food preparation is less critical at large sites if the kitchen is fully enclosed and proper exhaust fans are installed to filter odours.

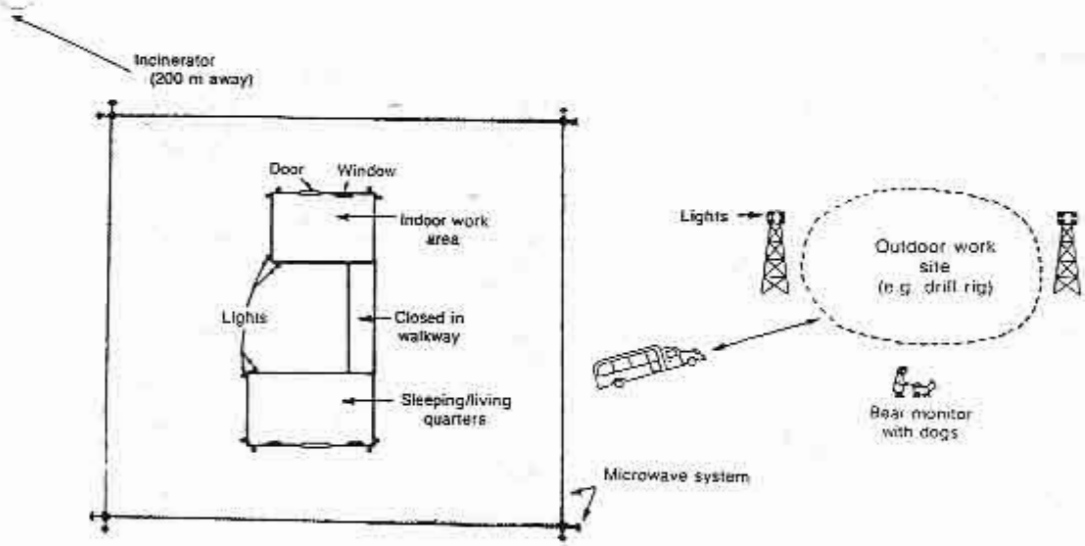


Figure 9. Recommended layout of a large, permanent industrial site.

3) Waste Disposal

Waste handling is especially important at large sites and may be the major factor influencing whether bears become a problem. General precautions and those for semi-permanent camps also apply to permanent sites, with one major exception: a forced-air solid waste incinerator is essential at large camps if garbage is not flown or trucked out daily. No other disposal method can effectively eliminate the quantities of garbage produced at large camps. Incineration may be required several times a day to avoid accumulation of wastes. Permanent sites must also have proper sewage treatment facilities.

4) Personnel Conduct

The actions of each person contribute to the safety, or lack of it, in camp. Personnel should be aware of the dangers of attracting bears and their role in preventing conflicts with bears. Every person must be informed of the precautions which increase his/her own safety as well as that of other workers.

- Check for bears and fresh tracks before leaving buildings.
- Keep outside doors closed and latched.
- Never travel or work alone outside the camp area.
- Let someone know where you are going if you leave the main camp.
- Use a vehicle if you travel during darkness and leave a lighted area. Scan the area with headlights or spotlight before getting out. Have a working two-way radio in the vehicle. If the vehicle stalls, call for help. Do not walk back.
- Do not litter outside the camp area. Bring garbage back to camp and dispose of it properly. Garbage thrown from a vehicle could lead a bear back to camp.

The effectiveness of any bear safety program will be greatly reduced if the following rules are not strictly enforced. These rules are important for the safety of everyone in camp.

- Feeding of all animals must be strictly forbidden. Foxes and birds may seem cute and harmless, but bears will be attracted to scraps intended for other animals. Feeding wildlife is dangerous and creates pests, not pets.
- Personnel must stay away from bears in camp, and must not stand around watching or taking pictures.

B16

5) Camp Security

- At a large camp, one person or several people working closely together (bear monitors, site superintendents, safety officers), should be given the responsibility for handling bear problems. Their duties should include:
  - maintaining portable spotlights for emergency use,
  - maintaining and handling deterrent equipment and firearms,
  - making sure the appropriate people are informed of a bear sighting,
  - imposing restrictions, if necessary, on personnel movement in the area of a bear sighting, and
  - taking responsibility for deterring and, if necessary, destroying a problem bear.
- Communication is important in a large camp. A system is needed to warn people working in, or moving through, an area where a bear has been seen. Make sure all personnel know what to do and who to contact if they see a bear.
- Choose detection and deterrent equipment that is appropriate for large camps (Chap. 6 and Chap. 7).

Homes in Remote Areas

Many guidelines listed under "General Precautions" and discussed for large camps will also apply to homes in rural areas or in remote communities within bear habitat. In addition to these guidelines, the following precautions may reduce the likelihood of problem bear incidents.

1) Layout and Design

- Dumps should be located downwind and several kilometres from homes.
- In polar bear country, community roads should be routed perpendicular to and inland from the coast rather than parallel and adjacent to the coast, when possible. Polar bears are more likely to travel a road that follows the coastline.
- Area surrounding homes and dumps should be cleared of dense bush which could provide a hiding place for bears.
- All homes in rural areas should have strong, well fitting doors. There should be no gaps in which a bear could fit a claw and tear the door off. Windows should have shutters so that the windows can be secured when the home is unoccupied.

2) Food Handling and Storage

- Store all game in a place that is inaccessible to bears. Never leave fish or game lying outside a home or in a porch attached to a home.
- In the home, food should be securely stored or put away when it is not being prepared or eaten. Never leave food out on a table. If a bear manages to enter and obtain food it will be more inclined to return.
- Feed dogs once a day. Ensure that all the food is consumed and not lying around where it could attract bears.

3) Waste Disposal

- Isolated communities should use oil fired incinerators to burn garbage, use proper landfills, or install electric fences (in black and grizzly bear country) around dumps (Chap. 7) so that edible waste is not accessible to bears. If these options are not practical, a community-wide effort could decrease the attractiveness of the dump to bears. This could include encouraging all community members to:
  - rinse food containers before they throw them away,
  - reduce overall food wastage, and
  - burn animal carcasses left at the dump.

Individuals can reduce the attractiveness of their homes to bears by following the precautions listed below.

- Do not use outdoor garbage cans for anything except non-food items.
- Food scraps or containers that previously held food should be stored in an area that is inaccessible to bears (e.g. in the home or in a secure shed).
- Burn left over food scraps in a woodstove.

Hunting Camps

Hunting camps present special problems and need extra precautions in bear country. Bears are capable of finding and claiming a hunter's kill, particularly in areas where hunting is common. A few safety measures will increase your security and save your meat.

- Avoid late evening hunts and returning to camp in the dark.
- Use ungulate calls or predator calls with caution. Some bears are attracted to high pitched noises.
- Stay alert and cautious when dressing game or handling meat.
- Dress game away from camp. Avoid puncturing the stomach.
- Do not shoot more than you, or your hunting party, can pack out in a single load. Remove meat from the field as quickly as possible, preferably within 24 hours.
- If you must leave meat in the field temporarily, place it near an easily recognizable landmark with a clear approach route.
- Do not drag meat into camp. Cache it at least several hundred metres downwind from camp in a location which is inaccessible to bears (e.g. placing it on a platform meat cache, suspending it between trees) and visible from a distance.
- Leave any bloody equipment (e.g., sleds) 200-300 m (650-975 ft) downwind from camp.
- Do not sleep in blood-stained clothes.

Hunting and fishing camps can be attractive to bears.

- During cold weather, leave firearms just outside heated tents to avoid condensation problems (Chap. 6), but take an axe or knife into the tent. In summer, firearms can be taken into tents.
- Approach a meat cache slowly, with a loaded gun. Watch for bear sign and make noise in case a bear is sleeping nearby.
- If a bear is at your cache, leave the area without disturbing it. Do not try to drive a bear from game unless you depend on the meat for survival. In most circumstances, loss of game does not justify killing a bear or risking personal injury.
- Change temporary camp locations from time to time to prevent odour build-up.
- Only pack-in as much food as you need for a particular hunting trip. Avoid stock-piling food.
- If there are horses in the camp, do not use horse grain mixtures that contain sweeteners, such as molasses, which may be more attractive to bears. Store all horse feed in bear proof containers or in an area that is inaccessible to bears.

The Department of Renewable Resources and residents of Spence Bay, N.W.T. are examining the use of bear proof cages to protect seal caches that are stored away from town. The cages are comprised of a steel frame with reinforced steel mesh. They weigh 365 kg (800 lb) and have a volume of 9.3 m³ (320 ft³). A bear proof cage will not reduce the initial attraction of bears to areas where meat is stored. However, it should prevent them from destroying food caches and obtaining food, and may discourage future visits.

Fish Camps

Fish camps, both recreational and commercial, can experience considerable bear problems if not properly set up and maintained. Fish odours are strong and attractive to bears.

- Clean and handle fish away from sleeping/living areas.
- Equipment and utensils smelling of fish should be cleaned or left away from camp.
- Do not sleep in clothes worn while handling fish.
- Do not store fish or bait in camp. Storing fish in the water reduces odours.
- Do not allow fish guts and scraps to accumulate. Depending on local regulations, they should be disposed of in the water or burned away from cooking and sleeping areas.

B 18

- Hang drying fish high enough that they cannot be reached by bears.
- Build smoke houses from sheet metal or wood with two exits. Install a proper floor which can be cleaned.

BEAR DETERRENT METHODS

CHAPTER 7

Preventing the attraction of bears through proper food storage, garbage disposal, and camp maintenance is the most economical and effective way to reduce bear problems. However, bears are sometimes attracted to clean and well maintained camps. Use of proven deterrents will increase human safety and reduce the need to kill problem bears.

N. CATTET

The effort needed to deter a bear depends on the circumstances.

Definition of a Deterrent

A deterrent is a method or device (physical, chemical or other) designed to chase away bears. It has two uses:

1) in the short-term, to protect people and property from immediate danger, and
2) in the long-term, to eliminate a bear's habit of visiting areas of human activity by having the bear associate such areas with an unpleasant experience.

A deterrent is successful if it chases a bear from the area. Sometimes a bear may return after it has been deterred. This does not mean the deterrent is ineffective. It demonstrates that a habit is hard to change, especially if it has been consistently reinforced with rewards (food scraps, garbage). A problem bear which has previously obtained food from human sources may need to be deterred several times before it learns to avoid people. However, a bear which is not familiar with people and their food might be chased away and not return after one exposure to a deterrent.

It is easier to prevent a habit from forming than to break it. For this reason, it is important to use a deterrent on a bear the first time, and every time, it enters human activity areas.

Using a Deterrent

There are few hard and fast rules governing the use of deterrents. You must rely on judgement and common sense to adapt guidelines for using deterrents to the unique circumstances of each bear encounter.

Consider the following guidelines regarding deterrents.

- There is no sure way to deter a bear. It is unwise to consider a deterrent 100% effective regardless of its experimental success.
- Concentrate on avoiding situations where a deterrent is necessary.
- The effort needed to deter a bear depends on circumstances (strength of the attractant, type of deterrent, the individual bear). For instance, a starving bear may not be easily scared off by any deterrent.
- Some deterrents, especially noise-makers, tend to become less effective with repetition.
- Deterrents must not make you overconfident in an encounter or less careful to avoid bear problems. Deterrents must not replace prevention. They are used when preventive measures are not effective.
- Training and practice are necessary to use deterrents safely and with confidence.
- Have a back-up weapon, or preferably a partner with a back-up weapon, for protection in case the deterrent fails. Teamwork is important; it can save lives.

Choosing a Deterrent

One solution is not suitable for all bear problems. You must choose the appropriate deterrent for your situation. Each deterrent has advantages and limitations which influence its effectiveness in a given situation.

B20

The best deterrent for your situation will depend on:

- its practicality, cost, and availability,
- the size and permanence of the camp,
- your training, experience, and confidence in using the deterrent,
- the type of bear encounters with which you may be faced,
- the behaviour of the bear, and
- the surrounding terrain.

Methods for Deterring Bears

There are several techniques that are commonly used for dealing with problem bear situations, for example firing warning shots, and chasing bears away with vehicles or dogs. Most of these techniques are used because they are readily available and easy to use; unfortunately, they often fail, especially if their use is not associated with the permanent removal of attractants.

A number of bear deterrents have been developed that are more effective and reliable than those commonly used, for example plastic slugs, rubber bullets, and electric fences. Practicality of these methods varies. Some are suitable for specific problems, locations, or species; others have a broader application.

Bear deterrents are commonly used in Canada for all bear species, and in U.S.A. for black and grizzly bears. However, only wildlife officers and individuals given a special take permit can deter polar bears in Alaska because polar bears are protected from harassment by the Marine Mammal Protection Act. This policy is currently under review as it does not allow private individuals to legally deter a polar bear in human-bear encounters.

Methods for deterring bears are described in the following section. Table 2 lists the effectiveness, practicality, advantages, and limitations of each method.

Table 2. Review of deterrent methods.

Method	Effectiveness	Practicality	Advantages	Limitations
Warning shots	- will not scare some bears - repeated use may decrease effectiveness	- practical for most situations where portable, short term deterrent is needed - suitable for people travelling in bear country	- readily available - easy to use - portable	- may injure bear, if not carefully placed
Cracker shells	- same as for warning shots - should not be relied on for personal protection	- same as for warning shots	- same as for warning shots	- not dependable - shells can misfire or fail to explode - limited to open areas - may be a fire hazard
Thunderflashes	- same as for warning shots - should not be relied on for personal protection	- same as for warning shots but effectiveness is limited	- same as for warning shots	- same as for cracker shells - limited range
Flare guns	- same as for warning shots - should not be relied on for personal protection	- same as for warning shots	- same as for warning shots	- same as for cracker shells
Airhorns (boat horns)	- same as for warning shots - may be used to prevent surprise encounter - should not be relied on for personal protection	- same as for warning shots	- same as for warning shots	- not reliable in very cold temperatures - may provoke aggressive or curious reactions from some bears - source of noise is on person
Birdscaring flare cartridge	- more effective than cracker shells but do not scare some bears	- same as for warning shots	- same as for warning shots - reliable - consistent trajectory - flare component useful in darkness	- limited to open areas - may be a fire hazard
Acoustic deterrents	- some frequencies (0.1 - 9 khz) have good potential - further research is required	- may be useful at permanent or semi-permanent camps	- appears physically harmless - versatile - easy to install	- further research is required to determine limitations

B 22

Method	Effectiveness	Practicality	Advantages	Limitations
Vehicles (snowmachines, all terrain vehicles, helicopters)	- engine noise often frightens bears away - chasing bears for a short distance is quite effective	- useful while travelling or in small camps where vehicles or helicopters are used	- easy if vehicle is accessible	- may be hazardous to person and bear if not used properly
Dogs	- specially trained dogs may be effective in some cases - not reliable	- suitable for camps of all sizes	- easy	- untrained dogs can aggravate a bear and/ or lead it back to camp - dogs can be killed - require a responsible handler
Rubber bullet (38 mm)	- very effective	- useful in most situations when a Renewable Resource Officer or R.C.M.P. can be contacted (see limitations)	- bears do not react aggressively toward person firing gun - may cause behavioural changes resulting in long-term deterrence	- restricted weapon; use limited to Renewable Resource Officers and R.C.M.P. in Canada - intensive training and practice necessary - may injure bear if shot not placed properly - special rifle required - expensive - single shot weapon
12-gauge plastic slugs	- very effective though some bears not deterred	- suitable for most problem bear situations	- accurate - can be fired from a 12-gauge shotgun - portable - inexpensive	- may injure bear if used at a closer range than recommended
Electric fences	- fence built to proper specifications will keep out grizzly and black bears - most effective for polar bears in wet locations	- suitable for semipermanent or permanent installations where grizzly or black bears are a problem - may not be practical for very large sites	- permanent deterrent method - 24 hr protection	- effort required for installation - regular maintenance required - can be hazardous to people
Capsicin sprays	- effective for black and grizzly bears in some circumstances - has not been rigorously tested on polar bears - should not be relied on for personal protection	- portable - useful as a backup for other deterrent methods useful while travelling or in small camps in areas where other forms of deterrence are not allowed	- readily available - portable - easy to use	- may not be useful in all situations (wind) - limited range (5-8 m) - not reliable in sub-zero temperatures

Method	Effectiveness	Practicality	Advantages	Limitations
Bear monitors	• can be highly effective if experienced with bears and well trained in the use of deterrents and firearms	• especially useful at large, established camps in polar bear habitat	• flexible	• need several monitors for 24 hour protection • need good system of communication
Relocation	• ineffective as a long-term deterrent	• not practical for polar bears • short-term solution to immediate problem (e.g. bear at campground) • personnel and means for capture must be available	• bear is removed from area at least temporarily	• expensive • time-consuming • bears often return to capture site • fails to address true cause of problem • must have access to road system or helicopter

1) Warning shots

Description - Firing warning shots with a rifle or shotgun is a commonly used method of scaring away bears.

Effectiveness - This method deters some bears but not others.

Practicality - Firing warning shots is a practical deterrent for any situation where a portable, short term deterrance is all that is needed.

Guidelines for use

- The number of warning shots to fire is your decision. Remember that each shot fired means one less shell in the gun.
- Warning shots may become less effective with repetition as the bear gets accustomed to the noise.
- If you fire a warning shot do not aim directly at the bear. Shoot in the air to the side of the animal and remember bullets can ricochet off ice. Shoot to hit only if you must kill the bear. Wounding a bear with a slug or 12-gauge shot is not a good way to scare it off and defeats the purpose of using a deterrent, i.e., to increase the safety of people and prevent the death of problem bears. An injured bear is dangerous to you, and to others who may encounter it later. If you accidentally wound a bear, it is your responsibility to kill it.
- Put another shell in the chamber immediately after firing a warning shot and reload the magazine as soon as possible.
- Before you fire a shot make sure there are no people in a position where they might be hit. This is easy to overlook in a tense situation.

2) Noise-makers

There are several types of noise-makers which produce a loud noise to scare bears (see below).

Effectiveness - As with warning shots, noise-makers frighten some bears, but not others. They may chase a bear away from the immediate area, hopefully long enough or far enough for you to reach safety. However, they are not an effective long-term deterrent, as they tend to lose their effectiveness with repetition.

Practicality - Noise-makers are inexpensive and easy to carry and use in any situation. They should be used when other deterrents are not available (see section on Bird Scaring/Flare Cartridges). However, they should not be relied on for personal protection as they are often ineffective. Have a back-up weapon available.

a) Cracker shells

Description - A cracker shell looks like a shotgun shell and is fired from a 12-gauge shotgun (with a cylinder choke) or .22 pistol. Several types of cracker shells are available, for example: "Bangers" travel 30 m

(100 ft) in the air before exploding with a loud noise; "Screamers" travel 125 m (400 ft) in the air while making a continuous high shrill.

Limitations

- Cracker shells can be effective as an initial deterrent. However, some bears ignore them. They are ineffective if the bear has been attracted to an area by animal carrion.
- They are not always dependable: shells may misfire or fail to explode.
- Their use is limited to open areas.
- An exploding shell could start a fire in dry forest or brush.

Guidelines for use

- Fire the gun at a 45° angle in the air to the side of the bear. Do not fire directly at the bear.
- Place explosive devices between you and the bear. An explosion behind the animal may scare it toward you.
- Do not use a semi-automatic shotgun, it may not eject the shells.
- Use a 12-gauge shotgun with an improved cylinder choke as shells may jam in a gun with a tighter choke (e.g. full or modified).
- Practice shooting the shells before you need them so you are familiar with their range and know where to aim.
- Use explosive devices with care.

Supply - Cracker shells can be purchased from commercial distributors (Appendix D).

b) Thunderflashes

Description - Thunderflashes look like large firecrackers or small road flares. They are lit, like a flare, and thrown by hand. They explode with a loud noise.

Limitations

- They have the same limitations as cracker shells.
- Their range is limited by the strength of your throwing arm, and by wind conditions. Throwing a Thunderflash against a strong wind is difficult.

c) Pencil Flare Guns

Description - Pencil flare guns are portable, pencil-size devices which shoot small flares. The flares produce a noise and a bright flash when they are fired. The range varies depending on the type of flare used.

Limitations

- They have the same limitations as cracker shells.

d) Airhorns

Description - Hand-held airhorns make a loud noise and are commercially available, small, and portable. They may be useful for preventing a surprise encounter by alerting a bear to your presence as you travel. However, like other noise-makers, they are not always an effective deterrent.

Limitations

- Airhorns may provoke aggressive or curious reactions in some bears.
- If a bear is attracted to the noise, remember you are the source of the noise and the bear will come toward you.
- Airhorns are not reliable in cold temperatures.

Noise-makers frighten some bears

3) Bird-Scaring/Flare Cartridge

Description - The bird-scaring/flare cartridge was initially designed to scare birds from airport runways. It is fired from a 38 mm flare pistol fitted with a 12-gauge adaptor or a 12-gauge shotgun with an improved cylinder choke. The projectile leaves a bright yellow trace as it travels, and explodes with a loud noise (110 dB) and bright flash before hitting the ground. The flash illuminates an area approximately 15 m (50 ft) in diameter for 3-5 seconds.

Effectiveness - During field tests this deterrent scared away most polar bears, but some bears ignored it. However, it is more effective than cracker shells and has several additional advantages:

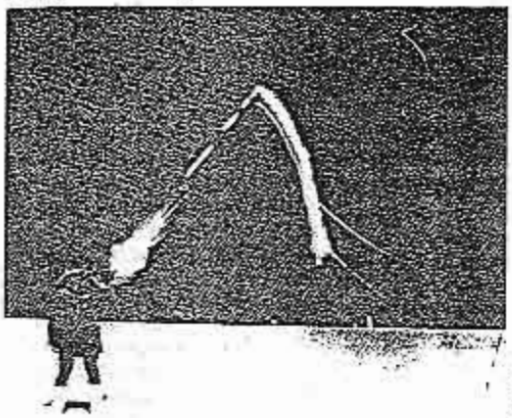
- it is more dependable; during tests the cartridge consistently travelled in a arc of about 120 m (400 ft) and exploded, and
- the flare can be used to reveal a bear's location in the dark.

Practicality - Flare cartridges are inexpensive, portable, and easy to use. They are suitable for anyone working, travelling or living in bear country. They should be available in camps and carried by people in the field.

However, you should have a back-up weapon for personal protection.

Guidelines for use - Guidelines are the same as for cracker shells. Use a 38 mm flare pistol fitted with a 12-gauge adaptor or a 12-gauge shotgun with an improved cylinder choke for firing flare cartridges. A tighter choke (full or modified) may cause the cartridge to jam in the barrel.

Supply - Appendix D lists a distributor of bird-scaring/flare cartridges.



G. STENHOUSE

The bird scaring/flare cartridge explodes with a loud noise and a bright flash.

4) Other Acoustic Deterrents

Description - Past tests have shown that loud recordings of barking dogs do not deter polar bears. Sound waves of varying frequencies have been tested on bears attracted to a bait station and were not effective as a deterrent in all cases.

Effectiveness - Further research is necessary before acoustic deterrents can be recommended. Preliminary results suggest that some sounds may deter polar bears. During field tests in Churchill, Manitoba, most bears were sensitive to sounds in the 0.1 khz to 9 khz frequency range and were effectively deterred at frequencies of 1 to 4 kHz, especially when the sounds were pulsed. Bears appeared agitated and often left the bait station in response to the noise.

R. SCHMENSEURG

Noise-makers frighten some bears but not others.

5) Vehicles as Deterrents

Description - Bears have been chased away with trucks, snowmachines, all-terrain vehicles, and helicopters. Sometimes, starting and revving a engine is enough to frighten away a bear.

Effectiveness - Most bears will run away from a vehicle, though some bears will not leave.

Guidelines for use

- Do not chase a fleeing bear for more than five minutes. It may become overheated and die. This is especially important in warm weather.
- Stay at least 30 m (100 ft) behind the bear. Never over-run it.
- Always carry a firearm with shells in the magazine.
- Do not turn the engine off until you are sure the bear will not return.
- Be careful if you use a helicopter. Chasing a bear with a helicopter for long periods or distances could cause enough stress to harm or even kill the bear. Use this deterrent method if you have no other option but to shoot the bear. Respect your pilot's judgement if he chooses not to go after a bear.
- Do not chase a bear with a vehicle or helicopter for any reason other than personal protection and to deter it from a particular camp or work site.

6) Dogs

Description - The previous chapter discussed the use of dogs for detection. In some circumstances, dogs can also be used to deter bears. Historically, dog teams

were used by Inuit when hunting. As bears were frequently encountered, the dogs became experienced in handling them. However, dogs teams have been replaced to a large extent by snowmachines. Most dogs now are inexperienced and must be specially trained to deal with bears.

Effectiveness - Although there is encouraging evidence that dogs may be effective deterrents if properly trained and handled, their overall performance has not been reliable. In some cases, dogs kept at Inuit outpost camps have chased bears away by barking. In other situations, dogs have been mauled or killed by bears. Residents of outpost camps have had to shoot bears on several occasions, even though dogs were present.

Research is required to determine the best breeds and most appropriate training and handling methods for deterring bears, however, the following breeds appear promising.

- Canadian Eskimo dogs (a special breed used historically by Inuit) have been used in one experimental polar bear deterrent program. The success of the program is difficult to determine because of its design. The dogs were allowed to roam free, and observations of polar bear-dog encounters were incidental. Dogs were seen chasing bears from camp on several occasions, but their overall effectiveness cannot be determined without knowing the total number of bears approaching camp and the total number chased by the dogs. There were no human deaths or injuries during the program, but one bear was shot.
- Karelian bear dogs are used in Finland and northwestern Asia to hunt big game and protect livestock and villages from brown bears. When confronted by a bear, bear dogs attack and attempt to bite the bear from behind. Trained bear dogs are capable of deterring bears or holding bears at bay. In North America Karelian bear dogs have been used to protect back-country homes. Research is currently underway in the U.S.A. to determine the effectiveness of these dogs as a bear deterrent in parks.
- "Guarding dogs", such as Akbash dogs, Komondors, and Anatolian Shepherds, typically used to deter predators from livestock may be useful for the protection of people and their property from black and grizzly bears in northern camps. These dogs can be trained to remain in a specific area and are large, aggressive, and able to withstand cold climates. A guarding dog reacts to the presence of a bear by barking and aggressively approaching it. Though few guarding dog-bear encounters have been observed, they suggest that black bears can be driven away in most circumstances, but grizzly bears are less readily deterred. Two dogs may be required in grizzly bear habitat.

Recognized breeders for the dog breeds discussed in this section are registered with the Canadian Kennel Club.

Handling requirements

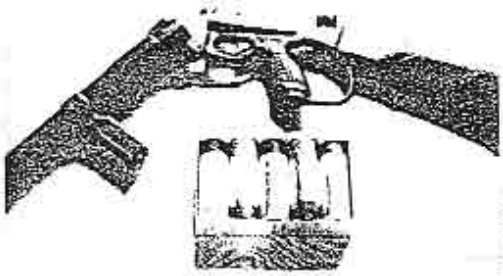
- If dogs are used for deterring bears, it is important that they be trained for that purpose by an experienced trainer. Dogs should be trained in basic obedience and taught at a young age to recognize and respond aggressively to the scent of bears.
- Dogs should not be used as deterrents unless they have proven their ability to chase away bears.
- Dogs used for detection should be chained, but dogs expected to aggressively chase a bear should be loose. However, they should be trained to stay in the camp area. The handler should be responsible for keeping track of the dog and making sure they do not leave the site. Roaming may be more common when using more than one dog. Early training and neutering can help reduce roaming. During periods of low bear activity, the dogs should be kept in a holding pen to prevent them from leaving the site.
- Surveys of the effectiveness of livestock guarding dogs suggest that neither the sex of the dog nor neutering affects its abilities as a guard dog.
- Several dogs working together are required to effectively deter a grizzly or polar bear. A dog working alone is more likely to be injured or killed.
- Refer to Chapter 6 for further guidelines on feeding and handling.

Limitations

- Dogs can be used to chase away bears already in the camp area. To date, there is little evidence that they keep bears away. Some bears may not be deterred by even the best dogs.
- During periods of low bear activity, dogs may leave the site if not penned. Roaming dogs present a hazard to local wildlife.
- Fighting between dogs can be expected when they are running loose. This could result in decreased performance.
- Dogs should not be used to the exclusion of other deterrent methods.

7) Rubber Bullet Gun

Description - The rubber bullet (or baton) is fired from a special 38 mm single shot rifle, originally designed to aid in riot control. The bullet is a hard rubber cylinder (101 x 37 mm (4 x 1.5 in), 135 g) and is sealed in a waterproof aluminum cartridge. It has an effective range of 30-50 m (100-160 ft). Refer to Appendix J for a full description of the rubber bullet and gun.



C. STEPHENSON

The rubber bullet, fired from a special gun, is an effective deterrent available to wildlife enforcement officers and RCMP.

Effectiveness - The rubber bullet is one of the most effective deterrents tested to date. It has been field-tested on more than 400 polar bears feeding at a bait station. All but one bear struck with the bullet were driven from the bait. (Deterrent attempts on this bear were discontinued because of the bear's poor health.) One bear was killed when stuck with the rubber bullet. None of the bears reacted aggressively toward the person firing the gun. The majority left immediately after a single hit.

Bears that required more than one hit typically flinched, took several steps away from the bait site and then moved back while keeping an eye on the person that fired the deterrent.

Some bears later returned to the bait station after being driven away with a rubber bullet. However, they appeared more cautious than animals which had never been struck, and took a longer time to approach the bait. This was the case even a year after a bear's initial experience with a deterrent.

Some bears have shown behavioral changes after being struck by a rubber bullet (e.g. running at the sight of an Officer with a rubber bullet gun). In one field situation, a charging polar bear was deterred when hit in the chest with a rubber bullet.

Rubber bullets have also been used to deter a black bear from a fishing lodge, and grizzly bears from industrial sites and garbage dumps. Field tests on black and grizzly bears are continuing.

Practicality - Although the rubber bullet has good potential as a reliable, effective deterrent, it has several limitations and is not practical or effective in all situations. In Canada its use is restricted to Renewable Resource, Conservation or Wildlife Officers and R.C.M.P. To date, officers have successfully used rubber bullet guns to deter bears in a number of field situations. If time and circumstances permit, you can contact an officer to deal with a problem bear. If not, you will have to rely on other deterrents.

Limitations

- Intensive training is necessary to use the gun effectively.
- The gun and bullets are large and may be awkward to carry while travelling.
- The gun and bullets are expensive.
- Rubber bullet guns are restricted weapons in Canada and the U.S.A. In Canada their use is restricted to Renewable Resource personnel and R.C.M.P.

M. GATTI

Training and practice are required to develop accuracy with the rubber bullet gun.

Guidelines for use - The rubber bullet gun is different from a conventional firearm (Appendix J). Considerable training and practice are required to become familiar with the gun's range, kick and noise, and to develop accuracy with the gun (Appendix J). Keep in mind that the rubber bullet gun is a lethal weapon. However, when used properly and accurately, the rubber bullet is

B28

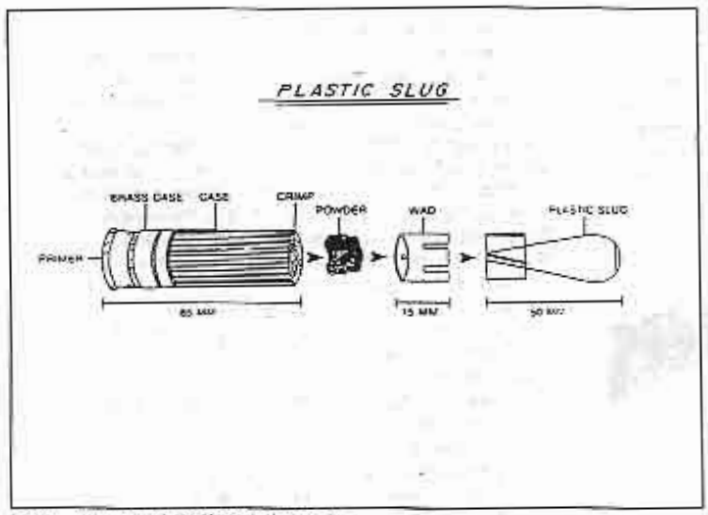


Fig. 14 Components of the 12-gauge plastic slug.

unlikely to injure a bear. The gun should be handled with care and not provided to people who are not authorized or trained to use it.

Maintenance - Clean a rubber bullet gun more frequently than other firearms (Chap. 8). Rubber tends to build up in the barrel and must be cleaned out regularly with a wire brush. Use a standard gun cleaning kit along with a 38 mm wire brush available from the distributor of the gun.

Supply - Appendix D lists the distributor of the gun and rubber bullets.

8) 12-Gauge Plastic Slugs

Description - Plastic slugs (Fig. 14) are fired from a short barrelled, 12-gauge shotgun or one with an improved cylinder choke - for best accuracy and reliability. Stabilizing fins on the projectile cause it to spin when shot, further enhancing accuracy. The slugs deliver a painful blow to the bear.

Effectiveness - Plastic slugs have been tested as a deterrent since 1982. At that time, slugs were unsuccessful in chasing feeding bears away from a bait site. In 1985, a plastic slug was developed that effectively deterred bears. There have been a few reports of a plastic slug piercing the hide of a bear. This may be caused by slugs used at a distance closer than recommended (see Limitations below). No bears were injured during the 1985 field-testing season.

Practicality - Plastic slugs are suitable for dealing with most bear problems. Plastic slugs have several advantages which make them more practical than 38 mm rubber bullets.

- Their use is not restricted.
- They are more accurate.
- They can be fired from a 12-gauge shotgun.
- No special training is required; many people are familiar with a 12-gauge shotgun.
- The plastic shells are portable and inexpensive.

Guidelines for use

- Place rifle sites on the shotgun to increase shooting accuracy.
- Use the plastic slug when the bear is 30-60 m (100-200 ft) away.
- Target the large rear muscle mass (rump-hip) when deterring a bear with a plastic slug. The head, neck and front shoulders should be avoided to minimize the risk of hitting and damaging the eye.
- Some bears require more than one shot before they are deterred.
- A back-up person with a loaded 12-gauge shotgun should be present during any deterrent attempt. If a back-up person is not available, it is possible to be your own back-up by placing lead slugs in the magazine and manually loading plastic slugs as they are required (Refer to The Three Slug System at the end of this chapter).

Limitations

- The plastic slug can not be used beyond the recommended range of 30-60 m (100-200 ft). Accuracy and effectiveness of the slug is diminished at distances over 60 m (200 ft), and there is a possibility of injuring the bear at distances less than 30 m (100 ft).

Supply - Appendix D lists a supplier for plastic slugs.

9) Capsicin Spray Repellents

Description - Several chemical sprays have been designed to deter bears, for example Counter Assault and Standoff. The sprays contain capsicin, a natural component of cayenne pepper. During use, the spray is directed at the face of the bear from a distance of less than 6 - 8 m (20-25 ft). Capsicin is a strong irritant of the eyes and nose, and is a bronchial constrictor. The effects of the spray last 5 to 15 minutes. Several of the repellents have been tested on captive and free-ranging black and grizzly bears. Studies are required to test the spray's effectiveness as a repellent of polar bears. These sprays have not been tested by the Department of Renewable Resources. Appendix N describes several human-bear encounters in which capsicin sprays were used.

Effectiveness - Most black and grizzly bears are immediately repelled when directly sprayed in the face with a spray containing capsicin, though test results indicate that highly motivated (such as a starving bear) or aggressive bears are less easily repelled. A few bears appear totally unaffected by the spray. Capsicin spray is not suitable for all situations, for example, wind substantially reduces the effective range.

Practicality - Capsicin sprays have been designed as a last resort deterrent. Do not depend on them for personal protection or as your only means of bear deterrence. They may be used in areas where firearms are prohibited, such as National parks, or by people who do not carry firearms. Capsicin sprays may serve as a backup system for hikers, researchers, etc., when one member of a team is carrying a firearm.

Advantages

- Bears have not reacted aggressively toward persons deterring them with capsicin spray.
- Canisters containing capsicin spray are carried easily.
- It is a non-firearm deterrent and can be carried in areas where firearms are prohibited.

Guidelines for use

- Briefly test each canister (i.e. release a few short bursts) prior to it's intended use to ensure that the propellent's delivery system is functional and to familiarize yourself with the product.

If faced with a bear:

- If possible, spray the bear when it is downwind from you.
- Direct the spray at the face of the bear from a maximum distance of 6 (Standoff) to 8 (Counter Assault) m (20-25 ft).
- Release the spray in short bursts.
- Continue spraying the bear until it has been deterred.
- If the spray contacts a person's skin, nose or eyes, repeatedly flush the affected area with cold water. Medical attention may be required if the spray is inhaled; administer oxygen.
- Discard unused canisters after three years.
- Extreme caution must be used when transporting capsicin sprays in small aircraft. Accidental release of spray during a flight could incapacitate the pilot. Package cans of capsicin spray well and place in the cargo hold. Do not keep cans on your person during a flight. Respect the right of pilots to refuse to carry canisters of capsicin spray.

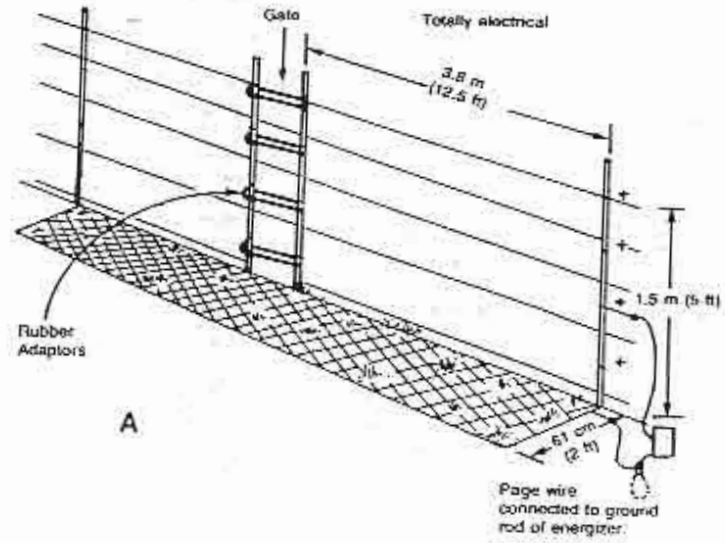
Limitations

- Capsicin spray is most effective at short range and therefore does not have broad application.
- Capsicin spray must be sprayed in the eyes of a bear to be effective.
- The propellent is not dependable in cold arctic weather and the effective range is greatly reduced at temperatures below 0°C (32°F).
- Capsicin spray is not recommended for use by people with respiratory problems or wearing contact lenses.

Supply - Appendix D lists distributors for sprays containing capsicin.

10) Electric Fences

Description - Several types of electric fences (Fig. 15) have been used to deter black and grizzly bears, including: 1) a portable, totally electrical fence of at least four strands of wire for black bears, and 2) various designs combining electric wires and a sturdy welded wire or chain link fence to keep out black and grizzly bears (Appendix K).



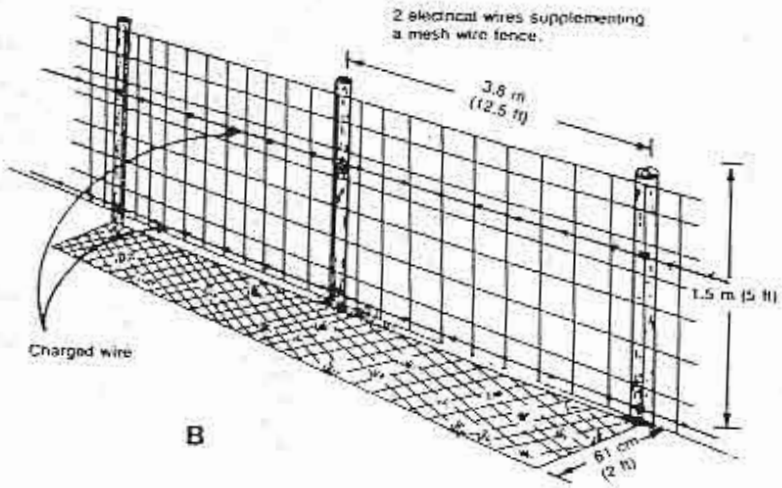
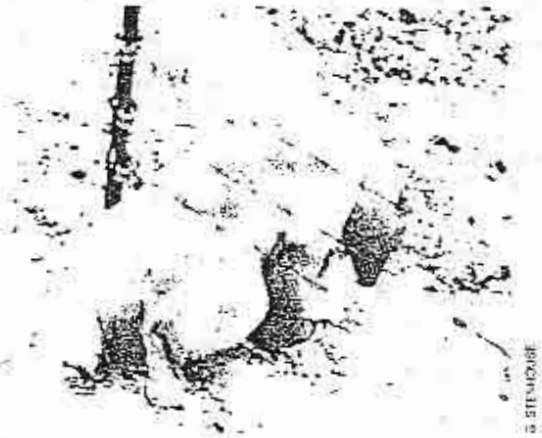


Figure 15. Electric fences used for black and grizzly bears.

Several electric fence designs have been used to deter polar bears: 1) a simple two strand, high voltage fence for use only in moist or wet areas, and 2) an electric fence with a charged chain-link skirt on the ground outside the fence for use on dry or frozen ground.

High voltage, low amperage fences are most effective to deter bears. An alternative design uses higher amperage with a short pulse width (Appendix K).



Further research is needed to develop an electric fence effective against polar bears on dry, frozen soil.

Effectiveness - Electric fences have been used effectively to keep black and grizzly bears out of bee yards, garbage dumps, and construction camps. Grizzly bears are more difficult to deter than black bears. Fences intended to deter grizzlies must be stronger, higher, and have a greater charge than fences for black bears.

Simple electric fence designs tested by the Department of Renewable Resources in arctic field conditions (frozen ground and/or snow) have not successfully stopped polar bears. Most bears did not receive a shock from the fence because of: 1) insulation provided by their fur and footpads, and 2) poor grounding conditions associated with snow or dry, frozen soil. Bears that received a shock were initially deterred, but apparently learned how to climb through the fence without getting shocked.

Electric fences have prevented entry by polar bears in some situations. A biology field station in Hudson Bay has used a fence which deterred all visiting polar bears. The bears received a strong shock as the fence was used in wet areas, where grounding conditions were good. Polar bears have been successfully kept out of a research camp on a dry beach near Churchill by using an electric fence that incorporated a ground mat connected to the ground pole of the fencer unit.

Extremely high charges might deter polar bears, but are not practical because of danger to people. There is a chance a person might be severely injured or killed by contacting a powerful fence.

Electric fences have recently been designed that incorporate charge and ground wires in a 2.5 cm (1 in) wide vinyl/fibreglass webbing (Appendix D). The webbing holds the charge and ground wires close together without allowing them to touch. When a bear touches the webbing, it will contact both the charge and ground wires and should receive a shock. Lightly scenting the webbing may encourage the bear to smell or lick the webbing, further ensuring that it receives a shock. This webbing has not been tested by the Department of Renewable Resources.

Practicality - Electric fences constructed of electric wire, chain link fence and a support system are only practical for sites which are permanent enough to justify the effort and expense required to construct the fence.

Fences of only electric wire are portable and suitable for more temporary camps, but are effective only for black bears (Appendix K).

Where polar bears are a problem the use of electric fences is most effective in wet areas where grounding is good.

Installation and use - There are several requirements for an electric fence designed to deter bears. Fence specifications are described in detail in Appendix K.

- A fence must be well-grounded to ensure that the bear receives a shock. One good solution is to suspend charged (+) wires 25 cm (10 in) out from a chain link fence and to ground (-) the chain link. A bear trying to go over or through the fence will have to touch both the charged wires and grounded fence and should receive a shock. Electric fence webbing (described above in "Effectiveness") may be suitable for use with portable fences.

B 32

- Bears (especially grizzlies) may dig under a fence if the chain link is not buried up to a metre (3 ft) deep.
- The fence must be properly charged. Voltage, amperage, and pulse width are important. Commercially available AC or DC chargers should be used.
- Human safety must be ensured. The chain link-charged wire design reduces the chance of a person being shocked. A person will not receive a shock from the chain link if the charged wire (25 cm (10 in) away) is not touched at the same time. A person will receive an unpleasant but harmless shock by touching the wire alone. Signs should be posted to indicate a fence is charged.
- The gate is an unavoidable weak point in the fence. At large camps with a chain link/electric wire fence, the gate should be operated by an attendant responsible for:
  - maintaining the fence and gates,
  - opening and closing the gate to allow passage of traffic, and
  - making sure the gate is closed when a bear is sighted and that the appropriate person is informed of the bear sighting.

Maintenance - Regular maintenance of a fence is essential. Bears may continue to test a fence if there is an attractant on the other side. A fence that is not working properly or receiving enough power will not deter a bear. One person should be responsible for doing daily checks of the fence to make sure it is properly charged. If batteries are used, they must be checked frequently and recharged or replaced as necessary (at least once every two weeks). Protect batteries from sunlight and rain. Keep vegetation from touching the fence to prevent a short-circuit of the fence. If the fence is used to surround a dump, garbage and other debris that is blown into the fence must be removed. Shock intensity is greatest when the ground is damp. The area immediately surrounding the fence can be watered and salted during dry periods to ensure that the ground retains moisture.

11) Barriers

Description - Extremely strong and high, non-electric fencing has been used to prevent polar bears from entering a permanent research camp located near Churchill, Manitoba. This fence uses 6-8 gauge wire mesh supported on poles which extend 2.5 m (8 ft) above the ground. The wire mesh is topped with barbed wire strands for another 30 cm (1 ft) making the fence just under 3 m (10 ft) high.

Effectiveness - Non-electric fencing has been successfully used to keep polar bears out of an enclosure located on flat terrain during spring and summer. Bears are not able to break through or crawl over fence. Non-electric fence may not be practical for use during winter in areas that receive heavy snow-falls. Bears would be able to walk over the fence if snowdrifts formed. Black or grizzly bears have been know to climb over barrier fences.

Practicality - Barriers are only practical for sites which are permanent enough to justify the effort and expense required to construct them. It may be impractical or impossible to build bear-proof barriers around all facilities.

Installation and use of fence - General guidelines are suggested below.

- To reduce the attractiveness of the area that is fenced to polar bears:
  - fence should encompass sleeping and eating quarters but not latrine facilities, and
  - compound must be free of garbage or other attractants.
- Posts should be sunk and cemented in place.
- Corner posts should be reinforced with diagonal support posts.
- To prevent the gate from being the weak point of the fence:
  - gates should close from the outside,
  - gates should be "stopped" against posts, i.e., the gate should not fit into a frame but should close against posts, and
  - gates must be made with the same strength of materials as the rest of the fence.

Maintenance of fence - These fences require low maintenance if treated poles and galvanized wire is used. Someone should be responsible for doing daily checks of the fence to ensure that it is secure.

12) Bear Monitors

Description - Bear monitors are trained persons (often local hunters) that are experienced with bears and hired to watch for and deter bears. They are especially useful at large, established camps in polar bear habitat.

Effectiveness - Use of bear monitors can, potentially, be a highly effective method for both detecting and deterring bears.

Bear Monitor Program

The following measures are recommended to maximize the effectiveness of a Bear Monitor Program.

Training

Bear monitors, and if possible their supervisors, should attend a training program to learn about detection and deterrent equipment, and safety precautions for camps. Principles of bear behaviour and the use of firearms should be taught to person with little experience in those areas. When available, local hunters who are experienced in dealing with bears should be asked to assist in the training program.

Hiring Standards

Standard procedures and requirements for hiring should be established and followed by all employees. Trained monitors should be hired when possible, particularly for positions in large camps.

Provision of Equipment

Employers should: provide deterrent equipment for monitors who have been trained to use the equipment; and ensure that monitors have adequate and well-maintained firearms.

Definition of Responsibility

The responsibilities of bear monitors should be clearly defined, and explained at the time of hiring. The primary responsibility of monitors is to ensure the safety of personnel and protection of property. Another major responsibility is to ensure that bears are not abused or killed unnecessarily. Monitors should attempt to deter bears whenever possible; shooting a bear should be a last resort.

Procedural guidelines for monitoring should be established by the employer and understood by the monitor.

Monitors and their supervisors should agree on a working relationship which defines authority and facilitates communication and decision-making.

N.W.T. RENEWABLE RESOURCES

Use of bear monitors can be an effective method for both detecting and deterring bears.

Site Operation Plans

Site-specific operation plans (Chap. 5 and Appendix M) should include guidelines to direct the responses of monitors and their supervisors when a bear is sighted.

Plans are based on the characteristics of each site (e.g. size, terrain, location, work situation), and should:

- establish systems of communication and decision-making between monitors, their supervisors, and other camp personnel,
- establish patrol areas for bear monitors, within the camp and in more remote areas,
- identify "risk areas" where bears could approach or hide unnoticed, and
- recommend when to use deterrent options or when to shoot a bear, in relation to a map of the site.

Responsibilities and Duties of Bear Monitors

The following suggestions are given to assist development of procedural guidelines for monitoring.

- Monitors should remain aware of their surroundings, the locations of workers and the presence of bears at all times.
- Monitors should ensure that their equipment (e.g. snowmachine, firearms) is in good working order.

B34

- The area defined by the site plan should be frequently patrolled (e.g. every two hours) by snowmachine. Monitors should look for bears and tracks, or other signs of bears. If a bear has been recently detected and/or deterred, the area should be patrolled more often.
- Monitors should always carry deterrent equipment and a firearm.
- "Risk areas" identified in the site operation plan and situations where workers are vulnerable to bear attack (e.g. working away from camp, loading or unloading aircraft, trucks, or barges, especially during darkness or storms) should be closely monitored.
- Any fresh sign of bears (e.g. fresh tracks or droppings) should be reported to the site superintendent so workers can be informed and kept away from the area, if necessary.

If a bear is sighted, monitors should follow a protocol similar to that listed below.

- Report the sighting to the rig supervisor if time and circumstances permit (i.e. if workers are not in immediate danger). The superintendent will assess the situation and determine what action, if any, is necessary.
- If there is a threat to personnel, act immediately to remove it:
  - direct workers to move to a safe area,
  - attempt to chase the bear away with an appropriate deterrent,
  - destroy the bear if it endangers people, and
  - notify the rig supervisor immediately.
- Notify the local Renewable Resource Officer if assistance is required or to report the injury or killing of a bear.
- Record the incident in the site operations plan and, if appropriate, fill out an Occurrence Record/ Nuisance Bear Report (Appendix E). Include the type of deterrent that was used, or provide the requested information to the Renewable Resource Officer.

Relocation

Description - Relocation has been a common method of dealing with problem bears. It is a management tool used by wildlife personnel, but it attempts to achieve the same end as a deterrent device - i.e. removal of a problem bear.

Relocation involves capturing the bear with a leghold snare or culvert trap, or by darting it from a helicopter, immobilizing it if necessary, and transporting it by road or air to an area away from people (Chap. 9 and 10). Ideally, the bear will stay in the new area and cease to be a problem.

Effectiveness- Relocation does not usually work. It is difficult for a bear to establish itself in unfamiliar country. Relocation of problem bears into areas occupied by other bears generally results in displacement of either the relocated bear or the resident bear. The young of female grizzly bears that have been relocated die at a higher-than-normal rate. In many cases, relocated bears return to their original home. Black and grizzly bears are known for their ability to "home" from the area of relocation, sometimes travelling over 100 km (60 mi).

Bears are more likely to remain in the relocation area if transported at a time of the year that they are normally less active, e.g. for grizzly bears the fall rather than spring.

Polar bears present a unique problem. Because of the expense involved in working in the vast and roadless areas of the far north, it is nearly impossible to relocate a polar bear far enough to prevent its return. Polar bears are very mobile and regularly cover great distances in search of food. They often travel 300-350 km (180-210 mi) in a week, and they have been known to go as far as 500 km (300 mi) in five days.

Relocation is often ineffective because the bear returns to its original home, sometimes travelling long distances.

Limitations - Relocation is expensive and time-consuming, especially in the north where helicopters are used because of the limited road access. The greater the relocation distance, the less likely it is that the bear will return. If relocation is necessary it is recommended that black and grizzly bears be relocated

at least 80-160 km (50-100 mi). Polar bears should be moved over 500 km (300 mi), or less if they are relocated during a time that they would normally be migrating out of an area. In areas with few roads, a move of such distance is a big project. Relocation must be evaluated on a case by case basis, taking into consideration the sex and past history of the bear involved, and characteristics of the release area (habitat similarity, food availability, presence of resident bears).

Relocation fails to address the cause of problem bears, that is, the bear's association of a reward rather than an unpleasant experience with human contact. Once a bear has learned to associate food with a human area, it may continue to be a problem in its new location. Relocation is usually only a temporary solution, and it often passes the problem to someone else.

The Three-Slug System

Often the best deterrent or protection system is a combination of deterrent devices. An example of this is the "three-slug system". By using a combination of cracker shells, plastic slugs, and lead slugs in a short-barrelled 12-gauge shotgun it is possible to scare a bear from a site and still be prepared to destroy it, if necessary. The cracker shell should be used as a bear is approaching the site, from a distance of 150-200 m (500-650 ft) (Chap. 7). A bear that is not deterred by a cracker shell, or that has returned subsequent to a deterrent attempt should be hit with a plastic slug when it is 30-60 m (100-200 ft) away. When a bear can not be deterred or the situation is not appropriate for a deterrent attempt, you should use a lead slug at close range (0-30 m (0-100 ft)) to destroy the bear.

B 36.

APPENDIX D

COLD WEATHER SAFETY
&
COLD WATER SURVIVAL

1. Cold Weather Safety

Working in cold weather could be dangerous to the untrained, and to people without adequate winter clothing. For a well informed and prepared worker, winter work can be enjoyable and fulfilling. To cope with winter, stay active, dress warmly and follow safety rules.

Why Worry About Cold?

- A cold environment takes away body heat.
- Too much heat loss can cause lowering of the inner body temperature to dangerously low levels causing hypothermia.
- Exposed body parts may freeze in extreme cold, causing frostbite.
- Loss of body heat (hypothermia) and frostbite (freezing of body tissue) can present serious danger to your health and can be life threatening.
- Cold air is dry air and can cause dry skin and loss of body fluid.
- If you have arthritis or rheumatism, cold weather can create more pain problems for you.
- Prolonged exposure to moderate cold and dampness can result in other types of injuries.
- Working in cold environments increases the risk of back injuries and other musculoskeletal injuries. Perform "warm up" stretching exercises before handling heavy equipment and material.

Why Worry About Working in Cold?

- Cold affects dexterity, affecting skill and ease of using the hands, and also mental skills and coordination.
- You must wear winter clothing, head protection, gloves and boots while working in the the cold, all of which restrict movement.
- The mobility of fingers slows down, which affects task performance;

CCOHS. (1997). Cold Weather Workers Safety Guide. 2nd ed. CCOHS: Hamilton.

D2

- Cold affects grip force, and the skin's ability to sense temperature and pain.
- Cold exposure reduces muscle power and time to exhaustion. Don't overexert.
- Special care is needed while using ladders or working on elevated platforms.
- Power tools and equipment need special care to be operational in a cold environment.
- Cold tool handles reduce grip force.
- Cold exposure aggravates vibration—induced white finger disease (Hand Arm Vibration Syndrome) making manual work painful.
- Blizzards can produce extremely cold conditions and endanger lives within minutes, seak shelter immediately.

2. How Cold Is It Out There?

Air temperature is not the only measure of cold. Wind makes it colder. Brisk winds and cold temperatures combine to make it dangerously cold.

Exposed human flesh freezes within one minute at -29°C (-20°F) when wind speed is 8 km/h (5 mph). When the wind speed increases to 32 km/h (20 mph) human flesh will freeze at -12°C (+10°F). *(See wind chill chart on following page).*

The danger warnings in the wind chill chart are applicable if your clothes and skin are dry. When you are wet, cold injury can result at much higher (less cold) temperatures.

High wind speed doesn't only occur when it's *windy*. Driving in an open vehicle will mechanically generate brisk air movement similar to high wind speeds.

Wind Chill Chart

Wind Velocity km/h	mph	Ambient Temperature (°C) 4	-1	-7	-12	-18	-23	-29	-34	-40
		Equivalent Chill Temperature (°C)								
Calm										
0	0	4	-1	-7	-12	-18	-23	-29	-34	-40
8	5	3	-3	-9	-14	-21	-26	-32	-38	-44
16	10	-2	-9	-16	-23	-30	-35	-43	-50	-57
24	15	-6	-13	-20	-28	-36	-43	-50	-58	-65
32	20	-8	-16	-23	-32	-39	-47	-56	-63	-71
40	25	-9	-18	-26	-34	-42	-51	-59	-67	-76
48	30	-16	-19	-22	-36	-44	-50	-62	-70	-78
56	35	-11	-20	-29	-37	-46	-55	-63	-72	-81
64	40	-12	-21	-29	-38	-47	-56	-65	-73	-82
		Little danger in less than one hour exposure of dry skin			DANGER—Exposed flesh freezes within one minute			GREAT ANGER Flesh may Freeze within 30 seconds		

Source: Threshold Limit Values (TLV™) and Biological Exposure Indices (BEI™) booklet; published by ACGIH, Cincinnati, Ohio

Temperature Conversion Chart

(See Wind Chill Chart)

COLD

°C	5	4	3	2	1	0	-1	-2	-3	-4	-5	-6	-7	-8	-9	-10
°F	41	39	37	36	34	32	30	28	27	25	23	21	19	18	16	14

VERY COLD

°C	-11	-12	-13	-14	-15	-16	-17	-18	-19	-20	-21	-22	-23	-24	-25	-26
°F	12	10	9	7	5	3	1 4	0	-2	-4	-6	-8	-9	-11	-13	-15

DANGEROUSLY COLD

°C	-27	-28	-29	-30	-31	-32	-33	-34	-35	-36	-37	-38	-39	-40
°F	-17	-18	-20	-22	-24	-26	-27	-29	-31	-33	-35	-36	-38	-40

The Saskatchewan Department of Labour has produced the following useful guide to help guess the wind speed.

- 8 kilometres per hour (5 mph)—moves a light flag;
- 16 kph (10 mph)—fully extends a light flag;
- 24 kph (15 mph)—raises a newspaper sheet;
- 32 kph (20 mph)—blowing and drifting snow.

3. Dress Warmly—Be Prepared

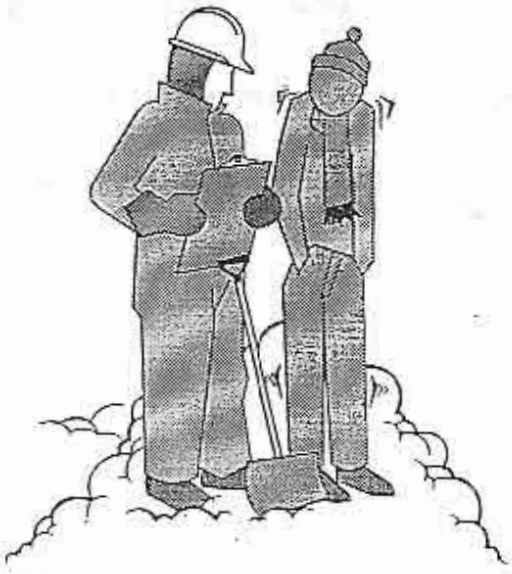
DO

WEAR cotton or polypropylene long underwear for all-over warmth.

WEAR multiple layers of light, loose-fitting clothes. Air between the layers provides warmth. Outer wear should be waterproof.

WEAR cold weather clothing or arctic clothing that is appropriate for the outdoor temperature range and the type of activity.

WEAR mittens instead of gloves whenever possible, as mittens are warmer.



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WEAR a warm hat with ear protection to prevent heat loss from the head. A wool knit cap provides the best protection. As much as 40% of body heat can be lost from an uncovered head.

USE an appropriate hard hat liner to reduce heat loss when wearing a hard hat.

WEAR woolen socks to protect your ankles and feet, CARRY an extra pair where moisture or sweat is likely, CHANGE when needed.

WEAR slip-resistant, insulated safety footwear. For heavy work, a felt-lined rubber-bottomed, leather-topped boot with a removable felt insole is preferred.

KEEP an extra pair of safety shoes for inside work.

PROTECT your vision from UV rays by wearing appropriate sunglasses while working in snow and ice on a bright day.

KEEP snow and water out of your footwear.

USE suspenders. Tight belts can constrict blood circulation.

WEAR a scarf or face mask while working in cold wind.

DO NOT

DO NOT WEAR dirty and oily clothing. Such clothing looses much of its insulation value.

DO NOT WEAR gloves, or scarves that can get caught in moving parts of the machinery.

4. Maintenance of Cold Weather Clothing

DO

CARRY your cold weather protective clothing with you at all times.

FLUFF waterfowl down garments when removing them from the duffle bag.

KEEP garments dry; brush off snow and frost before entering warm buildings or vehicles.

FOLLOW manufacturers guidelines for cleaning clothing. Incorrect cleaning and washing methods may cause harm to insulation, fur and leather parts.

DO NOT

DO NOT KEEP cold weather clothing stored or compressed in a duffle bag for long periods of time.

DO NOT STORE damp clothing in a duffle bag. Hang it on a hanger for drying.

DO NOT LEAVE rips or tears unmended. Temporary repairs can be made with electrical or duct tape.

Avoid Sweating

Normally we dress to remain warm while inactive. When we start working, we start sweating and sweat dampened clothes lose their insulation value. The following sequence is suggested when removing clothing to avoid sweating:

- Remove gloves/mittens, unless protection from snow and ice is needed.
- Remove headgear and neck wrapping.
- Open jackets at the waist and sleeves.
- Remove outer layers of clothing.

Replace clothing in the reverse sequence as soon as work is done. Do not wait until you start feeling cold. Rewarming will take time.

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Examples of Cold Weather Clothing

Clothing	Type
Long underwear	Wool or polypropylene; cotton in dry conditions
Pants	Wool; cotton in dry conditions
Shirts,Sweaters, Turtlenecks	Wool, fleece or synthetic substitutes
Headgear	Woolen, polyester or polyvinyl caps, scarves, face masks
Gloves	Loose fitting with wool liners, gloves inside heavy mittens for extremely cold conditions
Socks	Two pairs—light or medium inner; and heavy wool outer socks
Parka	Loose fitting filled with down or insulating fiber-fill; attached hood; outer layer of waterproof material

5. Working Safely on Snow and Ice—Learn to Cope

Winter work involves a lot of shovelling, lifting, scraping, pushing and pulling. It pays to learn to do these jobs safely without hurting your back.

Slips and Falls

DO

TAKE small steps to improve traction.

WALK slowly on slippery, icy surfaces to prevent danger of slipping. Stop occasionally to break the momentum.

USE approved snow removal compounds.

AVOID sand around entrances where it can be tracked inside and require additional cleaning and possibly cause a slip or fall.

USE mats at entrances to prevent slippery conditions indoors caused by melting snow or ice.

USE correct ladder techniques while removing snow from roofs. Watch out for slippery rungs.

STAY out of the way where icicles may drop on you like spears.

PROTECT others from falling icicles by erecting a barrier.

Safe Shovelling

Shovelling requires intense physical effort. You can burn up to 600 calories an hour shovelling snow. By shovelling the wrong way, you may end up with an aching back, or worse. The following precautions make snow shovelling easy and safe.

DO

CLEAR snow as soon as possible. Fresh snow is lighter than wet or packed snow.

USE the right shovels for the job; pushers for pushing and throwers for throwing.

WATCH for small obstacles while shovelling.

KEEP ice chippers in good condition.

PUSH to the sides rather than lifting and throwing.

STEP forward when you load your shovel.*

BEND your knees and keep your back straight to prevent pressure on your lower back. *

TAKE a break when you feel tired.

USE ergonomically designed shovels.

D 10

DO NOT DO NOT OVERLOAD your shovel.

DO NOT OVEREXERT yourself. Shovelling can raise your heart rate and blood pressure to a dangerous point very quickly.

DO NOT TWIST your spine when you toss the snow. Toss the snow directly in front of you.

* *See pages 52 and 53 on Shovelling and Digging*

Working With Large Equipment

DO LEARN how to use snow removal equipment effectively and safely.

MAKE sure your equipment is in good running condition.

FOLLOW electrical safety rules for electrically powered snow removal equipment.

PERFORM a circle check before operating a vehicle.

PAY particular attention to windshield wipers and windshield cleaning fluid.

Snow Blowers

Snow blowers come in different sizes and models, for different types of work—power brooms for small jobs and riding types for bigger jobs.

DO ALWAYS PUSH, never pull a snow blower, unless specifically designed to be pulled.

STOP THE ENGINE and DISCONNECT THE SPARK PLUG before clearing a clogged snow blower.

CARRY fuel in approved safety containers only.

CHECK and MAINTAIN built-in safety features of the snow blower frequently.

CARRY safety gear such as cones, flares, candles, etc, in case you break down.

DO NOT DO NOT REFUEL while the engine is still running or hot from use.

DO NOT OVERLOAD a power broom.

DO NOT LEAVE a snow blower running while taking a rest break.

DO NOT SCRAPE snow right down to the ground. Adjust the height of the snow blower one inch above the surface to prevent picking up and shooting dangerous missiles.

Winter Driving Techniques

DO CHECK traction regularly. Slow down or stop driving if conditions deteriorate.

BE PREPARED TO STOP. Manoeuvering may be difficult.

KEEP a safe following distance to allow you to brake on icy and slushy roads.

KEEP your windshield windows and mirrors clear and clean. Glare from snow and ice can blind you.

WATCH for pedestrians. People "bundled up" in parkas tend to have very poor side vision. Use warning signals and signs.

PERFORM routine "circle checks" before operating any vehicle. (See page 56)

BE AWARE that ice forms quicker on bridges and over passes as well as shaded areas and traffic intersections. Slow down and be prepared for problems.

LEARN winter driving skills from experts. Ask your local automobile association for information.

D 12

6. Ice Safety on Frozen Bodies of Water

Ice Testing—Do Not Walk on Thin Ice

Ice thickness must be tested before any workers, or vehicles, are allowed on the surface.

DO WEAR an approved life jacket or, preferably, an approved flotation suit when testing ice thickness.

STAY approximately 10 m (33 ft.) apart. The lead member must wear a safety harness attached to a 1 cm (3/8 in.) thick, and about 20 m (65 ft.) long polypropylene rescue rope held by trailing crew members.

TEST ice regularly for repeated work or travel over ice, to ensure continued safety.

Safe Ice Thickness

Clear blue ice is the strongest. White opaque ice is the least dense, weaker than clear blue ice. Grey ice indicates the presence of water from thawing and is unsafe as a load bearing surface.

Ice thickness is determined by the full thickness of clear blue ice, plus half the thickness of white continuously frozen ice.

Test holes should be cut according to procedures required by your employer. If the ice thickness is less than 15 cm (6 in.) test crew members should vacate the area immediately.

Load bearing capability of ice depends on its thickness. Charts are available showing thickness versus allowable load.

Safe Work Practices

DO PREVENT hypothermia by ensuring there is a warm place such as a truck cab or hut available.

FOLLOW procedures and practices recommended by your employer.

USE personal protective equipment and rescue equipment as required by your employer.

EAT high energy food such as nuts and raisins.

AVOID alcohol, tobacco and cafeine based drinks.

7. Vital Signs of Cold Injury—How Can You Help?

Frostbite and hypothermia are the two major health hazards resulting from cold exposure.

Frostbite

Frostbite is the actual formation of ice crystals (freezing) in exposed body parts. Pain in the extremities may be the first sign of danger. Ice forms in the tissue and destroys it. Frostbite usually affects the nose, fingers, or toes. The affected part becomes pale and numb.

Frostbite occurs when:

- extremities such as hands, feet, ears, nose, etc., are exposed (either unprotected or with improper protection) to cold for an extended period of time;
- touching a very cold metal such as car door handles, metal fences, etc.;
- blood supply to extremities is obstructed by tight clothing or tightly laced boots;
- contact occurs with gasoline or cleaning fluids left outdoors. These liquids do not freeze even when the temperature falls far below the freezing point and can cause *instant* frostbite.

If you suspect frostbite do the following:

DO

MOVE to a warm place. Apply warmth (not massage) to the affected parts.

BLOW on affected fingers. If your nose is frostbitten, apply your warm hands. If your hands are affected, put them in lukewarm (approx. 37°C) (not hot) water.

REMOVE tight clothes and jewelry. Use body warmth to warm the affected parts.

WRAP the frostbitten area in soft material and elevate the affected area. Frostbite is serious if the skin starts to harden and turn blotchy or blue.

OBTAIN medical help as soon as possible.

TAKE PRECAUTION against bacterial infection. Frostbitten skin is highly susceptible to bacterial infection. Loosely cover the affected area with sterile dressing.

DO NOT

DO NOT RUB the frostbitten area.

DO NOT PULL your hand away if you should accidentally become attached to cold metal. Pour warm water or any other fluid (even urine) to separate yourself.

DO NOT BREAK blisters that form as a result of frostbite.

DO NOT THAW frostbitten area unless you are sure it will not refreeze.

Hypothermia

Hypothermia is the over cooling of the body due to excessive loss of body heat which may lead to death.

An early sign of hypothermia is excessive shivering, blue lips and finger tips, slurred speech, and poor coordination. Shivering becomes more severe as body cooling continues and the inner body temperature falls below 35°C (normal body temperature is 37°C).

More profound hypothermia impairs mental functioning, resulting in confusion, disorientation, unconsciousness and poor decision-making. The desire or ability to seek protection from cold is lost, resulting in rapid loss of body heat which could be fatal.

Hypothermia slows down the heart rate. It may be difficult to feel the pulse rate of the victim.

In extreme cases, severe hypothermia can closely mimic death. Victims of such cases must be provided with medical care, as if they were known to be alive.

Hypothermia may occur at higher temperatures if a person is submerged in cold water well above the freezing point.

People with diabetes, injuries, kidney problems, epilepsy and arthritis are at a higher risk of hypothermia in comparison to healthy people.

Hypothermia can be fatal and needs immediate medical attention. Do the following as you wait for the first aid giver and medical help to arrive.

DO

GIVE dry clothes to a person removed from cold water. If no dry clothes are available, cover the person with material such as a plastic sheet or rain coat.

HELP or carry the co-worker to a warm shelter as soon as you notice signs of hypothermia. Such signs are excessive shivering, blue lips and finger tips, slurred speech and poor coordination.

USE a blanket and body-to-body heat to warm the person.

GIVE a conscious victim warm, non-alcoholic drinks in small quantities.

CONSULT a certified first aid person for the proper way to deal with hypothermia.

DO NOT

DO NOT USE alcohol as a warming agent. Alcohol may seem to provide warmth, but in reality it interferes with your ability to retain heat, resulting in a dangerous drop in body temperature.

D16

DO NOT SUBMERSE a hypothermia victim in hot water or a hot shower as a means of rewarming. This may result in "rewarming shock" which could be fatal.

DO NOT ALLOW a hypothermia victim to exert himself/herself. Physical exertion such as walking, climbing, lifting, etc. may cause heart failure and death. A mild hypothermia victim will slowly rewarm and return to normal health.

Trench Foot (Immersion Foot)

Trench foot is injury of the feet resulting from continuously having wet feet in cold water at near freezing temperatures. The symptoms of various stages of trench foot are:

Minimal: Reddening of the skin, slight numbness

Mild: Swelling, numbness (reversible)

Moderate: Swelling, redness, bleeding into the skin, nerve damage

Severe: Swelling, bleeding into the skin, gangrene

Prevention

DO

AVOID wet feet for prolonged periods.

KEEP a spare pair of dry socks available.

REMOVE boots and wet socks after work. Dry the feet and massage well to promote circulation.

8. Injuries That Happen Over Time

White Finger (Raynaud's phenomena, dead finger)

White finger is the blanching of the fingers, caused by use of hand-held vibrating tools. The early signs of disease are more noticeable only when fingers are exposed to cold.

The symptoms are tingling, numbness, and whitening of the fingers, and a reduced sense of heat, cold and pain.

Prevention

DO

KEEP hands warm and dry. Cold aggravates white finger disease.

ELIMINATE or reduce vibration exposure by using tools with anti-vibration devices.

MAINTAIN tools regularly. Tools in good operating condition vibrate less.

USE vibration absorbing gloves.

USE vibration absorbing handles for equipment.

KEEP hands warm and dry. Cold aggravates white finger disease.

AVOID smoking. Smoking may increase the effect of vibration.

Carpal Tunnel Syndrome and Tenosynovitis

Carpal Tunnel Syndrome results from damage to the nerve that runs through a channel (carpal tunnel) in the wrist. It is often found in people who do repetitive or stressful work with their hands, especially if they work with bent or twisting wrist, when using force. The symptoms are pain, burning, numbness, tingling and loss of strength. Often these conditions are strongest at night and on one side of the hand.

Tenosynovitis is inflammation of the tendons and tendon-muscle attachments. It is caused by overuse of the hand and arm muscles, especially during forceful repeated motions. Some areas of pain are: the base of the palm, the palm side of the fingers, the back of the wrist and the side of the wrist near the palm.

D18

Prevention

DO

KEEP your hands warm.

BE AWARE of the positions and movements of your hands and wrists as you work. Try to alternate or change movements to relieve strain.

ROTATE jobs and change tasks.

PLAN your work and work station to suit yourself rather than the machine.

USE tools which are light, balanced and sized to suit you.

KEEP your wrist in a comfortable, natural position while operating tools.

KEEP the lower part of the arm close to the body and supported whenever possible; doctors may advise wrist supports to prevent the damage caused by twisting motions.

9. Working in Remote Areas

DO

DEVELOP a list of clothing to carry.

DEVELOP a cold weather kit which includes items for emergency vehicle survival.

HAVE plenty of juices, soft drinks, fruits, nuts, raisins and other food available.

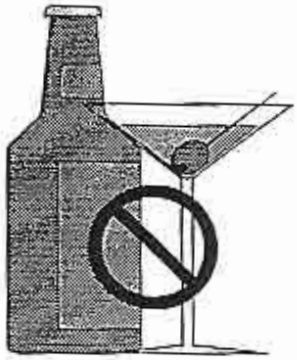
OBTAIN training to orient yourself to cold weather operations and policies.

IDENTIFY a warm shelter nearby where you can go in case of frostbite or hypothermia.

DRINK enough fluids to replace fluid lost through breathing and perspiration. Dehydration increases the risk of hypothermia.

DO NOT DO NOT WORK alone. The *buddy system* enables you to observe each other for early sings of frostbite and hypothermia.

DO NOT CONSUME alcohol when exposed to cold. Alcohol produces a deceptive feeling of warmth. Under the influence of alcohol you may expose yourself to fatal cold conditions without being aware.



DO NOT RISK getting frostbite if you have previously suffered from frostbite. You might be extremely sensitive to cold.

D20

COLD WATER SURVIVAL

The Canadian Red Cross Society

COULD YOU SURVIVE COLD WATER HYPOTHERMIA?

It's a warm spring day. You're out relaxing on a boat. Suddenly the unexpected happens! You, and maybe your companions, are in ice cold water! The shock takes your breath away!

There is no time to figure things out. You know you are in serious trouble. But there is a chance. If you made the necessary preparations, if you know how to do the right thing now – you can survive.

WHAT IS HYPOTHERMIA?

It's a numbing coldness that attacks the core heat of your body. When it happens, your insides become so cold that your body's normal functions slow down. If nothing is done, they will stop!

The fastest way to experience Hypothermia is to become immersed in cold water – the kind of water that is found in the lakes and oceans of Canada. If you use these waters for recreation or work you should have a full respect for their killing temperature.

D21

HERE ARE FIVE WAYS TO "PREPARE"

1) The most important step – wear a Personal Flotation Device (PFD). The suggested style is a Convertible Floatation Jacket. In addition to assisting you to keep your head above water, it has convertible shorts. The unit traps water within insulating foam and creates a barrier to the cold. This jacket usually has a hood stored in its collar. A vest type PFD or the normal floatation jacket also provides some protection from the cold.

Wearing a PFD with a whistle or signalling device attached is your most important survival decision. Wearing a hat is another important tip. In the water, your head can become a critical place of heat loss.

2) Check with your local weather office several hours before you head out. Be aware of the weather while on the water. Be alert to any change that could influence your safety. If in doubt – HEAD BACK.

3) Know the temperature of the water and maintain a respect for its power. A person wearing a PFD and light clothing, dumped into 10°C (50°F) water, normally cannot survive past three hours.

4) Know your craft and how to handle it in both calm and rough conditions. Do not overload. Be sure everyone understands the importance of keeping weight low and evenly distributed.

5) Avoid the use of alcohol. It cannot warm your inner core and will definitely interfere with your ability to make critical judgements.

"OH NO!" – YOU ARE IN BONE CHILLING WATER.

If you do become wet, here are the most important actions you can do:

- Get as much of your body out of, or above, the water as possible (especially your head and neck). Climb onto the boat, if you can. Cold water saps your body's core heat much faster than air.
- Avoid panic.
- If the water conditions are violent, get on the lee side of the boat.
- If you can't get out of water, protect your core heat by using the Heat Escape Lessening Position – H.E.L.P. To do this you must be wearing a PFD.

To achieve the H.E.L.P. position, cross your arms tightly against your chest. Draw your knees up close to your chest region. Remain calm and still. Do not try to swim. Unnecessary movement will use up valuable energy which your inner core requires for survival.

You should practice H.E.L.P. before you need it. The H.E.L.P. position can increase your survival time by 50 percent.

- If you are in the water with others, you should "HUDDLE". Everyone must be wearing a PFD to accomplish this survival technique. HUDDLE together so that the sides of everyone's chest are close, with arms around mid to lower back and legs intertwined. By doing this, your group may increase its survival time by 50 percent. Practice is encouraged.

  Children or elderly persons lose heat more rapidly than average. They should be put in the centre of the group.

If you didn't wear your PFD, you cannot achieve the H.E.L.P. or HUDDLE positions. Therefore, you have significantly reduced your chance for survival.

ASSISTING ANOTHER OR YOURSELF TO "SURVIVE"

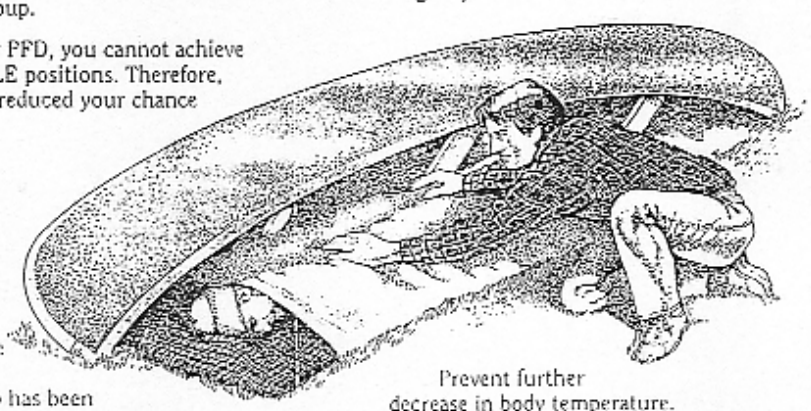
Hypothermia is a more serious problem than warming a person who has been chilled. The most obvious symptom of Hypothermia is vigorous shivering. The person is still conscious and able to talk. First aid should be employed.

1. Move the person to a dry shelter.
2. Remove wet clothing only if you can provide dry coverings, or a warm environment. Otherwise, leave the wet clothing on. Put a hat on the person's head and cover the neck.
3. To retain heat, construct a vapour barrier. Place the person in a sleeping bag enclosed in two large garbage bags, with a hole for the person's head.
4. Rewarm gently and slowly. Place warm, dry objects (40-45°C) near the neck and trunk. ie. Wrap water bottles or heat packs in a towel to avoid burning the sensitive skin.

   DO NOT RUB THE SURFACE OF THE PERSON'S BODY.

   Direct body to body contact is also an effective way to warm a person.
5. If the person requests a beverage, offer warm water, milk or juice. NEVER GIVE ALCOHOL.

SEVERE HYPOTHERMIA symptoms include stiffening, slurred speech, or unconsciousness. Shivering may be reduced or absent.



Prevent further decrease in body temperature.

Follow the steps outlined above. GET MEDICAL ASSISTANCE IMMEDIATELY

For additional information about Hypothermia or the Red Cross Water Safety program, please contact your Red Cross Office.

The programs of The Canadian Red Cross Society are made possible by the Voluntary Services and financial support of the Canadian people.

Canadian Coast Guard

Canada

The Canadian Red Cross Society

ISBN 0-921334-76-7

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D123

APPENDIX F

HEAT STRESS

Modifying wor[illegible]nd the environment

Management and [illegible]oint Health and Safety Committee can reduce heat stress in the following ways:

Engineering Controls

- Control the heat at source through the use of insulating and reflective barriers (insulate furnace walls).
- Exhaust hot air and steam produced by specific operations.
- Reduce the temperature and humidity through air cooling.
- Provide air-conditioned rest areas.
- Increase air movement if temperature is less than 35°C (fans).
- Reduce physical demands of work task through mechanical assistance (hoists, lift-tables, etc.).

Administrative Controls

- Health and safety committees should assess the demands of all jobs and have monitoring and control strategies in place for hot days.
- Increase the frequency and length of rest breaks.
- Schedule hot jobs to cooler times of the day.
- Provide cool drinking water near workers and remind them to drink a cup every 20 minutes or so.
- Workers should salt their food well, particularly while they are acclimatizing to a hot job (workers with a low salt diet should discuss this with their doctor).
- Assign additional workers or slow down work pace.
- Make sure everyone is properly acclimatized.
- Train workers to recognize the signs and symptoms of heat stress and start a 'buddy system' since people are not likely to notice their own symptoms.
- Pregnant workers and workers with a medical condition should discuss working in the heat with their doctor.

Personal Protective Equipment

- Light summer clothing should be worn to allow free air movement and sweat evaporation.
- Outside, wear light-coloured clothing.
- In a high radiant heat situation, reflective clothing may help.
- For very hot environments, air, water or ice-cooled insulated clothing should be considered.
- Vapour barrier clothing, such as acid suits, greatly increases the amount of heat stress on the body, and extra caution is necessary.

The Ministry of Labour uses the Threshold Limit Values for Heat Stress published by the American Conference of Governmental Industrial Hygienists. These values are based on preventing ill, acclimatized workers' core temperatures from rising above 38°C.

If you have questions about heat stress or how to measure it after reading this guide, call a Ministry of Labour office. For more technical information, ask for the Ergonomist or Hygienist.

Produced by the Professional and Specialized Services of the Occupational Health and Safety Branch, Ministry of Labour.
Disponible en français

Date: July 5, 1990
ISBN 0-7778-1575-3

Health and Safety Guidelines

Heat Stress

What Is Heat Stress?

Working or playing where it is hot puts stress on our body's cooling system. When the heat is combined with other stresses such as hard physical work, loss of fluids, fatigue or some medical conditions, it may lead to heat-related illness, disability and even death.

This can happen to anybody—even if you are young and fit. In Ontario, heat stress is usually a concern during the summer. This is especially true early in the season, when people are not used to the heat.

How We Cope With Heat

Your body is always generating heat and passing it to the environment. The harder your body is working, the more heat it has to lose. When the environment is hot or humid or has a source of radiant heat (for example, a furnace or the sun), your body must work harder to get rid of its heat.

If the air is moving (for example, from fans) and it is cooler than your body, it is easier for your body to pass heat to the environment.

Workers over 40 should be more careful because of a reduced ability to sweat.

Controlling Heat Stress

Acclimatization

The longer you do hard work in the heat the better your body becomes at keeping cool. If you are not used to working in the heat then you must take a week or two to get acclimatized or used to the heat. If you were ill or away from work for a week or so you can lose your acclimatization.

There are two ways to acclimatize:

1. If you are experienced on the job, limit your time in the hot environment to 50% of the shift on the first day and 60% on the second day. You can work a full shift the third day.

   If you are not experienced on the job (for example, a summer student), you should start off spending 20% of the time in the hot environment on the first day and increase your time by 20% each following day.
2. Instead of reducing the exposure times to the hot job, you can become acclimatized by reducing the physical demands of the job for a week or two.

If you have health problems or are not in good physical condition, you may need longer periods of acclimatization.

Hot spells in Ontario seldom last long enough to allow acclimatization. When it is hot, consider some of the following engineering and administrative controls. (See back page.)

Ontario

Ministry of Labour

HEAT STRESS HAZARDS

	Cause	Symptoms	Treatment	Prevention
Heat Rash	Hot humid environment; plugged sweat glands.	Red bumpy rash with severe itching	Change into dry clothes and avoid hot environments. Rinse skin with cool water.	Wash regularly to keep skin clean and dry.
Sunburn	Too much exposure to the sun.	Red, painful, or blistering and peeling skin	If the skin blisters seek medical aid. Use skin lotions (avoid topical anaesthetics) and work in the shade.	Work in the shade; cover skin with clothing; wear suntan lotions with a sun protection factor of at least 15. People with fair skin should be especially cautious.
Heat Cramps	Heavy sweating drains a person's body of salt, which cannot be replaced just by drinking water.	Painful cramps in arms, legs or stomach which occur suddenly at work or later at home. Cramps are serious because they can be a warning of other more dangerous heat-induced illnesses.	Move to a cool area; loosen clothing and drink cool salted water (1 tsp. salt per gallon of water) or commercial fluid replacement beverage. If the cramps are severe or don't go away, seek medical aid.	When working in the heat, workers should put salt on their food (if on a low-salt diet, this should be discussed with a doctor). This will give the body all the salt it needs; don't take salt tablets.
Fainting	Not enough blood flowing to the head, causing loss of consciousness.	Sudden fainting after at least two hours at work; cool moist skin; weak pulse	Fainting may be due to a heart attack or other illness. GET MEDICAL AID. Assess need for CPR. Move to a cool area; loosen clothing; make person lie down, and if the person is conscious, offer sips of cool water.	Reduce activity levels and/or heat exposure. Drink fluids regularly. Workers should check on each other to help spot the symptoms which often precede heat stroke.
Heat Exhaustion	Inadequate salt and water intake causes a person's body's cooling system to start to break down.	Heavy sweating; cool moist skin; body temperature over 38°C; weak pulse; normal or low blood pressure; person is tired, weak, clumsy, upset or confused; is very thirsty; or is panting or breathing rapidly; vision may be blurred.	GET MEDICAL AID. This condition can lead to heat stroke, which can kill. Move the person to a cool shaded area; loosen or remove excess clothing; provide cool water to drink (salted if possible); fan and spray with cool water.	Reduce activity levels and/or heat exposure. Drink fluids regularly. Workers should check on each other to help spot the symptoms which often precede heat stroke.
Heat Stroke	If a person's body has used up all its water and salt, it will stop sweating. This can cause body temperature to rise.	High body temperature (over 41°C) and any one of the following: the person is weak, confused, upset or acting strangely; has hot, dry, red skin; a fast pulse; a headache or dizziness. In later stages, a person may pass out and have convulsions.	CALL AMBULANCE. This condition can kill a person quickly. Remove excess clothing; fan and spray the person with cool water; offer sips of cool water if the person is conscious.	Reduce activity levels and/or heat exposure. Drink fluids regularly. Workers should check on each other to help spot the symptoms which often precede heat stroke.

APPENDIX G

TIPS FOR ATV RIDER

TIPS FOR THE ATV RIDER

INTRODUCTION

If you are about to become the owner of an all-terrain vehicle (ATV), you can look forward to lots of fun and excitement. Your ATV can master many types of off-road conditions, but it's really only as capable as you are. Proper instruction and practice are important because ATVs handle differently from other vehicles such as motorcycles and cars.

ATVs are not limited to play; they can work pretty hard, too. This booklet is limited to a discussion of recreational riding. Regardless of what kind of riding you do, however, all ATV riders should read this booklet thoroughly to learn tips that may be helpful in many kinds of riding.

We prepared this booklet to answer your questions about ATVs and help increase your knowledge of their operation and recreational use. It will help you learn and respect the capabilities of this wonderful new form of travel.

Know your vehicle before you begin riding. READ THE OWNER'S MANUAL SUPPLIED WITH YOUR ATV and practice riding techniques in an open, off-road area away from obstacles and other riders. Have an experienced rider assist you. Remember, ATV riding requires special skills and knowledge that must be learned over a period of time.

The information contained in this publication is offered for the benefit of those who have an interest in and ride all-terrain vehicles. The information has been compiled from publications, interviews and observations of individuals and organizations familiar with the use of ATVs. Because there are many differences in product design, riding terrain and riding styles, there may be organizations and individuals who hold differing opinions. Consult your local ATV dealers and experienced ATV riders about appropriate riding locations in your area. Although the Canadian All-Terrain Vehicle Distributors Council will continue to publish responsible viewpoints on this subject, it must disclaim specific or general liability for the views expressed herein.

The Canadian All-Terrain Vehicle Distributors Council is a national, non-profit association representing distributors of all-terrain vehicles in Canada. Founding members are Honda Canada Inc., Yamaha Motor Canada Ltd., Suzuki Canada Inc., and Canadian Kawasaki Motors Inc.

THE ALL-TERRAIN VEHICLE (ATV)

Knowing all you can about your ATV and the places you can ride is the best preparation for safe and enjoyable riding.

Remember, ATVs are intended for off-highway use only. Never operate an ATV on pavement. ATVs are not designed to be used on paved surfaces and may be difficult to control.

ATVs are different from other vehicles. They're also different from one another in many ways:

- There are three-wheeled and four-wheeled varieties of ATVs.
- Handling characteristics among ATVs vary depending upon their basic design and how they are equipped.
- Some ATVs have rear brakes only, while others have brakes front and rear. Be sure to learn the recommended stopping techniques for your machine.
- There are ATVs with electric starters, kick starters, and pull starters.
- There are water-cooled ATVs and air-cooled ATVs.
- Some ATV transmissions have automatic clutches; some have hand-operated clutches; and some transmissions are fully automatic. Some ATVs have a reverse gear.
- Some ATVs have solid drive axles and some have differentials.
- There are ATVs with chain drives or shaft drives.
- Some ATV throttles are controlled by twisting the hand grip; others by pushing a thumb lever next to the hand grip.
- Controls and their locations differ from one ATV model to another.

CONTROLS

Be sure you know the locations and operation of all the controls which your ATV may have; brakes, engine stop switch, throttle, shifter, clutch and parking brake. Learn how to find and use the controls without looking down at them. You will not have time to look for the controls when riding. If you switch to another vehicle, take the time to familiarize yourself with its controls. Control locations vary from model to model.

BE PREPARED

Sure, you're anxious to take a test run, but before you do, be sure you and your machine are ready. If you're not, the results can range from embarrassment to severe injuries.

PROTECTIVE GEAR

The nature of ATV riding demands that you wear protective clothing. Although complete protection is not possible, knowing what to wear and how to wear it can make you more comfortable when you ride and reduce the chance of injury in case of a spill. Never operate an ATV without an approved motorcycle helmet, eye protection, boots, gloves, long pants and long-sleeved shirt or jacket.

HELMETS

Your helmet is the most important piece of protective gear for safe riding. A helmet can help prevent a serious head injury.

There are a few basic tips to keep in mind when selecting a helmet. Select an approved helmet that meets or exceeds Standard D230 of the Canadian Standards Association or the appropriate standard of the Snell Memorial Foundation, the American National Standards Institute or U.S. Federal Motor Vehicle Safety Standard 218 and bears the symbol DOT.

Your helmet should fit snugly and it should be securely fastened. Full face helmets help to protect your face as well as your head. Open face helmets are lighter and cooler and should be used with mouth protection. Eye protection should be used with both types of helmet.

There is also a special time not to wear a helmet. When stopped to talk with landowners or other people you meet on the trails, always dismount the ATV and take your helmet off. To some people your helmet is a mask and can be intimidating.

EYE PROTECTION

You must be able to see clearly in order to ride safely. An object such as a rock, branch or even a bug that hits you in the face can distract you. But if you are hit in the eyes, you can be blinded. Regular sunglasses do not provide protection on an ATV. A face shield or goggles will help protect you. They should be:

- Free from scratches and shatterproof.
- Securely fastened.
- Well ventilated to prevent fogging.
- Tinted for riding on bright days, or clear for night riding. Yellow is best for overcast days.

CLOTHING

The well equipped rider

Good gloves will prevent your hands from getting sore, tired or cold as well as offer protection in the event of a spill. Off-road [illegible] gloves, available at motorcycle dealerships, provide the best combination of protection and comfort. They are also padded over the knuckles to prevent bruising.

The most protective footwear is a pair of strong, over-the-calf boots with low heels to prevent your feet from slipping off the footrests. Off-road style motorcycle boots offer the best protection for feet, ankles and legs.

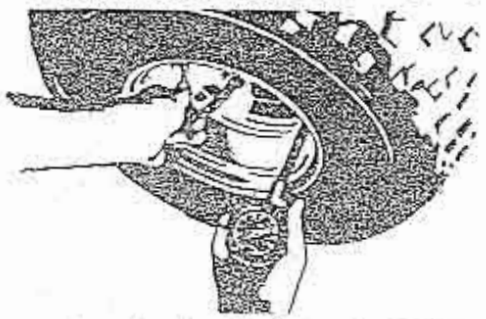
It's important to protect your skin from scratches. A long-sleeved shirt or jersey and long pants are minimal requirements for rider protection. Off-road riding gear such as off-road pants with knee pads, jersey and chest/shoulder protector provide better protection. You can look stylish and ready for action and still be well protected.

PRE-RIDE INSPECTION

Inspecting the mechanical condition of your ATV before each ride is important to minimize the chance of injury or being stranded, as well as to ensure long-term enjoyment of your ATV. Remember, you can ride farther in an hour than you can walk in a day. Your owner's manual will show you what to check on your particular machine. Here are the most common checks:

TIRE AND WHEELS

1. Air pressure – Always maintain the recommended tire pressure. Be sure that all tires are inflated to proper pressure. Check that tires on the left side of your ATV are inflated to the same pressure as the corresponding tire on the right side. If the tire pressure on one side is higher than the other side, the vehicle may pull to one side. Under-inflated tires may also cause wheel damage when riding over bumpy terrain. Over-inflation may damage the tires. If the tires are over- or under-inflated, your ATV may not steer or handle properly. To accurately measure pressure (usually around 2 to 6 psi), you'll need a low pressure gauge. Automotive tire gauges aren't accurate for this use.
2. Condition – Check for cuts or gouges that could cause air leakage.
3. Wheels – To avoid loss of control or injury, make sure axle nuts are tightened and secured by cotterpins. Check the wheel lug nuts to be sure they're tight



too. Grasp the tire at the front and rear and try to rock it on its axle to detect worn out bearings or loose nuts. There should be no free play or slip as you rock the wheel.

CONTROLS

1. Throttle and other cables – Make sure the throttle moves smoothly and snaps closed with the handlebars in any position. Check throttle operation while moving the handlebars from fully left to fully right. If your ATV is equipped with an adjustable throttle limiter, check that the adjustment is securely set. Check cables and controls for damage from a spill or accumulated dirt and mud which might restrict full operation.
2. Brakes – Do the controls operate smoothly and are the controls adjusted according to the owner's manual instructions? Are they positioned for easy reach? Your brakes are a critical part of riding and they must always be in tip top condition.
3. Foot shifter – Is it firmly attached and positioned for safe operation? It shouldn't be so low that your toes are pointed down at the ground or so high that shifting is awkward.

LIGHTS AND SWITCHES

1. Ignition switch (if equipped) – Check the condition of the switch and make sure it works properly by switching it off and on during your warm-up period.
2. Engine stop switch – Be sure it turns off the engine.
3. Lights (if equipped) – Be sure all lights are working.

OIL AND FUEL

1. Check oil level while the engine is off. Don't get stranded because you're out of oil or fuel.
2. Always start your ride with a full fuel tank in case you get lost.
3. Check for fuel or oil leaks.

CHAIN/DRIVE SHAFT AND CHASSIS

1. Chain – Inspect your chain for proper adjustment and adequate lubrication. Check for wear.
2. Drive shaft – If your ATV is equipped with a drive shaft rather than a drive chain, check for oil leaks. Maintain its oil supply as outlined in your owner's manual.

3. Nuts'n bolts – Rough terrain will loosen parts. Look and feel for loose parts while the engine is off. Shake handlebars, footrests, etc., before each ride and periodically check major fasteners with a wrench.

PERIODIC MAINTENANCE

Off-road riding is hard on your ATV, so it is especially important to perform periodic maintenance as outlined in your owner's manual. Don't risk injury or vehicle breakdown due to lack of proper maintenance.

TOOL KIT

OK, now you're finished with the pre-ride inspection. And you took care of those things that looked like they might cause trouble. But what if you have a problem out on the trail?

Have you ever walked out of the woods on a dark night? It's no fun. Carrying the right tools and equipment with you when you go riding is also important to safe enjoyment of your ATV. Examine the tool kit that came with your machine. You may want to add a few spare parts – a spark plug or two, perhaps some wire and tape, maybe a headlight bulb. Plan to carry what you need for emergencies. Consider carrying a good strong tow rope.

LET'S GET STARTED

Be sure you have a large, flat, open practice area, free of obstacles and hazards, to use while you learn how to ride your ATV. Take a few minutes to review the rest of the riding tips in this booklet before you start your engine.

Consult your owner's manual for the correct starting procedure.

- Check that the transmission is in NEUTRAL.
- Set PARKING BRAKE.
- Turn the FUEL valve on.
- Check that the engine stop switch is in the RUN or ON position.
- If the engine is cold, put the CHOKE in the ON position.
- Start the engine.

LET'S ROLL 'EM

- **Always keep your feet on the footrests while riding to prevent injury.**
- When mounting, take care not to step on the shifter.
- Be sure that the engine is sufficiently warmed up before you start riding.
- Apply the rear brake and shift into first gear.
- Release parking brake.
- Release the brake and apply the throttle slowly.
- If the vehicle has a manual clutch, release it slowly. If the clutch is engaged too quickly, the ATV might move suddenly, causing you to lose control or fall off the ATV.

RUNNING THROUGH THE GEARS

See your owner's manual for instructions on shifting your model of ATV. There are several types of transmissions on ATVs. Be certain you know how to operate the transmission of the ATV you are riding.

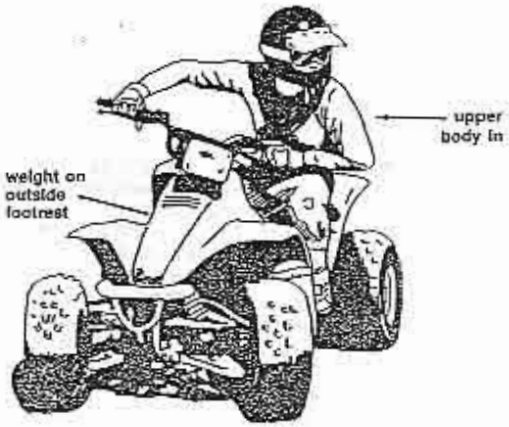
- Always close the throttle while shifting to prevent front wheel(s) lifting.
- Learn the sounds of your engine so you can shift to keep the engine speed in the most efficient range.
- If your ATV has a manual clutch, learn where the engagement point is to prevent stalling, and allow smooth shifting.

TURNING

ATVs with solid rear axles turn both rear wheels at the same speed. ATVs with unlocked differentials allow the rear wheels to turn at different speeds. Both types require their own special turning skills. Always check your owner's manual to determine your vehicle type.

Some tips for turning solid rear axle ATVs are:

- AT LOW SPEEDS: As you turn the handlebars in the direction of the turn, shift your body weight forward and to the outside of the turn.



(weight is supported on the outer footrest) while leaning your upper body slightly. Be sure to maintain throttle through the turn. In turning, the objective is to reduce weight on the inside rear wheel by shifting your body weight.

- **AT HIGHER SPEEDS:** The method of turning at higher speeds is similar to turning at low speeds. The difference is, as speed increases, you must lean your upper body farther toward the inside of the turn while keeping your weight on the outer footrest. This is to balance the higher cornering force as vehicle speed increases.

Special Note: If your ATV starts to tip while turning, lean your upper body further into the turn while gradually reducing the throttle and making the turn wider.

BRAKING

Your owner's manual describes your ATV's braking system. You may have both a front and rear brake or a rear brake only. Of course, your braking technique will depend upon your ATV's braking system, and the type of terrain you are riding on.

Some tips for braking are:

- Release the throttle.
- Shift to a lower gear to use the engine to slow the vehicle.
- Apply both brakes equally (if equipped).
- Avoid excessive braking while cornering.
- Apply brakes lightly on slippery surfaces.
- Shift to low gear when descending a hill and don't ride the brake for long periods.

Special Note: If your ATV stalls while travelling up a hill, do not let it roll backwards. See the section on hills on pages 10 & 11 for more details on this tricky situation and check your owner's manual.

PARKING

When parking your ATV you should:

- Shift to neutral and set parking brake, or shift into low gear if you don't have a parking brake.
- Avoid parking on an incline.

READING TERRAIN

You have to know the land you're riding on and what your machine will do in order to get the most out of the ride. Choose the places you ride. Use existing trails.

Stay away from terrain where you really don't belong, like dangerous slopes and impassable swamps. Watch carefully for sharp bumps, holes, ruts or obstacles.

An expert rider stays out of trouble not simply by handling the machine well, but by being smart enough not to get into risky situations in the first place. Learn to read the trail as you ride. An expert rider looks well ahead on the trail. Know what's coming; be prepared to react long before you get there. Be constantly alert for hazards. Never operate an ATV at excessive speeds. Go at a speed which is proper for the terrain, visibility conditions and your experience. Always be careful when operating an ATV, especially when approaching hills, turns and obstacles and when operating on unfamiliar terrain.

Here are some basic riding strategies you can use for different types of terrain. By learning them and practicing them, you will increase the pleasure of riding your ATV.

CLIMBING A HILL

Remember:

- Some hills are too steep for your abilities. Use your common sense.
- Some hills are too steep for your ATV regardless of your abilities.
- Never ride past your limit of vision – if you can't see what is on the other side of the crest of a hill, slow down until you get a clear view.

When approaching a hill you should:

- Keep both feet firmly on the footrests.
- Shift the ATV into a low gear and speed up BEFORE ascending a hill.
- For small hills, shift your body weight forward by sliding forward on the seat. For steep hills, stand on the footrests and lean well over the front wheel(s) in order to shift as much weight forward as possible.
- If the hill is steep and you must downshift to prevent stalling, shift quickly and smoothly. Also, don't forget to close the throttle while shifting. This will prevent front wheel lifting.

- If you don't have enough power to continue uphill but you have forward momentum and enough space to turn around safely, turn around before you lose speed and then proceed downhill.

- If you are riding up a hill and you lose forward momentum, apply the parking brake **before** you roll backwards, and dismount to the uphill side. Turn the handlebars fully to the left, and as you stand uphill, grasp the handlebars so that you can operate the brake lever with your right hand. Release the parking brake and pump the rear brake to let the ATV roll backwards and sideways to the hill. Turn the handlebars downhill. Let the ATV roll forward so that the ATV is pointing downhill. Reset the parking brake, remount the ATV from the uphill side, keeping as much weight uphill as possible. Ride the ATV downhill, keeping your weight to the rear. (Consult your owner's manual for directions specific to your ATV.) This should work on most hills, but on a steep hill, remounting is extremely difficult. In this situation, concentrate on keeping as much weight uphill as possible.

  If your ATV is not designed to accomplish these directions consult your owner's manual for instructions for turning on a hill.

Special Note: Do not let your ATV roll backwards on a hill. If your ATV has a front brake, you can try to stop the ATV using the **front brake only.** Move your body weight forward and use the front brake to slow the ATV to a stop. If the front brake does not slow the ATV, dismount to the side immediately. Do not attempt to back down a hill using the rear brake. Use of the rear brake could cause the ATV to roll over backwards.

DESCENDING A HILL

When descending a hill you should:

- Keep both feet firmly on the footrests.
- Point the vehicle directly downhill.
- Transfer your weight to the rear.
- Shift the transmission into low gear and descent with the throttle closed.
- Apply brakes to reduce speed.

TRAVERSING A SLOPE

Traversing a slope is tricky business. Use caution and avoid traversing slopes where there is slippery or very bumpy terrain. Follow these basic suggestions.

- Keep both feet firmly on the footrests.

- Lean uphill. You may want to put weight on the downhill footrest to increase traction, but most importantly, lean your upper body into the hill and steer slightly uphill.
- When riding on soft terrain, gently turn your wheel(s) slightly uphill to keep the vehicle on a straight line across the hill.
- If the ATV begins to tip, turn the front wheel(s) downhill if the terrain allows you to. If the terrain prohibits your turning downhill, dismount on the uphill side immediately.

RIDING THROUGH WATER

Your ATV is equipped to handle riding in water but some precautions must be taken:

When riding through water you should:

- Keep both feet firmly on the footrests.
- Never ford any stream with deep water because your tires may float, making it difficult to maintain control.
- Choose a course through a stream where both banks have a gradual incline. Try to cross at a known ford, or where you personally know it is safe.
- Proceed at a slow steady speed to avoid submerged obstacles and slippery rocks.
- Dry the brakes after crossing by applying light pressure to them while riding until they return to normal power.

G8

- Avoid water crossings where you may cause damage to stream beds, or erosion to the banks of the stream.

IN THE WINTER

ATVs are fun in the snow. But you have to learn to pick your snow conditions and riding area. On firm snow you can have a great time, and cause no problems. In soft snow under the wrong conditions, your ride can be a disaster. Wallowing through snowdrifts where you practically have to carry your ATV is not fun. What's more, careless winter riding can spoil things for you and everyone else. Snowmobilers get pretty upset and rightfully so when ATVs spoil carefully groomed trails. Landowners get upset when they have given permission for snowmobile trails and find others on them.

You can prevent these problems. Choose snow conditions carefully. Know who owns the land you ride on. Get to know your local snowmobilers. Contact your local ATV club. If there are snowmobile clubs in your area, get to know them, too. By working together, you can help to preserve riding opportunities. Remember that private land opened for snowmobiling in winter may be cropland that is off limits the rest of the year.

EXPANDING YOUR HORIZONS

How do you find good places to ride? You can start by talking to your dealer. Where do other customers ride? Who owns the land? What are the regulations for use? ATV clubs provide a way of working together to find good riding.

If you're working on your own, topographic maps can be a good way to find open land with dirt roads or trails. Find out who owns it, and whether they mind you using it. You can develop a network of good riding areas this way.

KNOW THE LAWS

The laws and regulations that control how and where you use your ATV are important. They help to keep you out of trouble; they help keep the sport healthy by controlling less responsible riders; they help protect the land you ride on and the people who own it. Dealers and ATV clubs can often provide you with a summary of local laws, or direct you to the appropriate mun[illegible] or provincial officials, or others who will be glad t[illegible] you.

YOU AND THE REST OF THE WORLD

There's one fundamental factor that controls your ATV riding – access to land. Developing and maintaining those riding opportunities means getting along with the rest of the world – private landowners, public land managers, and people you meet on the trails. The better you get along with all these people, the easier it will be to find and keep good riding areas.

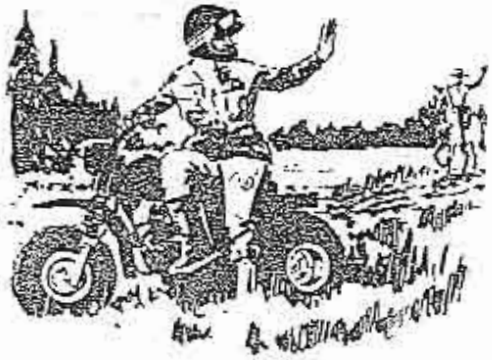
Mostly it takes common courtesy and consideration. Here are a few hints for getting along with people and keeping your riding areas open:

- Know who owns the land you're using. Get permission if you need it. Stay on marked trails if they are provided.
- Obey closure signs. That land is posted for a reason.
- Always leave gates and fences as you found them.

- Use courtesy when you meet others on the trails. Pull off and give right of way to horseback riders or hikers. It is best to shut off the engine whenever you are near horses – a panicked horse is a danger to you and its rider.

YOU AND MOTHER NATURE

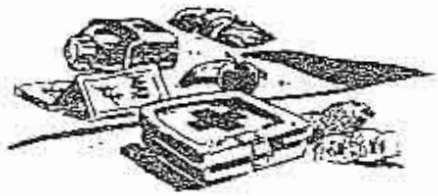
Riding behaviour that harms the land is self-defeating and irresponsible. Learn to protect and preserve your riding areas, in other words, Tread Lightly.



- Obtain a Travel Map from the Forest Service, or regulations from other public land agencies. Learn the rules and follow them.
- Keep your ATV quiet. Don't make your exhaust system noisier – there is nothing people dislike more than a loud off-highway vehicle. Keep your spark arrester in place.
- Avoid running over young trees, shrubs, and grasses – damaging or killing them.
- Stay off soft, wet roads and trails readily torn up by vehicles (particularly during hunting seasons). Repairing the damage is expensive.
- Travel around meadows, steep hillsides, or streambanks and lakeshores easily scarred by churning wheels.
- Resist the urge to pioneer a new road or trail, or to cut across a switchback.

- Stay away from wild animals that are rearing young – or suffering from food shortage. Stress can sap scarce energy reserves.
- Obey gate closures and regulatory signs. Vandalism costs tax dollars.
- Stay out of Wilderness areas. They're closed to all vehicles. Know where the boundaries are.
- Get permission to travel across private land. Respect landowner rights.

Future opportunities for exciting travel with your ATV are in your hands, so – **TREAD LIGHTLY!**



SAFE RIDING PRACTICES

Here are a few more tips to help make your ATV riding safe and enjoyable:

- Never operate an ATV without proper instruction. Take a training course. Contact the CATV for more information.
- Use antenna flags in hilly areas and wear bright clothing to increase conspicuity.
- Use maps and compass if you are riding in an unfamiliar area. Make a mental note of landmarks; you may need them if you are stranded. If you are lost at night, do not move around. You will waste valuable fuel that you can use to ride to safety in the daylight.
- Carry a first aid pack and vehicle repair kit with you.
- Never allow a child under 16 years old to operate an ATV without adult supervision. Children need to be observed carefully because not all children have the strength, size, skills or judge-

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ment needed to operate an ATV safely. Always follow these recommendations: – A child under 12 years old should never operate an ATV with an engine 70 cc or greater. – A child under 16 years old should never operate an ATV with engine size greater than 90 cc.

- Watch out for thin ice which may be camouflaged by snow.
- Never operate an ATV on a public road, even a dirt or gravel one, because you may not be able to avoid colliding with other vehicles. Also, operating an ATV on a public road is most likely against the law.
- Always tell someone where you're going and when you expect to return.
- Never follow directly behind another rider because this restricts your visibility.
- Never carry a passenger on an ATV. Carrying a passenger may upset the balance of the ATV and may cause it to go out of control.
- Never consume alcohol or drugs before or while operating an ATV, since this could seriously affect your judgement, cause you to react more slowly, affect your balance and perception and result in an accident.
- Never lend your ATV to anyone who has not taken a training course or has not been driving an ATV for at least a year.

REGISTRATION

You can't get street plates for your ATV; but in many provinces the law requires that you register your ATV as part of the province's off-highway vehicle registration program. ATVs used for agriculture or utility purposes may be subject to different provisions than recreational vehicles. You should check the registration requirements when you buy your ATV – your dealer should know the laws, and often can help you register. Fines for riding unregistered vehicles can get expensive, to say nothing of the risk of having your ATV impounded.

So enjoy your ATV, read your owner's manual, use common sense, obey all laws and please ride carefully and safely.

INFORMATION

For more information on all-terrain vehicle rider safety and the Canadian All-Terrain Vehicle Distributors Council write to:

CATV
7181 Woodbine Avenue
Suite 235
Markham, Ontario
L3R 1A3

ACKNOWLEDGMENT

This guide was reproduced through the cooperation and with the written authorization of the Specialty Vehicle Institute of America, 2 Jenner Street, Suite 150, Irvine, California 92718. We acknowledge their guidance and commend their commitment of the enjoyment of all-terrain vehicles as a safe form of recreation, sport and utility use.

Revised 1993
Canadian All-Terrain Vehicle Distributors Council

ATV Safe Rider Code

- Know Your Operator's Manual
- Check the ATV Before You Ride
- Wear Your Helmet
- Protect Your Eyes and Body
- Get Qualified Training
- Ride Off-Road Only, Never on Public Roads
- Ride With Others – Never Alone
- Ride Within Your Skills
- Carry No Passengers
- Respect Riding Area Rules
- Keep Noise Levels Low
- Ride Stralght – No Alcohol or Other Drugs
- Preserve the Environment
- Be Courteous to All You Meet
- Lend Your ATV to Skilled Riders Only
- Always Supervise Youngsters

MAKE YOUR GREAT ATVenture A SAFE ONE

APPENDIX H

ERGONOMICS:

Shovelling and Digging & Manual Materials Handling

7. Shovelling and Digging

CONTACT utilities for location of cables and pipes prior to digging.

CHOOSE the proper tool for the task. A spade for digging and a shovel for shovelling.

ALLOW for safe distance between people.

Shovelling

CHOOSE shovel length depending on the task:

- garden shovel should be between elbow and chest height
- snow shovel handle should come up to chest height
- a light shovel (about 1.5 kg or 3 lbs) is suitable for shovelling snow
- a heavier shovel (about 3 kg or 6.5 lbs) is suitable for shovelling soil

Guidelines for Shovelling

CCOHS. (1997). Cold Weather Workers Safety Guide. 2nd ed. CCOHS: Hamilton.

H 2

3 Shift weight to rear foot. Keep load close to body.

4 Turn your feet in direction of throw.

Guidelines for Digging

1 Push spade down using leg muscles.

2 Slide load close to body. Ensure load is loose from ground before lifting.

Notes

Total weight (shovel and load should be 5–7 kg) (10–15 lbs).

Most efficient shovelling rate is 15–20 scoops per minute. This rate should not last longer than 15 minutes.

8. Manual Materials Handling

Guidelines for Lifting

Store bags at waist height.

Do not bend over and try to lift the bag all at once.

To Lift from the Ground

1. Raise box upright.

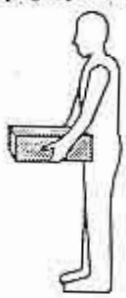
2. Put one knee against box.

3. Pull box up the leg.

4. Rest box on edge of knee of the other leg.

5. Stand upright.

6. Carry the load with your back in upright position.



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Guidelines for Transferring Weight

DO

REDUCE the load on your back by transferring weight. Shift body weight from one leg to the other. Avoid twisting your back. Momentum helps move the load.

USE the following sequence of motions for moving heavy or bulky materials:

SAFETY in Polar Bear Country

Each encounter with a polar bear is unique.

Good judgement, common sense and familiarity with polar bear behaviour are required in all situations. This pamphlet provides guidelines for avoiding and dealing with polar bear encounters. For your safety and the safety of the bears, please read this pamphlet carefully and seriously consider the risks involved with travel in polar bear country. Further information is available in the DVD *"Polar Bears: A Guide to Safety"* developed by Parks Canada and the Safety in Bear Country Society.

In the event of a **polar bear attack** or **encounter** follow this emergency check list:

1. **STAY CALM** and call for help by radio or satellite phone. (Get contact numbers at your orientation to the park).
2. Report location and time of incident.
3. Report number of people involved.
4. Report extent of injuries and property damage.
5. Check that all people in the group are accounted for.
6. Report numbers and last locations of all polar bears involved in the incident.
7. **Report reason for the attack if known** (Female protecting cubs, surprise, defending food source, etc.).
8. **Report description of bears** (male or female, size, markings, etc.)
9. Stand by to provide additional information to rescuers.

Polar bear behaviour is very different from that of grizzly and black bears.

Polar bears are predators, primarily hunting seals, while grizzlies and black bears mostly eat plants. As predators, polar bears will investigate humans, their camps and may even consider humans as a food source.

AVOIDING an ENCOUNTER

Ask Parks Canada staff about current bear activity.

Some areas may be closed due to bear activity; obey written and oral warnings.

Be alert and aware of your surroundings.

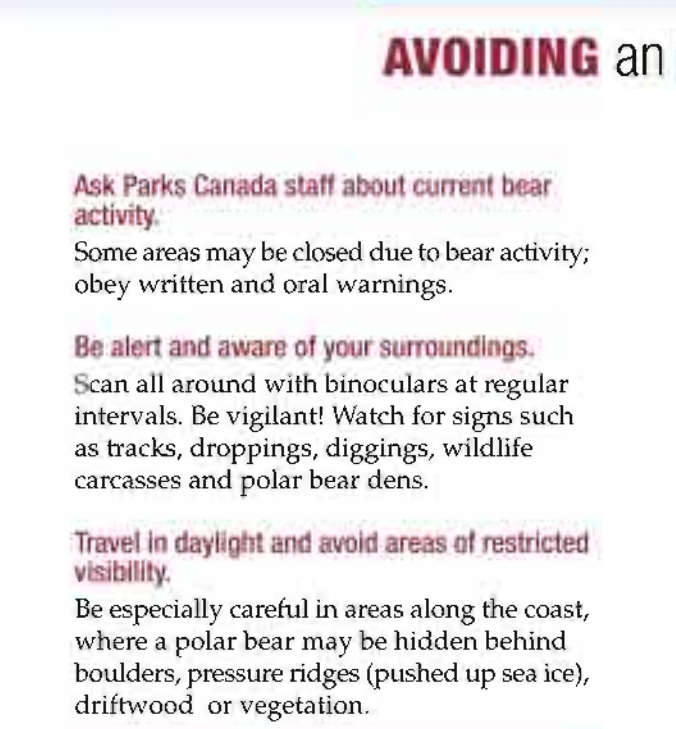
Scan all around with binoculars at regular intervals. Be vigilant! Watch for signs such as tracks, droppings, diggings, wildlife carcasses and polar bear dens.

Travel in daylight and avoid areas of restricted visibility.

Be especially careful in areas along the coast, where a polar bear may be hidden behind boulders, pressure ridges (pushed up sea ice), driftwood or vegetation.

Travel in groups and stay together to increase your safety.

The larger the group the greater the chances of deterring a bear.



Never approach a bear for any reason.

Every bear defends a "critical space", which varies with each bear and each situation: it may be a few metres or a hundred metres. Intrusion within this space is considered a threat and may provoke an attack.

Never approach a fresh kill or carcass as polar bears will defend their food.

Adult polar bears will often only eat the fat of seals and other kills, but other bears may scavenge from these carcasses.

Never feed bears or any wildlife.

A bear that finds food from a human source begins to associate humans with food. This can result in the bear losing its natural tendency to avoid people and becoming persistent in its search for human food. The consequences for you and the bear can be serious. A bear that associates food with humans is more likely to injure people and these bears may have to be relocated or killed.

Pack out all garbage and use sealed bags and containers or bear-proof canisters to store food and garbage.

Eliminate or reduce odours from yourself and your camp.

Avoid using scented soaps and cosmetics and avoid bringing strong smelling foods.

Consider hiring a guide if you are uncertain about your ability to deal with polar bears.

Ask about their experience, how they will avoid encountering a polar bear and about plans of action should you encounter a bear. A larger group can also increase safety, ask about the size of group.

MORE about Polar Bears

Polar bears are the largest land carnivore in North America. An adult male typically weighs 300-450 kg, stretching 3 metres from nose to tail. They are strong, fast, agile, on land or ice, and are expert swimmers and divers. Their sense of smell is exceptional, their eyesight comparable to a human's. Polar bears are naturally curious, not fearless as they have been labelled. They are shy and prefer to avoid confrontations with humans and other polar bears. Their primary prey is the ringed seal but they will also prey on birds, eggs, small mammals, and even humans. They also scavenge anything from beached whales to human garbage. In the heat of summer, polar bears may appear slow and docile, but they are capable of moving swiftly and with purpose.

This pamphlet was developed for National Parks in the Arctic. Polar bears and bear encounters are more numerous in Ukkusiksalik and Wapusk National Parks than other Arctic National Parks. Independent traveling in these parks is not recommended, but guided trips are available. Contact Ukkusiksalik or Wapusk National Parks for further information.

SUGGESTED READINGS

Brantley, Marianne. 1998. *Safety in Polar Bear Country*. Northwest Territories Renewable Resources. Yellowknife. 24 pp.

Canadian Wildlife Service. *Illustrated Who's Who*. http://www.cws-scf.ec.gc.ca/hww-qui/bear/bear.html

Suring, L. 1988. *Polar Bears*. University of Michigan Press. Available in soft cover from Fitzhenry and Whiteside. Markam, ON. 220 pp.

Safety in Bear Country Society. 2006. *Polar Bears: A Guide To Safety*. Available from Distribution Access. 1-888-440-4640. DVD.

CONSERVATION

Polar Bear

Nanuq, the great white bear, is found in many of Canada's northern national parks and in some national historic sites. Whenever bears and people occupy the same area, conflict can arise. Polar bears and people have coexisted for thousands of years but contact between the two must be minimized to continue this legacy. Successful polar bear conservation requires your co-operation.

For your safety, and the safety of the bears, learn about safe travel in polar bear country and take precautions. By choosing to travel in polar bear country you not only accept the associated risks, but also the responsibility to alter your plans, actions and attitudes to accommodate these magnificent animals.

Report all polar bear sightings and signs to park staff, as soon as possible.

FOR MORE INFORMATION:

Auyuittuq National Park and Quttinirpaaq National Park
Box 353
Pangnirtung, NU X0A 0H0
PHONE: **867-473-2500**
E-MAIL: Nunavut.info@pc.gc.ca

Sirmilik National Park
Box 300
Pond Inlet, NU X0A 0S0
PHONE: **867-899-8092**
E-MAIL: Sirmilik.Info@pc.gc.ca

Ukkusiksalik National Park
Box 220
Repulse Bay, NU X0C 0H0
PHONE: **867-462-4090**
E-MAIL: Ukkusiksalik.Info@pc.gc.ca

Tornagat Mountain National Park Reserve
Box 471
Nain, NF A0P 1L0
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E-MAIL: Torngats.Info@pc.gc.ca

Wapusk National Park
Box 127
Churchill, MB R0B 0E0
PHONE: **204-675-8863**
E-MAIL: Wapusk.rp@pc.gc.ca

Parks Canada Western Arctic Field Unit
Box 1840
Inuvik, NT X0E 0T0
PHONE: **867-777-8800**
E-MAIL: Inuvik.Info@pc.gc.ca

Margo Supplies
A supplier of bear deterrents and warning devices.
www.margosupplies.com

ISBN: R62-342/2007E 978-0-662-45612-4

Parks Canada Parcs Canada

Canada

SAFETY IN POLAR BEAR COUNTRY

CHOOSING a SAFE Campsite

Avoid bear feeding areas.

A polar bear's primary food source is seal so these species are often found in the same places.

- **In fall, winter and early spring** most polar bears are on the sea ice hunting seals by the floe edge, open water leads and along pressure ridges. Bears and seals can also be found in places where the ice is thin or cracked, such as tide cracks in land-fast ice or at toes of glaciers. Seals can more easily maintain breathing holes in these areas.
- **In early spring**, females with cubs tend to hunt along pressure ridges and cracks in land-fast ice (particularly in bays) where seal birthing dens are found.
- **During the ice-free summer season**, when polar bears are forced ashore, they generally hunt and scavenge along coastlines, beaches and rocky islands near the coast.

Stay away from polar bear den sites.

Unlike other bears, there is no time when all polar bears are inactive in dens.

- **Maternity dens** are excavated by pregnant females in snow drifts on leeward (wind protected) slopes of coastal hills and valleys. In the Baffin Region, dens can also be found at high elevations on snowfields and glaciers. Maternity dens are occupied from fall to early spring. The dens are inconspicuous, however, bear tracks leading to and from the site in early autumn or late spring or ventilation holes can indicate their presence.
- **Temporary dens** are excavated in snow drifts or pressure ridges by polar bears (males, females and females with cubs) that are active over the winter. The dens can be used as resting places or as temporary shelter from bad weather. They can be used from a few days to several months.
- **Summer retreat dens** are excavated during the open water season in the remaining snow banks or into the permafrost. These can also be at higher elevations on snowfields and glaciers or the valleys leading up to them. Male and female bears of all age groups use them to keep cool and avoid insect harassment.

Avoid camping on beaches, islands, along coastlines and on "bear highways".

- Before making camp, look around for tracks.
- Polar bears often travel along coastlines using points of land and rocky islets near the coast to navigate.
- In the summer, moving sea ice may transport polar bears into coastal areas. Avoid areas where the pack ice is blowing in to shore.
- Valleys and passes are often used to cross peninsulas and to move from one area to another.
- Polar bears travel and hunt along the edges of ice floes.

Camp inland on a butte or bluff with a good view of surrounding terrain.

Avoid areas where bears might hide, such as blind corners, snow banks, pressure ridges and other places with visual impediments.

Set up tents in a line rather than a circle and maintain at least 5 metres between them.

If a bear comes into camp, it will not feel surrounded and will have an avenue of escape without feeling threatened. Keep watch 24 hours per day. Take turns keeping watch during sleeping periods.

Do not sleep in the open without a tent.

You may look like a seal and polar bears are very curious. People sleeping in the open have been attacked.

Cook at least 50 metres from your sleeping area in a place visible from your tent.

Strain food particles from dishwater and store with garbage. Dump dishwater at least 50 metres from your sleeping area, rivers, streams and lakes.

Store food and garbage in bear-proof containers or sealed bags and containers secured under rocks within view of your tent.

Placing pots on top may serve as an alarm. If you have a warning system, store your food within its perimeter. DO NOT store food inside your tent.

HANDLING an ENCOUNTER

Before your trip, discuss possible plans of action for dealing with bears in a variety of circumstances and be sure everyone understands.

The actions of each individual either contribute to or detract from the safety of everyone else.

Stay calm and assess the situation.

What is the bear doing? What is the bear's behaviour?

If a bear does not know you are there:

- **quietly back away and leave the area** either in the direction you came or make a wide detour around the bear. Do not run, move quickly or make motions that might attract the bear's attention.
- **stay downwind, if possible**, so the bear cannot smell you and detect your presence.
- **keep an eye on the bear.**

If a bear knows you are there and shows signs of being curious, such as:

- moving slowly with frequent stops,
- standing on hind legs and sniffing the air,
- holding its head high with ears forward or to the side,
- moving its head from side to side, or
- trying to catch your scent by circling downwind and approaching from behind.

THEN:

- **help it to identify you as a human,**
- **wave your arms over your head and talk in low tones,**
- **move slowly upwind** of the bear so it can get your scent.

If the bear has been surprised at close range or shows signs of being agitated or threatened, such as:

- huffing, panting, hissing, growling or jaw-snapping,
- stamping its feet,
- staring directly at a person, or
- lowering its head with ears laid back.

THEN:

- **act non-threatening.** Do not shout or make sudden movements, which might provoke the bear. Never huff or hiss as this can cause a polar bear to charge.
- **avoid direct eye contact.**
- **back away slowly.** DO NOT RUN.
- **be prepared to use deterrents.**

If the bear shows signs of stalking or hunting you, such as:

- following you or circling you,
- approaching directly, intently and unafraid,
- returning after being scared away, or
- appears wounded, old or thin.

THEN:

- **fight back!** Use any potential weapon, group together and make loud noises.
- DO NOT RUN.
- **be prepared to use deterrents.**

If a bear charges:

- **stand your ground and be prepared to fight!** Bluff charges are rare.

Never get between a bear and her cubs.

If a female with cubs is surprised at close range or separated from her cubs she will likely attack to defend her cubs.

- **leave the area immediately.**
- **stay in a group.**
- **fight back if she attacks.**

Always leave an escape route for the bear.

Carry deterrents and know how to use them.

Report all bear sightings and signs to park staff.

CONTACT PARKS CANADA FOR MORE INFORMATION

DETERRENTS

Reducing the threat posed by a polar bear during an interaction may be difficult. Non-lethal deterrents have been developed for black and grizzly bears but they have not been thoroughly tested on polar bears and, therefore, they cannot be depended on to ensure safety. The best way to live safely with bears is to avoid contact with them.

Any potential weapon should be considered, such as skis, poles, rocks, blocks of ice or even knives.

Stay together as a group. This can be a deterrent and actions, such as making noise, jumping, waving arms, throwing things, may help to drive a polar bear away.

COMMERCIAL deterrents

- **Noisemakers** including air horns, pistol and pen launched bear bangers may scare a bear away.
- **Pepper spray** is effective against polar bears, but has some limitations. It must be warm enough to atomize and it must be used at close range. Also be aware of wind direction to avoid having the spray blow into your face.
- **Know how and when to use these deterrents and practice beforehand.**
- **Availability of commercial deterrents is limited in the north,** most will have to be purchased elsewhere and transported as dangerous goods.
- **Portable solar electric fences** may deter a bear at your campsite if properly installed and maintained.
- Contact Parks Canada for more information.

In National Parks of Canada it is unlawful to possess a firearm without a permit. The exception to this regulation is for beneficiaries of the Inuvialuit Final Agreement, the Nunavut Land Claim Agreement, the Labrador Inuit Land Claims Agreement and future land claim agreements, who can carry firearms when engaged in traditional activities within National Parks within their land claim area.

WARNING systems

Set up a portable trip-wire or motion detector alarm system around your tent to alert you if a polar bear approaches your camp. Before leaving home, contact Parks Canada for more information.

You may wish to take a dog, but only one that has proven experience with polar bears. Several dogs are better than one. Know how to handle them. Keep them staked so they cannot run to you for protection and stake them downwind from your sleeping area. Be sure to clean up any dog food leftovers. Dogs must be under control at all times within national parks to avoid wildlife harassment.

Designate a bear monitor to keep watch if a polar bear might be nearby. Consider moving your camp if there is a bear in the area.

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POLAR BEAR SAFETY IN NUNAVUT TERRITORIAL PARKS

When you travel in Nunavut you are in polar bear country. Polar bears are among the largest carnivores in the world. They are strong, fast and agile on ice, land, as well as in the water. The best way to be safe is to avoid them.

Polar bears can be found from the permanent pack ice and coasts of the Arctic Ocean and Arctic islands to southern Hudson Bay. They live mainly on sea ice or on land within a few kilometers of the coast. In summer, polar bears often travel along coastlines using points of land and rocky islets near the coast to navigate. They also travel inland and have been seen as far as 150 kilometers from the coast.

POLAR BEAR FEEDING AREAS

FALL, WINTER AND SPRING

Polar bears hunt seals along the sea ice edge, near open water and areas of pushed up sea ice. They also hunt for seals in places where sea ice is thin or cracked, such as at tide cracks in land-fast ice or at toes of glaciers.

SPRING

Females with cubs hunt for seal birthing areas along pushed up sea ice, as well as near cracks in land-fast ice, particularly in bays.

SUMMER

Polar bears are forced ashore when sea ice melts. They feed on birds, eggs, and small mammals along coastlines, beaches and rocky islands near the coast. They also scavenge anything from wildlife carcasses to human garbage.

POLAR BEAR DEN AREAS

FALL, WINTER AND SPRING

Maternity dens are located in snowdrifts along slopes of coastal hills and valleys. Maternity dens can also be found at high elevations on snowfields and glaciers. Dens are inconspicuous but bear tracks leading into or away from snowdrifts, as well as ventilation holes may indicate den locations.

WINTER

Temporary dens and daybeds are dug into snowdrifts or pushed up sea ice. These are used as resting places or as temporary shelters from bad weather for a few days up to several months.

SUMMER

During the open water season retreat dens are excavated in snow banks or permafrost. Dens may also be at higher elevations on snowfields, glaciers or in valleys leading up to them, keeping bears cool and away from insects.

POLAR BEAR ENCOUNTERS

You may encounter a polar bear by chance or because it is attracted to your activity. Polar bears are curious and may investigate any strange objects, smell or noise. Always stay calm and assess the situation. Each encounter with a polar bear is unique. Good judgment, common sense and familiarity with polar bear behaviour are important.

CURIOUS BEARS

If a bear knows you are there and shows signs of being curious such as moving slowly with frequent stops, standing on hind legs and sniffing the air, holding its head high with ears forward or to the side, moving its head from side to side, or trying to catch your scent by circling downwind and approaching from behind, back away slowly. Help the bear identify you as human by talking in low tones. Move slowly upwind of the bear so that it can get your scent. Always leave an escape route for the bear. Do not run.

DEFENSIVE BEARS

If a bear has been surprised at close range or shows signs of being agitated or threatened such as huffing, panting, hissing, growling, jaw-snapping, stomping its feet, staring directly at a person, or lowering its head with ears laid back, back away slowly. Do not shout or make sudden movements. Avoid direct eye contact. Act non-threatening. Be prepared to use deterrents. Do not run.

PREDATORY BEARS

If a bear shows signs of stalking or hunting you such as: following or circling you, approaching directly, intently and unafraid, returning after being scared away, or appears wounded, old or thin, group together and make loud noises. Be prepared to use deterrents. Be prepared to fight back. Do not run.

BEARS WITH CUBS

Never get between a bear and her cubs. If you come across a bear with cubs, do not run. Group together and leave the area immediately. Be prepared to fight back if the bear attacks.

If you experience a polar bear attack use any available weapons such as rocks, blocks of ice, knives, skis or poles.

AVOID ENCOUNTERS

Stay alert. Always travel in groups of at least four people and stay together to increase your safety. Make noise as you travel through bear country to communicate your presence. Always travel in daylight and be aware of your surroundings. Polar bears may be hard to see. Scan around with binoculars at regular intervals. Avoid areas of restricted visibility, pushed up sea ice, boulders, driftwood or vegetation. Watch for tracks, droppings and diggings.

Never approach a bear. Polar bears defend their space and may consider you a threat. Never feed bears or other wildlife. A bear that associates humans with food is dangerous. Never approach a wildlife carcass. A bear may be in the area. Leave immediately.

CAMP SAFELY

Avoid camping on beaches and along coastlines. In summer, polar bears often travel along coastlines using points of land and rocky islets near the coast to navigate. Avoid camping in narrow valleys and passes. These may be used by bears to cross peninsulas and to move from one valley to another. Camp inland, on high ground, where you have a good view of your surroundings. Look for bear tracks before you set up camp. Move your camp if there is a bear in the area.

KEEP YOUR CAMP CLEAN

Cook, clean, store food, stoves, pots and all cooking gear including the clothes you cook in, as well as garbage, food scraps, or any scented products at least 100 metres

When you travel in Nunavut you are in polar bear country. Polar bears are among the largest carnivores in the world. They are strong, fast and agile on ice, land, as well as in the water. The best way to be safe is to avoid them.

from your sleeping area. Use bear proof canisters or airtight containers for storage. Feces should be packed out or buried under rocks away from trails, at least 100 metres from your camp and away from all water sources. Put all toilet paper and tampons in a sealed bag with your garbage. Pack out all of your garbage including food scraps and packaging. Do not burn packaging as lingering food odours may become attractants to bears. Pick up any spilled food from your cooking and eating areas. Position your camping, cooking, storage and human waste areas so that you always have a clear escape route from a bear.

Never sleep in the open without a tent. Never bring strong smelling foods or scented products of any kind. Never cook, store food or scented products in your tent.

GET INFORMATION

Consider hiring a local guide if you are uncertain about your ability to deal with polar bears. Educate yourself about the area where you plan to travel. Contact the Nunavut Parks and Special Places division within the GN's Department of Environment for more information. Find out where and when polar bears have been observed and avoid those areas. Know the types of areas bears use at different times of the year. Get information about bear feeding areas and den sites so that you can avoid them. Pre-plan, rehearse and know what to do for different bear encounter scenarios. Report all encounters, sightings, tracks and other bear signs to Nunavut Parks staff or Wildlife officers as soon as possible.

WARNING SYSTEMS

All members of your group should be familiar with handling bear encounters in a variety of circumstances. Inform yourselves about bear warning systems and deterrents. Know how and when to use them before your trip. Consider bringing and setting up a portable trip-wire or motion detector system to alert you if a polar bear approaches your camp.

DETERRENTS

Availability of commercial bear deterrents such as noisemakers, air horns, as well as pistol and pen launched 'bear bangers' is limited in the Arctic. Most deterrents must be purchased elsewhere and transported as dangerous goods. Pepper spray may work on polar bears but has not been thoroughly tested. Be aware that pepper spray may not work when it is cold or wet.

FIREARMS

Check with Nunavut Parks staff for regulations governing carrying and using firearms.

DOGS

Only travel with dogs if they have proven experience with polar bears. Keep dogs under control at all times. Stake them downwind from your sleeping area. Be sure to clean up dog food leftovers.

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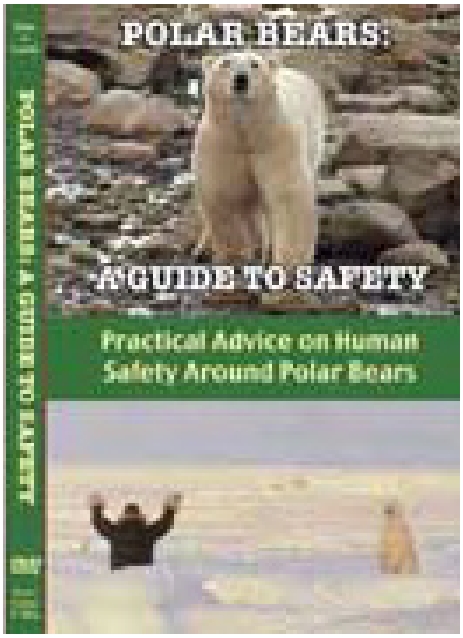

The Polar Bear Safety Video builds on the success of two other educational videos developed by the Safety in Bear Country Society (SIBCS): "Staying Safe in Bear Country" and "Working in Bear Country".

The Bear Safety DVD series is available through **Distribution Access** (www.distributionaccess.com)

Any proceeds from the sales of videos in the series are put directly back into further educational efforts.

For Information on the Safety in Bear Country Society (SIBCS):

Andy McMullen
BEARWISE
14 Tees Court
Yellowknife, NT X1A 3L5
Ph: (867) 766-4847
Email: janeandy@theedge.ca

POLAR BEARS: A GUIDE TO SAFETY

Through proper education, appropriate behaviour by human visitors can both increase human safety around bears, and decrease the unnecessary killing of bears.

Practical Advice On Human Safety Around Polar Bears

Polar bear country is experiencing unprecedented levels of community, industrial and tourism development. As human presence in polar bear country continues to rise, there is an increasing danger that both people and bears are being unnecessarily harmed. Each year, many polar bears are shot in defence of life and property which combined with other environmental factors could have a negative impact on polar bear populations. In addition, although human injury is rare, it does happen.

In 2002, the Minister of Sustainable Development commissioned a report on improvements to policy and practice to enhance visitor safety. The report's recommendations included the development of "*a polar bear safety video that would be mandatory viewing for all visitors registering for a trip in a park*". Since then, the Nunavut Department of Environment (both Parks and Wildlife) has been working with Canada (DIAND and Parks Canada), NTI, NWMB, elders, hunters, industry and the Safety in Bear Country Society (SIBCS) to produce "Polar Bears: A Guide to Safety" DVD. The production of the video cost approximately $350,000.

The "Polar Bear Safety" video is aimed at reducing negative polar bear encounters. It is approximately 25 minutes long, and its goal is to provide information on the principles and practices of polar bear safety, including:

- Bear biology, ecology and behaviour relevant to human safety
- Bear and human encounters
- Preventing bear encounters

The production of the DVD included hosting an IQ Workshop on polar bear behaviour and human safety with the steering committee; elders from Gjoa Haven, Repulse Bay, Clyde River, Iqaluit, and Pond Inlet; and science experts to ensure that both the text and video footage was up-to-date and would positively influence human behaviour. The IQ Workshop resulted in, among other ideas, the identification of three traditional Inuktitut words to describe the most common bear approaches. These three words provide the basis for the behavioural section of the video:

- **Suryuktuq:** Bear is approaching because it is curious.
- **Upatuqtuq:** Bear will charge or come close but will turn away. (Bluff charge)
- **Piqianiatuuq**:The bear is charging with the intent of attacking.

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Department of Environment
Havakviat Avatiligiyikkut
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NUNAVUT PARKS
& SPECIAL PLACES
Department of Environmnet
Government of Nunavut
P.O. Box 1000, Station 1340
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Queen's University Off-Campus Activity Safety Policy
Safety Planning Record

Pursuant to the Queen's University Off-Campus Activity Safety Policy, this form is to be completed by the Principal Investigator/Activity Coordinator and submitted to the Department/Unit Head (Person in Authority) ***prior to the start of a "higher risk" off-campus activity****, as defined in the Policy. Department/Unit Heads may set requirements regarding how far in advance of an activity the form must be submitted.*

NOTE: *A single Safety Planning Record may be used for multiple off-campus activities in the same calendar year, or in a single offering of an academic course, provided the activities and safety provisions are similar and all participants are identified. Additional sheets should be appended as necessary to capture the features of individual activities and any special safety provisions, as trips may be impacted by changes of season (monsoon, hurricane, etc.), changes in political landscape (armed conflict, civil unrest), changes in health and safety of the region (e.g., SARS epidemic, Avian Flu outbreak), etc.*

DEPARTMENT/UNIT:	**PRINCIPAL INVESTIGATOR/ACTIVITY COORDINATOR:**
Analytical Services Unit	Dr Allison Rutter
CATEGORY OF OFF-CAMPUS ACTIVITY: Ξ Research ☐ Athletic ☐ Academic ☐ Other extracurricular	**OFF-CAMPUS ACTIVITY LEADER:** Dr Allison Rutter; Rebecca McWatters

NATURE OF OFF-CAMPUS ACTIVITY:

Scientific Studies and Environmental Monitoring at a Former Military Base at Resolution Island, Nunavut

Student group if applicable (*e.g.*, Course # or Team Name): n/a

LOCATION OF OFF-CAMPUS ACTIVITY:

Country:	Canada
Geographical Site:	Resolution Island, Nunavut
Nearest City: (name, distance to)	Iqaluit, Nunavut 310 km

PLEASE ATTACH A COMPLETE TRAVEL ITINERARY (LOCATIONS, DATES)

Itinerary for arctic travel is subject to frequent weather delays, as such, the best information that can be provided at this time is presented below.

OUTGOING

Depart (ASU Van) Kingston, ON 5:50AM July 25, 2010-Arrive Ottawa, ON 8:00AM July 25, 2010. Depart (First Air) Ottawa, ON 9:05AM July 25, 2010-Arrive Iqaluit, NT 12:15PM July 25, 2009. Depart (Ken Borek Air) Iqaluit July 26, 2010-Arrive Resolution Island, NT July 26, 2010.

INCOMING

Depart (Ken Borek Air) Resolution Island, NT August 9, 2010-Arrive Iqaluit, NT August 9, 2010. Depart (First Air) Iqaluit, NT 1:45PM August 9, 2010-Arrive Ottawa, ON 4:50PM August 9, 2010. Depart (ASU Van) Ottawa, ON 5:45PM August 9, 2010-Arrive Kingston, ON 7:45PM August 9, 2010.

MODE(S) OF TRANSPORTATION (check all that apply): For complete transportation information and restrictions, see Section 6.5 of the Off-Campus Activity Safety Policy.

☐ private vehicle* _____ ☐ Other (please specify_____

Ξ commercial carrier First Air, Ken Borek Air

*The ASU work van will be used. The driver will be selected from the list of ASU employees on the ASU private insurance policy.

DATE OF DEPARTURE:	**DATE OF RETURN:**
25 July 2010 (all dates are weather dependent)	**9August 2010 (all dates are weather dependent)**

CHAIN OF RESPONSIBLE LEADERSHIP: List all those who have a leadership role (including alternates); attach additional sheet if necessary.	Leadership Role (specify)	Trained First Aider (current)	Other Special Training
Dr Allison Rutter	Principal Investigator		
Rebecca McWatters	On site team leader	X	*

Queen's University Off-Campus Activity Safety Policy

Safety Planning Record

*ATV Safety Training Course			
NUMBER OF PARTICIPANTS (other than the leadership team listed above): ___4__			

RISK ASSESSMENT:
List identified hazards associated with activities or environment (*e.g.*, extreme heat or cold, wild animals, endemic disease, firearms, explosives, transportation, crime, violence, political instability), and risk-management measures planned or taken for eliminating or reducing risks to acceptable levels. Please see the attached examples. **Append additional pages as required.**

Hazard Identification	Risk Analysis	Risk-Management Plan
1. Site Isolation and rugged environment	Evacuation to a hospital if medical attention is required may be impossible due to poor weather conditions on site. There are steep cliffs and rugged terrain on site, which increases risk of injury if care is not taken**.**	Staff, are warned of hazards and are required to read the Health and Safety Plan written for Resolution Island. An orientation meeting for all staff involved is held before leaving for the site.
2. Polar Bears	Polar bear attacks are a possibility in the arctic. Polar bears are frequently sited at Resolution Island.	A bear monitor is on site at all times. Personnel do not work alone and the bear monitor will accompany staff at all times.
3. Poor weather	Cold, rainy and foggy days are common even in the summer months.	All staff are advised of weather conditions before leaving for the site as well as every day on site. Additional rain gear and coats etc are provided on site. No one works alone outside and if weather conditions are very poor outdoor work is not performed.
4. ATVs	Personnel are often using ATVs as transportation around site.	Site rules regarding ATV use are also outlined in the H & S plan and ATV training provided for key personnel. ATV training is provided on site before any use of the ATVs is allowed.
5. Contaminants on site	There are soils and oils containing high levels of PCBs on site at Resolution Island. There are also soils containing high metal content. Contact with PCBs and metals, is potentially a health hazard.	All personnel are instructed in the use of appropriate protective equipment as necessary. The appropriate use of the equipment is described in the Health and Safety Plan.

Queen's University Off-Campus Activity Safety Policy

Safety Planning Record

Examples of Hazard Identification, Risk Analysis and Management

The examples given below relate primarily to international activities, but similar hazards may arise in domestic situations.

HEALTH:

List hazards associated with personal health or health insurance, and the measures of eliminating or reducing the risks to acceptable levels. Examples to consider are: What diseases are prevalent? Do you have any personal health factors that could constitute a risk (*e.g.*, allergies)? Do you have appropriate health-insurance coverage? Is medical help available in the region you will visit? Are English-speaking doctors available? etc…

A. HAZARD IDENTIFICATION	B. RISK ANALYSIS	C. RISK-MANAGEMENT PLAN
Example: Increased reports of Dengue Fever in parts of the country you are going to – as well as cholera, hepatitis A, malaria (regional) tuberculosis, typhoid fever, and yellow fever (regional).	I/we could get sick, temporarily or permanently. The trip could be cut short. I am not yet sure of which regions are affected so I don't know if I/we will be exposed. There is potentially a lot of risk. The risk is high if I/we go to those regions, but less if I/we avoid them. The warnings on DFAIT have confirmed this. I don't know how all these diseases are transmitted.	I will visit a Travel Health Clinic to research and get necessary immunizations and learn how diseases are transmitted. I/we will try to avoid areas where there is greater risk of infection. I will research area affected.

ENVIRONMENTAL HAZARDS:

List identified hazards associated with the environment, *e.g.*, issues relating to weather; extreme heat/cold; water potability; natural disasters such as earthquakes; wild animals.

A. HAZARD IDENTIFICATION	B. RISK ANALYSIS	C. RISK-MANAGEMENT PLAN
Example: Typhoon warnings from October – January.	Safety is threatened. Typhoons occur regularly all over the country. They will be difficult to avoid during the rainy season. Some areas will be at more risk than others. People living in less built up regions at more risk. Homes are often destroyed, and people can be injured by flying debris. Driving during typhoons is not recommended. Uncertain when a typhoon will hit.	I will talk to local Embassy to find out what steps need to be taken in case of a typhoon and plan accordingly. I will pay close attention to weather reports. I will contact my travel agent or tour representatives and hotels to ensure that all services are available.

LEGAL CONSIDERATIONS:

List identified hazards associated with the laws and legal system of the country in which you will be living, *e.g.*, laws relating to drugs/alcohol, sexuality; severity of punishment for crimes; nature of the legal system; obtaining legal assistance.

A. HAZARD IDENTIFICATION	B. RISK ANALYSIS	C. RISK-MANAGEMENT PLAN
Example: Photography at airports, railway stations, naval bases, air bases, military installations, public water and energy plants, police stations, harbors, mines and bridges is prohibited in the host country. Laws are strictly enforced and all restrictions should be observed. If in doubt, look for an official and ask for permission.	Traveler could be fined or jailed. Travel could be delayed. Traveler could be deported. Risk is very preventable. Awareness of the laws is the key to avoiding trouble. Foreigners are more likely to be at risk than locals. It is likely I/we will visit one of these locations at some point during the activity.	I/we will avoid taking photos at such locations. I/we will observe locals for behavioural etiquett I/we will research penalties and other laws. I/we will ask permission before taking pictures.

PERSONAL RISKS AND EMERGENCIES:

List any identified hazards that may not have been covered in other sections, *e.g.*, hazards arising from regarding personal choices, language differences, recreational activities, sexuality, accidents, violence.

A. HAZARD IDENTIFICATION	B. RISK ANALYSIS	C. RISK-MANAGEMENT PLAN
Example: Crime is an ongoing concern in your host country. Violent crimes, such as car hijacking, assault, and armed robbery are frequent. There have been cases of short-term kidnapping where the victim was forced to withdraw money from an automatic teller machine.	I/we could be a victim of any of the crimes mentioned. There is a very high risk of encountering this hazard. This is likely to happen to a lone traveler alone, or one who looks as though they have a lot of money, is wearing flashy clothes, *etc*. Women and travelers are probably more at risk. Impacts could be financial, or threat to personal safety. DFAIT warns Canadians about this risk.	I/we will avoid travel alone. I/we will consider other forms of currency, *e.g.*, traveler's cheques. I/we will avoid areas known for crime. I/we will dress conservatively. I/we will be aware of surroundings and people.

Queen's University Off-Campus Activity Safety Policy
Safety Planning Record

TRAINING REQUIRED: All terrain vehicles (ATV) are often used on site. Personnel will be instructed (on site) on how to operate ATV vehicles. The team leader will ensure the competency of any team members before allowing them to ride unsupervised. All rules pertaining to ATV use in and around the camp (as specified in the Resolution Island Health and Safety Plan) will be observed.

IDENTIFICATION OF DISABILITIES / SPECIAL NEEDS / MEDICAL NEEDS:

Do any of the off-campus activity participants have a disability or medical need that would affect their safe participation? ☐ yes X☐ no
If so, please provide details of the arrangements that have been made to accommodate the special/medical needs:

Do any of the participants have allergies (*e.g.*, to bee stings, food, drugs)? X☐ yes ☐ no
If so, please indicate the provisions that will be made to deal with allergic reactions should they arise.

Dan and Alex: penicillin Sonja: mayonnaise, msg Rebecca bee stings and has 2 epipens with her.

TRAVEL IMMUNIZATION/PROPHYLAXIS REQUIREMENTS:

☐ Altitude sickness medication	☐ Polio	Other (specify):
☐ Diphtheria	☐ Rabies	☐ _____
☐ Hepatitis A	☐ Rubella	☐ _____
☐ Hepatitis B	☐ Tetanus	☐ _____
☐ Japanese encephalitis	☐ Tuberculin testing prior to departure	☐ _____
☐ Malaria	and 3 months after return	☐ _____
☐ Measles	☐ Typhoid.	X☐ Not Applicable
☐ Meningococcal	☐ Yellow Fever	

EMERGENCY PROCEDURES: Please see Emergency Procedures Checklist below.
Detailed Emergency Plan for Activity location (communication and evacuation)

These are outlined in the Resolution Island Health and Safety Plan and are reviewed by the Health and Safety Officer during on site orientation which is required for all new personnel on site. A copy is located in two three inch binders in room 0625.

University Contacts and Phone Numbers (people at Queen's who are designated as emergency contacts for the field party):	**Local Contacts and Phone Numbers (contact information for the field party):**
1. See attached phone list provided to all participants. 24h hour mobile contact available for principal investigator.	1. See attached phone list provided to all participants.
2.	2.

EMERGENCY PROCEDURES CHECKLIST (ITEMS TO CONSIDER – ALL MAY NOT APPLY)

Communications

1.	Handout listing emergency numbers & mobile phone with group	X☐
2.	Emergency contact number for Campus Security Services (613-533-6111)	**n/a**
3.	Alternate address/numbers/information for off-campus emergency contacts including nearest Canadian embassy	**n/a**
4.	Identify if transport also has radio/phone & number	X☐

Procedures

5.	Outline process for contacting Emergency Support	X☐
6.	Emergency rendezvous site address	X☐
7.	Team Leader & line of authority	X☐
8.	Identification of First Aid certified participants	X☐
9.	Identification of translators	**n/a**
10.	Identification of alternate/emergency driver(s)	**n/a**
11.	Outline use of special equipment	**n/a**

Queen's University Off-Campus Activity Safety Policy

Safety Planning Record

ACKNOWLEDGEMENT and CONSENT

I, the undersigned, acknowledge that:
(a) I have been advised of the known/reasonably foreseeable risks associated with this off-campus activity and I consent to assume them;
(b) I have been advised that I have certain responsibilities as a Participant under the Off-Campus Activity Safety Policy and I consent to assume them;
(c) I am in a satisfactory state of health to undertake the off-campus activity and I have received all of the prescribed immunizations;
(d) I have been informed that I will need supplementary health insurance and that I am responsible for obtaining required visas and travel documents for my participation in international activities;
(e) I will comply with safety instructions from activity leaders; and
(f) I will act in a safe and responsible manner throughout the course of the off-campus activity, taking into account instructions received and the welfare of others.

PARTICIPANTS (add additional pages as necessary to include all participants):

Name (please print)	Signature	Date
Rebecca McWatters	RMcWatters	15-Jul-10
Sonja Koster	Sonja Koster	7 July 2010
Daniel Jones		7 July 2010
Alexandra Gerber		7 July 2010
Ellen Woolfenden	EWoolfenden	16 July 2010

Queen's University Off-Campus Activity Safety Policy

Safety Planning Record

I certify that in my capacity as Off-Campus Activity Leader I will ensure that the Activity described above will be conducted in accord with the Queen's University Off-Campus Activity Safety Policy and this Safety Plan.
I affirm that I will file a Post-Activity Incident Report (Form 3) within two weeks of the completion of the off-campus activity if any critical or non-critical incidents have occurred during the conduct of the activity.

Rebecca McWatters Research Associate.
Name & Title (Off-Campus Activity Leader)

Signature

19-Jul-10
Date

I certify that this Safety Planning Record accurately describes the scope of the Off-Campus Activity, identifies the foreseeable hazards, and documents the plans that have been put in place to manage the associated risks.
I affirm that I will ensure that, in accord with the Queen's University Off-Campus Activity Safety Policy, the participants are appropriately briefed and have received appropriate training prior to participating in the activity.

Allison Ritter, Director, ASL
Name & Title (Principal Investigator/Activity Coordinator)

Signature

15 July 2010
Date

I certify that I have reviewed and approved the above Off-Campus Activity Safety Plan:

Brian Cummings, Director, SEES
Name & Title (Department/Unit Head (Person in Authority))

Signature

21 July 10
Date

- Once completed, this Form is to be forwarded to the Department of Environmental Health and Safety, where it will be retained for a period established by the University's Records Management System.
- A copy is to be retained in the office of the Department/Unit Head (Person in Authority).
- In the case of an undergraduate student activity involving international travel, a copy is to be forwarded to the International Centre at least three weeks prior to the planned departure.

Appendix C: Biogenie Resolution Island Landfill Monitoring Report (Tier II, Airstrip Dump; Maintenance Dump)

Appendix D: Biogenie Revised Resolution Island Monitoring Program Recommendations (Letter)

March 29, 2011

CONFIDENTIAL

Stephen Hooey, P. Eng.
Senior Project Manager
Contaminated Sites Program Directorate
Indian and Northern Affairs Canada
P.O. Box 2200, Building 1104B
Iqaluit, Nunavut X0A 0H0

SUBJECT: Revised Resolution Island Long-Term Monitoring Program - Recommendations (O/Ref.: DI9653)

Dear Stephen:

In 2003, the Department of Indian Affairs and Northern Development produced the Resolution Island Monitoring Program as part of an application for a water license to the Nunavut Water Board (NWB App. #NWB5RES0308). Several monitoring activities were to be implemented upon completion of the remediation operations on Resolution Island. Most of these activities were associated with the newly constructed non-hazardous waste landfills, the Tier II Disposal facility and soil/sediment interceptor barriers.

The activities identified in the above-noted monitoring program included:

- Visual inspection of the Station and Beach Non-Hazardous Waste Landfills;
- Visual inspection, groundwater and soil sampling at the Maintenance and Airstrip Dumps;
- Visual inspection, groundwater and soil sampling and thermal monitoring of the Tier II Landfill;
- Visual inspection and soil/sediment sampling of the interceptor barriers;
- Analyses of soil and groundwater samples for metals, total petroleum hydrocarbons and polychlorinated biphenyls analyses.

The landfills and barriers baseline study was to be performed in 2006 with actual monitoring every year for the first 5 years (until 2011), and then in years 7, 10, 15 and 25, with a forecasted end in 2031. A full review of all data gathered was to be undertaken at the end of the fifth year.

ACTUAL REVISION TO THE MONITORING PROGRAM

The landfills baseline study was actually performed in 2005, one year earlier than planned. Since then, monitoring activities took place every year. The full review of all data gathered since 2005 was produced by Queen's University in the fall/winter of 2010/2011.

Since the monitoring activities started 1 year earlier than planned, the monitoring schedule should be revised as presented in Table 1. The new completion year is now estimated at 2030.

RECOMMENDATIONS FOR CONTINUED MONITORING

As for the 2010 Landfill Monitoring Report, all future monitoring reports should exclude the activities performed at the soil/sediment interceptor barriers. Queen's University is conducting research on these barriers and will develop associated closure plans.

Since annual activities may continue to take place on the island for several years, we recommend completing landfill inspection sheets every year for every landfill when qualified personnel are on site. Thermistor data from the Tier II Landfill could also be collected during the annual visit. These minimal activities would ensure prompt action is taken in case significant landfill stability problems are noted. Actions to be taken are clearly identified in Section 4 of the *Abandoned Military Site Remediation Protocol-Volume II (2009)*. They can be summarized as follows:

- Marginal Stability Rating: Increase monitoring frequency / Assess cause of instability;
- Significant Stability Rating: Assess cause of instability / Develop remedial action plan;
- Unacceptable Stability Rating: Implement emergency remedial plan.

Should additional information be required, please do not hesitate to contact us.

Sincerely,

Jean-Pierre Pelletier, B.Sc.
Team Leader, Northern Canada Office

JPP/ mr

S:\P\DI\9653\2011\Lanfill Monitoring.docx

Table 1: Monitoring requirements for BAF-5 Landfills

Landfill	Visual Inspection	Soil Sampling	Groundwater Sampling	Thermal Monitoring
YEAR 2012				
Tier II Landfill	✓	✓	✓	✓
Airstrip Landfill	✓	✓	✓	
Maintenance Area Dump	✓	✓	✓	
Non-Hazardous Waste Landfills (2)	✓			
YEAR 2015				
Tier II Landfill	✓	✓	✓	✓
Airstrip Landfill	✓	✓	✓	
Maintenance Area Dump	✓	✓	✓	
Non-Hazardous Waste Landfills (2)	✓			
YEAR 2020				
Tier II Landfill	✓	✓	✓	✓
Airstrip Landfill	✓	✓	✓	
Maintenance Area Dump	✓	✓	✓	
Non-Hazardous Waste Landfills (2)	✓			
YEAR 2030				
Tier II Landfill	✓	✓	✓	✓
Airstrip Landfill	✓	✓	✓	
Maintenance Area Dump	✓	✓	✓	
Non-Hazardous Waste Landfills (2)	✓			

Appendix E: Inuktitut Translations of Executive Summaries Appendices A to C

ᐅᓂᐦᑲᓕᐅᑭᑦ ᓇᐃᓐᓴᕐᓯᔾᔨᓪᓗ

ᑕᒡᓕᒪᑦ ᐅᑭᐅᑦ ᐊᓐᓄ ᐊᓂᔪᕐᓯᓕᓕᕐᖁᓪᓗ ᑕᐃᒪᓚᕐᑐᑦ ᐱᖏᓐᖁᑕᐅᓕᕐᖁᒪᒪᓕᓂᑦ ᐅᑎᕐᖁᑎᑕᑦᓯᓕᒪᕐᓂᕐᓴᕐᓂᑦ ᐱᓕᕐᓴᕐᖁᐊᓂᖅ ᑐᓴᐅᒃ. ᑕᓚᓄ ᐅᓂᐦᑲᓕᐅᑭᑦ ᖃᐅᐅᔾᔪᑎᐊᖃᓚᐅᑭᖅ ᖃᐅᐅᖏᐅᓕᔾᓂᐅ ᖃᐅᐅᖏᕐᓴᑦᓯᓕᕐᓴᐅᖁᓂᑦ ᐱᑎᕐᓴᐅᑦᓴᕐᓯᓕᕐᓂᑦ 2006-ᒥ. ᖃᐅᐅᖏᕐᓴᑦᓯᓕᕐᓂᖅ ᖃᐅᐅᖏᔾᔨᕈᐅᑐᓕᖃᑦᑕᖃᓕᕐᓂᖅ that ᐱᓕᒪᓚᐅᑦᓗᐊᖅᓯᑕᐃᓂᐅ ᐃᓕᓴᒧᓗᓇᖅᑐᑦᖃᖏᕐᓂᖅᓱᓕᑦ ᑭᓕᓴᐃᓇᓚᖅᑐᐃᓐᓇᖅ ᖃᐅᐅᖏᕐᓴᑦᓯᓕᕐᓂᑦ ᐊᓕᒪᓂᓗᑦᓯᓕᕐᖁᐅᓇᓕᖃᖅᑐᑦᓯᑐᓗᑦ ᐊᓕᒪ ᐱᖏᓇᓕᑦᑐᓗᓴᐅᓂᐅᒃ ᐅᑎᖅᑎᑕᑦᓯᓕᕐᓂᖅᑐᑦᓯᓇᓕᖃᖅᑐᖅᑭᓇᓕᑦᓗᑦ.

ᐊᐅᐅᓴᕐᑎᓕᐅᑭᑎᑦᓕᓇᑐᓕᖅ ᑕᐃᒪ ᐃᓂᓕᑎᒥᓂᕐᓂᓂᒃ ᐊᑦᑕᕐᕆᒪ ᑯᓴᒪᒃ. ᐃᑦᑕᓭᒥᒃ ᖃᓄᐃᓕᓕᕐᔪᑦᑐᒃ ᓴᓐᓗᑕᖅᑕᖃᖅᓱᓂᒃ ᖃᓄᖅᓯᒪᓂ ᐃᓴᐊᓂ ᑯᓴᒪᒃ. ᑕᐅᓴᐅᑎᓄᑦ ᓄᓇ ᐅᑎᖅᑎᑕᑦᓯᓚᕐᖁᑎᑦᓕᓗᒍ 2000-ᒥ, ᓴᓇᕐᑕᑎᓚᐊᑭᑎᓂᒃ ᖃᑭᓪᓕᖅᑐᓂᒃ ᐋᓱᐋᓂᒃ ᖃᐅᐅᔾᔨᖅᑐᓕᕐᓂᕐᓴᓕᔾᔨᖅ. ᑕᐃᓐᓇ ᖃᐅᐃᖅᓱᖅ ᑯᓴᖏᓐᓂ ᐃᖏᑕᐅᑦᑎᐊᓕᕐᓂᖅᑐᖅ ᐊᓕᒪ ᓴᓂᖅᑕᐅᓕᖅᑐᑦ ᐊᓕᒪ ᐊᑦᑕᕐᓴᐊᖅ ᐳᐊᖏᓚᖅᑕᐅᑦᓕᓗᒍ, ᑭᓱᓕᓂᓂᒃ ᐊᓱᐋᓂᒃ ᖃᐅᐅᔾᔨᖅᑐᓕᕐᓂᕐᓴᓕᔾᔨᖅ. ᑕᐃᓐᓇ ᖃᐅᐅᔾᔨᖅᑐᓕᕐᓂᕐᓴᓕᔾᔨᖅ ᓇᓗᓇᕐᓂᖅᑐᑦᓯᐊᓕᖅᑐᑦ ᐊᓕᒪ ᐃᓴᖅᑕᐅᓕᕐᓂᖅᑐᑦᓯᓇᓕᖃᖅᑐᑦ 2012-ᒥ. ᑕᐃᓐᓇ ᓴᐅᓗᑕᖅ ᖃᐅᐅᔾᔨᓴᖅᑕᐅᓕᕐᓂᐅᑦᓯᓕᕐᖁᑦᑕᑐᓴᓴᖅᑕᐅᓕᕐᓂᖅ ᐊᑦᕿᔪᑕᒧᑦ ᐊᓕᒪ ᐃᓕᓴᐅᕐᓴᐅᓗᑎᒃ ᓄᓇᓕᓐᓴᕐᑎᑦ ᐊᐅᑦᑕᕐᔨᓕᓚᐃᑦ ᓯᖅᑯᐊᓕᖅᑕᐅᓕᕐᖁᐊᓕᖅᑐᐃᓴᓴᖅᑕᐅᓕᕐᓂᑦ ᐱᐅᓗᐊᑦᓖᒧᑦᓕᒪᓐᓇᑦ. ᐃᓴᕐᓂ ᐊᐅᓕᑕᐅᓕᕐᓂᑦ ᐊᑕᓂ ᐱᑦᓴᐃᓕᑦ ᐱᑕᐊᓕᕐᓂᖅᑐᑦᓯᓂᐅᓴᓴᖅᑕᐅᓕᕐᓂᑦ ᐊᓕᒪ ᐃᓴᖅᑕᐅᓕᕐᓂᖅᑐᑦᓯᓇᓕᖃᖅᑐᑦᓯᓴᓴᖅᑕᐅᓕᕐᓂᑦ ᐊᓕᒪ ᐃᓕᓴᐅᕐᓴᐅᓗᑎᒃ ᓄᓇᓕᓐᓴᕐᑎᑦ ᐊᐅᑦᑕᕐᔨᓕᓚᐃᑦ ᐱᐅᓗᐊᑦᓖᒧᑦᓕᒪᓐᓇ

ᓄᓴᖅᓯᓄᑦᑐᑦ, ᓄᓇᒋᔭᐅᓂᐊᓱᖃᑦ ᐊᓪᓚ ᖃᐅᔨᓕᖅ ᐃᓕᓴᕐᕕᖅ ᖃᐅᔨᒍᓕᓪᓚᑦ ᒥᕐᕕᓪᓗ ᖃᐅᔨᓴᕐᕕᖏᓐᓇᕐᓂᖅᓯᓕᕆᓂᖅᖃᖅᑐᑦ ᐊᖏᔪᒋᑦᑎᓪ ᑕᐃᒪᐃᑕᐅᔭᕆᓚᐅᖏᖅᑐᑦᑕᑎᑦ ᐱᖏᔪᒪᓂᖅ.

ᖃᐅᓕᕆᓂ II-ᒥ ᐊᑕᖏᕕᖅ ᐃᓕᓴᕐᕕᖅ ᖃᐅᔨᓴᖅᖢᑦᓕᐊᔨᓴᓕᕐᖏᑦ ᓄᐊᖏᑎᓂᒃᑯᑦ ᐊᓪᓚ ᖃᑎᖏᑕᒃᑯᑦ ᐃᒥᖏᒃ ᖃᐅᔨᓴᖅᖢᑦᓕᐊᕕᖅᓂᓂ ᐃᒥᖅᑕᕕᖅᓂ, ᐃᓕᓴᕐᓂᖏᒃ ᖃᑎᖏᑕᒃᑯᑦ ᐊᓪᓚ ᓴᓇᔨᐅᓕᓴᓂᒃᑯᑦ. ᓴᐅᔭᐅᓕᓴᑦ ᓯᑕᖏᑐᓴᓕᐃᓕᑦ ᐃᓕᑎᑕᐅᓂᖅᓯᓕᕆᓂᖅᓯᑦ ᐊᓪᓚ ᓯᑕᖏᑐᓴᓕᐃᓕᑦ ᓄᓇᒋᔭᐅᓂᖅᓯᓕᕆᓂᖅᓯᑦ, ᐅᓇᖏᓂᖏᒃ ᖃᑎᖏᑕᒃᑯᑦ ᐊᓪᓚ ᓴᓇᔨᐅᓕᓴᓂᒃᑯᑦ. ᓴᐅᔭᐅᓕᓴᑦ ᓯᑕᖏᑐᓴᓕᐃᓕᑦ ᐃᓕᑎᑕᐅᓂᖅᓯᓕᕆᓂᖅᓯᑦ ᐊᓪᓚ

ᐅᓂᖅᑎᓕᐅᑦ ᓇᐃᓇᖅᓱᓪᓚᑦ

ᑭᓴᓇ ᐅᓂᖅᑎᓕᐅᑦ ᐅᖅᑎᐅᓱᖅᑕᑕᐅᓱᒪᐅᑦ ᑕᒪᑐᒋᖓ ᐱᓕᕆᐊᖓᓱᒪᔪᒥᑲ ᖃᑎᖅᑭᓂᖅᓯᒪᑦ ᐱᐅᓯᑎᕋᐅᑎᓕᕆᓚᒪᓯᑦ ძᐃᑦ ᐃᓕᓴᓂᐊᕐᕕᖏᓂᒃᓴᓂ 2010-ᒥ ᐃᓄᓕᕆᔨᑐᖅᑲᓴᓂ ᑲᓇᑕᒥ. ᑕᒪᓴᓇ 50-ᑎᕐᐅᑲᖅ ᐅᑎᐅᖅ ᐊძᓂᐅᔪᒥ ᖃᑲᐅᔨᖅᑕᑦᓕᓂᖅᓯᑦ ᐃᓂᑎᕐᓗᒥ ᐱᖏᓪᓗᑕᐅᓕᖅᑎᑦᓴᔭᔪ ᐅᑎᖅᑎᑎᐊᖅᑎᓂᒃ 2005-ᒥ. ᐃᓚᓂᖅᓴᐃᑦ ᖃᑲᐅᔨᕐᑎᑦ ᐱᓕᕆᐊᖓᔪᓂᕐᓂᖅᓴᓂᓕᑦ ᑕᒪᑕᒪᓂᖅ ᐊᑐᖅᑐᖅᓯᒪᔪᓂᖅ.

ᐃᒥᖅ, ᐃᓕᔪᖅ ᐊᓚᒪ ᓴᓂᓕᐅᖅძᑎᓄᑦ ᐱᓕᐅᓱᒪᔪᑦ ᐱᖓᓱᓂᑦ ᓯᕐᓴᕐᑕᑐᓂᑦ ᐊᓯᐃᓄᑦ ᑕᓄᑦᓯᑐᓂᑦ ᖃᑲᐅᔨᓴᖅᓂᕐᕿᐃᐅᑕᐅᖅᑐᑦ ᑲᑎᒪᔨᖅᑐᑦ ᐊᓚᒪ ᖃᑎᖅᑭᑦᑕᑦᑐᖅᓯᒪᔪᓂᖅ ᐱᑕᖃᖅᑐᑦᑕᖅᑐᑦᑕᐅᖅᑐᑦ ᐊᑕᖅᑐᑦᑕᐅᖅᑐᑦ ᐱᑕᖃᖅᑐᑦᑕᖅᓯᒪᔪᓂᖅ ᑲᑎᒪᔨᖅᑐᑦ ᐱᑕᖃᖅᑐᑦᑕᖅᓯᒪᔪᓂᖅ ᓴᓇᓂᖅᑐᑦ ᐅᑎᐅᖅ. ᐃᓕᓴᕐᓂᐊᕐᕕᖏᓂᒃᓴᓂ ᑕᑯᔭᖅᑐᑦ ᐊᓚᒪ ᓴᓂᓕᐅᖅᑐᑦ

ᐊᐅᓪᕎᑎᔨᓄᐊᖏᑐᐳᒪᔭᑦ ᓇᐃᓰᖏᑕᐅᓱᒪᔪᑦ

<ᐃᐅᔨᔭᓂᐳᑯᑦ, (Biogenie–ᑯᑦ), ᐃᓪᒥᕆᐅᔪᑦ ᐊᓐᔪᑐᐱᑯᑦ ᑯᐊᐳᓰᒃᖖᓐᓄᑦ (EnGlobe Corp–ᑯᑦ),. ᑲᓐᑐᓪᒋᖏᕆᑎᑕᐅᓪᓕᖏᑕᐅᓱᒪᔪᑦ ᐃᓄᓪᓕᐊᑐᑐᖏᑲᑯᓐᓄᑦ, ᐱᓪᓕᐊᔨᐅᓂᔭᒍᑦ ᖃᐅᔨᒪᖏᑦᐸᑦᓪᓕᐊᓂᖏᓐ ᑕᒪᐃᓐᓂᐳ ᐊᐳᑕᕐᓇᒃᖖᒪᔪᔪᓂᐳ BAF-5–ᒥ, ᐅᓇᒥᖏᑐᑐᒪᐃᑦ ᓇᓪᐅᔨᑎᖏᕆᓇᓇᓂᖓᑎᓐᓂ, ᑐᑦᓱᓂ ᖁᑭᖏᑕᓂ, ᓄᓇᕐᓚᒥ.

ᑐᕆᒪᖏᕆᒪᑕ ᓄᓇᒥᐅ ᐊᐳᑕᑯᖏᕆᓇᓐᓂ ᖃᐅᔨᒪᖏᐸᑦᓪᓕᐊᖓᑎᓐᓂᖏᖓ ᐱᔪᐊᑎᖏᖏᓂᐳᑎᐅ ᑲᑎᖏᓂᐳᓚᒥᓂᖏᖓ ᓇᓚᔪᓂᐳ ᖃᐅᔨᒪᔭᐊᑎᑲᖓᓂᐳ, ᑐᑭᑕᑭᑕᐅᖏᑕᑦᓂᓪᓕᐊᖏᑐᑐᓂᐳ ᐊᐅᑎᖏᑦᑎᐊᓂᖓᖖᑎᓂᐳ ᓄᓇᐃᑦ ᐊᐅᑎᖓᔨᓪᓗ ᐃᓂᐳᓪᓚᑎᑦᓗ, ᐃᐳᐱᑎᑦᔨᓪᓗ ᐊᐅᑎᖓᔨᓪᓗ.

<ᐃᐅᔨᔭᓂᐳᑯᑦ ᐃᑦᖏᓇᐃᔨᖏᑎᖓᑦ ᓄᓇᒦᓪᒥᕆᐅᔪᑕ ᑕᐅᐅᓂ ᐋᑎᓂ 5–11, 2010–ᒥ ᐊᓚᒪᓗ ᐃᓪᒥᐅᓪᒥᐅᖏᐳᑎᐅ ᓄᓇᒥᑎᑎᐅᐸᓂᐅ ᖃᐅᔨᒪᖏᑕᐅᕐᕿᓐᒥ ᐱᓪᓕᐊᓇᖓᓂ ᑯᐃᐟ ᔪᐃᓂᖓᐳᑎᐅᑯᑦ ᐃᑦᖏᓇᐃᔨᖏᑎᖓᖖᑎᓂᐳ.

ᖃᐅᔨᒪᖏᑕᐅᓂᐊᖏᑐᑦ ᐊᓚᒪᓗ ᖃᐅᔨᒪᔭᐊᑎᖏᒪᐃᑦ ᑲᑎᖏᐳᖏᑕᐅᓪᒥᐅᖏᑐᑦ ᑕᐅᐅᓂ ᑕᑯᓂᐊᖏᑕᐅᓱᒪᓪᓕᔪᐃᒍ BAF-5 ᓄᓇᖏᑐᓂ ᐊᐅᑦᕿᐃᑦ ᐅᑯᓇᓂᕐᑐᓂ: ᑐᓴᓪᖏᐸᒥ ᖃᑯᓪᓚᓪᓕᐊᖓᐳᒪᔪᖏᖏ ᐳᖏᑐᑐᖏ II, ᒥᑦᑕᕿᖓᒥ ᐊᐅᑕᑯᐃᑦ ᐊᓚᒪᓗ ᓴᓇᔨᓄᑦ ᐃᓂᖓᐳᓂ ᐃᓂᐅᕿᖅ. ᒪᓪᐅᑕᐅᔨᓪᓗᑎᐅ ᑕᐃᒃᑯᐊ ᓱᓕᓪᓕᖏᐸᒥ ᐋᑦᑭᐳᒪᓪᓕᐊᓂᖓᖖᑎᓂᐳᓂᐳ ᖃᐅᔨᒪᖏᑕᐅᓪᒥᐅᖏᑐᑦ, ᑕᒪᐃᓐᓂᐳ ᐊᑐᑦᑎᐊᓂᖓᖖᑎᓂ ᑲᒃᑯᐊ ᐱᖓᓱᓂ ᐊᐅᑕᑯᓕᐅᖏᑐᐳᒪᔪᑦ ᓇᓪᓕᐅᐃᖏᑕᐅᓱᒪᓕᖓᓂ ᓇᓚᒃᑐᒥᒃ.

11-ᖏᒍᐳᓂᐅ ᓄᓇᒥᐅ ᐅᐳᑐᕆᐃᖏᓐᓇᑦ ᑕᐅᓂᐊᖏᑕᐅᓱᒪᓪᓕᐅᖏᑐᑦ 2010–ᒥ ᐊᑦᕿᔪᒥ ᖃᐅᔨᒪᑦᖖᓂᖏᓐᓂ. ᐊᑕᐅᓱᖏ ᓄᓇᒥᐅ ᐊᔪᓱᖏᐅᓱᒪᑦᓪᓗᓂ ᐅᐳᑐᕆᑦᑕᒃᖖᖏ (0-15 ᒪᓐᑎᑦᑕᓪᓂ ᓄᓇᐅᑦ ᖃᐅᔨᒪᑦᖖᓂᖏᓐᓂ ᑲᑎᖏᓂᐳᓚᒥᓂᖏᖓ ᑕᑯᓂᐊᖏᑕᐅᓱᒪᓪᓕᐅᖏᑐᑦ ᐊᐅᑎᖓ ᑕᒪᐃᓐᓂᐳ ᐃᓂᐳᓪᓚᑎᑦᓗ ᐱᓪᓕᐊᓂᖓᖖᑎᓂᐳ ᐊᓐᔪᑐᐱᑯᑦ ᐃᓂᐳᓪᓚᑎᑦᓗ ᐊᐅᑎᖓᔨᓪᓗ

ᐃᓱᒪᓕᑎᒃᖁᐅᓇᖅᑐᑐᒃ. ᑕᐃᒃძᐊ ᑕᒪᖏᐅ ᖃᐅᐅᕆᐳᑎᑦ ᓂᖅᓪᓱᓴᑎᑎᓂᖏᐅ ᖃᐅᐅᕆᐳᑎᑦ ᐊᐧᖁᐅᒪᖏᐊᓪᓕᐅᖏᖏᓪᔪᒃ. ᖃᐅᐅᕆᒪᔨᔪᑎᒃᖁᐃᑦ ᓂᖅᓪᓱᐧᓂᖅᓴᓂᒃ ᖃᐅᐅᕆᐳᑎᑦᓂᒃ ᑲᑎᖁᐅᒪᖏᐊᓪᓕᐅᖏᖏᓪᔪᒃ ᑲᑎᒃᓴᖏᑕᐅᖏᖏᓪᔪᒃ ᖃᐅᖏᓱᖃᑕᐅᖏᖏᓪᔪᒃ ᑲᑎᖁᐅᒪᖏᐊᓪᓕᐅᖏᖏᓪᔪᒃ.

Appendix F: Biogenie Health and Safety Plan

LONG TERM MONITORING OF BAF-5 POLE VAULT MILITARY RADAR STATION
Resolution Island, Nunavut

HEALTH AND SAFETY PLAN

(O/Ref.: DI9653) (Y/Ref.: SOA 01-09.6039-3)

INDIAN AND NORTHERN AFFAIRS CANADA

July 2010

Biogenie, a division of EnGlobe Corp.
4495 Wilfrid-Hamel Blvd., Suite 200
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Tel.: 418-653-4422
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Table of Content

1. General Prevention Guide - Health & Safety
2. Fire & Emergency Plan
3. Safety Guidelines for Subcontractors and Visitors
4. Specific Prevention Program
5. Job Safety Analysis
6. Employee Commitment Form
7. Environment and Safety Meeting

MSDS Propane

MSDS Gasoline

MSDS Paint Thinner

MSDS Primer

MSDS Paint (alkyd)

MSDS Primer

General Prevention Guide - Health & Safety

EnGlobe Corp. Reference Guide
1450-GU01-EV1, 09-01-30

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TABLE OF CONTENTS

1 INTRODUCTION....1

2 OBJECTIVES....1

3 SCOPE....1

4 HEALTH, SAFETY AND ENVIRONMENTAL POLICY....2

PART I – GENERAL HSE PROVISIONS 3

5 LEGAL AND ADMINISTRATIVE CONSIDERATIONS....3
- 5.1 Legal and Regulatory Framework....3
- 5.2 General Employee Rights....3
- 5.3 Right to Refuse Dangerous Work....3
- 5.4 Preventative Re-assignment....3
- 5.5 Temporary Assignment....4

6 HSE RESPONSIBILITIES....4
- 6.1 Responsibilities of the Company, Territorial Divisions and Business Units....4
- 6.2 Responsibilities of Project Managers, Supervisors and Foremen....4
- 6.3 Responsibilities of Workers....5
- 6.4 Responsibilities of Subcontractors, Suppliers and External Consultants....6
- 6.5 Due Diligence....6
- 6.6 Behaviour-based Safety – Safety Without Compromise....6
  - 6.6.1 Last-Minute Risk Assessment (LMRA)....6
- 6.7 Specific Requirements for Construction Sites (in Quebec)....7

7 HSE DOCUMENT MANAGEMENT TOOLS....7
- 7.1 HSE Records....7
- 7.2 HSE Objectives, Targets and Corporate Prevention Plan....7
- 7.3 Site-specific HSE Prevention Programs....7
- 7.4 HSE Instructions....8

8 GENERAL PREVENTION AND SAFETY INSTRUCTIONS....8
- 8.1 Access to the Site and to Protective Equipment....8
- 8.2 Signage....8
- 8.3 Vehicle Traffic....9
- 8.4 Driving a Road Vehicle....9
- 8.5 Safety Clothing, Equipment and Devices....10
  - 8.5.1 Collective and Personal Protection Equipment....10
  - 8.5.2 Worksites and Other Sites....10
  - 8.5.3 Specific Instructions for Respirators....11
  - 8.5.4 Other Safety Accessories and Equipment....11
  - 8.5.5 Emergency Facilities....12
  - 8.5.6 Prohibited Accessories and Clothing (for Safety Reasons)....12
  - 8.5.7 Contact Lenses....12
- 8.6 Planning of Work Areas....12
  - 8.6.1 Facility Maintenance (Indoors)....12
  - 8.6.2 Material Piling....13

8.6.3 Worksite Preparation....13
8.6.4 Ventilation, Air Conditioning and Heating....14
8.6.5 Drinking Water and Sanitary Facilities....14
8.6.6 Prevention of Access....14
8.7 Particular Guidelines....14
8.7.1 Alcohol, Drugs and Medication (Illicit Substances)....14
8.7.2 Safe Use of Cell Phones and Walkie-talkies....15
8.7.3 Walk-mans, MP3s and iPods....15
8.7.4 Fatigue and Overstress....16
8.7.5 Smoking in the Workplace....16
8.7.6 Rough-housing and Running....16
9 PROVISIONS FOR SUBCONTRACTORS, VISITORS AND TRUCK DRIVERS....16
9.1 Subcontractor Qualification....16
9.1.1 Pre-qualification Program (for all Subcontractors)....16
9.1.2 Carrier Selection and Qualification....16
9.2 Safety Guidelines for Subcontractors and Visitors....17
9.2.1 Specific Safety Guidelines for Truck Drivers....17
9.2.2 Safety Guidelines for Visitors....17

PART II: HEALTH AND SAFETY PREVENTION PROGRAMS 19

10 IDENTIFICATION OF HAZARDS AND RISK ASSESSMENT....19
10.1 Hazards Associated with Company Operations and Tasks....19
10.2 General Prevention Measures....19
11 MECHANICAL, HYDRAULIC AND PNEUMATIC ENERGY....20
11.1 General Prevention Measures for Mechanical, Hydraulic and Pneumatic Power....20
11.1.1 Purchasing and Renting Policy....21
11.1.2 Protective Devices....21
11.1.3 Assessment of Risks Associated with a Machine or Equipment....21
11.1.4 Safety Control Devices....22
11.1.5 Lockout....22
11.1.6 Procedure for Accessing a Machine in Reduced-Speed Mode....22
11.1.7 Emergency Shutdown....23
11.1.8 Preventive Maintenance....23
12 ELECTRICAL ENERGY....23
12.1 Targeted Equipment....24
12.2 General Prevention Measures....24
12.2.1 Identification of Electrical Equipment....24
12.2.2 Staff Qualifications and Training....24
12.2.3 Adoption of Basic Safety Rules for Electrical Equipment....24
12.2.4 Securing of Operations and Lockout....25
12.2.5 Preventative Maintenance and Reliability of Electrical Equipment Components....25
12.3 Specific Prevention Measures: Electric Arcs and Excavations....26
12.4 Prevention Measures – Lightning....26
13 THERMAL ENERGY (HEAT OR COLD)....27
13.1 Targeted Equipment and Operations....27
13.2 General Prevention Measures (Equipment)....27

13.2.1 Protective Devices and Equipment Insulation 28
13.2.2 Staff Training 28
13.2.3 Preventive Maintenance of Equipment 28
13.3 Preventative Measures for Heat Stroke 28
13.4 Preventative Measures for Cold Temperatures 30

14 ELEVATED WORK, FALLS, CRUSHING AND ENGULFMENT 31
14.1 Targeted Facilities and Equipment 31
14.2 General Prevention Measures 31
14.2.1 Falls During Elevated Work 31
14.2.2 Slipping, Tripping and Falling on the Same Level 32
14.2.3 Falling Objects, Overturned Vehicles, Collapse and Engulfment 32
14.2.4 Falling into Water 33

15 WORKING IN CONFINED SPACES 33
15.1 Targeted Facilities and Equipment 34
15.2 Risk Situations Involving Confined Spaces 34
15.3 Assessment of Risks and Health Effects 35
15.4 General Prevention Measures 35
15.4.1 Identification of Confined Spaces and Risk Assessment 35
15.4.2 Procedure for Accessing a Confined Space 36
15.4.3 Worker Training (for Accessing Confined Spaces) 36
15.4.4 Preventive Maintenance 37

16 RISKS DUE TO CHEMICAL PRODUCTS AND CONTAMINANTS 37
16.1 Targeted Products 37
16.2 General Prevention Measures 37
16.2.1 Purchasing Policy 37
16.2.2 Regulatory Compliance: Labeling, Storage, Use and Transport 37
16.2.3 Management and handling 38

17 EXPOSURE TO MICRO-ORGANISMS 38
17.1 Targeted Materials and Equipment 38
17.2 Effects on Health and Safety 39
17.3 General Prevention Measures 39

18 PHYSICAL HAZARDS (NOISE, VIBRATIONS AND RADIATION) 40
18.1 Targeted Equipment 40
18.2 General Prevention Measures 40
18.2.1 Prevention – Noise 40
18.2.2 Prevention – Vibrations 41
18.2.3 Prevention – Ultraviolet and Infrared Radiation 41

19 RISKS ASSOCIATED WITH WILDERNESS AND WILDLIFE 41
19.1 Sources of Risk 42
19.2 General Prevention Measures 42

20 WORKING ALONE 42
20.1 Risk Situations 43
20.2 General Prevention Measures 43

21 ERGONOMIC RISKS 44
21.1 Ergonomic Risk Situations 44
21.2 General Prevention Measures 44

21.2.1 Lifting, Handling and Transport of Materials 44
21.3 Fixed Workstations and Repetitive Movement 44
21.3.1 Intensive Use of Computer Workstations 45

22 OTHER SPECIFIC RISKS 45
22.1 Working On or Near Oil and Gas Plants 45
22.2 Working with or close to pipes network 46
22.3 Manipulating valves 46
22.4 Carrying out towing or winching operations 46
22.5 Using portable heating units 46

PART III: FOLLOW-UP AND MONITORING 47

23 STAFF TRAINING PROGRAMS 47

24 MONITORING MEASURES 48
24.1 Employee Monitoring Measures 48
24.2 Environmental Monitoring Measures 48

25 WORKPLACE INSPECTIONS 49
25.1 Regular Workplace Inspections 49
25.2 Internal Audits 49
25.3 External Audits 50

26 HEALTH AND SAFETY COMMUNICATIONS 50

27 PROGRAM REVIEW 50
27.1 Review of Prevention Objectives, Targets and Plans 50

LIST OF APPENDICES

Appendix A - Petroleum Industry Guiding Principles for Worker Safety and Certificates (COR, MASE AND ISO 14001)

Appendix B – Limits of Access in a Contaminated Atmosphere

1 INTRODUCTION

The *General Prevention Guide - Health & Safety* gives an overview of the general health & safety guidelines that apply to all of EnGlobe's business lines. This guide provides also practical guidelines on the role and obligations of the relevant authorities, and the responsibilities, duties and rights of employers, workers and other interested parties.

2 OBJECTIVES

This guide has the following main objectives:

- Ensuring the protection of workers against risks in the workplace;
- Preventing or reducing injuries and occupational illnesses, and incidents that could pose a risk for the health and safety of workers;
- Facilitating and reinforcing the management of health problems and occupational health in the workplace;
- Improving knowledge and skills;
- Promoting effective cooperation between the employer and workers, in order to reinforce health & safety;
- Continuously improving the Company's performance in workplace health & safety management.

3 SCOPE

This guide provides practical guidelines and minimal instructions for all individuals within EnGlobe's facilities, including employers, individuals in charge of site supervision or maintenance, workers and subcontractors, with regard to their duties and obligations in matters of health & safety for all the Company's composting and soil remediation activities, management of organic waste and consulting engineering work.

This document also allows the Company to demonstrate its compliance with all the principles described in the document entitled "Petroleum Industry Guiding Principles for Workers Safety" (see Appendix C), which outlines the criteria of our COR (Certificate of Recognition), received as recognition of high-quality health and safety management in petroleum site rehabilitation projects. A similar certification was also obtained in France through the MASE pilot committee.

4 HEALTH, SAFETY AND ENVIRONMENTAL POLICY

EnGlobe has implemented a health, safety and environmental (HSE) policy that was signed by the EnGlobe Chief Executive Officer. Copies of this policy are displayed in each of the Company's places of business for all employees to read. This policy's content can be summarized as follows:

With the strong intent of avoiding and preventing accidents, the management at EnGlobe Corp. (EnGlobe) and all its subsidiaries have made the commitment to protect the environment and the health and safety of its personnel and the general public. From a sustainable development perspective, this commitment means that we take all necessary measures to ensure that our operations are environmentally friendly and safe. All members of the EnGlobe group are required to periodically review this policy, to eliminate risks of injury in the workplace, to promote well-being, and to reduce environmental nuisances and impacts associated with their activities. This policy was therefore developed to support this principle and involves:

- The deployment of a management system for health & safety and environmental protection that is integrated into EnGlobe's Quality system. This system includes periodic review mechanisms that allow the detection of gaps and the identification of potential improvements;
- The implementation of health & safety programs that are adapted to our sites, as well as the implementation of emergency and fire prevention measures;
- The development and periodic review of objectives and targets for health & safety and environmental protection, taking into consideration our past performance, the available technological breakthroughs, our resources and our position in different markets;
- Compliance with applicable legal and regulatory requirements in the jurisdictions where we carry out our operations, as well as the requirements of the associations and organizations that we belong to;
- The availability and efficient dissemination of this policy to our employees, our subcontractors and external organizations that request it;
- The availability of skilled personnel that is aware of risks associated with their work, and of their right to refuse to work in case of uncontrolled risks. To this effect, staff training is strongly directed toward the development of behaviours and reflexes that are based on the safeguard of health and safety and environmental protection;
- The accountability of supervisory personnel in the Company's places of business and project teams with regard to the achievement of this policy's objectives, and the accountability of all employees with regard to their compliance with established rules and the reporting of events that could pose a health and safety risk or environmental risk;
- The management and analysis of reported accidents and other events in order to prevent their reoccurrence;
- The importance of leadership for ensuring the efficient supervision of our subcontractors and support personnel, and for recognizing those who cooperate and share the same values of health, safety and environmental protection;
- The application of measures for preventing and prohibiting the use of drugs or alcohol in the workplace.

PART I – GENERAL HSE PROVISIONS

5 LEGAL AND ADMINISTRATIVE CONSIDERATIONS

5.1 LEGAL AND REGULATORY FRAMEWORK

All employees of EnGlobe or its subsidiaries must abide by the laws and regulations that are in force in the concerned country, province or territory where work is being carried out. All offices must have an updated list of laws and regulations associated to their activities.

5.2 GENERAL EMPLOYEE RIGHTS

EnGlobe acknowledges that workers are entitled to the following:

- Working conditions that protect their health, safety and physical integrity;
- Training, information and counselling services on workplace health & safety, particularly in relation to their job and work environment, as well as appropriate coaching and supervision;
- Preventive and curative health services based on the risks they might be exposed to.

5.3 RIGHT TO REFUSE DANGEROUS WORK

An employee has the right to refuse work if they have reasonable reasons to believe that this would expose them to a hazard to their health, safety or physical integrity, or could expose another person to such a hazard.

However, a worker cannot refuse work if this refusal immediately endangers the life, health, safety or physical integrity of another person, or if the conditions for the execution of this work are normal for the type of job occupied by the worker.

When a worker refuses work, they must immediately advise their immediate supervisor, their employer or a representative of their employer so that the Company may review the situation.

5.4 PREVENTATIVE RE-ASSIGNMENT

In accordance with the provisions of the concerned country, a worker who provides the employer with a medical certificate from a physician confirming their exposure to a hazardous contaminant represents a risk for his/her health (or for an unborn child due to her pregnancy) can ask to be re-assigned to duties that do not lead to such an exposure and that they can reasonably carry out, until their health condition allows them to return to their previous functions and until their working conditions are consistent with regulatory standards for the contaminant in question. In such a case, the physician must have detected signs of an alteration of the individual's health, and must have determined that such a re-assignment is necessary until the worker's recovery.

5.5 TEMPORARY ASSIGNMENT

EnGlobe favours temporary re-assignment when a worker cannot carry out their usual duties for a temporary duration, as long as this option is deemed acceptable by the physician who assessed the case of the worker who suffered an occupational injury or accident.

6 HSE RESPONSIBILITIES

EnGlobe has an internal accountability system that is based on the principle that all employees have responsibilities to fulfill in matters of efficient environmental management and workplace health and safety, in accordance with the applicable laws and regulations, at all Company levels and in all occupational groups.

6.1 RESPONSIBILITIES OF THE COMPANY, TERRITORIAL DIVISIONS AND BUSINESS UNITS

EnGlobe has made the commitment to uphold the following responsibilities through its Compliance division:

- Developing and implementing HSE policies, objectives and targets, and reviewing them annually;
- Ensuring that one or several representatives are designated to develop, maintain and review, on a regular basis, a specific HSE prevention program at each worksite and facility under its control;
- Ensuring that workers and their representatives are consulted and encouraged to actively participate in the development and review of prevention programs;
- Establishing standards to ensure that each site or facility has the required equipment and an appropriate lay-out to protect workers;
- Carrying out audits to assess whether work organization processes and work methods and techniques are safe and do not pose a risk for worker safety, with the issuance of recommendations and the necessary follow-ups;
- Distributing general information on HSE, and providing general instructions that can be customized for each site to ensure the complete protection of workers;
- Providing support to help managers and supervisors fulfill their role with regard to HSE;
- Participating in the development of the workers' training program on risks related to their work and the environment, and determining whether the level of training, coaching and supervision is sufficient to ensure that workers have the required skills, knowledge and supervision to safely carry out work assigned to them;
- Providing training sessions on the Company's general program or on specific subjects related to HSE;
- Carrying out investigations in cases of major accidents to reduce the likelihood of reoccurrence;
- Through the Human Resources division and in collaboration with the immediate supervisor, carrying out the administrative follow-up of workers' compensation files for injured workers.

6.2 RESPONSIBILITIES OF PROJECT MANAGERS, SUPERVISORS AND FOREMEN

EnGlobe managers and supervisors have the following responsibilities:

- Becoming familiar with the laws and regulations that apply in the concerned country;
- Developing specific prevention programs for their sites, and informing employees that work safety instructions must be applied at all times and that any violation could lead to disciplinary measures;
- Identifying, controlling and eliminating risks that could affect the health and safety of workers or damage the environment, and interrupting all work deemed to be dangerous;
- Including specific prevention instructions in their prevention program that are consistent with legal and corporate requirements, and that cover all tasks to be carried out within their units;
- Establishing preventative maintenance procedures to ensure the safe operation of machinery and equipment;
- Organizing HSE meetings according to corporate requirements and to the site's prevention program;
- Taking the fire safety measures prescribed by the applicable regulations in the concerned countries;
- Ensuring the presence of emergency and first aid equipment, and the presence of staff with first aid training to provide the necessary first aid care in the workplace;
- Reporting accidents, incidents and potential risks to EnGlobe corporate management according to the established terms;
- Participating in investigations following accidents or incidents and determining and implementing corrective actions;
- Applying disciplinary measures in cases of violations to HSE instructions;
- Ensuring that the required personal protective equipment is available and maintained adequately by workers, and ensuring that workers understand the reasons why they need to wear this equipment;
- Carrying out inspections or delegating a person for this task according to the terms set out in this guide;
- Ensuring that workers receive HSE information regarding the tasks they need to carry out, and ensuring the integration of new employees according to established practices.

6.3 RESPONSIBILITIES OF WORKERS

Workers have the following general responsibilities:

- Following the requirements of the prevention program specifically developed for their site and participating in HSE activities required for their job;
- Using safe work methods to protect their health, safety and physical integrity, and to ensure they do not endanger the health, safety or physical integrity of other people in or near the workplace;
- Using the tools and personal protective equipment required by the specific prevention program for their workplace;
- Participating in the identification and elimination of workplace accident or occupational illness risks;
- Reporting accidents, injuries and dangerous conditions to the site supervisor and their immediate supervisor as soon as possible;
- Helping new employees to recognize hazardous situations and following the work safety instructions provided in the specific prevention program for their workplace;
- Taking the health examinations required for the enforcement of applicable laws and regulations.

6.4 RESPONSIBILITIES OF SUBCONTRACTORS, SUPPLIERS AND EXTERNAL CONSULTANTS

Subcontractors, suppliers and external consultants have the following responsibilities:

- Following the specific prevention program of any worksite or facility where one or several EnGlobe employees work;
- Using safe work methods;
- Reporting accidents, incidents, near-accidents, time-loss injuries and potential hazards and risks to EnGlobe.

6.5 DUE DILIGENCE

With regard to workplace health & safety and environmental protection, due diligence means the employer's legal responsibility to take all reasonable precautions to prevent injuries and occupational illnesses, as well as damages to the environment, and to prove that it implemented them. Due diligence is the degree of judgement, care, prudence, firmness and action that can be reasonably expected from a company in certain circumstances.

Under the different health & safety and environmental legislations, a company's manager, site supervisor or senior manager can be charged with criminal negligence if it can be demonstrated that they did not show due diligence to prevent a serious accident from occurring. Thus, the most effective way of maintaining due diligence consists of establishing and applying health & safety and environmental management programs that are integrated into daily activities, taking the required corrective measures to prevent accidents and injuries, and maintaining records of all of these activities.

6.6 BEHAVIOUR-BASED SAFETY – SAFETY WITHOUT COMPROMISE

EnGlobe's *Safety Without Compromise* program reflects a corporate culture that aims to prevent accidents. This program is based on all documentation developed for the identification and mitigation of work-related hazards, but the most important part is the behaviour of employees with regard to health and safety. Accidents are effectively prevented when each employee follows the established instructions, and takes the time to identify and report risks, or takes the necessary measures to protect themselves and prevent injuries. This process is supported by supervisory personnel who provide the necessary resources to ensure a safe environment, and to ensure that all employees follow established guidelines.

6.6.1 Last-Minute Risk Assessment (LMRA)

One of the main tools of behaviour-based safety is the last-minute risk assessment (LMRA), which can be summarized with the phrase "Think before you act". This tool supports a simple mental exercise, without requiring any forms, that each of us must make before starting any task (as simple as it may be). Simply put, it consists of taking a few seconds to pause and consider the following four questions:

- What are the inherent risks of the task I'm about to undertake?
- Are my posture, my set-up and my equipment adequate for this task?
- What could go wrong when this task is carried out?
- What is the impact of my activities on my environment and vice versa?

Following this reflection period, all measures should be taken to eliminate or control identified risk factors in order to leave nothing to chance. Any form of risk should be considered and taken seriously, because even though we may choose to accept a risk or not, we cannot control the severity of the ensuing injury (e.g., a simple fall to the ground could lead to bruises or a fracture).

Why is it that we often say "If I had only…" after an accident, when we could have taken the time to apply a very simple preventative measure to prevent it?

Clearly, behaviour-based safety means that the deliberate choice to neglect a risk should never be considered a sign of bravery or an intelligent decision to save time. These bad behaviours are always linked to a lack of planning, laziness and/or pure and simple immaturity.

6.7 SPECIFIC REQUIREMENTS FOR CONSTRUCTION SITES (IN QUEBEC)

In Quebec, the legislation involves some specific requirements to all construction sites. A construction site is defined as being a site that is exclusively dedicated to foundation, erection, renovation, repair, maintenance, alteration or demolition work on a building or a civil engineering structure at the place of construction and on site, including preliminary ground preparation work, any other work determined by regulation, and the lodging, eating or recreational facilities put at the disposal of the construction workers by the employer. Please refer to the relevant regulation to know these specific requirements.

7 HSE DOCUMENT MANAGEMENT TOOLS

EnGlobe has implemented a quality system that governs HSE management, as well as other Company activities.

7.1 HSE RECORDS

The general Quality documentation related to HSE is available on EnGlobe intranet's site under "Corporate QHSE".

7.2 HEALTH & SAFETY OBJECTIVES, TARGETS AND CORPORATE PREVENTION PLAN

EnGlobe management has established objectives and targets based on elements such as audit results, health and safety statistics, and hazardous situations identified in internal and external inspections and audits carried out on all EnGlobe worksites and facilities. The objectives and targets are reviewed and amended, as needed, based on new developments and conditions.

7.3 SITE-SPECIFIC HSE PREVENTION PROGRAMS

A specific health & safety and environmental prevention program must be developed by managers and health and safety representatives for each worksite or facility. A standard form entitled 1450-FO01 "Site-Specific Prevention Program" is available on EnGlobe's intranet site for the development of prevention programs.

In the event of the client's health and safety prevention program is more restrictive than prescriptions describe in this guide, the client's requirements must be included in the site health and safety program.

7.4 HSE INSTRUCTIONS

Specific instructions associated to each task performed on the site must be written and attached to each site-specific prevention program. In order to facilitate their preparation, a list of standard specific instructions is available on the EnGlobe intranet site that user can adapt to the specific conditions of the site.

8 GENERAL PREVENTION AND SAFETY INSTRUCTIONS

8.1 ACCESS TO THE SITE AND TO PROTECTIVE EQUIPMENT

All access ways to buildings, entrances and exits, pedestrian crossings and access paths to protective equipment must always remain:

- In good condition and free of any obstruction;
- Maintained to ensure the surface is not slippery;
- Free from the hazard of falling objects or materials;
- Well-lit.

The yards or parts of yards used for the transportation of materials must be:

- Levelled;
- Drained to ensure their safe use, including preventing the instability of loads, vehicles or equipment.

You should always plan one or two emergency evacuation routes from the site and make sure all vehicles are parked with the front facing out to facilitate evacuation.

8.2 SIGNAGE

Yards, access ways and pedestrian crossings, as well as intersections with traffic lanes for vehicles must have the appropriate signage, including:

- Pictograms and appropriate messages, identified risks, and required personal protective equipment;
- A sufficient number of signs that are in good condition and in plain sight, where they are easily readable;
- Markers, cones or other appropriate accessories to delineate the working area;
- Illuminated signs for work done outdoors at night.

For a major worksite:

- The posted speed limit should normally be under 15 km/h when there is frequent vehicle traffic on the site;

- At the site's entrance, there should be a sign that clearly indicates the mandatory protective equipment to be worn, with a notice restricting access to authorized personnel and with the contact information of the person to call in case of an emergency.

8.3 VEHICLE TRAFFIC

Heavy machinery and vehicles are normally used in the majority of the Company's sites. Due to their size, these vehicles have many dead angles that limit peripheral vision, and prevent their drivers from seeing pedestrians and activities in the surrounding area. Therefore, there is a high risk of collision or crushing. The same hazard can be found on worksites located along a road or around commercial sites and heavy-traffic locations.

The general rules to follow to eliminate or reduce the risks associated with traffic on a worksite consist of the following:

- Advising workers or visitors to stay away from any heavy vehicle, ensure they are within the driver's sight, and wear the appropriate clothing or accessories;
- Establishing priority rules between pedestrians and vehicles;
- Ensuring the regular maintenance of the back-up warning alarms on heavy vehicles.

8.4 DRIVING A ROAD VEHICLE

Driving a vehicle entails many hazards, due to the fact that we need to share the road with other drivers. Planning an efficient driving route, using an appropriate vehicle that is in good condition, and abiding by the highway safety code are all ways of minimizing accident risks.

Before leaving:

- Ensure drivers have a valid drivers licence for the type of vehicles to be driven;
- Make sure the timeframes for driving tasks are reasonable and can be carried out by employees driving in a safe manner;
- Know your travel route ahead of time to avoid looking at maps while driving and plan your schedule to avoid travel at night or on less travelled, remote roadways;
- Check the weather forecast and road reports and consider delaying or postponing the trip until the weather clears;
- Perform a "walk around" before entering the vehicle;
- Ensure vehicle is in good working condition (tires, lights, windshield, wipers, horn, fuel level, dashboard lights, etc.) and report any malfunctioning or broken parts;
- Ensure the vehicle is equipped with the required emergency safety equipment and the driver has a cellular telephone in good condition for trips outside of urban areas;
- Remove snow and ice from all windows, lights and mirrors
- Be familiar with the vehicle and its capabilities and adjust mirrors and seat before travelling
- Ensure that all materials are securely fastened or stored to avoid potential risks associated with trying to retrieve a fallen item and or injury from items that may act as projectiles when turning or braking promptly;

On the road:

- Respect all traffic regulations
- Ensure seatbelts are worn at all times when travelling
- Always stay alert and focused on the road at all times and look far in front of you to see hazards on the road ahead of time
- Do not operate a vehicle under the influence of alcohol, drugs or medication that causes sleepiness or affects reflexes
- Avoid driving when tired or driving for a long period of time without taking breaks
- Do not tailgate or speed. Allow yourself the time and distance needed to react to the unexpected
- Avoid using a cellular telephone while driving; if necessary, stop the vehicle in a safe location
- Do not use a cellular telephone or hands-free device while driving in areas where this is prohibited by law
- Look for animal or pedestrian crossing signs, and slow down
- Be cautious when travelling at dusk or dawn when animals are most active
- If you see an animal on the road, slow down and steer around its rear end. If the collision is unavoidable, try to strike the animal at an angle;
- Avoid using cruise control on icy roads
- Brake and accelerate gently to reduce skids or spinouts
- In case of fog, reduce speed, avoid using the high beams to prevent being blinded by the glare, and increase your visibility by turning on the hazard lights if required.

The Company has had occasional cases of drivers falling when getting in or out of a heavy vehicle. Always use the three-point support technique to getting in or out of a vehicle or machinery.

8.5 SAFETY CLOTHING, EQUIPMENT AND DEVICES

8.5.1 Collective and Personal Protection Equipment

EnGlobe favours the reduction of hazards at the source. Collective protection equipment must be installed first, whenever possible, including machine protectors, efficient ventilation systems, equipment locking devices, parapet walls, etc. The use of personal protective equipment should normally constitute a second layer of protection for workers in case the installed collective protection equipment fails.

Safety equipment used as well collective as personal must always be in compliance with local regulation and maintained in good condition. They cannot be altered and not be used beyond its designated life or if there is any question about its suitability.

8.5.2 Worksites and Other Sites

All workers who need to walk around sites or workplaces with heavy vehicle traffic, construction work, excavation work or work involving mobile equipment or vehicles are required to wear:

Safety boots;

Work clothes with reflecting bands or safety jacket.

Other personal protective equipment can be required on other sites or in designated locations or worksites, based on the applicable regulations, the potential hazards and identified risks, and the ongoing operations, including:

- A hard hat;
- Safety glasses;
- Hearing protectors;
- Work gloves that are appropriate for the task to be carried out;
- Fireproof clothing;
- Special protection suits (against soiling, humidity, biological hazards, etc.);
- Respiratory protective equipment and/or dust mask.

The complete list of mandatory equipment must be included in the specific prevention programs developed for each site and facility.

Pictograms indicating the required equipment must be posted at the entrances of worksites and at access points of the designated locations.

8.5.3 Specific Instructions for Respirators

In particular manner, each user of a respirator must:

- Be trained for respirator use and be quantitatively fit tested on an annual basis;
- Conduct a positive-pressure test and a negative-pressure test before each use of the respirator;
- Be clean-shaven and if eyeglasses are worn, they must not interfere with the respirator's seal;
- If required, obtain authorization from a physician attesting that he is physically able to work and use a respirators;
- Safely store his/her respirator in a plastic bag away from humidity and chemicals vapors (store cartridges separately if they had already been used);
- Clean and disinfect his/her respirator according to manufacturer's instructions.

Air-purifying respirators do not provide protection against oxygen deficient atmospheres (<19.5%) or particular substances such as dangerous or deadly substances (ex.: H_2S). Never use in atmosphere exceeding the IDLH level (Immediately Dangerous to Life and Health – see appendix B).

8.5.4 Other Safety Accessories and Equipment

Accessories for the detection of contaminants or to secure work areas should be available on-site, or should be easily accessible at all times, before certain work or operations can begin, such as:

- A harness, a tripod and other accessories to enter into a confined space;
- Various types of contaminant detectors: ammoniac, carbon monoxide, oxygen level, hydrogen sulphide, etc.

The complete list of mandatory equipment must be included in the specific prevention programs developed for each site and facility.

8.5.5 Emergency Facilities

Each worksite, office building and laboratory should be equipped with the following:

- A fire extinguisher;
- A first-aid kit that complies with local requirements;
- An eye-wash station with periodical replacement of rinsing solution considering the expiry date (if required following the identification of workplace hazards).

This equipment must be located in clearly identified areas that are easily accessible to workers. Depending on the site's configuration and size, it may be necessary to have more than one piece of each equipment on the same worksite.

Some sites or facilities should have particular emergency devices and equipment according to the applicable regulations or activities being carried out, such as in the following cases:

- According to regulation in Alberta, worksites in that province must have a minimum of three blankets;
- In laboratory areas, workers need to have easy access to a complete shower, an eye-wash station and a fire blanket.

The complete list of mandatory equipment must be included in the specific prevention programs developed for each site and facility.

8.5.6 Prohibited Accessories and Clothing (for Safety Reasons)

For safety reasons, in places where there is a risk of contact with moving parts and in laboratories, all workers must abide by the following rules:

- Clothing should be well-adjusted and should not have loose and dangling parts;
- No jewellery or watches;
- Long hair must be tied back or held in a bonnet, hard hat or net.

8.5.7 Contact Lenses

Contact lenses shall not be worn during any work which would expose the wearer to chemicals, gases, vapours, dust or other materials that may harm the eyes or cause irritations.

Contact lenses must not be worn when using self-contained breathing equipment.

8.6 PLANNING OF WORK AREAS

8.6.1 Facility Maintenance (Indoors)

Traffic areas and any workstation inside a building must:

- Be well-maintained so they are not slippery due to wear or humidity;
- Be kept clear and be wide enough to allow the safe handling of materials;
- Have at least 2 metres of free space above the floor, unless a height hazard is announced with a visual sign;
- Have sufficient space between machines, devices or material deposits so that workers can carry out their work safely; this space cannot be less than 60 cm;
- Have parapet walls in places where there is a fall hazard.

In this respect, each employee must:

- Do not run, walk slowly inside the office and wear stable shoes;
- Ensure floors and aisles are kept clear and free of clutter;
- Avoid placing cables on the ground across an aisle, or cover the cables with adhesive tape;
- Be aware for carpet edges on the ground;
- Clean up liquid spills on the ground immediately;
- Remove or report any object that presents a risk of tripping;
- Use a ladder or stepladder to store or access objects overhead (never use chairs);
- Ensure cabinet drawers are kept closed when not in use, that only one cabinet drawer is open at one time and do not overload the top drawer if the bottom drawers do not hold sufficient weight to balance this load.

8.6.2 Material Piling

Materials must not be piled to a height that could compromise the pile's stability. Material piles should not hinder:

- The penetration of daylight or artificial light;
- The operation of machines and other devices;
- The circulation of people in traffic areas, stairways and elevators, or near doors;
- The access to electrical panels.

8.6.3 Worksite Preparation

In order to prepare its worksite properly, the project manager must beforehand:

- Identify the site's specific location and boundaries;
- Determine whether the site's condition is suitable for the scheduled work;
- Determine the location of traffic areas, parking spaces and the location of the worksite trailer, which should normally be located close to the site's entrance;
- Delimit the support, buffer and contamination zones (green, yellow and red zones);
- Delimit the reception and storage areas for materials, and the cleaning area for trucks, if required;
- Use the appropriate supports for materials to be stored;
- Establish one or several collection areas and determine the storage location of safety equipment;

- Assess the impact of traffic to and from the site on surrounding roads, and notify the authorities, if required;
- Ensure that all staff working on the site has received all directions provided by the client;
- Cut tall grass in working areas to ensure that the ground's surface is visible and remove as much as possible any materials that could form a surface slippery (water, snow, dirt on a hard and smooth surface, etc.);
- Prevent workers from walking on hazardous surfaces by delineating these areas with cones, banners, stakes, fences, etc.;
- Install fences and post signs at the worksite's entrances.

8.6.4 Ventilation, Air Conditioning and Heating

All ventilation, air-conditioning and heating equipment must be:

- Well maintained – filters must be kept in good working order and replaced when needed;
- Inspected and adjusted at least once a year.

Any potential source of gas, smoke, vapour, dust or mist emissions in a fixed workstation must be equipped with a local ventilation system that can extract and recover these emissions at the source.

8.6.5 Drinking Water and Sanitary Facilities

Drinking water must be available to workers at all of the Company's worksites and facilities, according to current regulatory standards in the concerned country or jurisdiction.

Sanitary facilities (washrooms and hand-washing facilities) must also be accessible within a reasonable distance from the site.

8.6.6 Prevention of Access

The last employee to leave must perform an overall verification of the facilities, shut down all unused equipment, and lock or prevent access to any hazardous work area left unattended.

8.7 PARTICULAR GUIDELINES

8.7.1 Alcohol, Drugs and Medication (Illicit Substances)

EnGlobe has a drug and alcohol use policy that is available on its intranet site. Essentially, this policy states the following:

- Using or being under the influence of alcohol or drugs in the workplace is prohibited;
- Work that requires vigilance cannot be carried out when a worker is under the effect of medication that causes drowsiness or affects reflexes.

EnGlobe reserves the right to temporarily or permanently expel any person from the workplace following an incident that had or could have had serious consequences, when there are reasonable reasons to believe that the incident could have led to such consequences.

EnGlobe has made the commitment to respect and apply the provisions of its clients' alcohol and drug policies in the case of projects assigned to the Company.

Generally, the provisions of this policy apply when a person in a position of authority personally notices the possession or use of these substances by an individual in the workplace.

This policy can also be applied following an accident involving a physical injury (excluding injuries that require only first aid) or following serious damage to the environment, materials or property (significant incident) that has occurred on sites where EnGlobe employees or subcontractors work.

8.7.2 Safe Use of Cell Phones and Walkie-talkies

When having a conversation on a cell phone or walkie-talkie, the following rules apply:

- Interrupt all work and operations that require vigilance;
- Move away from the areas where work is carried out.

On worksites, it is strongly recommended to:

- Leave cell phones inside trailers, vehicles or other designated areas;
- Use these communication devices only during breaks or in case of emergency.

On the road, it is strongly recommended to:

- Stop the vehicle in a safe place (hands-free devices do not compensate for the loss of vigilance associated with the use of a cell phone);
- Get informed in order to follow the requirements of certain jurisdictions that prohibit the use of cell phones while driving a road vehicle.

8.7.3 Walk-mans, MP3s and iPods

Portable radios, MP3 players, iPods and other similar devices with headphones are not allowed on worksites or hazardous work locations, as they may:

- Prevent users from hearing an alarm signal or the alarm of a vehicle backing up;
- Reduce the attention of workers, who may pay insufficient attention to hazards and risks that could be present in the workplace.
- These devices should never be used as hearing protection.

8.7.4 Fatigue and Overstress

In case of fatigue or overstress, one should not handle dangerous products, use tools or even drive a vehicle. In these conditions, an employee can become inattentive and negligent, and can lack foresight.

8.7.5 Smoking in the Workplace

Smoking is strictly prohibited in all offices, worksites and buildings of EnGlobe, its subsidiaries and its clients, with the exception of areas designated for this purpose.

Smoking areas must be located in a place that workers can access during their authorized breaks without posing a hazard to other workers or creating additional hazards in the surrounding areas.

8.7.6 Rough-housing and Running

Rough-housing and fighting are strictly prohibited.

It is also strictly prohibited to run on the clients' property or in the facilities of EnGlobe and its subsidiaries.

9 PROVISIONS FOR SUBCONTRACTORS, VISITORS AND TRUCK DRIVERS

9.1 SUBCONTRACTOR QUALIFICATION

The contractors hired by EnGlobe to carry out specialized work must be able to demonstrate that they have established a sufficient prevention plan for ensuring the safety of workers and the environment throughout the operations.

9.1.1 Pre-qualification Program (for all Subcontractors)

EnGlobe has established a pre-qualification program for subcontractors who work directly on the Company's or its clients' sites. This program consists of:

- Assessing and selecting contractors by taking into consideration the relevant criteria for health & safety and environmental management;
- Identifying, assessing and eliminating or controlling hazardous situations and risks associated with the contractor's activities, and with the materials and equipment used by the contractor;
- Identifying, assessing and eliminating or controlling hazardous situations and risks posed by EnGlobe's activities, materials and equipment for the contractors and their employees.

9.1.2 Carrier Selection and Qualification

Criteria have been established for the selection of the required types of equipment, trucks and semi-trailers in calls for tender. These criteria are used to choose, for a given contract, or for a series of

contracts, a carrier whose truck fleet will allow the planned work to be carried out safely, whatever the weather conditions, topography and location accessibility.

These criteria were established based on the following:

- The physical properties of transported materials;
- The topography of loading and unloading sites;
- The state of access ways and the general accessibility of the locations, in different weather conditions.

The equipment and types of trucks and semi-trailers required must be clearly mentioned in each call for tender issued to carrier companies.

9.2 SAFETY GUIDELINES FOR SUBCONTRACTORS AND VISITORS

Subcontractors and their employees must:

- Read and follow the "General Safety Guidelines for Subcontractors and Visitors";
- Read and follow the safety instructions that apply to them (refer to the health & safety and environmental prevention program developed for the project);
- Use functional equipment that is appropriate for the task and well-maintained;
- Wear the personal protective equipment required for their tasks (refer to the site's prevention program);
- Sign the register when required.

9.2.1 Specific Safety Guidelines for Truck Drivers

Truckers who drive on the worksites of EnGlobe or its subsidiaries must read and follow the safety and environmental protection instructions contained in the guide "Safety and Environmental Protection Guidelines for Truck Drivers".

9.2.2 Safety Guidelines for Visitors

Any visit to facilities operated by EnGlobe must be previously authorized by a project manager or director, and must follow the guidelines set out below.

The following individuals are considered visitors:

- Client's representatives;
- Any member of the management team of EnGlobe or its subsidiaries;
- Any EnGlobe employee who occasionally needs to work on a site or facility that isn't their usual workplace, except if they must work there for a long period of time. In the latter case, this individual is considered a regular worker, and must follow the safety guidelines and wear the safety equipment mentioned in the specific health & safety and environmental prevention program for that particular site, like all other workers;

- Any consultant or subcontractor making occasional visits to a site in relation to their duties;
- Any visitor, adult, child or teenager, making a visit accompanied with the individuals mentioned above or with EnGlobe communications personnel.

A few days prior to the visit, the EnGlobe employee responsible for the visit should give the main applicable instructions to visitors, including the obligation to wear safety boots, a luminescent vest and a hard hat. The site or office responsible for the site can, however, supply the safety vest and hard hat. No safety equipment is required if the visit takes place entirely inside a vehicle. For the visit of a specific unit, it may be necessary for the visitor to wear other safety equipment such as safety glasses, hearing protectors, etc. A pamphlet entitled 1450-GU04 “General Safety Guidelines for Subcontractors and Visitors” has been prepared and can be given to visitors to explain the general safety rules to follow during their visit.

In the case of an educational or media-related group visit, such an event must always be overseen by the persons responsible for the site. Visitors can, in this case, wear regular shoes with closed toes, as long as these individuals remain at all times in the designated circulating areas for visitors – away from materials and operations. If possible, the temporary interruption of activities (e.g., truck traffic) should be planned to ensure the safety of visitors. A hard hat must be worn in specified locations, and while this is preferable, it is not necessary to make young children wear a luminescent vest if they remain in a group and are physically supervised by a sufficient number of adults with vests. Each person responsible for a visit must ensure the availability of this equipment for each member of the group.

When they arrive on the worksite, all visitors should:

- Report to the reception;
- Where applicable, sign the visitor register (adults only) and fill out the required columns: date, signature at entrance, signature at exit, entrance and exit times;
- Wait for the person responsible for the visit;
- Put on the required safety equipment, according to the nature of their visit;
- Be explained the safety rules for their visit;
- Be accompanied throughout the visit by an employee who knows the site well and the nature of work carried out there, and who will ensure that visitors stay together and remain attentive to instructions and warnings;
- Avoid approaching or touching materials, equipment and machinery;
- Remain on the designated walking paths.

When they leave, visitors should:

- Sign the register;
- Return the safety equipment that was lent to them to the reception.

PART II: HEALTH AND SAFETY PREVENTION PROGRAMS

10 IDENTIFICATION OF HAZARDS AND RISK ASSESSMENT

In a workplace, a **hazard** is a situation faced by someone in the course of their professional activities. A hazard that is improperly managed could cause injury or harm to people or the organization. A **risk** is the probability that someone will sustain injury or harm to their health if exposed to a particular hazard.

This section of the guide presents the hazards to which some EnGlobe employees may be exposed, hazardous situations and equipment, possible health effects, and appropriate prevention measures. Risk levels vary according to each worker's position, tasks and exposure to these hazards.

10.1 HAZARDS ASSOCIATED WITH COMPANY OPERATIONS AND TASKS

The hazards associated with the operations and tasks at each EnGlobe site and facility must be identified. They can be classified according to the following categories:

- Safety hazards – vehicle traffic, driving vehicle on the road, use of equipment and tools, falling objects, confined spaces, elevated work, proximity to water, collapse of materials and engulfment, insecure footing, slipping and falling, working in isolation, and contact with dangerous energy sources;
- Physical hazards – noise, vibrations, issues due to cold and heat, radiation, etc.;
- Hazards due to the presence of chemical or biological substances – hazardous materials in the workplace, inhalable substances (gases, vapours, dust and smoke), exposure to pathogenic micro-organisms, and the presence of insects or animals;
- Hazards due to non-ergonomic workstations – repetitive movements and poor arrangement of workstations.

Any hazards identified must be reported within the prevention program specific to that site or facility, and the appropriate preventative measures must be applied accordingly.

10.2 GENERAL PREVENTION MEASURES

In applying prevention measures, priority should be given to measures that reduce hazards at the source. EnGlobe urges executives and managers to adopt the following preventative measures:

- Purchase of safer products, supplies and equipment;
- Modification of procedures to improve the safety of operations;
- Elimination of hazardous situations by using appropriate protective equipment;
- Use of technical control measures such as lockout or access to machines in reduced-speed mode;
- Use of safety devices in the workplace that increase awareness of potentially hazardous situations (e.g., warning lights, notices, alarms, etc.);

- Establishment of administrative measures, including training sessions and working procedures, as well as diagnostic activities such as procedural safety analyses and planned job observations (PJO);
- In the last resort, use of personal protective equipment, and measures to ensure its proper use and maintenance.

11 MECHANICAL, HYDRAULIC AND PNEUMATIC ENERGY

Potentially dangerous mechanical energy generally involves moving parts and crunching or pinching points. Such equipment may be powered by a diesel engine or gasoline, and/or may use another power source such as electricity or pneumatic or hydraulic energy. Some of them also represent risk of burns due to their heating devices, their powering system or by contact of the rotary parts overheated by friction. The equipment in question may still be powered on or not-if not, kinetic energy or residual momentum may still pose a significant risk, even once the power has been turned off.

Hydraulic energy is the energy that results from the displacement or accumulation of an incompressible fluid such as oil or water. In a hydraulic machine, oil is pressurized using a pump and injected into a cylinder, delivering a force of up to several tonnes. A break in such a cylinder, in a crane hoist for example, could lead to very serious accidents.

Pneumatic energy uses compressed air rather than fluid. It is used in pneumatic tools (e.g., hammers, drills, cleaning appliances, etc.) and in the control devices of automated machines. Breakages in pipes and the projection of particles due to the release of compressed air can pose major risks to worker safety.

Table: Main mechanically, hydraulically and/or pneumatically powered equipment

Mechanical	Hydraulic	Pneumatic
• Conveyors and bridge cranes • All-terrain vehicles • Automotive vehicles (tractors, loading machines, power shovels, etc.) • Saws (concrete and other) • Jackhammers • Lift trucks and pallet trucks • Hand tools and portable power tools	• Lifting machines • Trucks • Automotive vehicles (tractors, loading machines, power shovels, etc.) • Lift trucks and pallet trucks	• Compressed air tools (grinding machines, jackhammers, etc.) • Compressors • Compressed air cleaning equipment • Organic matter sprayers and sand blasters

11.1 GENERAL PREVENTION MEASURES FOR MECHANICAL, HYDRAULIC AND PNEUMATIC POWER

The following are the general prevention measures of highest priority in the elimination or reduction of risks related to mechanical, hydraulic and pneumatic power:

- Adopting a policy for purchasing or renting safe equipment that conforms to regulations;

- Installing protective devices on machines and equipment;
- Assessing the risks of machines and equipment;
- Installing safety control devices;
- Instituting lockout systems and a means of accessing machines in a reduced-speed mode, if a full operational stop is not possible;
- Installing appropriate emergency brakes, in sufficient number;
- Planning for the preventative maintenance of tools and equipment and report and tag out any items needing repair;
- Handle tools and equipment according to the instructions provided (never use a tool to carry out tasks that this tool was not designed for);
- Handle tools on a stable and appropriate surface;
- Ensuring that staff members are qualified and properly trained.

11.1.1 Purchasing and Renting Policy

Managers and purchasing managers must, as far as possible, choose to purchase or rent tools and equipment that meet approved safety standards. User must be sure that tools are in compliance with work to be performed.

11.1.2 Protective Devices

All hazardous areas inside or outside a machine that pose a risk to the health, safety or physical integrity of workers must be equipped with a shield or appropriate protective device to isolate, with at least a physical barrier, the dangerous area.

A fixed protector cannot be removed without the use of a tool. It is held in place permanently by soldering, for example. Use of a fixed protector is not always appropriate in a case where operators must regularly access the machine. In this case, the protector can be moveable, but with an interlocking safety mechanism that automatically stops the machine upon being removed. The protection system can also have a sensing device that serves to eliminate the risks associated with the hazardous area upon the approach of a worker to a given distance.

If the installation of a protector or a protective device on a machine is impracticable, the employer should take measures that take into account the absence of protective measures, and ensure an equivalent level of safety to workers through organizational means, staff training, terms of operation, and operating modes of the machine, and through personal protective equipment and means.

Design of protectors and protective devices must comply with the laws, regulations and standards in place in the country in question.

11.1.3 Assessment of Risks Associated with a Machine or Equipment

Before having protective devices installed on a machine or any equipment, the machine or equipment should undergo a risk assessment in order to identify and estimate the risks associated with hazardous areas, so that appropriate safety measures can be chosen and/or designed. This process will determine

exactly which locations need to be protected, as well the type of protectors or protection mechanisms required, taking into consideration the following factors:

- The degree of harm to the worker;
- The frequency and duration of exposure to hazardous situations;
- The probability of the hazardous event occurring;
- The probability of avoiding any harm.

11.1.4 Safety Control Devices

Every machine must be equipped with a safety control device that ensures it can be turned on and off safely. The safety control devices should be designed, installed and maintained so as to avoid any accidental starting or stopping of the machine.

11.1.5 Lockout

Before undertaking any adjustment, maintenance, repair or unblocking within a dangerous area of a machine, the following safety measures must be taken:

- Setting the control device in the “stop” position;
- Complete operational stop of the machine;
- The lockout of all sources of energy of the machine by all personnel exposed to danger, in order to avoid any accidental start-up of the machine while the work is being carried out.

11.1.6 Procedure for Accessing a Machine in Reduced-Speed Mode

When a worker needs to access a dangerous area of a machine for adjustments, unblocking, maintenance, training or repair (including the detection of faults), where the machine must continue to operate but protectors must be removed and/or protective devices must be neutralized, the machine must only be functional in manual-control mode, or according to a safety procedure specifically planned for such a situation. This manual control mode or safety procedure should conform to the following specifications:

- It should take precedence over all other control modes or all other procedures (depending on the case);
- It should not allow dangerous components of the machine to operate, except when using a control device that requires a continuous action or a bimanual control device;
- It should not allow such dangerous components to operate, except under heightened safety conditions e.g., reduced speed, low-energy, step-by-step, or stop and start modes.

If the start-up of a machine poses a danger for people in the immediate vicinity, such a start-up must be announced in advance on a loudspeaker or by some other effective means of communication, with a reasonable warning period.

11.1.7 Emergency Shutdown

All machines whose operation requires the presence of at least one worker must be equipped with an emergency shutdown device which stops the machine as quickly as possible given the nature of the machine and without posing additional risk. This device should conform to the following specifications:

- It should be well placed, visible and within the worker's reach;
- Its activation should require a single action;
- It should be clearly identifiable.

The restoration of an emergency shutdown device after its use should not itself entail the restarting of the machine. Any shutdown device emergency or otherwise of a machine that is part of a larger group of machines which are designed to function in conjunction with one another must be able to shut down those machines which feed into or are fed by the machine in question, if their continued operation constitutes a threat to worker safety.

11.1.8 Preventive Maintenance

All Company machines and equipment must be used, maintained and repaired such that their use does not compromise the health, safety or physical integrity of workers.

The reliability of all essential safety devices must be tested and ensured, in particular certain motion detectors. The electrical components of protectors and protective devices must be especially reliable, since their failure could expose people to hazardous situations, and also because unreliability can encourage attempts to deactivate the device.

It is also important to minimize the necessity to access dangerous areas of a machine by locating access points for maintenance, greasing and adjustments outside of the danger zones. This measure will greatly reduce the exposure of workers to potential hazards.

Specific work instructions for each machine or piece of equipment must be completed and appended to the health, safety and environment prevention program for each site.

Maintenance sheets must be updated and should be easily accessible for consultation.

12 ELECTRICAL ENERGY

The risks associated with electrical power should entail caution with electrical appliances and equipment, but also with regard to possible exposure to external sources such as live power lines located near a worksite (overhead or underground power lines).

For many of the Company's employees, a large part of their professional activities take place outdoors, often in remote areas. As they are often handling metal tools and equipment, and are often working in open and sometime elevated areas, these workers face an increased vulnerability to lightning.

12.1 TARGETED EQUIPMENT

The following are the concerned equipment and utilities:

- Electrical tools and equipment (these can all pose risks to users under certain conditions);
- Overhead or underground power lines.

12.2 GENERAL PREVENTION MEASURES

The following are general measures to be taken to avoid or reduce the risks associated with electrical energy:

- Identifying all electrical equipment;
- Ensuring that staff are qualified and properly trained;
- Observing the basic rules for safety in the presence of electrical equipment;
- Securing all operations and installing lockout devices on equipment;
- Ensuring the preventative maintenance of all equipment and the reliability of replacement parts;
- Outdoor work stoppage when lightning.

12.2.1 Identification of Electrical Equipment

In order to protect workers and the public, it is essential to:

- Clearly identify all electrical equipment, including circuits, appliances, conductors, switchboards, industrial control panels and motor control centres that may require inspections, ongoing maintenance, or maintenance while equipment is powered on;
- Indicate areas of particular risk for electrical shock using the appropriate standardized symbols prescribed by current regulations;
- Ensure that cables are insulated according to the risk of the surrounding environment (e.g., water, dust, mechanical damage, chemical products), and in accordance with applicable standards.

12.2.2 Staff Qualifications and Training

Any operations with electrical equipment must be carried out by an experienced company or individual. All others who must work near an electrical facility should receive appropriate training. Even those who are qualified must always be aware of the risk of potential electrical arcing.

12.2.3 Adoption of Basic Safety Rules for Electrical Equipment

Electrical equipment must always be used with caution, taking care not to cause damage through shocks, immersion, or exposure to excessive heat. Those who use this equipment must monitor its state and report any deterioration to an electrician.

The following basic rules must be observed at all times:

- Protect conducting wires from the risk of damage by not laying them down across the path of a vehicle;
- Hold the plug and not the cord when unplugging appliances;
- Never use a cord to pull or move an electrical appliance;
- Never leave an extension cord plugged in unless it is connected to an electrical appliance;
- Never touch a bare wire if only one end is visible;
- Never touch a plug with wet hands or on moist ground;
- Never cut the ground pins when using an extension cord.

12.2.4 Securing of Operations and Lockout

Operations with or near electrical equipment (e.g., repairs, connections, fuse or bulb replacement, testing, checks, record-keeping, cleaning, etc.) must be carried out in the following safe working conditions:

- Precisely identify the location of electrical equipment and facilities (e.g., underground utilities during excavations or drilling);
- Ensure sufficient work space;
- Limit the number of people allowed in the area of operations;
- Undertake the work when the equipment is powered off, wherever possible;
- Limit access to electrical control cabinets, which should be kept locked;
- Avoid doing piecemeal work on damaged electrical lines and plugs (no anarchic installations with extensions, idle sockets, idle wires, connectors with no insulating screw joints, etc.);
- Use electrical material with double insulation and with a safe low-voltage power source.

Work to be done on equipment that is powered on must be carried out in accordance with the specific work instructions for the equipment in question and the nature of the work to be done.

These instructions must be appended to each site-specific prevention program, and should indicate those elements that are critical and indispensable for work safety, such as:

- Identification of tasks that absolutely must be done while equipment is powered on;
- Identification of work phases that carry a risk of major accidental short-circuits;
- The procedures for shutting down or restarting facilities (e.g., ventilation, refrigeration, etc.);
- The appropriate lockout procedure for the type of work being done;
- Identification of any personal protective equipment required for the work.

12.2.5 Preventative Maintenance and Reliability of Electrical Equipment Components

Electrical equipment, as well as the facilities that they are a part of, or to which they are connected, must be used, checked, maintained and repaired so as not to compromise the health, safety or physical integrity of workers.

The Company encourages its managers and maintenance staff to use reliable and durable replacement parts when doing maintenance work. Improving the reliability of a machine's components reduces the frequency of required repairs, and thereby reduces susceptibility to the risks associated with electricity.

12.3 SPECIFIC PREVENTION MEASURES: ELECTRIC ARCS AND EXCAVATIONS

More specific prevention measures must be taken in cases where work being done may lead to the formation of electric arcs, such as excavations being carried out near underground lines, as well as work being carried out near overhead power lines.

Excavations and all other work being done near electrical lines must conform to current standards in the country in question. Standardized work safety instructions are available on EnGlobe's intranet site. These instructions must be adapted to the particularities of each site, worksite and project.

An electric arc is a flash of electricity that results when a current travels through the air separating one exposed, live conductor from another, or from the ground. The main causes of electric arcing are the following: dust and impurities, corrosion, water condensation on the surface of insulating material, spark discharge, accidental contact, dropping tools, improperly maintained electrical meters, over-voltage across narrow gaps, failure of insulating materials, badly designed or improperly used equipment, improper work procedures, and human error.

Electric arcs can produce temperatures of up to 35,000 degrees Fahrenheit (approximately 19,000 degrees Celsius), a temperature at which all known materials are instantly vaporized. An arc inside an enclosure, such as a motor control centre or a switching device, is considerably magnified, and the energy transmitted rushes out from the open side of the enclosure, toward the worker, potentially resulting in significant injuries and burns.

To the extent possible, workers should take the following precautions:

- Avoid working on equipment that is powered on, wherever possible;
- Follow the appropriate work instructions for the equipment and the nature of the work being done (see the applicable prevention instructions);
- Protect themselves and ensure that they are trained to understand the risks associated with electric arcs, how they are initiated, and how to use the appropriate personal protective equipment (PPE) when undertaking work on or near electrical facilities.

12.4 PREVENTION MEASURES – LIGHTNING

Lightning tends to strike higher ground and prominent objects, especially good conductors of electricity such as metal. It is particularly important that those who work outdoors observe the following preventative measures regarding electrical storms:

- Protect themselves from lightning before the storm begins by taking shelter in the nearest secure building or in a closed vehicle. A safe building is one that is completely enclosed with a roof, walls and a floor, and in which the electrical wiring, plumbing, telephone lines and antennae are all grounded, so as to prevent lightning from striking the building directly;

- Ensure that the vehicle is not parked under a tree or other tall object that may fall on top of it during the storm. Throughout the storm, keep the windows closed and avoid touching the metal of the frame or any wired device (including the steering wheel or cellular phone plugs);
- There is no safe place outdoors to take shelter during an electrical storm. However, there are places that are less dangerous than others. Stay away from tall objects such as trees or electrical poles, water, and other conductors of electricity (motorized equipment such as tractors, loading machines, power shovels, metallic hand tools, metal fences, etc.);
- When there are no nearby buildings or safe vehicles, seek out a low altitude area such as a furrow or a trench. A group of workers should spread out leaving several metres between each person;
- On flat ground, health and safety organizations are now recommending not to lie down on the ground, as was formerly advised. It is now considered to be better to sit on your heels, with feet close together, hands on your knees and head down to form as small a target as possible, and at the same time, minimize contact with the ground.

13 THERMAL ENERGY (HEAT OR COLD)

For many of the Company's employees, a large part of their professional activities take place outside of heated or air conditioned buildings. At certain times of the year, these workers are exposed to temperature extremes that may pose serious risks to their health and safety, depending on the type of activity and the level of exertion involved.

Certain equipment and machines used by the Company also constitute a considerable source of heat, which may pose significant risks to the safety of workers, either by direct or indirect contact.

13.1 TARGETED EQUIPMENT AND OPERATIONS

Boiler rooms, manufacturing and maintenance workshops, laboratories, and numerous other facilities within the Company are sites where equipment or operations taking place may produce extreme heat that could cause burns to workers:

- Motors and other equipment that emit heat while operating;
- Boilers and high-pressure steam lines;
- Work requiring heat such as soldering and other operations involving equipment that may produce sparks or electric arcs;
- Operations involving the use of a flame at a workstation;
- Cooking operations (ovens, pressure cookers, boiling liquids, combustion equipment, etc.);
- Operations that require working with electricity;
- Mechanical maintenance operations.

13.2 GENERAL PREVENTION MEASURES (EQUIPMENT)

The following are general prevention measures to avoid the risks associated with thermal energy:

- Installing protective devices and insulating equipment and ducts;

- Ensuring that staff are properly trained;
- Observing basic safety rules for electrical equipment;
- Securing all operations and installing lockout devices on equipment;
- Ensuring the preventative maintenance of all equipment and the reliability of replacement parts.

13.2.1 Protective Devices and Equipment Insulation

All areas containing machinery that poses a thermal risk should, as far as possible, be equipped with a protector, an appropriate protective device, or be covered with insulating material in order to act as a physical barrier and limit access to the dangerous area of the machine.

Ducts used to transport vapours or hot liquids should be positioned at a sufficient distance from human or vehicular traffic, in order to avoid accidental contact, and to protect workers in case of accidental breakage.

The design of protectors and protective devices and the insulating materials used must all comply with the laws, regulations and current standards in the countries in question.

13.2.2 Staff Training

Operators of pressurized appliances, as well as staff working in higher risk environments such as manufacturing and maintenance workshops and laboratories, should all receive proper training in order to avoid, reduce and control the risks associated with thermal energy.

The minimum training for operators and other concerned employees should cover the safe handling of equipment, required checkpoints of the equipment, regular maintenance procedures, and the identification of situations requiring the attention of a specialist.

13.2.3 Preventive Maintenance of Equipment

Regular, well-planned preventative maintenance of facilities and equipment can avoid or reduce accidents and breakages that could lead to the projection of hot substances or liquids:

- Protectors and insulating materials must be checked, maintained, and changed when necessary so that they remain effective at all times;
- Boilers and pressurized steam lines, ovens, pressure cookers, and any equipment posing a risk must be checked regularly by qualified technicians;
- Maintenance sheets must be updated and be easily accessible for consultation.

13.3 PREVENTATIVE MEASURES FOR HEAT STROKE

Even when exposed to the same temperature, reactions will vary from person to person, and even from day to day for the same person. Those over 40 years of age should be particularly careful in hot weather, as our ability to sweat diminishes with age. A greater risk is also faced by workers who are not acclimatized to the heat, those in poor physical condition, those with recent health issues, those on

certain medications, and those who are lacking sleep or who have been drinking alcohol. Extreme heat can, however, also affect people who are young and in good health.

Whatever the ambient thermal conditions may be, anyone showing symptoms or any sign of heat stroke must stop working immediately, and must be given first aid treatment as soon as possible. The next table lists the symptoms that may indicate potential heat stroke, the signs of advanced heat stroke, and the treatment to be administered depending on the severity of the case. Untreated heat stroke can be fatal.

Table: Symptoms and Treatment of Heat Stroke

Classic heat stroke (body is unable to reduce excess body heat)	Elderly people; young children; those with at least one risk factor; arises in the absence of physical exertion	Preliminary signs of heat stroke: • Unusual fatigue or general malaise; • Nausea; • Upset stomach; • Headache; • Muscle cramps; • Chills; • Dizziness, vertigo; Signs of advanced heat stroke: • Mental confusion (agitation, incoherence, irritability, aggression); • Vomiting; • Loss of balance; • Loss of consciousness (even when lying down); • Hot, dry skin; • Body temperature of over 40° C.	What to do? Someone who is exhibiting preliminary symptoms of heat stroke should immediately: • Alert their co-workers; • Rest in the shade or in a cool area; • Drink water frequently, in small quantities (or slightly saline liquids such as sports drinks) until completely recovered. If the person does not completely recover or shows any signs of advanced heat stroke, the situation is potentially fatal and should be treated as a medical emergency: • Call for first aid immediately; • Move the person to the shade or a cool area, remove their clothing; • Spray body with water; • Ensure maximum ventilation; • If the person is conscious and lucid, administer fresh water in small quantities.
Heat stroke due to physical exertion (body is unable to reduce excess body heat)	Arises as a result of physical exertion in high temperatures, particularly at the beginning of a heat wave, upon return from vacation, or in the case of a newly hired employee.		

In general, the basic principles can be summarized as follows:

- As far as possible, allow workers time to acclimatize to new temperature conditions;
- Provide workers with ample fresh water so they can drink at least one glass of water every 20 minutes, and encourage them to do so;
- Encourage workers and supervisors to monitor one another.

On sites where workers tend to be exposed to conditions that pose a risk of heat stroke, managers must prepare specific instructions on the risks associated with the extreme temperatures experienced on that site, including prevention measures to be adopted according to the particularities of that site and the positions occupied by workers. The manager of each of these sites should ensure that the situation conforms to current standards by using the recommended methods. The thermal constraints must be evaluated by considering air temperature, humidity, direct sunlight, the level of acclimatization of workers, the intensity of the workload, the nature of the facilities and of the clothing workers must wear.

If an assessment of thermal constraints suggests that working conditions do not conform to current standards, managers must take measures to reduce the thermal constraints to a safe level. Thermal constraints can be reduced by:

- Adjusting the work pace and workloads according to the weather conditions, and also taking into consideration workers' individual capacities and levels of acclimatization;
- Establishing a rotation of tasks where possible;
- Encouraging teamwork so as to reduce the exertion required for certain tasks;
- Providing mechanical assistance for manual labour;
- Allowing workers to take breaks every hour and not allowing them to work alone;
- Setting up small air-conditioned enclosures for stationary work stations: e.g., monitoring stations or control stations for equipment or machines, etc.;
- Arranging the space so that rest areas for breaks are cool, shaded, or air-conditioned;
- Postponing the more strenuous and non-essential tasks until a later date or a cooler time of day;
- Equipping workers with personal protective equipment such as cooling vests.

13.4 PREVENTATIVE MEASURES FOR COLD TEMPERATURES

Beyond dressing properly for cold weather, there are also more technical and administrative measures that can be taken. In some cases, engineering measures may also be taken:

- Provide specific training to employees who work in Nordic areas;
- Installing heated cabins for fixed workstations or for breaks;
- Covering hand grips and metal bars with a thermal insulator.

However, some other measures could be followed to prevent us from cold temperature:

- Regularly drink lukewarm fluids (no alcohol or caffeinated fluids)
- Eat high-energy foods (nuts, raisins, etc.)
- Try to keep out of the wind

- Move frequently to promote blood circulation
- Be aware of the signs of frostbite and react as soon as the first symptoms appear (numbness, tingling, progressive or total loss of sensitivity, redness with white spots, white, icy and waxy skin, or blisters)
- Report any unusual behaviour observed if a fellow worker is incoherent or shows signs of abnormal weakness and fatigue, and provide emergency treatment

14 ELEVATED WORK, FALLS, CRUSHING AND ENGULFMENT

The Company's various facilities and equipment, machinery and vehicles can expose certain workers to the risks of falling (from a height or the same level), of falling objects, or of situations that could result in sliding materials that could potentially engulf a worker.

Elevated work includes all work carried out on a platform, an installation, scaffolding, a roof, or near an excavation, in the absence of a rail and where there is a risk of falling from a height of at least 1.5 m (5').

14.1 TARGETED FACILITIES AND EQUIPMENT

The following are equipment and facilities that can be found at one or more Company sites and that comprise a risk of falling, falling objects, or engulfment:

- Ladders, stepladders, and scaffolding;
- Installations poorly adapted and improvised for reaching a higher elevation;
- Vehicles and machinery (trucks, loading machines, tractors, power shovels, etc.);
- Platforms and foot bridges to access various equipment;
- Pallets and pallet racks;
- Pits and basins for wastewater treatment;
- Waste pits for industrial sludge.

14.2 GENERAL PREVENTION MEASURES

14.2.1 Falls During Elevated Work

The risks associated with elevated work are among those that are dealt with most thoroughly by the various laws and regulations governing work health and safety.

The following collective and individual prevention measures should be implemented:

- Installing anti-falling protective devices (handrails and guard rails);
- Ensuring that facilities comply with current standards (e.g., the height of rails, materials used, anti-skid surfaces on walkways, etc.);
- Ensuring that equipment and facilities are adequately maintained clear away any residues or substances that may lead to falls (e.g., water, oil, etc.);

- Ensuring that workers use adequate personal equipment when doing elevated work (anti-skid footwear, harness, lifeline, etc.);
- Ensuring that staff is trained in the prevention measures and specific prevention instructions provided with respect to elevated work for each Company site, facility and activity.

Site managers must establish their own specific work instructions for each task related to elevated work, based on current laws and regulations.

14.2.2 Slipping, Tripping and Falling on the Same Level

Slipping and falling on the same level may happen for many reasons, but it occurs most commonly as a result of insufficient maintenance of a workplace, carelessness on the part of the worker, insufficient lighting, or working in an unfamiliar space (e.g., worksites, decontamination or rehabilitation sites, etc.).

Slippery surfaces pose a risk of falling and sometimes sustaining serious injuries. The presence of water, ice and mud, or a situation that requires walking across a membrane are examples of frequently encountered slippery surfaces.

The following are preventative measures to avoid slipping, tripping and falling on the same level:

- Ensuring that working areas are well maintain ed i.e., clear of tools that are not in use, of solid or liquid residues, and of snow and ice, any of which can lead to falls among workers;
- Placing anti-skid materials wherever needed;
- Filling in holes that are created on worksites, as soon as possible once they have served their purpose;
- Define safe walkways and avoid venturing off the designated walkways;
- Providing ample lighting in areas of high traffic;
- Encouraging workers to pay constant attention to their work environment and to report any potential risks to site supervisors.

14.2.3 Falling Objects, Overturned Vehicles, Collapse and Engulfment

Falling objects may come from fixed storage equipment (e.g., pallet racks, shelves, etc.), from portable equipment (e.g., lifting equipment, mechanical shovels, loading machines, lift trucks, heavy vehicles, etc.), or from a higher level (e.g., a pedestrian overpass or a platform).

The collapse of a material pile (e.g., soil, compost, etc.) or of a trench can lead to the engulfment or burial of workers.

The following operations should all have corresponding work instructions: the transport of loads using cranes, boom trucks, dump trucks, or any other heavy mechanical machinery equipped with a sling and chains or cables for the towing, removal or placement of materials.

The following general prevention measures are intended to reduce the probability of a worker being hit by an object causing injury, or of a worker being engulfed or buried:

- No loads must be moved overhead of any worker;

- Install toe boards or protective barriers on platforms or pallet racks wherever there may be a danger of falling objects;
- Ensure the stability of storage facilities (e.g., pallet racks) in order to avoid collapse;
- Ensure that lanes are large enough for the type of loading/unloading being carried out;
- Install bollards or signs to keep unauthorized vehicles at a safe distance from pallet racks;
- Limit the height of piles according to the nature of the objects and their packaging;
- Establish a maintenance program for storage equipment and access points;
- Ensure that treatment and storage areas are properly levelled to reduce the risk of overturned heavy vehicles;
- Ensure the stability of any piles of soil or compost, or other loose materials accumulated in mounds;
- Ensure the stability of excavations and trenches. Excavations deeper than 1.20 m (4') must be entered safely. The following are the minimum requirements to avoid the collapse of piles and engulfment of workers:
    - Identify the composition of the soil so as to determine the slope and/or any shoring required;
    - Have any non-standard slopes approved by an engineer (onsite documented approval);
    - Deposit materials at least 1.2 m (4') from the peak of the pile;
    - Do not allow any vehicles to come within 3 m (10') of the peak of the pile;
- Ensure that workers are adequately trained on the risks of falls and the collapse of materials and engulfment, and on the applicable preventative measures;
- Encourage staff to check their work environment regularly in order to avoid objects falling on themselves or other employees;
- Ensure that workers wear their personal protective equipment (e.g., hard hat, safety footwear, etc.);
- Ensure that the work instructions provided on elevated work, mechanical hoisting of loads, work carried out with mobile equipment, and the excavation of soil and test pits are all well understood and applied;
- Ensure that workers use proper lifting equipment.

14.2.4 Falling into Water

Composting facilities include several basins to carry out the treatment of wastewater and leachates. There are also numerous trenches and channels that transport treated water into the surrounding environment. More specific instructions need to be prepared and appended to the prevention program.

15 WORKING IN CONFINED SPACES

Confined spaces are generally referring to a space that is totally or partially closed e.g., a reservoir, a silo, a tank, a hopper, a room, a vault, a pit, a sewer (manhole), a pipe, a smokestack, an access shaft, or a truck storage tank. A confined space has the following characteristics:

- It is not designed to be occupied by people, but may occasionally be occupied so that work may be performed;

- It has a restricted entrance and exit;
- It may pose health and safety risks to workers due to its design, location, or insufficient natural or mechanical ventilation (possible presence of contaminants, toxic or flammable gases, and/or deficiency of oxygen).

15.1 TARGETED FACILITIES AND EQUIPMENT

All the confined spaces mentioned in the preceding section can be found on one or more of the Company's sites.

15.2 RISK SITUATIONS INVOLVING CONFINED SPACES

The following are situations that could pose a risk to the safety of Company workers:

- Entry into closed buildings where intensive composting or screening operations are taking place (e.g., bunker silos, screening facilities, etc.);
- Working inside reservoirs with low oxygen due to the presence of rust (e.g., uncoated steel reservoirs in which the rusting process is consuming the available oxygen);
- If the lack of ventilation and the restricted entry and exit can qualify an excavation site as a "confined space", a specific set of instructions must be developed to describe how to access it safely;
- Entry into manholes, pits or restricted areas with insufficient ventilation for maintenance, repair or sampling operations, which entails the following risks:
    - The possible presence of aerobic bacteria that could reduce oxygen levels through the decomposition of organic material e.g., in the presence of wastewater from composters or the treatment of contaminated soil;
    - The presence of contaminants in wastewater and in pipes, having numerous possible sources: liming of sewage sludge (ammonia emissions); biogas emitted by anaerobic and/or aerobic bacteria through the decomposition of organic material (e.g., methane, hydrogen sulphide, carbon dioxide and ammonia); heavy and light hydrocarbon vapours from soils and equipment, carrying a risk of intoxication and/or possible explosion;
- Soldering and flame-cutting work in confined spaces (emission of contaminants and lack of oxygen due to combustion);
- Cleaning operations inside reservoirs that contained certain substances can pose risks to the health and safety of workers (nitrogen compounds used in the manufacture of fertilizers (ammonia emissions), hydrocarbons, etc.);
- Cleaning operations in restricted spaces, with substances that can pose risks to the health and safety of workers hydrocarbon-based solvents that could lead to explosions at certain concentrations, chlorine products used as disinfectants (emission of chlorine gas);
- Work in restricted spaces using equipment with internal combustion motors (carbon monoxide emissions).

15.3 ASSESSMENT OF RISKS AND HEALTH EFFECTS

A large part of the accidents that occur in confined spaces are related to oxygen deficiency, explosions or fire, or to the presence of toxic gas or vapours.

Air is normally composed of approximately 21% oxygen. When the oxygen concentration drops below 19.5%, it is not safe to enter a confined space. The symptoms of oxygen deficiency are:

- Between 14% and 16% oxygen – impaired judgement, euphoria, fatigue and malaise;
- Between 10% and 11% – accelerated breathing and heart rate, euphoria, headache;
- Between 6% and 10% – nausea and vomiting, inability to move freely, possible loss of consciousness, and collapse while remaining conscious;
- Under 6% – respiratory failure followed by a cardiac arrest and death within minutes.

The presence of toxic gas and contaminants pose numerous health and safety threats, depending on the specific contaminants involved:

- Ammonia – toxic, an irritant and corrosive to eyes (at 35 ppm and higher), skin (at 500 ppm) and respiratory channels (at 25 ppm) can be fatal at high concentrations (5,000 ppm);
- Methane – produced by the decomposition of organic matter odourless, highly flammable, and can lead to asphyxiation and death;
- Hydrogen sulphide – sewer gas, very toxic and an irritant to the upper respiratory tract, eyes and skin, can be fatal;
- Argon – used in welding work to make a flammable and explosive atmosphere inert (e.g., soldering a reservoir that contained hydrocarbons), argon displaces oxygen and can lead to asphyxiation for workers not wearing appropriate respiratory protection;
- Carbon dioxide – found in high concentrations in sewers, displaces oxygen in the air, and can lead to asphyxiation;
- Nitrogen – released from an anaerobic waste digester, displaces oxygen in the air, and can lead to asphyxiation.

15.4 GENERAL PREVENTION MEASURES

The basic principles for managing confined spaces are the same anywhere:

- Identification of confined spaces and the risks entailed;
- Development of procedures and work instructions for accessing those spaces;
- Reviewing and approval of these procedures and instructions by competent persons;
- Providing training programs for workers;
- Equipment maintenance;
- Monitoring procedures.

15.4.1 Identification of Confined Spaces and Risk Assessment

All enclosed spaces on Company sites must be identified, and then subjected to a risk assessment:

- An inventory must be carried out of areas and equipment representing confined spaces at each site, worksite and facility (name, type, location);
- A risk assessment must be performed for each confined space, and any contaminants determined where possible;

15.4.2 Procedure for Accessing a Confined Space

An access procedure must be followed before entering a confined space. Managers should consult the standard instructions for entry into confined spaces, and adapt it according to the regulations in effect and to the particular characteristics of the confined spaces found on each site. The basic elements of the procedure are as follows:

- Obtain specialized equipment for entry into confined spaces and for possible rescue (e.g., tripod, winch, ventilators, detectors for contaminants and oxygen levels, personal protective equipment, etc.);
- Clearly determine the steps to follow and the operations to be carried out;
- Document the possible contaminants in the confined space, before entering and periodically thereafter according to the results of the risk assessment and/or the established plan, and enter the results in a record book kept onsite;
- Ensure the presence of a monitor, posted just outside the confined space, who should always be within sight or earshot of the worker, or in contact by other effective means;
- Plan a rescue procedure before the worker has even entered the confined space.

15.4.3 Worker Training (for Accessing Confined Spaces)

The type and the content of training programs will differ according to the regulations in effect. In any case, it will be necessary to have qualified individuals to identify, assess and monitor the hazards associated with a confined space, and to ensure that only workers with the knowledge and the required training or experience to work in enclosed spaces are allowed to enter.

Target participants whose responsibilities require that they receive practical training (e.g., workers who enter confined spaces, supervisors, permit holders (if applicable), contaminant samplers, executive staff, etc.).

Determine the type and content of training programs required according to regulations in effect.

Ensure that those deemed qualified to enter the confined spaces have the permits required by regulations in effect (i.e., certificate, registration, etc.);

Ensure that rescue practices are carried out periodically and according to regulations in effect, if applicable.

15.4.4 Preventive Maintenance

All the equipment required to enter confined spaces, including personal protective equipment and detectors, must be properly maintained on a regular basis, according to the applicable requirements.

16 RISKS DUE TO CHEMICAL PRODUCTS AND CONTAMINANTS

16.1 TARGETED PRODUCTS

The diversity of the Company's activities entails a wide range of chemical products that could potentially come into contact with workers:

- Organic or inorganic raw chemical materials laboratory products, concentrated fertilizers, cleaning products, pressurized gas cylinder, etc.;
- Gas and vapour emissions resulting from activities: ammonia, carbon monoxide or dioxide, hydrogen sulphide, etc.;
- Contaminants and Hydrocarbon vapours;
- Solvents, cutting oil, hydraulic oil, etc.;
- Fuel;
- Others.

16.2 GENERAL PREVENTION MEASURES

16.2.1 Purchasing Policy

Those responsible for making purchases at each site and facility must work in collaboration with those who deal with hazardous materials and, if required, with representatives from the Health & Safety and Environment department in order to obtain the products needed, while ensuring that the health and safety of workers is prioritized. The choice of products should also take into consideration their impact on the environment, including that of any secondary or waste products they may generate.

16.2.2 Regulatory Compliance: Labeling, Storage, Use and Transport

All materials considered hazardous must be labelled, stored, used, transported and disposed of according to the standards, regulations and laws in effect (see Appendix A and EnGlobe's intranet site for a list of laws, regulations and standards in effect in the country in question). The various regulations are concerned with the following main elements:

- Labelling according to the standards in effect in the country in question;
- The availability of fact sheets (or signs) at each worksite, with information on each hazardous product identified;
- Staff training: every worker using or coming into contact with one or more hazardous materials must receive training in WHMIS (Workplace Hazardous Materials Information System) or COSHH (Control of Substances Hazardous to Health) in UK;

- Duty of suppliers—when selling something classified as a controlled product, suppliers are legally required to label it or its container, and to provide clients with a fact sheet on its safe use. The labels should clearly identify the nature of the hazardous material, and the fact sheet should explain the hazards involved.

16.2.3 Management and handling

Before or when handling any chemical products, each user must:

- Get information on the product properties and the applicable first aid procedures;
- Wear the necessary protective equipment (gloves, goggles, protection suit, visor, face mask, etc.);
- Work in a stable location and in a well-ventilated area;
- When work is performed outside, take the direction of the wind into account if there is a risk of vapour emissions;
- Keep away all source of flame, ignition or heat;
- Keep chemical product in proper container and do not store incompatible products together;
- Replace damaged containers and discard altered or unnecessary products;
- When transferring flammable solvents in metal containers, include grounding;
- Do not mix incompatible products and do not expose reactive products to an environment that could provoke an uncontrolled reaction;
- Ship and handle only the necessary quantities;
- Use the proper equipment and labels for the transportation of chemical products and gas;
- Avoid clinking of products stored in glass containers;
- Know the emergency measures and the recovery techniques for the product and have necessary cleaning and spill recovery material ready;
- Dispose of products according to regulation and in an environmentally respectful way.

When refuelling vehicle or motorized equipment:

- Do not refuel machinery or equipment when the engine is running;
- Do not go back into the vehicle when fuelling up (risk of accumulation of static electricity), keep your hand on the nozzle;
- Avoid smoking.

17 EXPOSURE TO MICRO-ORGANISMS

Due to the nature of the Company's activities, certain workers must regularly come into contact with organic wastes, compost and soils that may contain pathogenic micro-organisms.

17.1 TARGETED MATERIALS AND EQUIPMENT

- Organic waste materials received and treated in the composting centres;
- Humus and other additives used in making products;

- Contaminated soils in the process of being treated;
- Process water from basins and leachates;
- Industrial and domestic sludge;
- All equipment, clothing, boots and personal protective equipment that has been in contact with any of the above-mentioned materials.

17.2 EFFECTS ON HEALTH AND SAFETY

Organic waste material (from animals or plants), soils, immature compost, dust and airborne aerosols can all pose potential health problems.

Micro-organisms can cause:

- Infectious diseases such as hepatitis and tetanus;
- Respiratory problems or inflammatory reactions, allergic or otherwise;
- Allergies and occupational diseases such as allergic asthma;
- Gastrointestinal problems—diarrhea, vomiting, abdominal pain, aches, fatigue, headaches, and dehydration.

17.3 GENERAL PREVENTION MEASURES

Susceptibility to health problems depends upon each individual's general state of health as well as their exposure to certain situations and general hygiene. It is possible to effectively reduce the risk of infection by:

- Adopting adequate hygiene practices—e.g., washing hands with a disinfectant soap before eating;
- Refraining from borrowing anything from someone who is ill;
- Wearing personal protective equipment—i.e., appropriate protective gloves, disposable or washable outerwear, and filter masks;
- Having workers vaccinated against hepatitis and tetanus;
- Avoiding contamination of facilities with soiled disposable outerwear by depositing them immediately in a designated container, which should then be immediately disposed of;
- Hiring a company that specializes in cleaning washable outerwear;
- Washing other personal clothing onsite if possible (i.e., washer and dryer in the workplace);
- Ensuring regular maintenance and adequate disinfection of all areas (rest areas, eating areas, etc.) as well as sanitary facilities;
- Ensuring that staff is adequately trained on the risks associated with pathogenic micro-organisms, on proper hygiene, and on the use of appropriate personal protective equipment.

18 PHYSICAL HAZARDS (NOISE, VIBRATIONS AND RADIATION)

Certain Company activities or operations expose workers to noises, vibrations, and ultraviolet (UV-B and UV-A) and infrared radiation that could pose a threat to their health. The sun is also a source of ultraviolet and infrared radiation.

18.1 TARGETED EQUIPMENT

- Mechanical tools or pneumatic hand tools: pneumatic hammers or wrenches, electric drills, etc. (noise and vibration);
- Vehicles and motorized equipment: cars, pickup trucks, heavy vehicles and construction equipment, lift trucks, etc. (noise and vibration);
- Conveyors, and screening, bagging and pallet-loading operations (noise);
- Electric-arc welding equipment (ultraviolet radiation);
- Blowpipe welding equipment (infrared radiation);
- Certain photocopiers and laser printers (ultraviolet radiation);
- Industrial lighting (infrared radiation);
- Heating equipment (infrared radiation).

18.2 GENERAL PREVENTION MEASURES

18.2.1 Prevention – Noise

Measures for the reduction of noise levels at the source and for the regular maintenance of tools and equipment are preventative measures that should be favoured, including:

- Eliminating sources of noise whenever possible;
- Using silencers on equipment;
- Insulating equipment using materials or acoustic panels;
- Having equipment and tools checked regularly by specialized technicians;
- Ensuring that equipment is adequately lubricated (i.e., gears and other moving parts).

If the reduction of noise at the source and the maintenance of equipment does not result in an acceptable level of noise in the workplace, supplementary prevention measures must be taken, such as:

- Equipping workers with personal protective equipment according to current standards (earplugs, helmets, etc.);
- Taking the time to inform employees of the importance of wearing hearing protection equipment;
- Training staff on the effective use and maintenance of such equipment.

18.2.2 Prevention – Vibrations

The following prevention measures are designed to reduce the exposure of workers to various sources of vibrations:

- Choosing tools and equipment with less vibration whenever possible;
- Having tools and equipment regularly checked by specialized technicians;
- Ensuring that equipment is properly lubricated;
- Installing anti-vibration seats in motorized equipment and road vehicles that are used on a regular basis by the same workers;
- Providing anti-vibration gloves for prolonged work with tools that vibrate;
- Reducing the duration of exposure to vibrations by reorganizing activities, more frequent or longer breaks, etc.
- Ensuring that workers are properly informed of the risks associated with exposure to vibrations.

18.2.3 Prevention – Ultraviolet and Infrared Radiation

All work that entails a dangerous level of radiation emissions in the ultraviolet range—such as arc welding and resistance welding—is being carried out, the following measures must be taken:

- Surrounding the emission source with protective screens to shield workers—aside from welders—from direct exposure (screens may be opaque or transparent to visible light, but treated to filter out UV rays);
- Protecting the hands and forearms of workers exposed to larger doses, using gloves or protective creams;
- Protecting eyes and faces by requiring workers to wear eye protection or face protection, in accordance with prescribed standards;
- Ensuring that staff is properly trained and informed on the risks associated with exposure to radiation, and on the safe handling of welding equipment.

For those who work outdoors, it is recommended to limit exposure to ultraviolet and infrared radiation by:

- Wearing opaque clothing that covers arms and legs;
- Using sun protection cream to protect the face and hands;
- Wearing sunglasses with effective ultraviolet protection (UV-A and UV-B);
- Following the recommendations provided in the section on heatstroke.

19 RISKS ASSOCIATED WITH WILDERNESS AND WILDLIFE

Some workers in the Company must work in forested areas and in wild areas remote from human habitation. They may come in contact with plants, insects or animals that could pose a risk to their health or safety.

19.1 SOURCES OF RISK

The main risks being faced by such workers are:

- Insect bites and stings (bees, wasps, mosquitoes, etc.);
- Coming into contact with plants that are potentially toxic (poison ivy), irritant (nettles), or prickly (thistles, wild roses, etc.);
- Coming into contact with rodents carrying the virus responsible for the hantavirus pulmonary syndrome, or contact with their excrement or with dust particles contaminated with their excrement;
- Being attacked by a wild animal;
- Encountering a bear (brown, or polar for those working in the North) or another wild animal (cougar, wolf, etc.);
- Being hit by a projectile (e.g., from a firearm).

19.2 GENERAL PREVENTION MEASURES

Managers of sites and employees affected by one or more of the risks associated with wilderness and wildlife should implement protective measures to eliminate the expositions to workers of these sources of danger as:

- Know the fauna and flora that you could encounter on the site and be aware of the risks associated with them;
- Know how to recognize noxious plants;
- Be prepared to use the necessary protection;
- Report your presence verbally or post signs if presence of hunters;
- Watch out for signs of wildlife activity, such as droppings (never touch them), hair, tracks and clawed trees (bears);
- Avoid attracting wildlife by staying with the group and storing your food and luggage in the vehicle;
- If possible, avoid working at dawn and dusk when animals and insects are usually the most active;
- Avoid perfume, aftershave, cologne, fragrant lotions, soaps and hairsprays;
- Use an insect repellent spray (do not apply on hard hats);
- If a person has an known allergy (e.g., bee stings), report his or her condition and ensure the person has the necessary medication or emergency supplies (anti-histamine, adrenaline syringe);
- If needed, wear a bell or any other noisy instrument to ward off animals such as bears;
- Keep all vehicles unlocked on the site with the keys in the ignition;
- Hire a bear monitor if polar bears could be present around the site.

20 WORKING ALONE

Working alone is not always dangerous, but certain situations can pose risks. The level of risk depends on the location and the type of work, and on the consequences of an emergency situation, such as an

accident or injury. A person is considered to be working alone when they cannot depend on anyone but themselves—i.e., when there is no one who can hear or see them, or when it is unlikely that another worker will come by and visit over a certain period of time.

Some workers within the Company occasionally or regularly perform work that requires them to be apart from their colleagues for a certain part or even most of the day.

20.1 RISK SITUATIONS

The following situations may pose risks to worker safety:

- Working with dangerous equipment or facilities in isolated areas of composting centres, soil treatment centres, or rehabilitation sites—inside buildings or outdoors (e.g., working in isolated areas of conveyors, in hoppers, on footbridges, with heavy equipment, with pressurized equipment, etc.);
- Working outside regular hours (office work or manual labour, indoors or outdoors);
- Frequent travel to areas outside of regular worksites.

20.2 GENERAL PREVENTION MEASURES

Certain types of hazardous work are forbidden to anyone working alone—e.g., working in confined spaces. In other cases, administrative and technical measures can be taken to reduce the isolation, such as:

- Reconsidering whether the isolation is necessary and no individual must be ever left alone to undertake high-risk work;
- Finding ways to reduce the isolation, even partially;
  - Move an operation to a less isolated area whenever possible;
  - Add a window to an interior or exterior wall so that the worker is visible;
  - Provide the worker with a means of maintaining constant communication with a supervisor or another worker (e.g., a walkie-talkie or cell phone);
  - Arrange to make contact at regular intervals, automatically or otherwise (however, the designated caller may lose track of time);
- Evaluating and addressing as thoroughly as possible the hazards and risks associated with the tasks being performed by the isolated worker (e.g., the suitability of equipment and facilities);
- Training the isolated worker on the possible troubles that may be encountered, and establishing ahead of time the actions that should be taken to resolve problems, taking into consideration the individual capabilities and experience of the worker—i.e., ensure that they know to stop what they are doing when a problem has exceeded their capabilities.
- Ensuring that the worker understands that contacting a supervisor or seeking the help of someone more experienced in the case of such a problem is not a sign of weakness but of good judgement;
- Encouraging exchanges between staff on encountered problems, so that experience can be shared even among those who are not working together;
- Ensuring the presence of detection and surveillance systems (detecting vital signs) for work that is considered to be too risky even after the preceding measures have been applied.

21 ERGONOMIC RISKS

The workstations that are most likely to present ergonomic risks are those that require significant physical effort, those that require workers to sustain uncomfortable or unusual positions, and those that require standing or sitting for prolonged periods.

21.1 ERGONOMIC RISK SITUATIONS

Certain types of work done within the Company have the potential of causing joint and muscle problems, in the back or other parts of the body:

- Handling large or heavy loads (e.g., pulling tarpaulins over soil treatment piles, lifting boxes, etc.);
- Improper posture required for the work being done—e.g., maintaining, unblocking or repairing equipment in constrained positions (such as hoppers or conveyors), sweeping or shovelling in cramped or hard-to-access areas, etc.;
- Repetitive movements at a workstation (e.g., manual de-bagging and sorting of municipal waste);
- Prolonged work at a computer station, in the case of professionals and office staff.

21.2 GENERAL PREVENTION MEASURES

21.2.1 Lifting, Handling and Transport of Materials

The following general prevention measures should be implemented:

- Organize workstations so as to eliminate or reduce handling, by providing workers with specialized equipment: lift trucks, pallet trucks, dollies, mechanical lift tables, etc.);
- Use equipment to facilitate the handling of loads—e.g., gloves, handles, straps, transport tanks, etc.;
- Limit loads to a reasonable weight for the person in question—so as not to require too great an effort on a repetitive basis;
- Provide the equipment necessary to allow workers to safely access the tops of material piles—e.g., ladders, stepladders, handles, or any other equipment designed for this purpose;
- Train staff on the postures and movements that should be used in undertaking their various tasks;
- Ensure that workers are trained properly and according to regulations in the use of any specialized equipment (e.g. lift trucks, etc.).

21.3 FIXED WORKSTATIONS AND REPETITIVE MOVEMENT

- Table heights and seat positioning should be adjusted according to the worker and the work being done, so as to ensure proper seating position and reduce fatigue;

- Tools, levers and materials should be placed so as to facilitate the work being done and reduce the effort required;
- Chairs and benches should be made available to workers whose work allows them to sit.

Workers who are engaged in a task of a repetitive nature should be encouraged to do exercises to warm up the muscles being used, to assume a comfortable position to carry out the work, and if possible, to alternate with work of another type in order to allow those muscles to relax.

Make use of the equipment that is available to reduce the effort associated with repetitive movement during work.

21.3.1 Intensive Use of Computer Workstations

The Company has many workstations where workers may spend a large part of the day, sometimes spending more than 3 or 4 consecutive hours at a time, doing intensive work. Organizations that specialize in ergonomics recommend the following general measures to avoid or reduce musculoskeletal problems and various pains (e.g., tendonitis, lower back pain, carpel tunnel syndrome, etc.):

- Provide workers with office equipment that is adapted to the characteristics of each user—i.e., according to their weight, height, sex, and whether they are right- or left-handed;
- Adjust the various elements of the workstation to the personal characteristics of the user;
- Try to find an arrangement that allows workers to change their posture, and avoid any exaggerated, repetitive or sustained twists of the torso or the neck by properly positioning the height of the various elements of the workstation (e.g., desk, keyboard, mouse, screen, telephone, reference documents, and footrest);
- Ensure that staff are properly trained in any prevention measures applicable to computer stations, such as:
  - Alternating tasks after an hour in front of the screen, to change postures and use different movements;
  - Taking mini-breaks;
  - Changing postures;
  - Performing eye exercises every 20 minutes, while looking away from the screen.

22 OTHER SPECIFIC RISKS

22.1 WORKING ON OR NEAR OIL AND GAS PLANTS

- Ensure all workers and contractors receive a site specific orientation by the client's site supervisor for the site in question;
- Determine whether work permits are required by checking with the client's site supervisor before starting work (hot work permit, work in confined spaces, ground disturbance permit before carrying out intrusive work, etc.);
- Ensure all personnel working in an area where H2S concentrations may exceed 10 ppm are be provided with training and are equipped with a personal air monitoring device, and the necessary respiratory protection and rescue equipment, before beginning the work assignment on the site;

- Be aware site of evacuation procedures should an emergency alarm be sounded;
- Never perform any activities or enter any hazardous areas if you are not trained and authorized to do so;
- Keep all non-essential workers out of the immediate work area.

22.2 WORKING WITH OR CLOSE TO PIPES NETWORK

- With presence of various products, identify the content of each pipe;
- Avoid standing or walking on pipes, and use a wooden platform or planking;
- Tiers of pipe must be properly blocked to prevent the hazard of rolling pipes;
- Do not use hands and feet to position heavy pipes to avoid back injuries;
- Never walk or work under a suspended pipe, unless the load is fully secured or supported.

22.3 MANIPULATING VALVES

- Ensure the valves are operated by qualified and authorized personnel;
- Do not use excessive force to open stubborn valves, to avoid injuries and falls that could result from the valves rupturing;
- Monitor pressure changes after opening a valve that could produce sufficient energy to project this valve or its gasket.

22.4 CARRYING OUT TOWING OR WINCHING OPERATIONS

- Use proper cables and in good conditions;
- Never stand between the winching vehicle and the vehicle being winched;
- Wear leather gloves when handling cables;
- Use hand-over-hand action to prevent the cable from slipping through the hands;
- Take up the slack until the line is taut, then apply steady power to control both vehicles.

22.5 USING PORTABLE HEATING UNITS

- Get the client's authorization before installing a heating unit on the site
- Only competent, trained workers can install portable heaters in this type of site
- Follow the manufacturer's instructions for the use and maintenance of portable heaters
- Ensure adequate ventilation to avoid the build-up of exhaust gases

PART III: FOLLOW-UP AND MONITORING

23 STAFF TRAINING PROGRAMS

EnGlobe believes that training and informing employees is essential so that they may gain the skills necessary to take on their tasks and responsibilities in matters of health and safety.

The health and safety training programs were established according to a protocol developed by EnGlobe's Health & Safety and Environment department, Human Resources department and site managers. The content varies according to the target audience. A complete training program that is adapted to a diverse audience should contain the following elements:

- General training in health & safety and environment;
- Training and coaching of managers including efficient communication and management of health and safety;
- Training and integration of new staff;
- Safety training on specific tasks;
- Training and drills for emergency responders.

Training and information programs should convey relevant information to workers according to the positions they hold within the organization:

- Safe operational modes of equipment they are responsible for;
- Specific work instructions for tasks they need to fulfill in the course of their duties;
- The content of the health & safety and environmental policy, and the procedures of its quality system;
- The relevant requirements of the specific health & safety prevention program developed for their worksite;
- Their rights and responsibilities with respect to health & safety and environmental management;
- The potential consequences of a failure to comply with legal requirements, regulations, and any other requirements.

Training and information activities are:

- Systematically evaluated by participants during the annual employee appraisal;
- Revised and modified according to staff needs and evaluations, to ensure their ongoing relevance and effectiveness;
- Documented and recorded by the Human Resources division, as specified in the procedure.

24 MONITORING MEASURES

24.1 EMPLOYEE MONITORING MEASURES

Measures for monitoring workers may include the following:

- Measures intended to identify and assess the health characteristics necessary to undertake a type of work;
- Measures intended to identify the characteristics of each worker in a facility in order to assign tasks that correspond to their abilities, and to thereby avoid any threats to their health, safety or physical integrity;
- Medical monitoring of workers for early detection and prevention of health issues that may be caused or aggravated by work;
- Medical examinations and blood tests upon hiring all new workers who will be working in the presence of contaminants;
- Blood tests in the case of any incident involving injuries or major material or environmental damages;
- Optional annual medical checkups for workers exposed to contaminant-related risks (e.g., treatment of soils contaminated with petroleum products, PCB's, etc.), in order to keep an updated list of workers exposed to each contaminant.

24.2 ENVIRONMENTAL MONITORING MEASURES

For EnGlobe's purposes, environmental monitoring is intended to assess working conditions with regard to the following elements:

- Toxic substances (e.g., gases, smoke, dust, fog, contaminants);
- Oxygen level;
- Optical radiation;
- Temperature and humidity;
- Relative humidity;
- Noise;
- Vibrations;
- Micro-organisms.

These monitoring measures depend on the risks associated with each particular site or facility. If even one of the risks is present at a location, monitoring measures should be implemented:

- According to the frequencies specified by regulation (if covered by regulations in effect);
- At a frequency to be determined according to the nature of the risk and the frequency of worker exposure (when no frequency is specified by the regulations or standards in effect).

If one or more of the risks mentioned above have been identified at a worksite, the monitoring measures should be recorded in the health & safety prevention program for the site or facility in question.

25 WORKPLACE INSPECTIONS

EnGlobe uses three types of workplace inspections:

- Regular inspections conducted by site managers or their representatives;
- Internal audits, conducted by internal auditors;
- External audits, conducted by external organizations.

25.1 REGULAR WORKPLACE INSPECTIONS

The form entitled “Health and Safety Monitoring” should be used for conducting regular workplace inspections. Each targeted element should be checked completely or partially depending on the frequencies and conditions established in the prevention program of the site in question.

General inspections are carried out by the supervisor of the site, worksite or facility, or by a designated representative. Those elements being inspected are checked off and dated. Inspection sheets are kept and should be made available for consultation.

25.2 INTERNAL AUDITS

EnGlobe has instituted an internal auditing program for all the Company’s sites, worksites and facilities. The audit schedule and elements to be audited are established by the site director and in collaboration with the QHSE Corporate Director. The frequency of the audits is determined according to the frequency and seriousness of accidents occurring on each site, worksite and facility, and according to the potential health and safety risks to workers or the environment. However, at least one internal audit per 2 years must be held at each site, worksite and facility.

Internal audits are carried out by at least one principal auditor with the appropriate training. The main auditor should be accompanied by one or more employees familiar with site activities.

The results and findings of the audits are prepared by the principal auditor, who sends them to the site manager and their immediate supervisor. The latter individuals determine the corrective measures to be incorporated into the action plan of the specific site, worksite or facility. They should also establish a timeline and operating framework with the QHSE Corporate Director, who will ensure their follow-up.

25.3 EXTERNAL AUDITS

External health & safety and environmental audits may occasionally be conducted by external public or private organizations for insurance purposes, or to ensure compliance with laws and regulations. The results and findings of these audits are treated in the same manner as those of internal audits.

Any measures intended to address issues of non-compliance should be prioritized.

26 HEALTH AND SAFETY COMMUNICATIONS

EnGlobe has established procedures for sending, receiving and documenting any internal or external communications related to health & safety and environmental management.

The purpose of these procedures is to:

- Efficiently send any information on health & safety and the environment to the Company's management, including monthly reports on health & safety and environmental performance, accident reports and potential risk reports as well as their associated investigation reports, and the status of any preventative and corrective actions;
- Inform employees about any hazardous situations and risks that have been identified;
- Communicate audit results to the relevant site managers and the Company's management;
- Establish a mechanism that takes into account the concerns, ideas and comments of workers, and of health and safety committees and their representatives;
- Establish a mechanism for communicating with external interested parties.

EnGlobe plans to use the following means of communication to encourage the active participation of its employees:

- Posting policies in all Company sites and facilities;
- Sending bulletins to managers of sites, worksites and facilities for posting purposes;
- Publishing communications on matters of health & safety and environment in the Company's newsletter;
- Providing access to documents and forms on the Company's intranet site;
- Providing access to an incident file which provides all employees with information on events that have occurred at worksites and any resulting recommendations;
- Information and training sessions.

27 PROGRAM REVIEW

27.1 REVIEW OF PREVENTION OBJECTIVES, TARGETS AND PLANS

Our corporate policies, this guide, the objectives, targets and prevention plan are all subject to an annual review, at a date determined by EnGlobe's management, and generally within the first trimester of the calendar year.

APPENDIX A - **Petroleum Industry Guiding Principles**

For Worker Safety

We, the members of the petroleum industry, have a responsibility to protect all workers engaged in its activities from personal injury and health hazards. To meet our responsibility we will operate under the following guiding principles:

RESPONSIBILITY

The operating company, when acting as prime contractor, is responsible for coordination and general supervision of all activities at the work site, including activities carried out by contractors, sub-contractors, service companies and suppliers. While all parties have a responsibility to promote worker safety, the operating company recognizes its leadership role in promoting worker health and safety on the basis that it has the greatest power to influence work site situations. It is the responsibility of workers and employers to refuse to perform unsafe work practices.

PRIORITY

Activities will be conducted on the basis that safety of all personnel is of vital importance, whether those personnel are employed by an operating company, a contractor, a sub-contractor, a service company or a supplier.

RECOGNITION

The process of selecting contractors, sub-contractors, service companies and suppliers, and the administration of contracts, will include recognition and support of good safety performance. Support and recognition based on good safety performance will also be provided by all employers to their employees.

IMPROVEMENT

The operating company, in cooperation with service companies within the industry, will promote methods and practices that have potential for improving safety performance.

CAPP

Chairman of the Board
Canadian Association of Petroleum Producers

CAGC
CANADIAN ASSOCIATION OF GEOPHYSICAL CONTRACTORS

Chairman of the Board
Canadian Association of Geophysical Contractors

CAODC

Chairman of the Board
Canadian Association of Oilwell Drilling Contractors

PSAC
PETROLEUM SERVICES ASSOCIATION OF CANADA

Chairman of the Board
Petroleum Services Association of Canada

CEPA

Chairman of the Board
Canadian Energy Pipeline Association

sepac

Chairman of the Board
Small Explorers and Producers Association of Canada

Chief Executive Officer

Company Name

Chief Operating Officer

Company Name

Partnerships in HEALTH AND SAFETY

CERTIFICATE OF RECOGNITION

This certificate recognizes that

BIOGENIE S.R.D.C. INC.

In keeping with the principles of *Partnerships* has:

- developed and implemented a workplace health and safety management system and,
- met the standard for *Partnerships* through an independent evaluation of their health and safety system.

ENFORM
Certifying Partner in Health and Safety

Certificate # 20060406-0785
WCB Industry Code(s): 86414

Joe Childs
Director, Workplace Partnerships

Expiry Date: April 06, 2009

Alberta
HUMAN RESOURCES AND EMPLOYMENT

APPENDIX B – LIMITS OF ACCESS IN A CONTAMINATED ATMOSPHERE

				Without respirator (ppm)	Half-mask with cartridges (ppm)	Full face piece mask with cartridges (ppm)	Supplied-air respirator (ppm)
Compound	OEL[1] (ppm)	IDLH[2] (ppm)	LEL[3] %	OEL or IDLH or 10% LEL	10 x OEL or IDLH or 10% LEL	50 x OEL or IDLH or 10% LEL	1 000 x OEL or 10% LEL
Acetone	500	2 500	2,5	500	2 500	2 500	2 500
Acetylene	2 500	2 500	2,5	2 500	2 500	2 500	2 500
Ammoniac	25	300	15	25	250	300	15 000
Benzene	1	500	1,2	1	10	50	1 000
NIOSH Recommended Limit	0,1			0,1	1	5	100
Diesel	NS	NS	0,7	700	700	700	700
Gasoline	300	NS	1,4	300	1 400	1 400	1 400
Hexane	50	1 100	1,1	50	500	1 100	1 100
Hydrogen Sulfide	10	100	4,3	10	100	100	4 300
Methane	NS	5 000	5	5 000	5 000	5 000	5 000
Naphtha (Paint Solvent)	500	1 100	1,1	500	1 100	1 100	1 100
Naphthalene	10	250	0,9	10	100	500	900
Phenol	5	250	N/A	5	50	250	5 000
Propane	1 000	2 100	2,1	1 000	2 100	2 100	2 100
Tetrachloroethene (PCE)	25	150	N/A	25	150	150	25 000
Toluene	50	500	1,1	50	500	500	1 100
Trichloroethene (TCE)	50	1 000	8	50	500	1 000	8 000
Xylenes	100	900	1	100	900	900	1 000

1: OEL = Occupational Exposure Limit (Quebec or US; the most severe based on 8 working hours)
2: IDLH = Immediate Danger for Life and Health
3: LEL = Lower Explosive Limit

Fire and Emergency Plan

EnGlobe Corp. Reference Guide
1450-GU02-EV1, 09-06-03

OFFICIAL VERSION
Distribution of this copy was uncontrolled

Safety
without compromise

TABLE OF CONTENTS

1 INTRODUCTION....1

2 EMERGENCY ORGANIZATION....1
- 2.1 Roles and Responsibilities....2
  - 2.1.1 All Personnel....2
  - 2.1.2 Immediate Supervisors, Directors and Project managers....2
  - 2.1.3 HSE Officer and Alternate HSE Officer....2
  - 2.1.4 2nd HSE Officer(s)....3

3 IMPLEMENTATION OF THE FIRE AND EMERGENCY PLAN....5
- 3.1 Evacuation and Equipment Localization Plan....5
  - 3.1.1 External Muster Area(s)....5
  - 3.1.2 Internal Muster Area(s)....5
- 3.2 First-Aid Contact List....5
- 3.3 Emergency Equipment....5
- 3.4 Communication....6
  - 3.4.1 Employees....6
  - 3.4.2 Visitors....6

4 EMERGENCY RESPONSE....7
- 4.1 Fire....7
  - 4.1.1 Fire Alarm System....7
  - 4.1.2 Fire Sprinkler System....7
  - 4.1.3 Fire Evacuation Procedures....7
- 4.2 Incidents....8
- 4.3 Bomb Threats....9
- 4.4 Explosion....9
- 4.5 Inside Gas Leaks and Fumes....9
- 4.6 Chemicals or Contaminated Substances Spill....9
- 4.7 Power Outages....10
- 4.8 Severe Weather Warnings/Tornado/Earthquake....10
- 4.9 Suspicious Intruder....10
- 4.10 Suspicious Packages....11
- 4.11 Confirmed External Toxic Chemical Release....11

1 INTRODUCTION

This manual describes the emergency intervention plan to be followed on the work sites and in the offices of EnGlobe. It describes safe and effective responses to urgent and emergency situations that all of our employees, our subcontractors and visitors must know. The plan covers various types of emergency situations along with descriptions of personnel and occupant roles and responsibilities, and the proper procedures to follow. Emergency plan(s) should be office and/or site specific and are to be prepared when completing 1450-FO01 "Site Health and Safety Program".

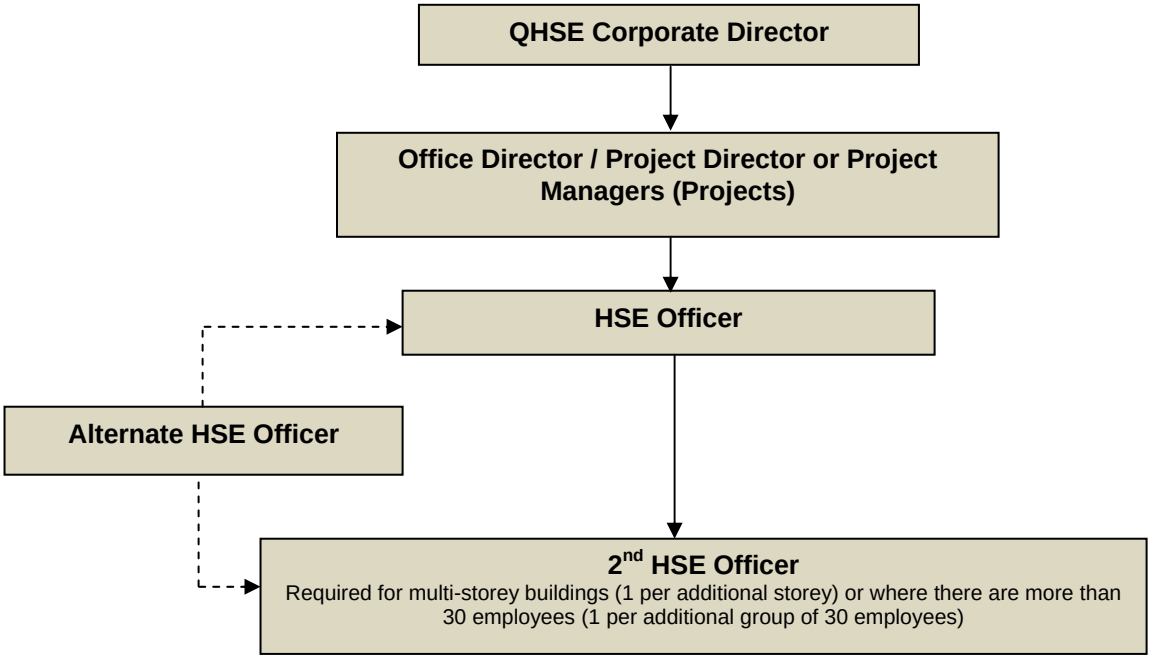
The plan was drawn up by taking into account, in particular, Alberta's occupational health and safety laws and regulations, and it complies with the Alberta Municipal Health and Safety Association's (AMHSA) Certificate of Recognition (COR) audit program.

2 EMERGENCY ORGANIZATION

For each of the company's facilities or projects, the person responsible for the site or project has the responsibility to prepare a site-specific "Prevention Program". The conception of this "Prevention Program" implies the appointment of a Site "Health-Safety and Environment Officer" (HSE Officer) who has the responsibility to supervise the application of the concepts included in the "Prevention Program" and also the responsibility to coordinate the implementation of the emergency plan in case of an emergency.

This same principle is applied to the management of this plan in the case of an emergency occurring in one of our offices.

The organizational chart in the event of an emergency is shown in the following figure.



2.1 ROLES AND RESPONSIBILITIES

2.1.1 All Personnel

Duties – Regular

- Be familiar with the procedures of the "Fire & Emergency Plan" and where your assembly area(s) (muster area) area(s) are located;
- Become familiar with your work area, the nearest exit, and the locations of fire alarm pull stations;
- Ensure that evacuation routes or access to emergency equipment is unobstructed;
- If a specific duty was personally assigned to you to be performed during an emergency situation, remain familiar with the procedures and responsibilities involved;
- Establish a "buddy" system with a fellow employee so someone knows where you are in the event of an emergency.

Duties – During an emergency

- Immediately report any observed potential dangerous situations to the HSE Officer and your immediate supervisor;
- Identify yourself (and any visitors/clients you may have) to your HSE Officer for head count at the appointed muster area;
- Identify any missing co-workers, visitors, clients, or occupants;
- Do not leave the muster area(s) until authorization to do so is given by the HSE Officer.

2.1.2 Immediate Supervisors, Directors and Project Managers

- Provide all needed resources and support to facilitate the work of the HSE Officer and his/her 2nd HSE Officers, if any.

2.1.3 HSE Officer and Alternate HSE Officer

Role:

- Is the lead individual responsible for communicating and promoting information regarding the site "Fire & Emergency Plan";
- Is the lead individual responsible for coordinating and monitoring the evacuation or for the internal sheltering of all personnel during an emergency situation;
- Is the primary contact for emergency service providers during an evacuation.

Duties – Regular

- Have a thorough knowledge of the site “Fire and Emergency Plan” procedures;
- Communicate and promote awareness of the “Fire and Emergency Plan”;
- Have a thorough knowledge of the evacuation areas, exit means, fire extinguisher locations, and fire pull stations;
- Assist in the recruitment of a new 2nd HSE Officer(s) or when replacements are required;
- Coordinate scheduling with the Alternate HSE Officer to cover absences;
- Complete the HSE Monitoring Checklists (1450-FO18) as often as required by the “Prevention Program”;
- Plan and execute emergency response drills and complete an Evacuation Report (1450-FO19), once a year per facility and occasionally per client site, as required;
- If required, ensure that the staff list and visitor sign-in sheet are maintained (1450-FO16);
- In the case of an office or a site that permanently has more than 10 employees, periodically update (at least once every 3 months) the list of employees under his/her responsibility;
- Attend regularly scheduled meetings and training sessions related to the “Fire and Emergency Plan”;
- Assist in implementing changes and revisions to the “Fire & Emergency Plan”;
- Make a follow-up on every report of an accident occurring on his/her site (1450-FO17);

Duties - During an Emergency

- Confirm, coordinate and monitor the evacuation;
- Conduct a search of his/her sector (including the restrooms) and be the last to leave the premises;
- Conduct a head count of the staff, using his/her staff list, or where available, obtain the head count made by the assistant controllers;
- Acquire a head count from the 2nd HSE Officer(s) and any other information gathered to complete the head count;
- Prepare a description of the situation for the emergency service providers for their arrival. This may include a report of any people who may still be inside the building and the location or nature of the hazards or fire;
- Sound the “all-clear” and permit access back into the building when, and only when, the emergency service providers have advised that the building is safe for re-entery.

2.1.4 2nd HSE Officer(s)

Role:

- Assists in communicating and promoting information regarding the site “Fire and Emergency Plan”;
- Responsible for the evacuation or internal sheltering of personnel within a specific area during an emergency situation;
- Reports directly to the HSE Officer.

Duties – Regular

- Have a thorough knowledge of the procedures of the site “Fire & Emergency Plan”;
- Have a thorough knowledge of the locations of specific evacuation area(s), exit(s), fire extinguisher locations, and fire pull stations;
- Ensure that a staff list and visitor sign-in sheet are maintained for their specific area;
- Periodically update (at least once every 3 months) the list of employees under his/her responsibility;
- Assist in the planning and execution of emergency response drills;
- Attend regularly scheduled meetings and training sessions relating to the “Fire and Emergency Plan”.

Duties - During an Emergency

- Confirm, coordinate and monitor the evacuation of their specific area;
- Conduct a search of his/her sector (including the restrooms) and be the last to leave the premises;
- Conduct a head count of the staff under his/her responsibility, using his/her staff list;
- Remain the primary contact for the HSE Officer;
- Complete and report a head count including information on any people who may still be inside the building and the location or nature of the hazards or fire for the HSE Officer.

3 IMPLEMENTATION OF THE FIRE AND EMERGENCY PLAN

3.1 EVACUATION AND EQUIPMENT LOCALIZATION PLAN

Every office and major project must have an "Evacuation and Equipment Location Plan" that all individuals may refer to in order to know the exit pathways and the location of safety equipment (extinguishers, first aid kit, fire alarm pull stations, etc.) and the location of the power unit. This plan must show the location of internal and external muster areas for the personnel in the event of emergency.

3.1.1 External Muster Area(s)

External muster area(s) are used in the event of an evacuation that would take place due to a fire, gas leak, or other situation, which exists within the building or the site itself. An evacuation is usually preceded by an audible alarm and/or an announcement from the HSE Officer. When the building or a site is evacuated, all employees must go to the designated external muster area(s). In case of bad weather, only the HSE Officer can designate an alternate muster area.

3.1.2 Internal Muster Area(s)

Internal muster area(s) or assembly area(s) are used in the event of a gas or substance leak from a neighbouring or outside source, or in response to the onset of severe weather. This procedure is used when evacuating the building or the site is not the safest course of action. The internal muster area(s) is preferably located away from windows, doors, outside walls, or spaces with large roofs. Announcement to move to an internal assembly area may be heard through the building intercom system or by announcement from the HSE Officer. On site, a vehicle could represent a shelter in the event of a sever weather (excluding tornadoes).

3.2 FIRST-AID CONTACT LIST

The internal telephone list presents all employees who have a valid first-aid training. In the event of an emergency, anyone may call upon one of the listed first aid providers to receive immediate assistance. However, on a worksite or at the office, the designated HSE Officer generally has a valid first-aid training and should be the primary person of contact.

3.3 EMERGENCY EQUIPMENT

The emergency equipment located in our offices and used on our sites must comply with the local regulation in term of specifications, quantity, and location. Each office must have a minimum of 1 fire extinguisher at each exit, 1 first-aid kit generally located in the coffee room, an audible alarm in a event of fire, and sufficient emergency lights to allow a safe evacuation. On the sites, there must be at least 1 extinguisher and 1 first-aid kit near the work area. Sites considered as permanent facilities and on which dangerous chemicals are handled must have showers/eye-wash stations. Temporary projects must have portable eye-wash stations.

3.4 COMMUNICATION

3.4.1 Employees

All employees must know the content of this document and the "Evacuation and Equipment Location Plan" of their office. The office or department director is responsible for distribution of this information to new employees within days of their hiring. Furthermore, employees and subcontractors must know the content of each "Prevention Program" prepared for projects requiring their participation. This information is communicated during the project start-up meetings.

3.4.2 Visitors

Prior to entering a site, visitors must receive a brief orientation from the HSE Officer. This orientation is a brief overview of the site "Prevention Program" (including the "Evacuation and Equipment Location Plan", if applicable) and the reading of the main rules presented in the "General Health and Safety Prevention Program" (1450-GU01).

At the office, the visitors will be invited to read a copy of the "Evacuation and Equipment Location Plan" located at each exit of the building. Visitors must stay at the reception area or be accompanied by an employee to circulate inside the office. An employee who receives a visitor or sub-contractor is responsible for providing him/her with the necessary orientation and ensuring his/her evacuation in the event of an emergency. If desired, a visitor register could be kept at the reception area for the use of the HSE Officer in the event of emergency during the head count.

4 EMERGENCY RESPONSE

4.1 FIRE

4.1.1 Fire Alarm System

If applicable, the fire alarm system is activated by manually pulling the handle of afire alarm pull station, or may be activated by detecting heat and/or loss of pressure in the fire sprinkler system. The location of the fire alarm pull stations is shown in the plans located at each building exit. The fire alarm system may also be monitored 24 hours a day by a central station that will notify emergency service providers in the event of an alarm.

4.1.2 Fire Sprinkler System

The majority of our offices are equipped with a fire sprinkler system that will be activated by fire or excessive heat causing the closest sprinkler board to release a water spray. Only the sprinkler heads affected by heat will activate. Upon the release of water/pressure, the fire alarm system will activate, sound the alarms and depending on each office set-up, it may notify the central monitoring station. When the fire sprinkler system activates, do not attempt to shut the system down without the fire department's assistance.

4.1.3 Fire Evacuation Procedures

- Operate the nearest fire pull station if applicable;
- Warn people nearby of the nature of the emergency;
- Proceed immediately to your muster area;
- If you are trained in the use of a fire extinguisher, attempt to extinguish the fire only if it is small and do not stand with fire located between you and the exit. If one extinguisher does not control the fire, leave the area immediately;
- For larger fires or smoke conditions, evacuate the area immediately and close any doors behind you to confine the fire and smoke.

If you hear the fire alarm or a co-worker tells you to leave the premises:

- Leave the building or site immediately using the nearest safe exit and go to your muster area;
- Once outside, keep clear of exterior doorways in order not to block the exit for those following and to keep the area clear for emergency service providers;
- If there is a closed door on your evacuation route, pause before opening it. Check for heat towards the top of the door and then the door handle. If it is hot, or smoke is visible around the door frame, do not open. Choose an alternative evacuation route;
- If time permits, where applicable, turn off any ventilation equipment (furnace, air conditioner, hood fan, etc.) and leave windows closed. Close the doors behind you as you leave. Do not break windows unless it is your only means of escape;
- Once outside, move away from the building to your muster area. Check in with your appointed HSE Officer; and report if anyone is suspected of remaining in the building;

- Never attempt to re-enter a burning or smoke filled building. Remain outside until advised by the HSE Officer.

Advancing through flames:

- If forced to advance through flames: hold your breath, move low and quickly, cover head and hair, keep head down and keep eyes closed as much as possible.

If caught in smoke:

- Drop to your hands and knees and crawl; hold your breath as much as possible. Breath through your nose, filter your inhalation with a blouse, shirt, jacket, etc.

If clothes catch on fire:

- If your clothes catch on fire, stop, drop and roll.

If trapped in a room:

- Place cloth material around/under door to prevent smoke from entering;
- Close as many doors as possible between you and the fire;
- Do not open or break windows unless necessary to escape (outside smoke may be drawn in);
- Call emergency and explain the situation and your location;
- Be prepared to signal your location through a window.

4.2 INCIDENTS

In the event of a major incident or illness of an employee(s) or visitor(s), the response must be carried out in an orderly manner, in the following three PAR stages:

P – PROTECT the first-aid worker and the victim

A – ALERT the person's surroundings and get assistance

R – RESCUE using first-aid trained techniques

Inform your immediate supervisor of the incident as soon as you can. If you called for external assistance, have someone meet the emergency unit at the main entrance to the building or site. If you take the victim to a medical centre yourself, be sure there is, in addition to the driver, someone who travels with the injured individual if there is a probability that his/her condition changes during the transport. Complete an incident report.

4.3 BOMB THREATS

Bomb threats are a criminal act and as such, all bomb threats must be reported to the police. If you receive a bomb threat, obtain as much information as possible from the individual making the threat.

- If you receive a bomb threat by phone, stay calm;
- While attempting to record as much information as possible on the bomb threat, try and attract a co-worker's attention and have them notify the police while the caller is still on the line;
- After the police has been notified, report the incident to your immediate Supervisor/Office Director;
- An evacuation of the site will occur upon the advice of the responding police officer or at the discretion of the HSE Officer.

4.4 EXPLOSION

- Fall to the floor and take immediate shelter under tables, desks, or other objects that will offer protection against flying debris. Protect your face and head with your arms;
- After the effects have subsided, activate nearest fire alarm pull station and call emergency;
- Evacuate building by the quickest designated exit;
- Do not re-enter the building until cleared by the HSE Officer.

4.5 INSIDE GAS LEAKS AND FUMES

If you smell a minor gas odour in/on the site:

- Please notify a Supervisor. The Supervisor will contact Facility Services;
- If the gas odour is strong, evacuate the immediate area and call the Emergency Services Department. Refer to the contact sheet for additional contact numbers.

Other airborne gas odours may be detected that are not originating from inside the building or site. These gas odours may be the result of a diesel truck left running in the area or odours originating from industry. If you are unable to determine the reason for the odour(s), contact a Supervisor. Emergency Services Department will be contacted for directions on the appropriate course of action. Refer to the contact list for additional contact numbers.

4.6 CHEMICALS OR CONTAMINATED SUBSTANCES SPILL

- Stop the source of the spill, if applicable;
- If required, order the evacuation of the premises, and if needed, establish a security perimeter appropriate to the size of the spill;
- Get help, and if required, call for emergency services (major problem involving dangerous products);
- If the premises are safe, take action, using the appropriate protection equipment;
- Prevent dispersion of toxic substances to sensitive points (sewers, streams, vegetation, etc.);
- If required, inform local authorities;
- Use a spill kit to recover the product and clean the area;

- Dispose of the product in conformity with the regulations and in an environmentally friendly manner;
- Complete an accident report.

4.7 POWER OUTAGES

If a power outage occurs inside the offices, battery operated emergency lights normally illuminate to allow safe movement and exit. During a power outage:

- Contact Facility Services to inform of the power outage;
- Take precautions when walking in areas where the lighting levels are low;
- When normal building power resumes, wait five (5) minutes before operating computers, as the power supply may still be unstable. This will prevent accidental loss of electronic files.

4.8 SEVERE WEATHER WARNINGS/TORNADO/EARTHQUAKE

Internal sheltering may be deemed the safest procedure to follow:

- An announcement will be made that severe weather is imminent;
- Move away from windows, doors, outside walls or spaces with large roofs;
- Move to the designated internal muster area(s);
- Do not evacuate the site until notified by the HSE Officer. If advised of evacuation plans, follow the evacuation procedures;
- Following evacuation of the site, account for all occupants;
- Do not return to your work station without the approval of the HSE Officer.

In the event of a tornado, external sheltering may be required if no safe internal shelter is available. In this case:

- Lie flat in a ditch, ravine, or other low-lying area. Keep alert for possible flash floods;
- If you are in your vehicle and you can't drive away at right angles from the tornadoes' path, abandon your vehicle and lie flat in a ditch or under a low bridge/overpass. Choose a location where your vehicle will not be tossed or rolled onto you;
- Account for all individuals that may have been with you;
- Notify your Office Director/Supervisor that you are "ok".

4.9 SUSPICIOUS INTRUDER

- Approach the person and offer assistance;
- If there is no response or their reaction is hostile, back off and contact your supervisor;
- If there is reason to believe that the intruder/trespasser is armed, do not approach the person and notify emergency services immediately.

4.10 SUSPICIOUS PACKAGES

Suspicious packages may be discovered as the result of a bomb threat. The suspicious package will be dealt with as a suspected bomb. Because of the imminent danger, immediate action must be taken.

- If you discover a suspicious package, do not touch it or move it;
- Immediately contact the police. Contact the HSE Officer in case evacuation is required.

4.11 CONFIRMED EXTERNAL TOXIC CHEMICAL RELEASE

Internal sheltering may be deemed the safest procedure to follow:

- An announcement will be made that there is a confirmed external toxic chemical release. Personnel are to stay indoors and meet in the internal muster area(s);
- Move all occupants away from windows and doors to a secure area;
- Keep all doors and windows closed, allowing people to enter the building with minimal door opening;
- If possible, the HSE Officer will take steps to shut down all air exchange systems;
- Until the gas has been identified and deemed safe, turn off all sources of ignition. Do not operate light switches or electrical appliances.

Do not evacuate the building until notified to do so by the HSE Officer. The HSE Officer will be following the direction of the emergency service providers.

enGlobe

Safety
without compromise

SAFETY INSTRUCTIONS FOR SUBCONTRACTORS AND VISITORS

Biogénie

CELTIC
Design and Construct Remediation

gsi

SOLUTION
CENTRE DE TRAITEMENT DE SOL

TANKNOLOGY
Your Fuel Management Partner

This site is dedicated to environmental work involving the management of residual organic matter or the assessment/rehabilitation of soil and water contaminated by hazardous substances. Without proper preventive measures, this work can pose several risks to your health and safety. In some cases, adverse effects can appear a long time after exposure to the hazardous agent.

WELCOME TO OUR SITE!

In order to preserve your physical integrity and that of others, please **follow the safety and environmental instructions** provided in this pamphlet as well as the instructions provided by your escort.

GENERAL INSTRUCTIONS:

1- Do not enter the site without prior authorization.

2- Follow the safety guidelines and pay attention to any warnings given during your visit.

3- Familiarize yourself with the emergency procedures.

4- Wear the required safety equipment (boots, gloves, hard hat, safety vest, goggles, etc.).

5- Do not smoke, except in designated areas.

6- Do not bring or be under the influence of drugs or alcohol; failure to comply will result in immediate expulsion.

.

7- Do not venture alone on the site without prior authorization, and walk only on designated paths.

8- Walk slowly and watch out for uneven or slippery ground.

9- Avoid coming into contact with the equipment and materials. If required, wear the recommended safety equipment, depending on the material's properties*, and wash your hands regularly.

* Ask about the precautions to take for handling materials that contain hazardous substances, pathogens or hot components (such as ashes).

10- Keep a safe distance from the machinery, equipment and ongoing operations (min. of 20 ft. or 6 metres).

11- Remain alert to avoid being hit and do not block the path of heavy vehicles.

12- Do not stand under loads that are being lifted or in the dead angles of machines and heavy vehicles. If you need to approach this machinery, warn the operator and wait for his or her signal.

13- Report any incident that poses a safety risk.

SPECIFIC INSTRUCTIONS FOR SUBCONTRACTORS:

1- Show your qualification card upon request and attend the health and safety meetings on the site.

2- Work with appropriate and well-maintained machinery and equipment.

3- Lower any lifted components (buckets, forks, loads, etc.) before allowing anyone to approach your equipment.

4- Maintain three points of contact when getting in and out of machines.

5- Use restraint devices and follow the instructions for elevated work, work near a pit, work in a confined space, etc.

6- Lock out any equipment being used before intervening.

ENVIRONMENT:

1- Keep the site clean and safe.

2- Use resources (water, paper, electricity, fuel, etc.) responsibly.

3- Encourage the reduction, reuse and recycling of waste. Otherwise, dispose of waste in an environmentally friendly manner.

☐ **EnGlobe** ☐ **GSI** ☐ _____
X **Biogenie** ☐ **Solution EAS**
☐ **Celtic** ☐ **Tanknology**

Registration: 1450-100-EN01
Sequence:

SPECIFIC PREVENTION PROGRAM (HEALTH-SAFETY AND ENVIRONMENT)

Site (project / office / factory / etc.)**:**	Resolution Island

1 PROGRAM IMPLEMENTATION

This program was specifically prepared for the above-mentioned sites and is intended to complement the General Prevention Program (1450-GU01) which presents the Health, Safety, and Environment policy, responsibilities of managers and employees, as well as the general rules of prevention which all personnel must respect. A second guide related to emergency measures (1450-GU02) also constitutes a component of this prevention program.

Additionally, a list of Job Safety Analysis (JSAs) which present the preventive measures to adopt for the execution of specific tasks performed on this site is also available as a complement to this prevention program.

2 HEALTH-SAFETY AND ENVIRONMENT REPRESENTATIVES

Title / Role	**Name**	**Title**
Project Manager (internal)	Nicolas Audet	Project Manager
HSE Officer	Pierre Doyon	Camp Superintendent
Members of HSE Committee (if applicable) Or Second HSE Officer(s)	Kailapi Alorut	
	Robert Lévesque	

3 CERTIFICATIONS STATUS

Training	**Renewal**	Engineers	Foramen / Supervisors	Technicians	HSE Officer	Laborers	Machinery Operators		
First Aid and CPR	3 years	☒	☒	☒	☒	☐	☐	☐	☐
WHMIS		☒	☒	☐	☒	☐	☐	☐	☐
H&S on Construction Sites		☒	☒	☐	☐	☐	☐	☐	☐
Petrochemical Industries	None	☐	☐	☐	☐	☐	☐	☐	☐
Fire Security Training		☒	☒	☒	☐	☐	☐	☐	☐
Fork-Lift Truck Training	NA	☐	☐	☐	☐	☐	☐	☐	☐
Machinery Operations	NA	☐	☐	☐	☐	☐	☐	☐	☐
HAZWOPER (United-States)	NA	☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐
		☐	☐	☐	☐	☐	☐	☐	☐

4 IDENTIFICATION OF POTENTIAL DANGERS AND ENVIRONMENTAL RISKS

Types of Danger and Environmental Risks:	**Origin:**
☒ **Chemical** (fuel, solvents, dangerous matters, etc.)	Gasoline, Diesel Fuel, solvent, paint, glue
☒ **Biological** (bacteria, virus, insects, animals, etc.)	Bugs at the peak season
☒ **Physical** (moving, cutting or rotary parts, radiation, etc.)	Flying debris during renovation
☒ **Ergonomic** (repetitive motion, work organization)	Transportation of camp material (redundant), operation of gas powered generator
☒ **Psychosocial** (stress, schedule, work conditions)	Remote and isolated communities, possibility of tight deadlines, downtime
☒ **Environment** (ground condition, weather, working at height, etc.)	ATV cruising at high speed, high temperatures, dehydration, wildlife

☒ **Odor, Noise or Dust Emission**	Noise: ATVs and generators
☐ **Contamination of Air, Water or Soil**	
☒ **Consumption of Water, Electricity or Material Resources**	Water for food, electricity from generators
☒ **Waste Production**	Residuals from building materials wrapping, boxes, plastic membranes
☒ **Accidental Spill**	Small spill during refueling of generators and ATVs

5 LIST OF PERMITS AND AUTHORIZATIONS FOR THIS SITE

Number	Title	Issue Date	Expiry Date
IBR-RES0916	Nunavut Water Board Water License	2009-06-19	2015-06-18

6 ENVIRONMENTAL MONITORING (nuisance and pollution monitoring)

Elements to be monitored	Limits	Frequency of measurements	Actions to be taken if limits are exceeded
NA			

7 LIST OF MAIN CHEMICAL PRODUCTS HANDLED ON THIS SITE*

Name	Health and Safety hazards
Unleaded Gasoline	Flammable, irritant, respiratory hazard
Paint thinner	Flammable, eye and skin irritant. Vapours are flammable
Floor paint	Eye, skin and respiratory irritant. Vapours are flammable
Paint (alkyd)	Eye, skin and respiratory irritant. Vapours are flammable.
Primer (oil base)	Eye, skin and respiratory irritant. Vapours are flammable.
Propane	Compressed gas and flammable.

*** For more information, refer to the Material Safety Data Sheets attached to this specific prevention program**

8 AIR MONITORING

Elements to be monitored	Limits*	Frequency of Measurements	Actions to be taken if limits are exceeded
Temperature	< 4 or > 32 ^{o}C	Each day when working outside	Refer to Guide 1450-GU01

***** TWA = Time-Weighted Average (8 hours), STEL = Short Term Exposure Limit (15 minutes)

9 PERSONAL PROTECTION EQUIPMENT (PPE)

Activities / tasks	Safety Boots	Coveralls	Hard Hat	Working Gloves	Chemical Gloves	Safety Glasses	Coverall Tyvec/Nomex	Respirator with cartridges	Dust Mask	Vest / Stripes
PPE - Minimal requirement on the site	☒	☒	☒	☐	☐	☒	☐	☐	☐	☒
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Activities / tasks (cont.)										
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Comments:

10 EMERGENCY CONTACTS *(major incident)*

Name or Service	Telephone	Fire	Body Injury	Theft / Vandalism	Spill / Accident. Reject	Damage to Publ. Infrastr.	Intoxication	Wildlife encounter	
Site Manager (internal)	418-653-4422	☒	☒	☒	☒	☒	☐	☐	☐
Site HSE Officer	418-653-4422	☒	☒	☒	☒	☒	☐	☐	☐
Client Representative	(867) 920-3413	☒	☒	☒	☒	☒	☐	☐	☐
First-Aid Worker	On site	☐	☒	☐	☐	☐	☐	☐	☐
Fire Department Iqaluit	867-979-4422	☒	☐	☐	☒	☒	☐	☐	☐
North Warning System Operations (Iqaluit)	867-979-4818	☐	☒	☐	☐	☐	☐	☐	☐
Kenn Borek Air (MEDEVAC)	867-979-0040	☐	☒	☐	☐	☐	☐	☐	☐
Ambulance Medevac Iqaluit Ambulance	867-979-4018	☐	☒	☐	☐	☐	☐	☐	☐
Baffin Regional Hospital	867-979-7300	☐	☒	☐	☐	☐	☐	☐	☐
Kimmirut Health Center	867-979-2217	☐	☒	☐	☐	☐	☐	☐	☐
Ministry of Environment	(867) 920-8130	☐	☐	☐	x	☐	☐	☐	☐
Poison and Drug Info. Service (NWT)	(867) 669-4100	☐	☐	☐	☐	☐	☒	☐	☐
Police Iqaluit	(867) 979-7300	☐	☐	☒	☐	☐	☐	☐	☐
Police Kimmirut	(867) 939-0123	☐	☐	☒	☐	☐	☐	☐	☐
24-hour Spill Line	867-920-8130	☐	☐	☐	☒	☐	☐	☐	☐
Canadian Transport Emergency Centre (CANUTEC)	613-996-6666	☐	☐	☐	☒	☐	☐	☐	☐
Department of sustainable development Gov't of Nunavut	867-975-5907	☐	☐	☐	☒	☐	☐	☐	☐
Qikiqtani Inuit Association 24 h	867-975-8419	☐	☐	☐	☒	☐	☐	☐	☐
Workers' Compensation Board 24-hour Accident Reporting Line	1-877-404-4407	☐	☒	☐	☐	☐	☐	☐	☐
Nunavut Wildlife Management Board	**867-975-7300**	☐	☐	☐	☐	☐	☐	☐	☒
Hunters and trappers association	**867-979-6848**	☐	☐	☐	☐	☐	☐	☐	☒

Comments:

* If their infrastructures are involved in the event

11 LIST OF FIRST-AID WORKERS FOR THIS SITE *(also refer to EnGlobe's telephone list)*

Name:	Telephone:	Name:	Telephone:
Nicolas Audet	418-653-4422		

12 LOCATION OF THE NEAREST HOSPITAL

Name:	Baffin Regional Hospital	Distance:	330 km

Address:	Iqaluit	**Route:**	Air
Travel route from site to the designated hospital attached to this program ☐Yes ☒No		**Local map of the designated hospital attached to this program** (surrounding streets) ☐ Yes ☒No	

***** Post a copy of this page or an equivalent document on the site *****

13 EMERGENCY PLAN

The guide 1450-GU02, entitled Fire and Emergency Plan, presents the preventive measures to be adopted when an emergency occurs. Please refer to section 10 for emergency contacts.

Posting an Evacuation and Equipment Location Plan at Site Entrances*	☐ Yes ☒ No
- This plan illustrates exits and means of access	☐ Yes ☐ No
- This plan illustrates the localization of emergency equipment	☐ Yes ☐ No
- This plan illustrates the muster areas	☐ Yes ☐ No
- This plan illustrates the Exclusion, Contamination Reduction and Support Zones	☐ Yes ☐ No
- This plan illustrates the environmental sensitive points	☐ Yes ☐ No

* Applicable for permanent sites and major projects

The HSE Officer will announce a site evacuation by means of a:

☒ Verbal Call ☐ Whistle ☐ Compressed Air Horn ☐ Siren ☐ Other:

Do you expect to perform emergency drills:	☒ No ☐ Yes, frequency:

14 DECONTAMINATION PLAN

Waste Management: All waste will be taken back to Iqaluit

Decontamination of Sampling Equipment: NA

Decontamination of Vehicles and Machinery: N/A

15 EQUIPMENT MAINTENANCE PROGRAM

The measuring equipment and those associated with operations have a logbook that presents maintenance work to be performed and the frequency. Each maintenance or repair must be recorded for traceability purposes.

Presence of a list of equipment that includes maintenance schedule	☒ Yes	☐ No	N/A
The measuring equipment has a periodical calibration program	☒ Yes	☐ No	N/A

16 PREVENTION PROGRAM MANAGEMENT

Activity	Document	Frequency
☒ HSE General Meeting	Meeting Form	Quarterly
☒ HSE Site Meeting (tailgate)	1450-FO15 or equivalent (optional)	Daily

☒ Commitment of Employees	1450-FO16 or equivalent	After presentation of this prevention program
☒ Commitment of Subcontractors	1450-FO16 or equivalent	After presentation of this prevention program
☐ Commitment of Visitors	1450-FO16 or equivalent	After presentation of this prevention program

☐ HSE Monitoring of Site	1450-FO18 or equivalent	Project Start-up + Monthly
☐ Planned Job Observation*	1110-FO05	According to the business unit annual planning
☐ Audit interne*	1110-FO02	According to the business unit annual planning

* These elements are planned by the management of each business unit and the frequency is recorded in the QHSE Action Plan

☒ Incident Report (accident, material damage, spill, near miss, etc.)	1450-FO17 or equivalent	Each event

☐ Medical Surveillance (blood and urine testing)[1]	HR Database	Each year (voluntary)
☐ Vaccination (tetanus)[2]	HR Database	1 time / 10 years
☐ Vaccination (hepatitis)	HR Database	1 time + 2 boosters

* Employee in frequent contact with 1: dangerous chemical products, 2: rust or soil, 3: pathogen agents (biosolids, faecal matters, etc.)

☐ Respirators Fit-Testing	Free	Annual

☐		
☐		
☐		
☐		
☐		

Prepared by: Erwan Carrière **Date:** July 9th, 2010

Approved by: Jean Pierre Pelletier **Date:** July 20th, 2010

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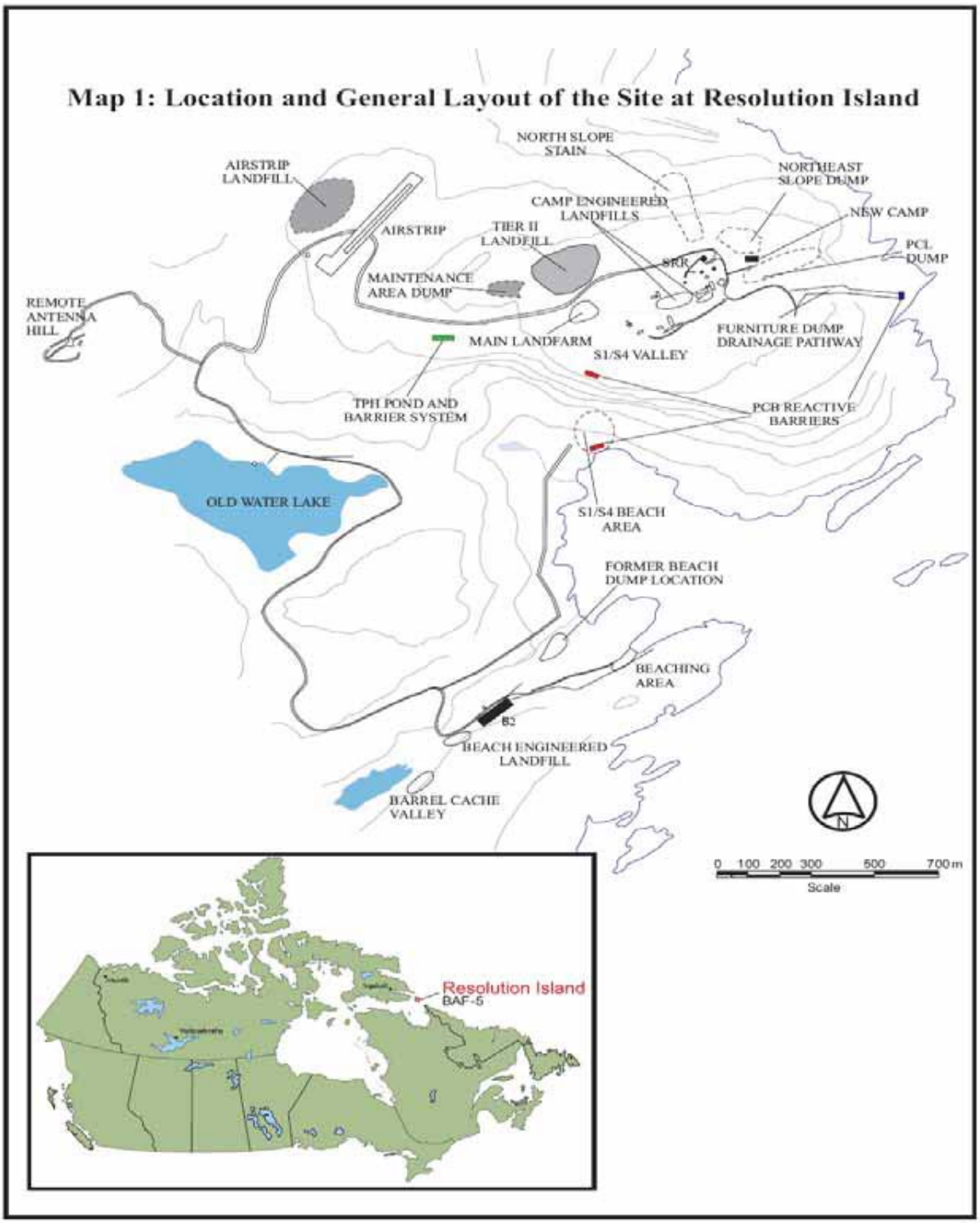
Map 1: Location and General Layout of the Site at Resolution Island
NORTH SLOPE STAIN
AIRSTRIP LANDFILL
NORTHEAST SLOPE DUMP
CAMP ENGINEERED LANDFILLS
NEW CAMP
AIRSTRIP
TIER II LANDFILL
PCL DUMP
SRR
MAINTENANCE AREA DUMP
REMOTE ANTENNA HILL
FURNITURE DUMP DRAINAGE PATHWAY
MAIN LANDFARM
S1/S4 VALLEY
TPH POND AND BARRIER SYSTEM
PCB REACTIVE BARRIERS
OLD WATER LAKE
S1/S4 BEACH AREA
FORMER BEACH DUMP LOCATION
BEACHING AREA
B2
BEACH ENGINEERED LANDFILL
BARREL CACHE VALLEY
N
0 100 200 300 500 700 m
Scale
Resolution Island
BAF-5

☐ EnGlobe
☒ Biogenie
☐ Celtic

☐ GSI
☐ Solution EAS
☐ Tanknology

☐ _____

Registration: 1450-100-EN01
Sequence:

JOB SAFETY ANALYSIS (JSA)
Summary Sheet for SAR Activities

1 LIST OF APPLICABLE JSAs *(attach JSAs - form 1450-FO12)*

☐ Soil Excavation	☐ Test Pits
☐ Borehole Drilling and Monitoring Wells Installation	☒ Site Visit and Preparation
☐ Surveying	☐ Groundwater Monitoring and Hydrogeological Testing
☐ Shoring	☐ Underground Tank Removal and Disposal
☐ Oil Skimming from Water	☒ Pumping of Liquids or Flammable Products
☐ Soil Loading or Unloading	☐ Leveling of Treatment and Storage Areas
☐ Installation of Treatment Pipes	☐ Installation or Removal of Cover-up Tarpaulins
☐ Biopile Soil Movement and Amendment	☐ Monitoring and Maintenance of Treatment Equipment
☐ Sampling of a Biopile	☒ Demolition Work
☐ Mobile Heavy Equipment Activities	☐ Activities in Traffic Areas
☐ Working Near or On Open Water or Ice	☐
☐	☐
☐	☐
☐	☐

2 LIST OF APPLICABLE CRITICAL TASKS *(attach checklists - form 1450-FO14)*

☐ Working at Height	☐ Confined Space
☒ Electrical/Mechanical Isolation	☐ Sub-surface Clearance
☐ Entry into Excavations	☐ Hot Work (in an Explosive Atmosphere)
☐ Heavy Equipment Lifting	☐ Working Near Overhead Power Lines
☐	☐
☐	☐

3 OTHER APPLICABLE SUBJECTS *(see the General HSE Prevention Guide 1450-GU01)*

Subject	Section of the Guide:
☒ Driving a Road Vehicle	8.4 – Driving a Road Vehicle
☒ Worksite Preparation	8.6 – Planning of Work Areas
☒ Equipment Purchasing or Renting	11.1.1 – Purchasing and Renting Policy
☒ Working under Extreme Weather	13 – Thermal Energy (Hot or Cold)
☒ Using Portable Heating Units	22.5 – Using Portable Heating Units
☒ Exposure to Chemical Products	16 – Risks due to Chemical Products and Contaminants
☐ Exposure to Micro-Organisms	17 – Exposure to Micro-Organisms
☒ Circulation on Uneven or Slippery Surface	14.2.2 – Slipping, Tripping and Falling on the Same Level
☐ Working Alone	20 – Working Alone
☒ Administrative Tasks	21 – Ergonomic Risks
☒ Wilderness and Wildlife	19 – Risks Associated with Wilderness and Wildlife
☒ Noise	18 – Physical Hazards (Noise, Vibrations and Radiation)
☐ Working On or Near Oil and Gas Plants	22.1 – Working On or Near Oil and Gas Plants
☐ Towing or Winching Operations	22.4 – Carrying out Towing or Winching Operations
☐	
☐	
☐	

Prepared by: _____ Date: _____

4 AKNOWLEDGMENT *(section to be completed when required by the client)*

Each undersigned hereby declares that he has read and reviewed on the worksite the applicable JSAs and the other related subjects (sections 1 et 3)*.

Name (Please Print)	**Company**	**Signature**	**Date**

* The checklists for critical tasks (section 2) are individually signed by the relevant persons.

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☐ Solution EAS
☐ Tanknology

☐ _____

Registration: 1450-100-EN01
Sequence:

EMPLOYEE COMMITMENT FORM (HSE PROGRAM)

1 DECLARATION

I certify that I have read the Specific Prevention Program and I agree to comply with the requirements. I also agree to commit to acting in a safe manner at all time, to respect the environment and to report all situations that involve a potential risk.

Name (please print)	**Company**	**Signature**	**Date**

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☐ Biogenie ☐ Solution EAS
☐ Celtic ☐ Tanknology

Registration: 1450-200-EN05
Sequence:

ENVIRONMENT AND SAFETY MEETING

Activities Review:	☐ Specific Instructions, JSA, Work Permit ☐ Review of Time Schedule
General Rules Review:	☐ PPE ☐ No Smoking ☐ Drugs, Alcohol and Medication ☐ Violent Games ☐ Incidents / Near Miss Report Procedure
Emergency Response Review:	☐ Safety Equipment ☐ Contacts List ☐ Evacuation Plan ☐ Muster Areas ☐ Closest Hospital
Injuries and Near Misses Review:	☐ Incident Reports ☐ Info: Safety and Environment, Safety-Alert, etc.

Task Hazard Assessment	**Presence**	**Description**
Risk associated with the environment and chemicals		
Contact with chemicals or contaminated substances	☐	
Inhalation of dust, vapor, gas	☐	
Electricity	☐	
Underground utilities (Ground disturbance)	☐	
Air quality (Oxygen deficiency, high LEL, etc.)	☐	
Weather, source of heat, cold or radiation	☐	
Noise	☐	
Risk of hit or being hit by something		
Moving or flying equipment / Falling object	☐	
Circulation of vehicles and machinery	☐	
Protruding, sharp or jagged object	☐	
Risk of being caught or in or between something		
Confined space, hole, trench or excavation	☐	
Fallen soil or piled material	☐	
Pinch point	☐	
Risk of slipping, tripping or falling		
Circulation on slippery or uneven surface)	☐	
Elevated area (Working at height)	☐	
Risk of over exertion or strain		
Lifting or pulling	☐	
Repetitive task	☐	
Environmental aspect		
Odor, noise, dust emission	☐	
Soil, water or air pollution	☐	
Water, electricity or raw materials consumption	☐	
Production / Collection of waste materials	☐	
Accidental spill / Emergency situation	☐	

Other Topics Discussed / Employees Suggestions

Prepared by: _____ **Date:** _____
(Site Supervisor or HSE Officer)

ATTENDEES

Name	Company	Signature

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MATERIAL SAFETY DATA SHEET

SECTION I – PRODUCT INFORMATION

Product Name: Propane
Trade Name: LPG (Liquefied Petroleum Gas)
Chemical Formula: C3H8
WHMIS Classification: Class A – Compressed Gas
Class B, Division I – Flammable Gas

Supplier:

Business:

Non Medical Emergency:

Uses and Occurrence: Propane is commonly used as fuel for heating, cooking, automobiles, forklift trucks, crop drying and welding and cutting operations. Propane is used in industry as a refrigerant, solvent and as a chemical feedstock.

CEPA: CANADIAN ENVIRONMENTAL PROTECTION ACT

All components of this product are either on the Domestic Substances List (DSL) or are exempt.

SECTION II – HAZARDOUS INGREDIENTS

Components	**CAS Registry No.**	**Proportion of Product**	**LC50**	**LD50**
Propane	74986	95% - 98%	N/A	N/A
Ethane	74840	3% - 5%	N/A	N/A
Butane	791068	1% - 3%	N/A	N/A
Iso-Butane	75285	0.1% - 0.3%	N/A	N/A
Methane	74828	0.1% - 0.2%	N/A	N/A

Note: Composition given is typical for Grade 1 Propane; exact composition will vary from shipment to shipment.

- Explanation for change – HD5 refers to American specification, Grade 1 is Canadian equivalent in CGSB 3.14 Standard

SECTION III – CHEMICAL AND PHYSICAL DATA

Form: While stored under pressure – liquid and/or vapour
Boiling Point: -42 ^{o}C atm
Freezing Point: -188 ^{o}C
Evapouration Rate: Rapid (Gas at Normal Ambient Conditions)
Vapour Pressure: 1,013 (kPa) @ 26.0 ^{o}C
Vapour Density: 1.52 (Air = 1)
Coefficient of Water/Oil Distribution: Not available
PH: Not available
Soluble in Water: 6.1% by Volume @ 17.8 ^{o}C and 753 mmHg
Specific Gravity: 0.51 (Water = 1)
Appearance: Colourless liquid and vapour while stored under pressure.
Colourless and odourless gas in natural state at any concentration.
Commercial propane has an odourant added which is commonly ethyl mercaptan which has an odour similar to boiling cabbage or rotten eggs.
Odour Threshold: 4800 PPM
See Note 1 - Odourants

SECTION IV – FIRE OR EXPLOSION HAZARD DATA

Flash Point: -103.4 ^{o}C **Method**: Closed Cup
Flammable Limits: Lower 2.4%, Upper 9.5%
Auto Ignition Temperature: 432 ^{o}C
Products Evolved Due to Heat or Combustion: Carbon monoxide can be produced when primary and secondary airs are deficient while combustion is taking place.
Fire and Explosive Hazards: Explosive air-vapour mixtures may form if allowed to leak to atmosphere.
Sensitivity to Impact: No
Sensitivity to Static Discharge: Yes
Fire Extinguishing Precautions: Use water spray to cool exposed cylinders or tanks. Do not extinguish fire unless the source of the escaping gas that is fuelling the fire can be turned off. Fire can be extinguished with carbon dioxide and/or dry chemical (BC). Container metal shells require cooling with water to prevent flame impingement and the weakening of metal. If weakening, the area must be evacuated. If gas has not ignited, liquid and vapour may be dispersed by water spray or flooding.
Special Fire Fighting Equipment: Protective clothing, hose monitors, fog nozzles, self contained breathing apparatus.

SECTION V – REACTIVITY DATA

Stability: Stable
Conditions to Avoid: Keep separate from oxidizing agents. Gas explodes spontaneously when mixed with chlorine dioxide.
Incompatibility: Remove sources of ignition and observe distance requirements for storage tanks from combustible material, drains, and openings to buildings.
Hazardous Decomposition Products: Deficient primary and secondary air can produce carbon monoxide.
Hazardous Polymerization: Will not occur.

SECTION VI – TOXICOLOGICAL PROPERTIES OF MATERIAL

ACUTE EXPOSURE:

Eyes: As a gas, none, Liquid causes "cold burns'.
Respiratory System: Little physiological effect at concentrations below 10.000 PPM. Higher concentrations may cause dizziness and unconsciousness due to asphyxiation. ***SEE NOTE 2 – ASPHYXIANT.***
Chronic Exposure: There are no reported effects from long-term low-level exposure.
Other: Liquid can cause burns and frostbite if in direct contact with skin.
Sensitization Properties: Skin – unknown, **Respiratory** – unknown.
Carcinogenicity: Not determined. ***SEE NOTE 3 (NORM).***

MEDIAN LETHAL DOSE:
Oral: Not applicable for gas.
Inhalation: Not determined.
Dermal: Not applicable for gas.
Other: Not determined.
IRRITATION INDEX:
Skin: No appreciable effect (gas).
Eyes: No appreciable effect (gas).
Symptoms of Exposure: Above 10,000 PPM – dizziness, stupor, unconsciousness. ***SEE NOTE 2 attached.*** American Conference of Governmental Industrial Hygienists (ACGIH) classifies propane as an asphyxiate; there is no recommended "Threshold Limit Value" (TLV).
Teratogenicity: Not determined.
Mutagenicity: Not determined.

SECTION VII – OCCUPATION CONTROL PROCEDURES

Eyes: Safety glasses, goggles, or face shield required when transferring product.
Skin: Insulated gloves if contact with liquid or liquid cooled equipment is expected. Wear gloves and long sleeves when transferring product.
Inhalation: In atmosphere, where the concentration of propane would reduce oxygen level below 18% in inhaled air, self contained breathing apparatus required. ***SEE NOTE 3 – (NORM).***
Ventilation: Explosion proof ventilation equipment required in confined spaces.

SECTION VIII – EMERGENCY AND FIRST AID PROCEDURES

FIRST AID:
Eyes: Should eye contact with liquid occur, flush eyes with lukewarm water for 15 minutes. Obtain immediate medical care.
Skin: In case of "Cold Burn" from contact with liquid, immediately place affected area in lukewarm water and keep at this temperature until circulation returns. If fingers or hands are frostbitten, have the victim hold his hand next to his body such as under the armpit. Obtain immediate medical care.

SPILL OR LEAK:
Eliminate leak if possible.
Eliminate source of ignition.
Ensure cylinder is upright.
Disperse vapours with hose streams using fog nozzles, watch for low area, as propane is heavier than air and can settle in low areas. Remain upwind of leak, keep people away.
Prevent vapour and/or liquid from entering into sewers, basements or confined areas.

SECTION 1X – TRANSPORTATION, HANDLING AND STORAGE

- Transport and store cylinders and tanks secured in an upright position in a ventilated space, away from ignition sources (so relief valve is in contact with vapour space of cylinder or tank).
- Cylinders that are not in use must have the valves in the closed position and be equipped with a protective cap or guard.
- Do not store with oxidizing agents, oxygen or chlorine cylinders.
- Transport, handle and store according to applicable federal and provincial regulations (CGA B149.2). ***SEE NOTE 4 – MAGNETIC RESIDUES.***

TDG Classification: 2.1 (gas)
TDG Shipping Name: Liquid Petroleum Gas (Propane)
TDG Special Provisions: 56, 90, and 102
PIN UN: 1075

SECTION X – PREPARTATION INFORMATION

Prepared by: Propane Gas Association of Canada
(403) 543-6500

Date prepared: September 2008

The information contained herein is believed to be accurate. It is provided independently of any sale of the product. It is not intended to constitute performance information concerning the product. No express warranty or implied warranty of merchantability or fitness for a particular purpose is made with respect to the product information contained herein.

This information is in addition to the information supplied on the MSDS and forms a part of the MSDS by reference to note numbers indicated:

NOTE 1 ODOURANTS:

Odourants are not completely effective warning agents in all cases.
Certain odourants are polar and/or chemically reactive and may be depleted by reaction or absorption.
Sensitivity to odourants differs from person to person and may decrease with age or impaired physical conditions such as colds or respiratory allergies.
Prolonged exposure to odourants can create desensitization to the odour.

NOTE 2 ASPHYXIANT AND NARCOTIC EFFECTS OR PROPANE:

LPG's can displace air and can act as an asphyxiant. Lack of oxygen may cause dizziness, headaches, diminished awareness, faulty judgment, increase in fatigue and impaired muscular co-ordination. If these symptoms are identified while working in close proximity to propane that is released, go immediately into a fresh air environment.

LPG's are anaesthetic gases within the upper explosive limits and higher concentrations. A person working around propane in an enclosed space or in close proximity to a propane source such as filling cylinders, purging lines, investigating leaks, etc. who feels light-headed, dizzy, drunken, sleepy, or intoxicated should go immediately into fresh air. This narcotic effect may impair a person's judgment temporarily but will rapidly disappear in fresh air.

NOTE 3 NATURALLY OCCURRING RADIOACTIVE MATERIAL (NORM):

Sludges and tank scale from propane storage tanks, bulk delivery truck tanks, railway tank cars, and fuel filters and strainers screens may contain Naturally Occurring Radioactive Material (NORM) in the form of lead 210.

Equipment used for the transfer of propane such as propane piping and hoses, pumps and compressors may have detectable levels of radioactive lead 210 on inner surfaces.

Workers involved in cleaning, repair or maintenance on inner surfaces of such equipment should avoid breathing dust generated from such activities. Suitable codes of practice should be developed for the activities, detailing appropriate occupational hygiene and disposal practices.

NOTE 4 MAGNETIC RESIDUES IN PROPANE:

Magnetic residues generated in automotive fuel tanks from "mill scale" or corrosion processes may impair the operation of magnetic gauges and electronic solenoid valves.

Collection of gross amounts of solid residues can affect the proper operation of lock offs, mixers, pressure release valves, etc.

Solid residues could contain NORM (see note 3).

AMERADA HESS CORPORATION

MATERIAL SAFETY DATA SHEET

Gasoline, All Grades **MSDS No. 9950**

EMERGENCY OVERVIEW
DANGER!
EXTREMELY FLAMMABLE - EYE AND MUCOUS MEMBRANE IRRITANT - EFFECTS CENTRAL NERVOUS SYSTEM - HARMFUL OR FATAL IF SWALLOWED - ASPIRATION HAZARD

NFPA 704 (Section 16)

High fire hazard. Keep away from heat, spark, open flame, and other ignition sources.

If ingested, do NOT induce vomiting, as this may cause chemical pneumonia (fluid in the lungs). Contact may cause eye, skin and mucous membrane irritation. Harmful if absorbed through the skin. Avoid prolonged breathing of vapors or mists. Inhalation may cause irritation, anesthetic effects (dizziness, nausea, headache, intoxication), and respiratory system effects.

Long-term exposure may cause effects to specific organs, such as to the liver, kidneys, blood, nervous system, and skin. Contains benzene, which can cause blood disease, including anemia and leukemia.

1. CHEMICAL PRODUCT and COMPANY INFORMATION (rev. Jan-04)

Amerada Hess Corporation
1 Hess Plaza
Woodbridge, NJ 07095-0961

EMERGENCY TELEPHONE NUMBER (24 hrs): **CHEMTREC (800)424-9300**
COMPANY CONTACT (business hours): Corporate Safety (732)750-6000
MSDS Internet Website www.hess.com/about/environ.html

SYNONYMS: Hess Conventional (Oxygenated and Non-oxygenated) Gasoline; Reformulated Gasoline (RFG); Reformulated Gasoline Blendstock for Oxygenate Blending (RBOB); Unleaded Motor or Automotive Gasoline

See Section 16 for abbreviations and acronyms.

2. COMPOSITION and INFORMATION ON INGREDIENTS * (rev. Jan-04)

INGREDIENT NAME (CAS No.)	CONCENTRATION PERCENT BY WEIGHT
Gasoline (86290-81-5)	100
Benzene (71-43-2)	0.1 - 4.9 (0.1 - 1.3 reformulated gasoline)
n-Butane (106-97-8)	< 10
Ethyl Alcohol (Ethanol) (64-17-5)	0 - 10
Ethyl benzene (100-41-4)	< 3
n-Hexane (110-54-3)	0.5 to 4
Methyl-tertiary butyl ether (MTBE) (1634-04-4)	0 to 15.0
Tertiary-amyl methyl ether (TAME) (994-05-8)	0 to 17.2
Toluene (108-88-3)	1 - 25
1,2,4- Trimethylbenzene (95-63-6)	< 6
Xylene, mixed isomers (1330-20-7)	1 - 15

A complex blend of petroleum-derived normal and branched-chain alkane, cycloalkane, alkene, and aromatic hydrocarbons. May contain antioxidant and multifunctional additives. Non-oxygenated Conventional Gasoline and RBOB do not have oxygenates (Ethanol or MTBE and/or TAME). Oxygenated Conventional and Reformulated Gasoline will have oxygenates for octane enhancement or as legally required.

3. HAZARDS IDENTIFICATION (rev. Dec-97)

EYES
Moderate irritant. Contact with liquid or vapor may cause irritation.

SKIN
Practically non-toxic if absorbed following acute (single) exposure. May cause skin irritation with prolonged or repeated contact. Liquid may be absorbed through the skin in toxic amounts if large areas of skin are exposed repeatedly.

INGESTION
The major health threat of ingestion occurs from the danger of aspiration (breathing) of liquid drops into the lungs, particularly from vomiting. Aspiration may result in chemical pneumonia (fluid in the lungs), severe lung damage, respiratory failure and even death.

Ingestion may cause gastrointestinal disturbances, including irritation, nausea, vomiting and diarrhea, and central nervous system (brain) effects similar to alcohol intoxication. In severe cases, tremors, convulsions, loss of consciousness, coma, respiratory arrest, and death may occur.

INHALATION
Excessive exposure may cause irritations to the nose, throat, lungs and respiratory tract. Central nervous system (brain) effects may include headache, dizziness, loss of balance and coordination, unconsciousness, coma, respiratory failure, and death.

WARNING: the burning of any hydrocarbon as a fuel in an area without adequate ventilation may result in hazardous levels of combustion products, including carbon monoxide, and inadequate oxygen levels, which may cause unconsciousness, suffocation, and death.

CHRONIC EFFECTS and CARCINOGENICITY
Contains benzene, a regulated human carcinogen. Benzene has the potential to cause anemia and other blood diseases, including leukemia, after repeated and prolonged exposure. Exposure to light hydrocarbons in the same boiling range as this product has been associated in animal studies with systemic toxicity. See also Section 11 - Toxicological Information.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
Irritation from skin exposure may aggravate existing open wounds, skin disorders, and dermatitis (rash). Chronic respiratory disease, liver or kidney dysfunction, or pre-existing central nervous system disorders may be aggravated by exposure.

4. FIRST AID MEASURES (rev. Dec-97)

EYES
In case of contact with eyes, immediately flush with clean, low-pressure water for at least 15 min. Hold eyelids open to ensure adequate flushing. Seek medical attention.

SKIN
Remove contaminated clothing. Wash contaminated areas thoroughly with soap and water or waterless hand cleanser. Obtain medical attention if irritation or redness develops.

INGESTION
DO NOT INDUCE VOMITING. Do not give liquids. Obtain immediate medical attention. If spontaneous vomiting occurs, lean victim forward to reduce the risk of aspiration. Small amounts of material which enter the mouth should be rinsed out until the taste is dissipated.

INHALATION
Remove person to fresh air. If person is not breathing, ensure an open airway and provide artificial respiration. If necessary, provide additional oxygen once breathing is restored if trained to do so. Seek medical attention immediately.

5. FIRE FIGHTING MEASURES (rev. Dec-97)

FLAMMABLE PROPERTIES:

FLASH POINT:	-45 °F (-43°C)
AUTOIGNITION TEMPERATURE:	highly variable; > 530 °F (>280 °C)
OSHA/NFPA FLAMMABILITY CLASS:	1A (flammable liquid)
LOWER EXPLOSIVE LIMIT (%):	1.4%
UPPER EXPLOSIVE LIMIT (%):	7.6%

FIRE AND EXPLOSION HAZARDS

Vapors may be ignited rapidly when exposed to heat, spark, open flame or other source of ignition. Flowing product may be ignited by self-generated static electricity. When mixed with air and exposed to an ignition source, flammable vapors can burn in the open or explode in confined spaces. Being heavier than air, vapors may travel long distances to an ignition source and flash back. Runoff to sewer may cause fire or explosion hazard.

EXTINGUISHING MEDIA

SMALL FIRES: Any extinguisher suitable for Class B fires, dry chemical, CO2, water spray, fire fighting foam, or Halon.

LARGE FIRES: Water spray, fog or fire fighting foam. Water may be ineffective for fighting the fire, but may be used to cool fire-exposed containers.

During certain times of the year and/or in certain geographical locations, gasoline may contain MTBE and/or TAME. Firefighting foam suitable for polar solvents is recommended for fuel with greater than 10% oxygenate concentration - refer to NFPA 11 “Low Expansion Foam - 1994 Edition.”

FIRE FIGHTING INSTRUCTIONS

Small fires in the incipient (beginning) stage may typically be extinguished using handheld portable fire extinguishers and other fire fighting equipment.

Firefighting activities that may result in potential exposure to high heat, smoke or toxic by-products of combustion should require NIOSH/MSHA- approved pressure-demand self-contained breathing apparatus with full facepiece and full protective clothing.

Isolate area around container involved in fire. Cool tanks, shells, and containers exposed to fire and excessive heat with water. For massive fires the use of unmanned hose holders or monitor nozzles may be advantageous to further minimize personnel exposure. Major fires may require withdrawal, allowing the tank to burn. Large storage tank fires typically require specially trained personnel and equipment to extinguish the fire, often including the need for properly applied fire fighting foam.

See Section 16 for the NFPA 704 Hazard Rating.

6. ACCIDENTAL RELEASE MEASURES (rev. Dec-97)

ACTIVATE FACILITY SPILL CONTINGENCY or EMERGENCY PLAN.

Evacuate nonessential personnel and remove or secure all ignition sources. Consider wind direction; stay upwind and uphill, if possible. Evaluate the direction of product travel, diking, sewers, etc. to confirm spill areas. Spills may infiltrate subsurface soil and groundwater; professional assistance may be necessary to determine the extent of subsurface impact.

Carefully contain and stop the source of the spill, if safe to do so. Protect bodies of water by diking, absorbents, or absorbent boom, if possible. Do not flush down sewer or drainage systems, unless system is designed and permitted to handle such material. The use of fire fighting foam may be useful in certain situations to reduce vapors. The proper use of water spray may effectively disperse product

vapors or the liquid itself, preventing contact with ignition sources or areas/equipment that require protection.

Take up with sand or other oil absorbing materials. Carefully shovel, scoop or sweep up into a waste container for reclamation or disposal - caution, flammable vapors may accumulate in closed containers. Response and clean-up crews must be properly trained and must utilize proper protective equipment (see Section 8).

7. HANDLING and STORAGE (rev. Dec-97)

HANDLING PRECAUTIONS

******USE ONLY AS A MOTOR FUEL******
******DO NOT SIPHON BY MOUTH******

Handle as a flammable liquid. Keep away from heat, sparks, and open flame! Electrical equipment should be approved for classified area. Bond and ground containers during product transfer to reduce the possibility of static-initiated fire or explosion.

Special slow load procedures for "switch loading" must be followed to avoid the static ignition hazard that can exist when higher flash point material (such as fuel oil) is loaded into tanks previously containing low flash point products (such as this product) - see API Publication 2003, "Protection Against Ignitions Arising Out Of Static, Lightning and Stray Currents.

STORAGE PRECAUTIONS

Keep away from flame, sparks, excessive temperatures and open flame. Use approved vented containers. Keep containers closed and clearly labeled. Empty product containers or vessels may contain explosive vapors. Do not pressurize, cut, heat, weld or expose such containers to sources of ignition.

Store in a well-ventilated area. This storage area should comply with NFPA 30 "Flammable and Combustible Liquid Code". Avoid storage near incompatible materials. The cleaning of tanks previously containing this product should follow API Recommended Practice (RP) 2013 "Cleaning Mobile Tanks In Flammable and Combustible Liquid Service" and API RP 2015 "Cleaning Petroleum Storage Tanks".

WORK/HYGIENIC PRACTICES

Emergency eye wash capability should be available in the near proximity to operations presenting a potential splash exposure. Use good personal hygiene practices. Avoid repeated and/or prolonged skin exposure. Wash hands before eating, drinking, smoking, or using toilet facilities. Do not use as a cleaning solvent on the skin. Do not use solvents or harsh abrasive skin cleaners for washing this product from exposed skin areas. Waterless hand cleaners are effective. Promptly remove contaminated clothing and launder before reuse. Use care when laundering to prevent the formation of flammable vapors which could ignite via washer or dryer. Consider the need to discard contaminated leather shoes and gloves.

8. EXPOSURE CONTROLS and PERSONAL PROTECTION (rev. Jan-04)

EXPOSURE LIMITS

Component (CAS No.)	Exposure Limits			
	Source	TWA (ppm)	STEL (ppm)	Note
Gasoline (86290-81-5)	ACGIH	300	500	A3
Benzene (71-43-2)	OSHA	1	5	Carcinogen
	ACGIH	0.5	2.5	A1, skin
	USCG	1	5	
n-Butane (106-97-8)	ACGIH	800	--	2003 NOIC: 1000 ppm (TWA) Aliphatic Hydrocarbon Gases Alkane (C1-C4)
Ethyl Alcohol (ethanol) (64-17-5)	OSHA	1000	--	
	ACGIH	1000	--	A4
Ethyl benzene (100-41-4)	OSHA	100	--	
	ACGIH	100	125	A3

Component (CAS No.)	Exposure Limits			
	Source	TWA (ppm)	STEL (ppm)	Note
n-Hexane (110-54-3)	OSHA	500	--	
	ACGIH	50	--	skin
Methyl-tertiary butyl ether [MTBE] (1634-04-4)	ACGIH	50		A3
Tertiary-amyl methyl ether [TAME] (994-05-8)				None established
Toluene (108-88-3)	OSHA	200		Ceiling: 300 ppm; Peak: 500 ppm (10 min.)
	ACGIH	50	--	A4 (skin)
1,2,4- Trimethylbenzene (95-63-6)	ACGIH	25	--	
Xylene, mixed isomers (1330-20-7)	OSHA	100	--	
	ACGIH	100	150	A4

ENGINEERING CONTROLS

Use adequate ventilation to keep vapor concentrations of this product below occupational exposure and flammability limits, particularly in confined spaces.

EYE/FACE PROTECTION

Safety glasses or goggles are recommended where there is a possibility of splashing or spraying.

SKIN PROTECTION

Gloves constructed of nitrile or neoprene are recommended. Chemical protective clothing such as that made of of E.I. DuPont Tychem ®, products or equivalent is recommended based on degree of exposure.

Note: The resistance of specific material may vary from product to product as well as with degree of exposure. Consult manufacturer specifications for further information.

RESPIRATORY PROTECTION

A NIOSH-approved air-purifying respirator with organic vapor cartridges or canister may be permissible under certain circumstances where airborne concentrations are or may be expected to exceed exposure limits or for odor or irritation. Protection provided by air-purifying respirators is limited. Refer to OSHA 29 CFR 1910.134, NIOSH Respirator Decision Logic, and the manufacturer for additional guidance on respiratory protection selection and limitations.

Use a positive pressure, air-supplied respirator if there is a potential for uncontrolled release, exposure levels are not known, in oxygen-deficient atmospheres, or any other circumstance where an air-purifying respirator may not provide adequate protection.

9. PHYSICAL and CHEMICAL PROPERTIES (rev. Jan-04)

APPEARANCE

A translucent, straw-colored or light yellow liquid

ODOR

A strong, characteristic aromatic hydrocarbon odor. Oxygenated gasoline with MTBE and/or TAME may have a sweet, ether-like odor and is detectable at a lower concentration than non-oxygenated gasoline.

ODOR THRESHOLD

	Odor Detection	Odor Recognition
Non-oxygenated gasoline:	0.5 - 0.6 ppm	0.8 - 1.1 ppm
Gasoline with 15% MTBE:	0.2 - 0.3 ppm	0.4 - 0.7 ppm
Gasoline with 15% TAME:	0.1 ppm	0.2 ppm

BASIC PHYSICAL PROPERTIES

BOILING RANGE:	85 to 437 °F (39 to 200 °C)
VAPOR PRESSURE:	6.4 - 15 RVP @ 100 °F (38 °C) (275-475 mm Hg @ 68 °F (20 °C)
VAPOR DENSITY (air = 1):	AP 3 to 4
SPECIFIC GRAVITY (H_2O = 1):	0.70 – 0.78
EVAPORATION RATE:	10-11 (n-butyl acetate = 1)
PERCENT VOLATILES:	100 %

SOLUBILITY (H_2O): Non-oxygenated gasoline - negligible (< 0.1% @ 77 ^oF). Gasoline with 15% MTBE - slight (0.1 - 3% @ 77 ^oF); ethanol is readily soluble in water

10. STABILITY and REACTIVITY (rev. Dec-94)

STABILITY: Stable. Hazardous polymerization will not occur.

CONDITIONS TO AVOID

Avoid high temperatures, open flames, sparks, welding, smoking and other ignition sources

INCOMPATIBLE MATERIALS

Keep away from strong oxidizers.

HAZARDOUS DECOMPOSITION PRODUCTS

Carbon monoxide, carbon dioxide and non-combusted hydrocarbons (smoke). Contact with nitric and sulfuric acids will form nitrocresols that can decompose violently.

11. TOXICOLOGICAL PROPERTIES (rev. Dec-97)

ACUTE TOXICITY

Acute Dermal LD50 (rabbits): > 5 ml/kg
Acute Oral LD50 (rat): 18.75 ml/kg
Primary dermal irritation (rabbits): slightly irritating
Draize eye irritation (rabbits): non-irritating
Guinea pig sensitization: negative

CHRONIC EFFECTS AND CARCINOGENICITY

Carcinogenicity: OSHA: NO IARC: YES - 2B NTP: NO ACGIH: YES (A3)

IARC has determined that gasoline and gasoline exhaust are possibly carcinogenic in humans. Inhalation exposure to completely vaporized unleaded gasoline caused kidney cancers in male rats and liver tumors in female mice. The U.S. EPA has determined that the male kidney tumors are species-specific and are irrelevant for human health risk assessment. The significance of the tumors seen in female mice is not known. Exposure to light hydrocarbons in the same boiling range as this product has been associated in animal studies with effects to the central and peripheral nervous systems, liver, and kidneys. The significance of these animal models to predict similar human response to gasoline is uncertain.

This product contains benzene. Human health studies indicate that prolonged and/or repeated overexposure to benzene may cause damage to the blood-forming system (particularly bone marrow), and serious blood disorders such as aplastic anemia and leukemia. Benzene is listed as a human carcinogen by the NTP, IARC, OSHA and ACGIH.

This product may contain methyl tertiary butyl ether (MTBE): animal and human health effects studies indicate that MTBE may cause eye, skin, and respiratory tract irritation, central nervous system depression and neurotoxicity. MTBE is classified as an animal carcinogen (A3) by the ACGIH.

12. ECOLOGICAL INFORMATION (rev. Jan-04)

Keep out of sewers, drainage areas and waterways. Report spills and releases, as applicable, under Federal and State regulations. If released, oxygenates such as ethers and alcohols will be expected to exhibit fairly high mobility in soil, and therefore may leach into groundwater. The API (www.api.org) provides a number of useful references addressing petroleum and oxygenate contamination of groundwater.

13. DISPOSAL CONSIDERATIONS (rev. Dec-97)

Consult federal, state and local waste regulations to determine appropriate disposal options.

14. TRANSPORTATION INFORMATION (rev. Jan-04)

DOT PROPER SHIPPING NAME:	Gasoline
DOT HAZARD CLASS and PACKING GROUP:	3, PG II
DOT IDENTIFICATION NUMBER:	UN 1203
DOT SHIPPING LABEL:	FLAMMABLE LIQUID

PLACARD:

15. REGULATORY INFORMATION (rev. Jan-04)

U.S. FEDERAL, STATE, and LOCAL REGULATORY INFORMATION

This product and its constituents listed herein are on the EPA TSCA Inventory. Any spill or uncontrolled release of this product, including any substantial threat of release, may be subject to federal, state and/or local reporting requirements. This product and/or its constituents may also be subject to other federal, state, or local regulations; consult those regulations applicable to your facility/operation.

CLEAN WATER ACT (OIL SPILLS)

Any spill or release of this product to "navigable waters" (essentially any surface water, including certain wetlands) or adjoining shorelines sufficient to cause a visible sheen or deposit of a sludge or emulsion must be reported immediately to the National Response Center (1-800-424-8802) or, if not practical, the U.S. Coast Guard with follow-up to the National Response Center, as required by U.S. Federal Law. Also contact appropriate state and local regulatory agencies as required.

CERCLA SECTION 103 and SARA SECTION 304 (RELEASE TO THE ENVIRONMENT)

The CERCLA definition of hazardous substances contains a “petroleum exclusion” clause which exempts crude oil, refined, and unrefined petroleum products and any indigenous components of such. However, other federal reporting requirements (e.g., SARA Section 304 as well as the Clean Water Act if the spill occurs on navigable waters) may still apply.

SARA SECTION 311/312 - HAZARD CLASSES

ACUTE HEALTH	CHRONIC HEALTH	FIRE	SUDDEN RELEASE OF PRESSURE	REACTIVE
X	X	X	--	--

SARA SECTION 313 - SUPPLIER NOTIFICATION

This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act (EPCRA) of 1986 and of 40 CFR 372:

INGREDIENT NAME (CAS NUMBER)	CONCENTRATION WT. PERCENT
Benzene (71-43-2)	0.1 to 4.9 (0.1 to 1.3 for reformulated gasoline)
Ethyl benzene (100-41-4)	< 3
n-Hexane (110-54-3)	0.5 to 4
Methyl-tertiary butyl ether (MTBE) (1634-04-4)	0 to 15.0
Toluene (108-88-3)	1 to 15
1,2,4- Trimethylbenzene (95-63-6)	< 6
Xylene, mixed isomers (1330-20-7)	1 to 15

US EPA guidance documents (www.epa.gov/tri) for reporting Persistent Bioaccumulating Toxics (PBTs) indicate this product may contain the following deminimis levels of toxic chemicals subject to Section 313 reporting:

INGREDIENT NAME (CAS NUMBER)	CONCENTRATION - Parts per million (ppm) by weight
Polycyclic aromatic compounds (PACs)	17
Benzo (g,h,i) perylene (191-24-2)	2.55
Lead (7439-92-1)	0.079

CANADIAN REGULATORY INFORMATION (WHMIS)

Class B, Division 2 (Flammable Liquid)
Class D, Division 2A (Very toxic by other means) and Class D, Division 2B (Toxic by other means)

16. OTHER INFORMATION (rev. Jan-04)

NFPA® HAZARD RATING	HEALTH:	1	Slight
	FIRE:	3	Serious
	REACTIVITY:	0	Minimal
HMIS® HAZARD RATING	HEALTH:	1 *	Slight
	FIRE:	3	Serious
	REACTIVITY:	0	Minimal
	* CHRONIC		

SUPERSEDES MSDS DATED: 12/30/97

ABBREVIATIONS:

AP = Approximately < = Less than > = Greater than
N/A = Not Applicable N/D = Not Determined ppm = parts per million

ACRONYMS:

ACGIH	American Conference of Governmental Industrial Hygienists
AIHA	American Industrial Hygiene Association
ANSI	American National Standards Institute (212)642-4900
API	American Petroleum Institute (202)682-8000
CERCLA	Comprehensive Emergency Response, Compensation, and Liability Act
DOT	U.S. Department of Transportation [General Info: (800)467-4922]
EPA	U.S. Environmental Protection Agency
HMIS	Hazardous Materials Information System
IARC	International Agency For Research On Cancer
MSHA	Mine Safety and Health Administration
NFPA	National Fire Protection Association (617)770-3000
NIOSH	National Institute of Occupational Safety and Health
NOIC	Notice of Intended Change (proposed change to ACGIH TLV)
NTP	National Toxicology Program
OPA	Oil Pollution Act of 1990
OSHA	U.S. Occupational Safety & Health Administration
PEL	Permissible Exposure Limit (OSHA)
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit (NIOSH)
SARA	Superfund Amendments and Reauthorization Act of 1986 Title III
SCBA	Self-Contained Breathing Apparatus
SPCC	Spill Prevention, Control, and Countermeasures
STEL	Short-Term Exposure Limit (generally 15 minutes)
TLV	Threshold Limit Value (ACGIH)
TSCA	Toxic Substances Control Act
TWA	Time Weighted Average (8 hr.)
WEEL	Workplace Environmental Exposure Level (AIHA)
WHMIS	Workplace Hazardous Materials Information System (Canada)

DISCLAIMER OF EXPRESSED AND IMPLIED WARRANTIES

Information presented herein has been compiled from sources considered to be dependable, and is accurate and reliable to the best of our knowledge and belief, but is not guaranteed to be so. Since conditions of use are beyond our control, we make no warranties, expressed or implied, except those that may be contained in our written contract of sale or acknowledgment.

Vendor assumes no responsibility for injury to vendee or third persons proximately caused by the material if reasonable safety procedures are not adhered to as stipulated in the data sheet. Additionally, vendor assumes no responsibility for injury to vendee or third persons proximately caused by abnormal use of the material, even if reasonable safety procedures are followed. Furthermore, vendee assumes the risk in their use of the material.

Material Safety Data Sheet

Section 1 General Information

Manufacturer:
Zinsser Company, Inc.
173 Belmont Drive
Somerset, NJ 08875
(732) 469-8100

Emergency Telephone: Chemtrec (800) 424-9300 **Date: December 1, 2006**

Product Name: Parks Paint Thinner

Codes: 002011 002012 002015 002023

Section 2 Hazardous Ingredients

Hazardous Component	CAS#	OSHA PEL	ACGIH TLV
Stoddard Solvent	8052-41-3	500 ppm	100 ppm
1,2,4 Tri Methyl Benzene	95-63-6	10 ppm (TWA) 25 ppm (Ceiling)	25 ppm

Section 3 Hazard Identification

Emergency Overview: This material is a colorless liquid with a characteristic kerosene-like odor. It is flammable and has a flash point of 105º F. The vapor is heavier than air and may travel along the ground. Ignition of the vapor by distant ignition sources is possible.

Primary Routes of Exposure:

Skin Contact
Eye Contact
Inhalation

Potential Acute Health Effects:

Eye: Contact may cause eye irritation.

Skin: May cause skin irritation. Repeated or prolonged contact with skin may cause dermatitis.

Ingestion: May be harmful if swallowed. This material may pose an aspiration hazard. Swallowing the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis. The substance may cause effects on the central nervous system. This substance may cause gastrointestinal tract distress and central nervous system depression.

Inhalation: High vapor concentrations may be irritating to the eyes, nose, throat and lungs.

Potential Chronic Health Effects: The substance may defat the skin. This substance may have effects on the central nervous system.

Target Organ: Eyes, skin, respiratory system, central nervous system, kidneys.

(See also Sections 4, 8, and 11 for related information)
Signs and Symptoms: None known

(See also Sections 4, 8, and 11for related information)

Section 4 First Aid Measures

Eye contact: Immediately flush eyes with water for at least 15 minutes. Get medical attention if irritation persists.

Skin contact: Wash thoroughly with soap and water. Get medical attention if irritation develops or persists.

Ingestion: If swallowed, Contact a physician or Poison Control Center. This material may pose an aspiration hazard. Do Not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. The symptoms of chemical pneumonitis often do not become manifest until a few hours have passed and they are aggravated by physical effort. Rest and medical observation is therefore essential.

Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Section 5 Fire Fighting Measures

Flash Point (method)**:** 105^{o}F, TCC.

Extinguishing Media: Foam, Dry Chemical, Water Fog, CO_2

Protection of Firefighters: As in any fire, wear self-contained breathing apparatus pressure-demand, NIOSH and full protective gear. Evacuate area and fight fire from safe distance.

LEL: 1.0% **UEL:** 6.0%

Section 6 Accidental Release Measures

Clean Up Methods: Eliminate all ignition sources. Keep unnecessary people away. Dike and contain spill with inert material (sand, earth, etc.). Transfer liquid to containers for recovery or disposal, or absorb with absorbent materials and place into containers for disposal. Keep spill out of sewer and open bodies of water. Floors may be slippery; care should be exercised to avoid falls during clean up operations.

(See also Section 8 for information on Exposure Controls and Personal Protective Equipment)

Section 7 Handling and Storage

Handling: Keep away from heat, sparks and open flame. Use with adequate ventilation. Keep container closed. Personnel should avoid inhalation of vapors. Personal contact with the product should be avoided. Should contact be made, remove saturated clothing and flush affected areas with water.

Storage: Keep away from heat, sparks and open flame. Keep container closed

Section 8 Exposure Controls / Personal Protection

Engineering Controls: Use in well-ventilated areas. If necessary use mechanical local exhaust ventilation or general room dilution ventilation to reduce vapor concentrations.

Personal Protective Equipment (PPE):

Eye Protection: Prevent eye contact. Wear chemical splash goggles or similar eye protection if the potential exists for eye contact.

Skin Protection: Prevent skin contact. Wear chemical-resistant flexible-type gloves (neoprene, PVC, butyl, nitrile or similar). Depending on conditions of use additional protective equipment may be necessary such as face-shield, apron or coveralls.

Respiratory Protection: None required for normally expected use conditions. If occupational exposure limits are exceeded or if irritation is experienced, wear an appropriate NIOSH approved respirator with organic vapor cartridges.

General Hygiene Practices: Wash after handling material. Prevent Eye contact. Avoid prolonged skin and inhalation contact. Wash thoroughly before handling food, cosmetics, or before smoking. Remove contaminated clothing and launder before reuse.

Section 9 Physical Data

Appearance: Colorless liquid	**Odor:** Kerosene-like odor.
Physical State: Liquid	**pH:** N/A
Boiling Point: 310 – 405° F	**Melting Point:** N/D
Vapor Pressure: 2 mmHg	**Vapor Density:** 4.9
Odor Threshold: N/D	**Viscosity:** N/D
Solubility in Water: Negligible (<5%)	**Specific Gravity:** 0.78

Section 10 Stability and Reactivity

Hazardous Polymerization: Will not occur.

Hazardous Decomposition Products: Reacts with chloroform and bromoform under basic conditions, causing fire and explosion hazard.

Stability: Stable.

Incompatibility: Strong oxidizers. May react with strong oxidizer causing fire and explosion hazard. Attacks some forms of plastics, rubber, and coatings.

Section 11 Toxicological Information

Carcinogenicity: This material is not listed as a carcinogen by IARC, NTP or OSHA.

(See also Section 15 for related information)

Section 12 Ecological Information

Chemical Fate and Effects: None known

Section 13 Disposal Considerations

RCRA Hazardous Waste: This material, when discarded or disposed of, could be a hazardous waste according to federal regulations (40 CFR 261) due to characteristics of ignitability (D001). The transportation, storage, treatment, and disposal of this waste must be conducted in compliance with 40 CFR 262,263,264,268, and 270. Disposal can only occur in properly permitted facilities. Check state and local regulations for any additional requirements as these may be more restrictive than federal laws and regulations. Chemical additions, processing or otherwise altering this material may make the waste management information presented in this MSDS incomplete, inaccurate, or otherwise inappropriate.

Section 14 Transportation Information

Regulated by the DOT: No, (Combustible liquid)

DOT Proper Shipping Name: N/A

UN / NA Number: N/A

Hazard Class: N/A

Packing Group: N/A

Section 15 Regulatory Information

CERCLA:

The Comprehensive Environmental Response Compensation and Liability Act of 1980 (CERCLA) requires notification to the National Response Center for releases of quantities of Hazardous Substances equal to or greater than the reportable quantities (RQs) in 40 CFR 302.4 (for CERCLA 102).

Components present in this product at a level which could require reporting under the statute are:

Chemical Name	CAS#	Maximum Concentration (Wt. %)
None	N/A	N/A

SARA Title III, section 311/312:

The Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III requires emergency planning based on Threshold Planning Quantities (TPQs) and release reporting based on Reportable Quantities (RQs) in 40 CFR 355 (used for SARA 302, 304, 311 and 312).

Components present in this product at a level which could require reporting under the statute are:

Chemical Name	CAS#	Maximum Concentration (Wt. %)
None	N/A	N/A

SARA Title III, section 313:

The Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III requires submission of annual reports of release of toxic chemicals that appear in 40 CFR 372 (for SARA 313).

Components present in this product at a level which could require reporting under the statute are:

Chemical Name	CAS#	Maximum Concentration (Wt. %)
1,2,4 Tri Methyl Benzene	95-63-6	3.5%

TSCA:

The components of this mixture are listed in the Toxic Substance Control Act Inventory of Chemical Substances.

This product does not contain any chemicals that require export notification under Section 12(b) of the TSCA regulation.

Section 16 Other Information

Legend: **N/A**: Not Applicable
N/D: Not Determined
N/E: Not Established
N/R: Not Required
cps: Centipoise
KU: Krebs Units
STEL: Short Term Exposure Limit
C: OSHA Ceiling Value
PPM: Parts Per Million
PPB: Parts Per Billion
PEL: Permissible Exposure Limit
TLV: Threshold Limit Value
TWA: Time Weighted Average
mg/m^3: Milligrams per cubic Meter
mppcf: Million particles per cubic foot of air.
ACGIH: American Conference of Governmental Industrial Hygienists
OSHA: Occupational Safety and Health Administration (US Dept. of Labor)
RCRA: Resource Conservation and recovery Act
SARA: Superfund Amendment and Reauthorization Act
TSCA: Toxic Substance Control Act
FHSA: Federal Hazardous Substance Act

Prepared By: Zinsser Health and Safety Manager, Regulatory Compliance Dept.
173 Belmont Drive Somerset, NJ 08875 (732) 469-8100

Disclaimer: Zinsser Co., Inc. believes, to the best of its knowledge, information and belief, the information contained herein to be accurate and reliable as of the date of this material safety data sheet. However, because the conditions of handling, use, and storage of these materials are beyond our control, we assume no responsibility or liability for personal injury or property damage incurred by the use of these materials and make no warranty, expressed or implied, regarding the accuracy or reliability of the data or results obtained from their use. All materials may present unknown hazards and should be used with caution. The information and recommendations in this material safety data sheet are offered for the users' consideration and examination. It is the responsibility of the user to determine the final suitability of this information and data and to comply with all applicable international, federal, state, and local laws and regulations.

BÉTONEL
Le vrai magasin de peinture

MATERIAL SAFETY DATA SHEET

MANUFACTURER'S NAME

Bétonel Ltée
8600, av. De l'Épée
Montreal, Quebec H3N 2G6
Tel: (514) 273-8855 or (450) 471-6345
WHMIS CODE: B2, D2B, B3, D2A

PRODUCT IDENTIFICATION

CODE: 50-120
NAME: ALKYD ENAMEL UNDERCOAT
CHEMICAL NAME: Not applicable

HAZARDOUS INGREDIENTS

	% (wt)	CAS number	DL50 (Rat/Oral)	CL50 (Rat/Inhal)
Petroleum naphta	25-35	64741-65-7	N/A	N/A
Limestone	35-45	1317-65-3	N/A	N/A
Petroleum Distillate	0-5	64742-48-9	N/A	N/A
Quartz	0-1	14808-60-7	N/A	NA

PHYSICAL DATA

Physical state: White Liquid
Odor and appearance: Mineral spirits odour
Odor threshold: Not available
Specific gravity (g./cc) 1.2 -1.4 at 25°C
Vapour pressure: 7.0 at 38°C
Vapour density (g./cc): 5.65
Evaporation rate: 0.1
Boiling point: 171-205°C
Freezing point: N/A
P.H.: N/A

Coefficient of water/oil distribution: Not available

FIRE AND EXPLOSION DATA

Flammability: Yes: ✔ No: ___

If yes, under which conditions: Combustible liquid. May form explosive vapour-air mixture between upper and lower flammable limits.

Means of extinction: Dry chemical, carbon dioxide, foam, water fog.

Flash point: 43°C

Flammable limit: *Upper*: 6.0% *Lower*: 1.0%

Auto ignition temperature: N/A

Hazardous combustion products: Carbon monoxide and dioxide, some hydrocarbons.

Explosion data: *Sensitivity to impact*: N/A *Sensitivity to static discharge*: N/A

REACTIVITY DATA

Chemical stability: Yes ✔ No ___

If not, under which conditions:

Incompatibility with other substances: Yes ✔ No ___

If yes, which one: Strong oxidizing agents, Lewis or mineral acids.

Reactivity under which conditions: Excessive heat, open flames, all sources of ignition.

Hazardous decomposition products: Carbon monoxide and dioxide.

TOXICOLOGICAL PROPERTIES

Route of entry:
Skin contact: ✔ Skin absorption: ___ Eye contact: ✔ Inhalation: ✔ Ingestion: ✔

Effects of acute exposure: May be irritating to skin, eyes and respiratory tract. Vapours are moderately irritating to respiratory tract.

Effects of chronic exposure: Prolonged exposure to high vapour concentration may cause headache, dizziness, nausea and central nervous system depression. In rare cases, it may sensitize heart muscle, causing heart arrhythmia.

Irritation: May be irritating to skin, eyes and respiratory tract.

Sensitization to product: This product is not a skin sensitizer after exposure of short duration. Prolonged and repeated contact with skin may cause drying of the skin resulting in skin irritation and dermatitis.

Reproductive effects: N/A **Carcinogenic effects**: N/A **Teratogenicity**: N/A

Mutagenicity: N/A **Synergistic materials:** N/A

PREVENTIVE MEASURES - Personal protective equipment

Respirator: If exposure exceeds occupational exposure limits, wear a NIOSH approved respirator.

Eyes: chemical safety goggles **Clothing**: work clothing **Footwear**: work shoes

Gloves: work gloves **Other**: none

Engineering controls: Provide sufficient mechanical or local exhaust ventilation.

Leak and spill procedures: Eliminate all sources of ignition. Absorb residue or small spills with absorbent material. Avoid breathing vapours.

Waste disposal: Small spills may be disposed in a landfill in accordance with local regulations. In case of large spills, incinerate with approval of environmental authority at a licensed waste disposal site.

Handling procedures and equipment: Use in a well ventilated area. Avoid all sources of ignition.

Storage requirements: Keep container tightly closed in a cool area.

Special shipping information: None.

FIRST AID MEASURES

Skin contact: Wash affected area with mild soap and water. Remove contaminated clothing. In case of persistent irritation, obtain medical attention.

Eye contact: Flush eyes with water for at least 15 minutes.

Ingestion: Do not induce vomiting. Obtain medical attention immediately.

Inhalation: Remove victim from further exposure. Obtain medical attention.

BÉTONEL
Le vrai magasin de peinture

MATERIAL SAFETY DATA SHEET

MANUFACTURER'S NAME

Bétonel Ltée
8600, av. De l'Épée
Montreal, Quebec H3N 2G6
Tel: (514) 273-8855 or (450) 471-6345
WHMIS CODE: B3, D2A

PRODUCT IDENTIFICATION

CODE: 85-110
NAME: ALKYD SEMI-GLOSS, SUPER WHITE
CHEMICAL NAME: Not applicable

HAZARDOUS INGREDIENTS

	% (wt)	CAS number	DL50 (Rat/Oral)	CL50 (Rat/Inhal)
Petroleum naphta	15-25	64741-657	N/D	N/D
Petroleum Distillate	5-10	64742-48-9	N/D	N/D
Limestone	15-25	1317-65-3	N/D	N/D
Cristobalite	0-7	14464-46-1	N/D	N/D
Quartz	0-1	14808-60-7	N/D	N/D

PHYSICAL DATA

Physical state:	White Liquid	**Vapour density (g./cc)**:	5.65
Odor and appearance:	Mineral spirits odour	**Evaporation rate**:	.1
Odour threshold:	Not available	**Boiling point**:	171-205°C
Specific gravity (g./cc)	1.2 - 1.3 at 25°C	**Freezing point**:	N/A
Vapour pressure:	7.0 at 38°C	**P.H.**:	N/A

Coefficient of water/oil distribution: Not available

FIRE AND EXPLOSION DATA

Flammability: Yes: ✔ No: ___

If yes, under which conditions: Combustible liquid. May form explosive vapour-air mixture between upper and lower flammable limits.

Means of extinction: Dry chemical, carbon dioxide, foam, water fog.

Flash point: 43°C

Flammable limit: *Upper*: 6.0% *Lower*: 1.0%

Auto ignition temperature: N/A

Hazardous combustion products: Carbon monoxide and dioxide, some hydrocarbons.

Explosion data: *Sensitivity to impact*: N/A *Sensitivity to static discharge*: N/A

REACTIVITY DATA

Chemical stability: Yes ✔ No ___

If not, under which conditions:

Incompatibility with other substances: Yes ✔ No ___

If yes, which one: Strong oxidizing agents, Lewis or mineral acids.

Reactivity under which conditions: Excessive heat, open flames, all sources of ignition.

Hazardous decomposition products: Carbon monoxide and dioxide.

TOXICOLOGICAL PROPERTIES

Route of entry:
Skin contact: ✔ Skin absorption: ___ Eye contact: ✔ Inhalation: ✔ Ingestion: ✔

Effects of acute exposure: May be irritating to skin, eyes and respiratory tract. Vapours are moderately irritating to respiratory tract.

Effects of chronic exposure: Prolonged exposure to high vapour concentration may cause headache, dizziness, nausea and central nervous system depression. In rare cases, it may sensitize heart muscle, causing heart arrhythmia.

Irritation: May be irritating to skin, eyes and respiratory tract.

Sensitization to product: This product is not a skin sensitizer after exposure of short duration. Prolonged and repeated contact with skin may cause drying of the skin resulting in skin irritation and dermatitis.

Reproductive effects: N/A **Carcinogenic effects**: N/A **Teratogenicity**: N/A

Mutagenicity: N/A **Synergistic materials:** N/A

PREVENTIVE MEASURES - Personal protective equipment

Respirator: If exposure exceeds occupational exposure limits, wear a NIOSH approved respirator.

Eyes: chemical safety goggles **Clothing**: work clothing **Footwear**: work shoes

Gloves: work gloves **Other**: none

Engineering controls: Provide sufficient mechanical or local exhaust ventilation.

Leak and spill procedures: Eliminate all sources of ignition. Absorb residue or small spills with absorbent material. Avoid breathing vapours.

Waste disposal: Small spills may be disposed in a landfill in accordance with local regulations. In case of large spills, incinerate with approval of environmental authority at a licensed waste disposal site.

Handling procedures and equipment: Use in a well ventilated area. Avoid all sources of ignition.

Storage requirements: Keep container tightly closed in a cool area.

Special shipping information: None.

FIRST AID MEASURES

Skin contact: Wash affected area with mild soap and water. Remove contaminated clothing. In case of persistent irritation, obtain medical attention.

Eye contact: Flush eyes with water for at least 15 minutes.

Ingestion: Do not induce vomiting. Obtain medical attention immediately.

Inhalation: Remove victim from further exposure. Obtain medical attention.

Prepared by: Technical service (450) 471-6345 Date: June 1st, 2007

BÉTONEL
Le vrai magasin de peinture

MATERIAL SAFETY DATA SHEE

MANUFACTURER'S NAME

Bétonel Ltée
8600, av. De l'Épée
Montreal, Quebec H3N 2G6
Tel: (514) 273-8855 or (450) 471-6345
WHMIS CODE: D2A

PRODUCT IDENTIFICATION

CODE: 450-110
NAME: SELECTION LX – Primer and sealer interior acrylic latex
CHEMICAL NAME: Not applicable

HAZARDOUS INGREDIENTS

	% (wt)	CAS number	DL50 (Rat/Oral)	CL50 (Rat/Inhal)
Ethylene glycol	1-2	107-21-1	4700 mg/kg	N/A
Limestone	1-5	1332-58-7	N/A	N/A
Kaolin	15-20	131765-3	N/A	N/A

PHYSICAL DATA

Physical state: Liquid
Odor and appearance: White liquid
Odor threshold: Not available
Specific gravity (g./cc) 1.2 - 1.4
Vapour pressure: 20
Vapour density (g./cc): N/A
Evaporation rate: >1
Boiling point: 100°C
Freezing point: 0°C
P.H.: 8.5-9.5

Coefficient of water/oil distribution: Not available

FIRE AND EXPLOSION DATA

Flammability*:* Yes: ___ No: ✔
If yes, under which conditions:

Means of extinction: Not applicable

Flash point*:* Not applicable

Flammable limit: *Upper*: N/A *Lower*: N/A

Auto ignition temperature: Not applicable

Hazardous combustion products: Not applicable

Explosion data: *Sensitivity to impact*: N/A *Sensitivity to static discharge*: N/A

REACTIVITY DATA

Chemical stability: Yes ✔ No ___
If not, under which conditions:

Incompatibility with other substances: Yes ___ No ✔
If yes, which one:

Reactivity under which conditions: Not applicable

Hazardous decomposition products: Not applicable

TOXICOLOGICAL PROPERTIES

Route of entry:

Skin contact: ✔ Skin absorption: ___ Eye contact: ✔ Inhalation: ___ Ingestion: ✔

Effects of acute exposure: Liquid and mists may cause eye, skin and respiratory irritation. Severe liver and kidney damage can follow the swallowing of large volume of ethylene glycol.

Effects of chronic exposure: Inhalation of mists may affect the central nervous system.

Irritation: May be irritating to skin, eyes and respiratory tract.

Sensitization to product: This product is not a skin sensitizer after exposure of short duration.

Reproductive effects: N/A **Carcinogenic effects**: N/A **Teratogenicity**: Contains ethylene glycol.

Mutagenicity: N/A **Synergistic materials:** N/A

PREVENTIVE MEASURES - Personal protective equipment

Respirator: If exposure exceeds occupational exposure limits, wear a NIOSH approved respirator.

Eyes: chemical safety goggles **Clothing**: work clothing **Footwear**: work shoes

Gloves: work gloves **Other**: none

Engineering controls: Provide sufficient mechanical or local exhaust ventilation.

Leak and spill procedures: Absorb residue or small spills with absorbent material. Flush with plenty of water.

Waste disposal: Small spills may be disposed in a landfill in accordance with local regulations.

Handling procedures and equipment: Use in a well ventilated area.

Storage requirements: Keep container tightly closed in a cool area.

Special shipping information: None.

FIRST AID MEASURES

Skin contact: Wash affected area with mild soap and water.

Eye contact: Flush eyes with water for at least 15 minutes.

Ingestion: Do not induce vomiting. Obtain medical attention immediately.

Inhalation: Remove victim from further exposure. Obtain medical attention.