Pond Inlet Sewage Lagoon Dye Test Technical Report (GN Project #10-2008)

November 6, 2012

Submitted to: **GOVERNMENT OF NUNAVUT – COMMUNITY AND GOVERNMENT SERVICES**

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6 November 2012
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Attention: Mr. Patricio Fuentes

Re: Pond Inlet Lagoon Dye Test Technical Report (GN Project #10-2008)

ARKTIS Piusitippaa Inc. is pleased to provide Government of Nunavut, Community and Government Services with a ***final*** report for the above referenced project. We trust that the information presented in this report satisfies the requirements of the project. Please do not hesitate to contact the undersigned if there are any questions or comments.

Yours very truly,

ARKITS Piusitippaa Inc.
Matthew Hamp, P.Eng
Vice President, Nunavut Affairs & Operations

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1.0 INTRODUCTION

The Government of Nunavut, Department of Community and Government Services (GN-CGS) contracted ARKTIS Piusitippaa Inc. (ARKTIS) to complete a tracer study, and associated analysis and reporting, on the sewage lagoon in the Hamlet of Pond Inlet (GN Project #10-2008: Pond Inlet Sewage Lagoon Dye Test). The location of the sewage lagoon in relation to the community is shown in **Appendix B, Map 1**. The purpose of the tracer study was to identify potential leakage through the lagoon berm. The study involved the following main components:

i. Select a non toxic and non environmental impacted dye to use in the lagoon water;
ii. Quantify the available water volume in the lagoon;
iii. Quantify the amount of dye required and supply to the site:
iv. Use the best engineering approach to mix the dye with Lagoon water;
v. Record by pictures of the lagoon water before dye is injected;
vi. Conduct the test, and observe the behaviour of the colour of the water inside and outside of the berm of the lagoon for the next 24 hours;
vii. Take pictures showing the presence of the dye in water inside and outside of the berm of the lagoon;
viii. Prepare a technical report on the test procedure, findings and recommendation;
ix. Sign and stamp the technical report by the engineer and submit two hard copies and one electronic copy in a CD format;
x. The technical report will be submitted to Department of Community and Government Services for review and evaluation for final acceptance by the Nunavut Water Board (NWB); and,
xi. Answer questions if raised by the regulatory agencies.

This document was developed to report on the results of the components of the study mentioned above, which include the tracer experiment conducted between 4 and 7 September 2012 in Pond Inlet, Nunavut.

The presentation of this report is as follows:

- Section 1.0: Introduction;
- Section 2.0: Background Information;
- Section 3.0: Site Inspection;
- Section 4.0: Methodology;
- Section 5.0: Results;
- Section 6.0: Discussion;
- Section 7.0: Recommendations;
- Section 8.0: Closing;

- Appendix A: Tables;
- Appendix B: Maps;
- Appendix C: Photographs;
- Appendix D: Figures;
- Appendix E: General Terms and Conditions; and,
- Appendix F: Rhodamine WT Material Safety Data Sheet

A CD with an electronic copy of the report is attached to the physical copy of this report.

2.0 BACKGROUND INFORMATION

2.1 Discussions with GN-CGS

A start-up meeting with the GN-CGS occurred on 15 June 2012. The meeting was attended by: GN-CGS Project Officers Sean Regher and Grigor Hope; Pat Fuentes, GN-CGS Manager Projects Division; Bhabesh Roy, GN-CGS Regional Municipal Planning Engineer; Matthew Hamp, ARKTIS Project Manager; and Morgan Shauerte, ARKTIS Environmental Specialist (via telephone). During the meeting, the following information pertaining to the sewage lagoon was communicated to ARKTIS:

i. The lagoon is lined, including the berms.
ii. The lagoon is suspected to be leaking at up to two locations along the easternmost berm.
iii. Surface water accumulates in small puddles at the base of the eastern berm of the lagoon on an annually recurring basis at the points of interest where the suspected leaks are located.
iv. The lagoon has been in operation since 1996 and has been exhibiting signs of leakage since its commissioning.

At this time, ARKTIS representatives also confirmed that this tracer test would not be visible by the naked eye since an extremely costly amount of powdered tracer would be required to conduct a visible test, and thus the perceived benefits of a visible test would not be outweighed by the high cost of purchasing and shipping the dye. It was reiterated that the benefit of the fluorescent dye is that a relatively small concentration can be detected using a fluorometer, compared to visual detection, which could require an order a magnitude more dye (and hence more cost) in order to be visible.

3.0 SITE INSPECTION

A preliminary site inspection of the sewage lagoon was performed on 3 August 2012. Based on the distance between the high water line and a series of marker flags located at intervals around the inside bank of the lagoon berms, and comparing this distance to observations made in previous years by the GN-CGS, it was noted at this time that the

liquid level within the lagoon was uncharacteristically low and there was no evidence of any surface water accumulation at the points of interest outside of the lagoon and adjacent to the berm toe identified during the start-up meeting, nor at any other locations around the perimeter of the lagoon. With no water present outside of the lagoon, it was not possible to conduct the dye test.

At this time, the GN-CGS requested that ARKTIS return to the site at a later date to perform the dye test, when sufficient water was present for sampling outside of the lagoon. It was agreed at this time that the GN-CGS would provide two weeks notice to ARKTIS prior to when the dye test would be performed to allow sufficient lead time to obtain the test equipment and ship it to the community.

A follow-up site inspection was undertaken on 23 August, at which time it was noted that there had been some accumulation of water at the points of interest outside of the lagoon and adjacent to the berm toe identified during the start-up meeting. The liquid level within the lagoon was noted at this time to have not changed perceptibly since the last inspection.

At this time, ARKTIS informed the GN-CGS that although there was some accumulation of liquid to the east and adjacent to the access roadway along the outside of eastern lagoon berm, the liquid level inside the lagoon may not provide sufficient hydraulic head to drive fluid through the lagoon berm within the detectable lifespan of the Rhodamine dye. At best, under these conditions, the test would only be sufficient to show that the lagoon was indeed leaking; it would not be possible to conclude that the lagoon was not leaking if there was no measurement of dye outside the lagoon. Due to the low probability of achieving good results, ARKTIS therefore recommended that the dye test not be conducted at this time, and that the GN-CGS wait until conditions were more favourable to conduct the test. In a subsequent conversation with ARKTIS on 27 August, the GN-CGS acknowledged the limitations of conducting the dye test under the conditions that existed at the time and instructed ARKTIS to proceed with the test.

A third and final pre-test inspection was undertaken on 1 September, at which time it was noted that the conditions which existed at the time of the previous inspection were identical to those which existed during the current inspection.

Appendix A, Table 1 contains the site inspection results and map references to the relevant locations along the sewage lagoon for which observations were made during the inspection. A photographic record of the tracer testing was completed by ARKTIS.

An accompanying CD has been provided with this report that contains this report and the photographic record.

4.0 METHODOLOGY

4.1 Tracer Dye Selection

On 15 June 2012, Mr. Bhabesh Roy of GN-CGS stated that Rhodamine WT could be used as a tracer dye. Rhodamine WT was selected as the dye for use in the seepage test for the following main reasons:

- Typically used in industry;
- Non-sorbing;
- Resists photo-degradation;
- Easily observable in water and red in colour;
- Detectable at a different wavelength than common water contaminants; and,
- Rhodamine WT is non-carcinogenic and has low potential for toxicity and adverse effects in the environment[1].

The Material Safety Data Sheet for the dye is provided in **Appendix E** of this report.

4.2 Fluorometer Selection

The fluorometer chosen for the monitoring was the Turner Designs Aquafluor, a field fluorometer. The fluorometer is a rugged hand held unit, and uses cuvettes to measure Rhodamine WT. This fluorometer has a testing range of 0-400 μg/L[2] with an accuracy of 0.4μg/L. This fluorometer was selected for this tracer study for the following reasons:

- Accuracy;
- Suitability for field use; and,
- Fast analysis of tracer concentration.

4.3 Fluorometer Calibration

The Aquafluor fluorometer was calibrated according to the calibration procedure outlined in the manual[3]. A summary of the calibration procedure is as follows:

1. A primary standard of a known concentration of Rhodamine WT is prepared.
2. The Aquafluor calibration program is started, which involves:
    a. Inserting and reading a sample of distilled water; and,
    b. Inserting and reading the prepared primary standard solution.

[1]Environment Canada. http://www.ec.gc.ca/esee-eem/default.asp?lang=En&n=E93AE5BC-1&offset=2&toc=show. Accessed on August 22, 2011.
[2] Turner Designs. http://www.turnerdesigns.com/t2/doc/brochures/aquafluor_brochure.pdf. Accessed on September 13, 2011
[3] Turner Designs. http://www.turnerdesigns.com/t2/doc/manuals/aquafluor_manual.pdf. Accessed on September 13, 2011

The calibration program was completed immediately before the tracer study began. In addition, a solid secondary standard (which is a piece of equipment that emits a set amount of fluorescence) was used during the tracer study to verify equipment calibration.

4.4 Tracer Study

The following describes the methodology used to design and conduct the tracer study.

4.4.1 Dye Volume

Prior to the site visit, the water volume contained in the sewage lagoon was estimated using the average depth of the sewage lagoon that was reported by the GN-CGS, and an approximate footprint calculated from satellite imagery and measurements taken at site. The water volume contained in the lagoon was estimated to be 65,000 m^3.[4]

Assuming an area of 45,000 m^2 for the lagoon, a uniform depth of 1.4 m and using the full 15.91 kg of Rhodamine WT brought to Pond Inlet for the tracer study, the estimated concentration of Rhodamine WT in the sewage lagoon during the tracer study was 0.252 mg/L.

4.4.2 Rhodamine WT Dye Addition

The following is the methodology followed to add tracer to the lagoon and begin the tracer experiment.

1. A 3.6 m diameter, 0.6 m deep soft-sided pool was inflated at the top of the westernmost berm of the lagoon, approximately 30 m north of the sewage truck discharge point (see **Appendix C, Photograph 9**).
2. A flexible hose, approximately 50 mm in diameter and 10 m in length was connected near the base of the pool on the edge facing the lagoon; the end of the hose connected to the pool was closed with a plastic stopper; the opposite end of the hose was placed at the fluid edge in the lagoon (see **Appendix C, Photograph 13**).
3. A municipal water truck filled the mixing pool with fresh water to approximately 0.4 m depth (see **Appendix C, Photograph 9**).
4. The powdered tracer was added to the mixing pool by immersing the 20 L pail in which it was packaged into the water, removing the lid, slowly emptying the contents (see **Appendix C, Photograph 10**).
5. A 2 m long wooden stick was used to stir and agitate the mixture until all of the dye was dissolved in the mixing pool (see **Appendix C, Photograph 11**).
6. The plastic stopper was removed from the flexible hose.

[4] This estimated volume was also provided independently by the GN-CGS Regional Municipal Planning Engineer

7. The tracer dye solution was slowly added to the lagoon over a period of approximately 6.5 hours (**see Appendix C, Photograph 14**).

4.4.3 Sample Site Selection

Based on the information gathered from the site inspection, background information provided by the GN-CGS, and information needed to conduct the tracer study, five locations were chosen for sampling. Three of these locations are located within the lagoon, in attempts to assess when the lagoon is fully mixed, and to provide a baseline for the source concentration of tracer. Two locations were selected along the toe of the westernmost berm, in the two potential leakage locations identified during the start-up meeting, and a third sampling location was selected along the toe of the southernmost berm, after the GN-CGS requested inclusion of this sample location partway through the test. **Appendix A, Table 2** lists the location, descriptions, and reference photographs for each of the selected sample points.

4.4.4 Sampling Methodology

The following methodology was followed for testing the water for Rhodamine WT concentration:

1. Grab samples were obtained for analytical testing using a cuvette.
2. The cuvette was flushed three times with water, wiped with a lint free towel, and inserted into the fluorometer for measurement.
3. The fluorometer was operated according to manufacturer specifications.
4. The fluorometer results were recorded.

5.0 RESULTS

5.1 Observations

Visual observations and other pertinent information were recorded during each sample cycle and throughout the study. These observations have been compiled and summarized in **Appendix A, Table 3**.

A general summary of the observations is as follows:

- Dye was added to the lagoon from a high point on top of the lagoon berm at the south-west corner.
- The tracer reached pseudo-equilibrium within the lagoon after an elapsed time of approximately 16 hours after initial release of the dye.
- The tracer was no longer visible within the lagoon by the time equilibrium was reached.
- A background level of florescence was measured outside of the lagoon. Based on the results of the tracer measurements, there was no discernible change in fluorescence from any of the samples procured from outside of the lagoon.

- Air temperatures dropped below freezing after an elapsed time of approximately 14 hours after initial release of the dye.
- The puddles and pond at sampling points E1, E2, and E3, began to freeze permanently (i.e. they did not thaw during the day) after an elapsed time of approximately 40 hours.
- The municipality began decanting the lagoon after an elapsed time of approximately 48 hours.
- For the entire duration of the test, tracer was not measured at any of the locations sampled outside of the sewage lagoon.
- The tracer concentration at sampling points I1, I2, and I3 from the final sampling run had decreased slightly from the previous sample run.
- By the final sample run, the lagoon water froze at the edges and sampling points E1, E2, and E3 froze over with a thick layer of ice, making continued sampling at these locations impossible. At 64 hours and 44 minutes after the tracer addition, the test was completed.

5.2 Rhodamine WT Concentration Results

The plotted concentrations measured from the fluorometer are contained in **Appendix D**. **Appendix D**, **Figure 1**, **Figure 2**, and **Figure 3** display the concentration curves for the interior sampling points (I1, I2, and I3). The concentration curves for the exterior sampling points (E1, E2, and E3) are located in **Appendix D**, **Figure 4**, **Figure 5**, and **Figure 6**.

The locations of the sampling points are displayed in **Appendix B, Map 3**.

6.0 DISCUSSION

Tracer concentration reached pseudo-equilibrium within the lagoon approximately 16 hours after the initial release of dye. None of the sampling locations outside of the lagoon showed visual or analytical signs of tracer, or any obvious visual signs of leakage. The low liquid level in the lagoon may not have provided sufficient hydraulic head to drive the tracer through the berm within the 64 hour timeframe that the test was conducted. Further, the onset of freezing temperatures partway through the test could have restricted fluid flow through the liner and lagoon berm.

Subject to the conditions under which this tracer test was conducted, the results suggest that the lagoon is not leaking. Given the limitations of conducting this test (discussed in **Section 3.0** above), along with the onset of freezing temperatures partway through the test, these results are not an indication that there would not be a leak through the lagoon liner under different testing conditions. The findings from this tracer test are limited in that the lagoon liquid level was low and that there may have been influence by freezing conditions. Thus, it is unknown at this time if a leak would be

detected if the tracer test were conducted under a different testing condition (higher liquid level in lagoon and warmer temperatures).

7.0 RECOMMENDATIONS

It is recommended that an additional tracer study be completed when the lagoon is at near capacity and when daily temperature lows are not less than 5°C, if possible. This would maximize the potential for the tracer test in providing results that could more readily show the presence or absence of a leak.

8.0 CLOSING

This report has been prepared for the exclusive use of the GN-CGS for the specific application described in **Section 1.0** of this report. It has been prepared for informational purposes only. No other warranty is made, either expressed or implied. For further limitations, please refer to the General Conditions provided in **Appendix F**.

We trust that this report meets your present requirements. Please contact the undersigned should there be any questions.

ARKTIS Piusitippaa Inc.

Matthew Hamp, P.Eng
VP Nunavut Affairs & Operations

REGISTERED PROFESSIONAL ENGINEER
J.F. VAN GULCK
LICENSEE
11/05/12
NWT/NU

Jamie VanGulck, Ph.D., P.Eng
Chief Technical Officer

PERMIT TO PRACTICE
ARKTIS PIUSITIPPAA INC.
Signature
Date 11/05/2012
PERMIT NUMBER: P 745
NWT/NU Association of Professional Engineers and Geoscientists

APPENDIX A - TABLES

Table 1 – Observations from the site inspection of the sewage lagoon. The locations are depicted in **Appendix B – Map 3**.

Location	Comments	Photograph Reference
Point 1	Identified during the start-up meeting as the primary point of interest; visible signs of settlement across the berm and access roadway in this area	Appendix C, Photographs 1 and 2
Point 2	Surface water accumulation approximately 15m south of Point 1	Appendix C, Photograph 7
Point 3	Toe of northernmost berm; no standing water present	N/A
Point 4	Large pond to the south of the lagoon; determined to be comprised of run-off from the municipal dump site This point was later including in the sampling run partway through the dye test at the request of the GN-CGS	Appendix C, Photograph 8

Table 2 – Locations of fluorometer sampling points

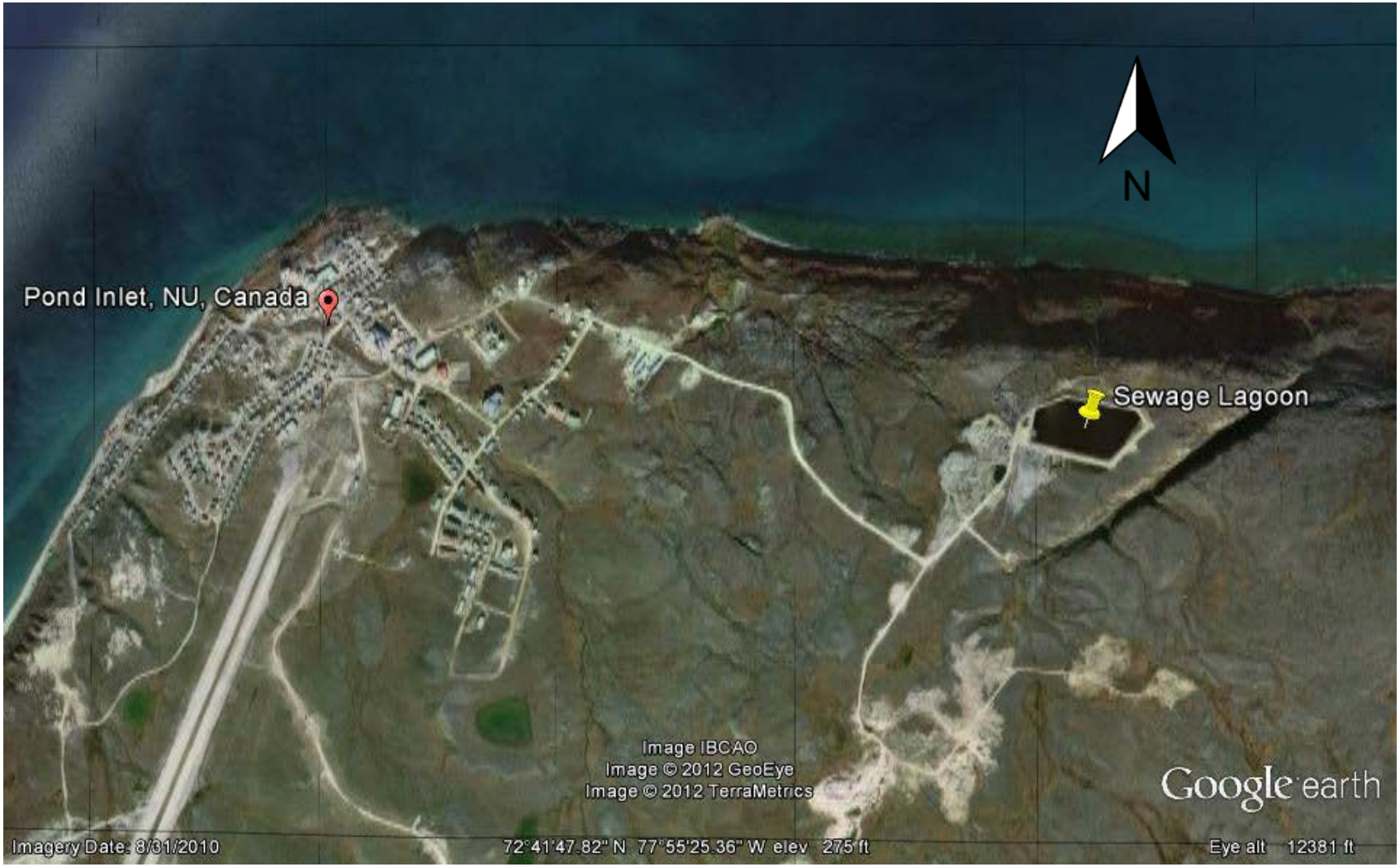
Designation	Description of Location	Photograph Reference
Interior 1 (I1)	Inside lagoon at northwestern corner	Appendix C, Photograph 3
Interior 2 (I2)	Inside lagoon midway along northernmost berm	Appendix C, Photograph 4
Interior 3 (I3)	Inside lagoon midway along easternmost berm	Appendix C, Photograph 5
Exterior 1 (E1)	Potential Leak #1: puddle of water adjacent to access roadway midway along easternmost berm	Appendix C, Photograph 6
Exterior 2 (E2)	Potential Leak #2. puddle of water adjacent to access roadway approximately 15m south of E1	Appendix C, Photograph 7
Exterior 3 (E3)	Pond located south of access roadway running parallel with the southernmost berm; sampling at this location requested by GN-CGS approximately 21 hours after dye release	Appendix C, Photograph 8

Table 3 – Observations from the tracer study

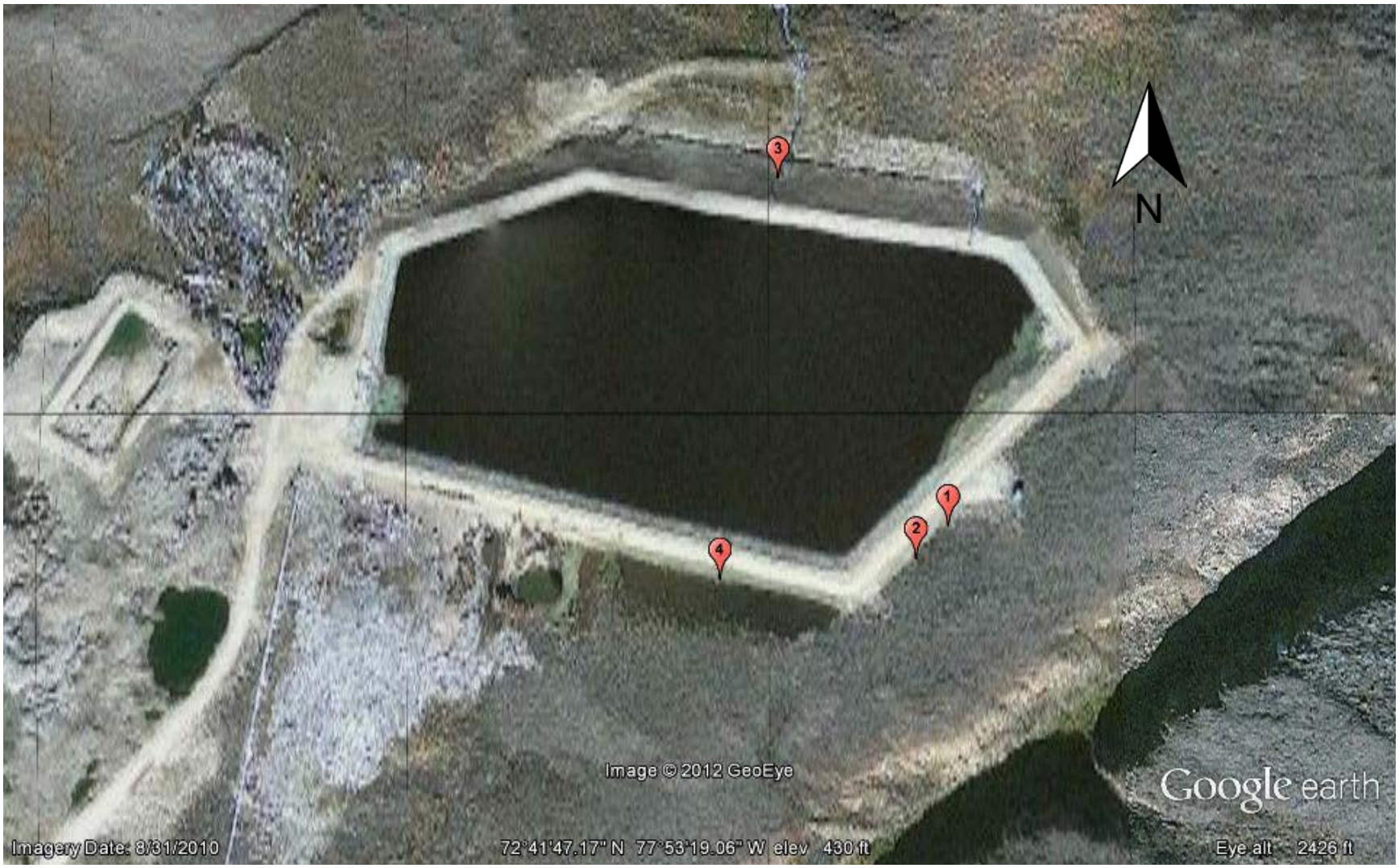
Sample Cycle	Date	Time	Elapsed Time from the Addition of Tracer (hour:min)	Observations	Photograph Reference
-	9/4/2012	14:35	-	Water was added to the mixing pool	Appendix C, Photograph 9
-	9/4/2012	15:20	-	Rhodamine WT Tracer was added to the mixing pool	Appendix C, Photograph 10
-	9/4/2012	15:29	-	Mixed dye was released into the lagoon	Appendix C, Photograph 13
-	9/4/2012	15:49	0:20	Dye plume visible diffusing east and north; not yet visible at northwest corner of lagoon	Appendix C, Photograph 15
1	9/4/2012	16:00	0:31	No discernible change in tracer concentration at sampling point I1; no visible sign of dye.	N/A
2	9/4/2012	18:00	2:31	Tracer concentration spike at sample location I1; no visible sign of dye	N/A
3	9/4/2012	20:00	4:31	Puddles at sample locations E1 and E2 beginning to freeze over; thin surface ice must be broken to obtain samples	N/A
-	9/4/2012	20:43	5:14	Dye faintly visible inside lagoon at northwest corner	Appendix C, Photograph 17
4	9/4/2012	22:00	6:31	Concentration peak at sample location I1 and I2; tracer faintly visible at sample location I2 Dye drained completely from mixing pool	N/A
8	9/5/2012	6:15	14:46	Puddles at sample locations E1 and E2 noticeably drying and with thin ice layer on top; size reduced to approximately 2/3 compared to at start of test Ground frozen	N/A
-	9/5/2012	7:31	16:00	Tracer concentration has approximately reached equilibrium within the lagoon; tracer no longer visible within lagoon	N/A

Sample Cycle	Date	Time	Elapsed Time from the Addition of Tracer (hour:min)	Observations	Photograph Reference
-	9/5/2012	12:05	20:36	Puddles at sample locations E1 and E2 thawed completely since previous sample run Ground thawed	N/A
-	9/5/2012	12:30	21:01	GN-CGS requests that samples be taken from location E3 outside of the lagoon midway along the southernmost berm	Appendix C, Photograph 8
16	9/6/2012	4:00	36:31	Air temperature below freezing	N/A
17	9/6/2012	8:05	40:36	Air temperature below freezing; puddle at sample location E1 frozen over; puddle at sample location E2 partially frozen; edges of pond at sample location E3 frozen	N/A
19	9/6/2012	16:02	48:33	Lagoon decant startedPuddles at sample locations E1 and E2 no longer frozen over	N/A
20	9/7/2012	0:11	56:42	Surface of lagoon frozen approximately 1m at edges	N/A
21	9/7/2012	8:13	64:44	Approximately 3/4 of lagoon surface frozen; ice is thickening and difficult to break through to obtain samples Test completed	N/A

APPENDIX B - MAPS



Map 1 – Sewage Lagoon location in relation to the Hamlet of Pond Inlet



Map 2 – Locations of interest noted during the start-up meeting and site inspections.

Map 3 – Points chosen for sampling during the tracer study, and the tracer addition point.