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1.0 Introduction

1.1 GENERAL

At the request of Northern Pulp Nova Scotia Corporation (Northern Pulp), Stantec Consulting Ltd. (Stantec) has completed an evaluation of the existing groundwater and surface water compliance monitoring programs currently being undertaken at the Boat Harbour Treatment Facility site (Figure 1, Appendix A). It is Stantec's understanding that the Boat Harbour Treatment Facility consists of twin settling basins, an aerated stabilization basin and a sludge disposal cell (refer to Drawing No. 121411647-1, Appendix A).

The work was completed as required by Condition 9 II (d) of Nova Scotia Environment (NSE) Approval No. 2011-076657, for the operation of a pulp mill. This condition required Northern Pulp to retain the services of a qualified professional to *"...identify the presence and susceptibility of surface water and groundwater receptors associated with the Effluent Treatment Facility"* and make recommendations for surface water, groundwater monitoring, and/or management programs relating to the facility (as required).

1.2 SITE DESCRIPTION

1.2.1 Location and Facility Overview

The Boat Harbour Treatment Facility is located on Simpson Road, near the community of Pictou Landing in Pictou County, Nova Scotia. The facility is situated on a 101.17 ha property, legally described by Service Nova Scotia (SNS) Property On-line as Property Identification (PID) No. 00801191, and owned by NSE.

The facility treats industrial wastewater (mill effluent) from the Northern Pulp Abercrombie Point Pulp Mill. The wastewater is delivered to the Boat Harbour Treatment Facility via a 3.6 km pipeline, and enters the facility at Point A (refer to Drawing No. 121411647-1, Appendix A) where it receives primary and secondary treatment, consisting of primary treatment in the settling basin and secondary treatment in the aerated stabilization basin (ASB) prior to discharge. Until 1996, under an agreement between the mill operator/owner and the Province of Nova Scotia, the province was responsible for treating all mill effluent generated.

The Boat Harbour Treatment Facility also includes a sludge disposal cell, which operates under NSE Approval No. 94-032, for the disposal of primary and secondary settling basin sludges. In addition to influent from the primary and secondary settling basins, the ASB also receives leachate collected from the underdrain system associated with the sludge disposal cell. The province continues to perform monitoring around the sludge disposal cell, and is responsible for a portion of the sludge present in the cell.

Treated effluent is discharged from the ASB into Boat Harbour at Point C (refer to Drawing No. 121411647-1, Appendix A). Under the former NSE Approval No. 96-033 for the Boat Harbour Treatment Facility, Boat Harbour itself was considered to be part of the treatment facility (polishing pond); as a result, final discharge compliance sampling was formerly at Point D (Drawing No. 121411647-1, Appendix A).

1.2.2 Site Topography and Drainage

The Boat Harbour Treatment Facility is situated in a generally low-lying area. Land surface slopes upwards from the site, in all directions, except where the property is bounded by the waters of Boat Harbour. In addition to Boat Harbour, and the constructed basins associated with the treatment system present on the site, there are several natural ponds/wetlands located on the subject site (refer to Drawing No. 121411647-1, Appendix A).

Based on a review of topographic mapping for the area, the Boat Harbour Treatment Facility appears to be located in a discharge area. The inferred direction of surface drainage and/or overland flow is indicated on Drawing No. 121411647-1 (Appendix A).

1.2.3 Geology

The Boat Harbour Treatment Facility site is underlain by bedrock of the Pictou Group (early-Carboniferous or mid-Pennsylvannian aged), consisting of interbedded sandstone, siltstone, conglomerate and minor shale. Bedrock was encountered at depths of 5.8 m to 8.5 m (mean 7.3 m) in the boreholes associated with monitor wells MW 1A/B to MW 4A/B. No other site-specific depth to bedrock information was available; however, based on a review of the available mapping, seven water well records exist at locations on and/or immediately adjacent to the subject property. Depth to bedrock reported in the seven water well records ranges from 3.4 m to 9.7 m below grade (mean 6.2 m below grade).

Surficial geology at the Boat Harbour Treatment Facility site consists of sandy till. The anticipated thickness of the till in the vicinity of the site is from 3 m to 10 m, based on depth to bedrock information.

1.2.4 Hydrogeology

Based on information obtained from shallow bedrock and overburden groundwater monitoring conducted around the Boat Harbour sludge disposal cell during 2010 (refer to Drawing No. 121411647-2, Appendix A, for monitor well locations), the water table occurs within the till which blankets the site, at an estimated depth ranging from 2.3 m below grade (on the up-gradient side of the sludge disposal cell), to 3.4 to 4.2 m below grade (on the downgradient side of the disposal cell). It is anticipated that the water table is present at or just below grade for the low-lying lands present around the settling basin and the ASB.

The horizontal direction of local (shallow) groundwater flow on the Site and in the surrounding area, is anticipated to coincide with the assumed surface water drainage and/or shallow

groundwater discharge patterns indicated on Drawing No. 121411647-2 (Appendix A), with groundwater flow and discharge anticipated to be towards the natural ponds/wetlands located adjacent to the settling basin and ASB, and to Boat Harbour.

All four monitoring well pair locations show a consistent downward hydraulic gradient, with the gradient typically being higher in MW 1 A/B, MW 2A/B and MW 3A/B, than in MW 4A/B, which is the furthest pair away from the expected discharge points (natural ponds/wetlands and Boat Harbour).

The permeability of till overburden underlying the site is unknown. A site specific determination would be required to establish an estimate of hydraulic conductivity for the till overburden present at the site.

Pumping test information reported for the Pictou Group in the Pictou Landing area suggests an overall low transmissivity for this water bearing bedrock unit, typically under 10 m^2/d, with much of the yield to wells anticipated to be due largely to secondary permeability features within the rock (e.g. along bedding planes, joints, fractures, etc.). According to Gibb et al. (1980), groundwater quality within the Pictou Group is described as moderately hard to hard calcium-sulfate and calcium bicarbonate-type water of moderate TDS. Concentrations of manganese, fluoride and iron occasionally exceed Health Canada's *Guidelines for Canadian Drinking Water Quality* (GCDWQ).

Based on a search of the Nova Scotia Well Logs Database, the surrounding residential properties along Pictou Landing Road and Chance Harbour Road obtain domestic water supplies from wells completed within the Pictou Group. Over 210 water well records were identified in the database for the community of Pictou Landing. The average depth of the wells is 37.7 m, average casing length is 13.2 m, and average depth to bedrock is 8.0 m. All supply wells in the area appear to be hydraulically up-gradient of the site.

1.3 SCOPE OF WORK

The scope of work for this Hydrogeological and Hydrological Evaluation of the Boat Harbour Treatment Facility was set out in Stantec's Proposal for Groundwater and Surface Water Studies and Monitoring and Industrial Landfill Studies dated June 23, 2011 for Northern Pulp (Stantec Proposal No. 121510817). The scope of work is outlined below.

- Identify the presence and susceptibility of potential groundwater and surface water receptors at the Boat Harbour Treatment Facility site, which we understand includes only the settling basins, aerated stabilization basin, and the sludge disposal cell.

- Provide recommendations for changes to the current hydrogeological/hydrological monitoring and sampling program being conducted at the treatment facility (including, but not limited to, expansion/reduction of the current monitoring network, expansion/reduction of the current analytical program, increasing/decreasing monitoring frequency, alterations to monitoring timing, etc.).

- Prepare a report outlining the results of Stantec's review of the current monitoring program, including placement of monitoring locations, monitoring and sampling frequency, chemical analyses, identification and susceptibility of potential groundwater and surface water receptors, and recommendations (if any).

- Provide the results of the evaluation in a written report to Northern Pulp for review and comment prior to finalizing the document and submitting to NSE on or before September 30, 2011.

2.0 Description of Existing Monitoring Programs

Existing water quality and/or compliance monitoring programs currently being undertaken at the Boat Harbour Treatment Facility include:

- compliance monitoring of effluent discharge quality from the mill effluent treatment system by Northern Pulp in accordance with the current NSE Approval No. 2011-076657, and formerly in accordance with NSE Industrial Approval No. 96-033; and,

- quarterly monitoring of groundwater and leachate effluent quality for the sludge disposal cell by Stantec, on behalf of Nova Scotia Transportation and Infrastructure Renewal (NSTIR; on-going since 1995; described in Sub-section 2.2 below).

2.1 SETTLING BASIN AND ASB MONITORING

2.1.1 Description of Current Program

It is Stantec's understanding, that Northern Pulp has completed surface water quality monitoring at the settling basin, ASB and treated effluent discharge location since 1996, this has included continuous, daily, weekly, semi-monthly, monthly and annual programs for a variety of parameters including flow, total suspended solids (TSS), carbonaceous biological oxygen demand (BOD), toxicity testing (including acute lethality to Daphnia magna and rainbow trout), sulfate, nitrate+nitrite, ammonia (as N), colour, electrical conductivity, pH, chemical oxygen demand (COD), total phosphorus, total Kjeldahl nitrogen (TKN), volatile suspended solids (VSS), hydrogen sulphide, dissolved organic carbon (DOC) and ortho-phosphorus, absorbable organic halogens (AOX), and dioxins and furans. A full description of the current program is set out in the NSE Approval No. 2011-076657.

Sampling locations included as part of ongoing monitoring work conducted by Northern Pulp are Points A, B, C and D, and Cell 1, Cell 2 and Cell 3 (refer to Drawing 121411647-2, Appendix A, for sampling point locations). The former and current Approvals require compliance monitoring only at the final effluent discharge (Point D until July 1, 2010; Point C after July 1, 2010).

2.1.2 Regulatory Framework

It is Stantec's understanding that the regulatory framework applied to the program historically has been set out in former NSE Approval No. 96-033. The current regulatory framework is set out in existing NSE Approval No. 2011-076657.

2.2 SLUDGE DISPOSAL CELL MONITORING

2.2.1 Description of Current Program

Groundwater Monitoring

Stantec (former Jacques Whitford Limited) has completed quarterly groundwater monitoring at the sludge disposal cell of the Boat Harbour Treatment Facility (refer to Drawing No. 121411647-1, Appendix A) since 1995, after establishing a groundwater monitoring network around the sludge disposal cell in 1994. The quarterly monitoring program was initiated to provide on-going hydrogeochemical and water level information for the area immediately surrounding the disposal cell.

Four monitor well pairs are present around the sludge disposal cell, each pair consisting of a shallow (B-series; screened in till overburden) and deep (A-series; screened in shallow bedrock) monitoring point. One well pair (MW 4A/B) is located hydraulically up-gradient of the sludge disposal cell, and the remaining three monitor well pairs (MW 1A/B, MW 2A/B and MW 3A/B) are located hydraulically down-gradient of the sludge disposal cell. The location of each monitoring well pair is provided on Drawing No. 121411647-2, Appendix A.

Groundwater samples from each of the monitor wells are analyzed for general inorganic chemistry, metals and fluoride. Prior to 2002, samples were also analysed for extractable organic compounds (by US EPA Method 625).

Leachate Effluent Monitoring

Commencing on June 29, 1999, leachate effluent discharging from the sludge disposal cell was sampled quarterly (when sufficient effluent discharge was present). Continued monitoring of leachate effluent at the free-flowing point of discharge to the ASB provides an on-going characterization of sludge indicator parameters which have the potential to impact groundwater quality, and may provide an indication of the decomposition rate for the waste material in the disposal cell.

Leachate effluent samples are analysed for general inorganic chemistry, metals, TKN, BOD, COD, TDS, TSS, total phosphorus, phenols, and fluoride. In 2002, analysis of EPA 624 volatile compounds, EPA 625 semi-volatile compounds, and dioxins and furans was carried out. Based on the results of the 2002 sampling, further sampling and analysis for EPA 624 and 625 parameters was discontinued in 2003. No further dioxin/furan analysis has been done.

2.2.2 Regulatory Framework

General inorganic and metals groundwater chemistry has, in recent years, been assessed against the 2008 Health Canada *Guidelines for Canadian Drinking Water Quality* (GCDWQ).

Effluent discharge chemistry has been assessed against the Federal Effluent Guidelines (1976 Environment Canada *Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments*, Report EPS 1-EC-76-76-1), Nova Scotia Sewage Effluent Guidelines (1992 NSE *Standards and Guidelines Manual for the Collection, Treatment and Disposal of Sanitary Sewage, Criteria for Lakes, Rivers or Estuaries*) and Canadian Council of Ministers of the Environment Freshwater Aquatic Life Guidelines (2007).

3.0 Review of Historical Monitoring Results

3.1 SETTLING BASIN AND ASB MONITORING

Based on a review of inlet (Point A) and outlet (Point C and D) results provided by Northern Pulp, the treatment system appears to have effectively reduced concentrations of TSS, BOD, COD, VSS, hydrogen sulfide and DOC in the wastewater stream prior to discharge.

3.2 SLUDGE DISPOSAL CELL MONITORING

A sample of the sludge liquid placed in the disposal cell was collected in late September 1996 and analysed for major ion chemistry and dissolved metals. Of the nineteen leachate indicator parameters identified in this sample, chloride, nitrate + nitrite, specific conductance and boron were considered to be the best indicator parameters for assessing the disposal cell's integrity for containing leachate generated from the sludge. Historical chemistry data for these key indicator parameters, along with alkalinity, hardness, TDS, total organic carbon (TOC) and sulfate, have been documented and analyzed for on-going trends by Stantec since 1996.

The review and interpretation of groundwater general chemistry, metals and organic chemistry analytical results from the baseline condition study (November, 1994 to March, 1996) to the end of 2010 indicates that there are no significant changes in groundwater chemistry in the monitoring wells surrounding the sludge disposal cell since monitoring commenced in 1996. Concentrations of key indicator parameters measured in the groundwater monitoring wells have shown an overall stable to decreasing trend after the placement of sludge in the cell (February 1998, and again in the spring of 2008). Although some increasing trends occurred after placement, concentrations of key indicator parameters were found to be below the GCDWQ.

Manganese and turbidity concentrations above the GCDWQ frequently occur in some of the site monitor wells. However these parameters are not considered to be reliable site leachate

indicators and may be elevated due to natural occurrences in Nova Scotia, the effects of rainfall infiltration on shallow wells, and/or the effects of well completion and physical sampling.

Review of the results of quarterly monitoring of the leachate effluent discharge exiting the underdrain network into the ASB show that for the effluent discharge sample analyses, CCME FAL guidelines for nitrite, ammonia, aluminum, cadmium, copper, iron, lead, thallium and zinc were exceeded in some or all effluent discharge samples collected to date. It should be noted that at the present time there are no specific guidelines for effluent discharge into an ASB lagoon. As set out in Drawing No. 121411647-2, the leachate effluent discharge from the sludge disposal cell is located near the discharge compliance point, Point C.

4.0 Identification of Potential Migration Pathways and Data Gaps

A review of the topography, geology and hydrogeology of the Boat Harbour Treatment Facility site and immediately surrounding lands suggests that the site is within a discharge area, with discharge anticipated to be to the natural ponds/wetlands present and Boat Harbour (refer to Drawing No. 121411647-2, Appendix A).

4.1.1 Settling Basin and ASB Monitoring

Mill effluent from the settling basin discharges to the ASB for further treatment. It is anticipated that seepage (if any) from the settling basin would enter shallow groundwater, follow a short sub-surface flow path, and then discharge to Pond 2 (inferred down-gradient of the settling basin) and downstream portion of Pond 1 (inferred cross-gradient to down-gradient of the settling basin) as baseflow. Pond 1 appears to discharge to Pond 2 at Point B and Pond 2 appears to discharge to Boat Harbour at Point 2 (refer to Drawing No. 121411647-2, Appendix A).

Treated mill effluent discharge from the ASB goes directly to Boat Harbour. Seepage (if any) from the ASB would be anticipated to enter shallow groundwater, follow a short flow path, and then discharge to Boat Harbour as baseflow.

Based on a review of the existing monitoring program, and the potential migration pathways and/or receptors, the following data gaps have been identified relating to the settling basin and ASB monitoring program:

- no groundwater monitoring points are present down-gradient of the settling basin to assess the potential for seepage from this structure, and potential impacts to shallow groundwater; and
- no surface water monitoring points are present downstream of the settling basin to assess potential seepage, and subsequent discharge and potential impacts to surface water on the site, from this structure.

In addition, the following data gaps have been identified related to source characterization and chemical analytes:

- no mill effluent (source) chemical characterization has been completed, which would allow for the determination of key indicator parameters associated with the mill effluent; and,

4.1.2 Sludge Disposal Cell Monitoring

Subsurface seepage (if any) from the sludge disposal cell is anticipated to be collected within the underdrain network, which discharges to the ASB immediately north of the disposal cell (refer to Drawing No. 1214116476-2). Any sub-surface seepage from the sludge disposal cell not collected by the underdrain network is anticipated to be directed to the north, towards the ASB and Boat Harbour. It is anticipated that seepage not collected in the underdrain network (if any) would enter shallow groundwater, follow a short flow path and then discharge to the ASB and/or Boat Harbour.

Based on a review of the existing monitoring program, and the potential migration pathways and/or receptors, the following data gaps have been identified relating to the sludge disposal cell monitoring program:

- there is no analytical data demonstrating that metals concentrations, which exceed the CCME FAL guidelines at the sludge disposal cell underdrain network discharge to the ASB, do not occur at the Boat Harbour Treatment Facility discharge compliance location (Point C).

5.0 Conclusions and Recommendations

Based on a review of the current monitoring and sampling programs conducted at the Boat Harbour Treatment Facility, it is concluded that several data gaps are present in the current monitoring programs. These data gaps include:

- a lack of groundwater monitoring points down-gradient of the settling basin to assess the potential for seepage from this structure, and potential impacts to shallow groundwater;

- a lack of surface water monitoring points downstream of the settling basin to assess potential seepage, and subsequent discharge and potential impacts to surface water on the site, from this structure;

- a lack of mill effluent (source) chemical characterization (including general chemistry, metal, dioxins and furans, and AOX), which would allow for a better determination of key indicator parameters; and

- a lack of analytical data demonstrating that metals concentrations, which exceed the CCME FAL guidelines at the sludge disposal cell underdrain network discharge to the ASB, do not occur at the Boat Harbour Treatment Facility discharge (Point C).

It is recommended that the existing monitoring and sampling programs be continued. In order to address data gaps identified in the current program, the following recommendations are made:

- Collect a minimum of two samples of mill effluent at Point A, spaced over a one month period, for the purpose of source characterization. Where possible, the sampling could be timed to occur at the time of the existing program. This analysis should include: general chemistry, metals, dioxins and furans, and AOX.

- Commence quarterly monitoring of surface water at Point 1 and Point 2 (refer to Drawing 121411647-2). Analysis would include general chemistry, metals and any key indicator parameters established from the source characterization outlined above. It is anticipated that seepage from the settling basin would discharge to natural ponds/wetlands present in the immediate area (particularly Pond 2). Sampling of Point 1 would establish background surface water quality, while sampling at Point 2, downstream of Pond 2, would serve to establish if any impacts originating from the settling basin are occurring downstream. If impacts are identified, the installation and routine monitoring of a groundwater monitoring network around the settling basing should be undertaken.

- Samples collected from the Boat Harbour Wastewater Treatment Facility discharge (Point C) should be analysed for metals on a regular basis to demonstrate that metals exceeding the CCME FAL guidelines, originating from the sludge disposal cell underdrain network are not being discharged to the receiving water body (Boat Harbour).

6.0 Closure

This report has been prepared for the sole benefit of Northern Pulp Nova Scotia Corporation. The report may not be used by any other person or entity without the express written consent of Stantec Consulting Ltd. and Northern Pulp Nova Scotia Corporation.

Any use that a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. Stantec accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken, based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and

scientific practices current at the time the work was performed. Conclusions and recommendations presented in this report should not be construed as legal advice.

The conclusions presented in this report represent the best technical judgement of Stantec based on the data obtained from the work. The conclusions are based on the site conditions observed by Stantec at the time the work was performed at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and groundwater conditions, as well as the history of the site reflecting natural, construction and other activities. In addition, analyses have been carried out for a limited number of chemical parameters, and it should not be inferred that other chemical species are not present. Due to the nature of the investigation and the limited data available, Stantec cannot warrant against undiscovered environmental liabilities.

If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

This evaluation was prepared by Rebecca Ferguson, M.Sc., P.Eng. and reviewed by Don Carey, M.Sc., P.Eng., FGS and Michael Charles, P.Eng.

STANTEC CONSULTING LTD.

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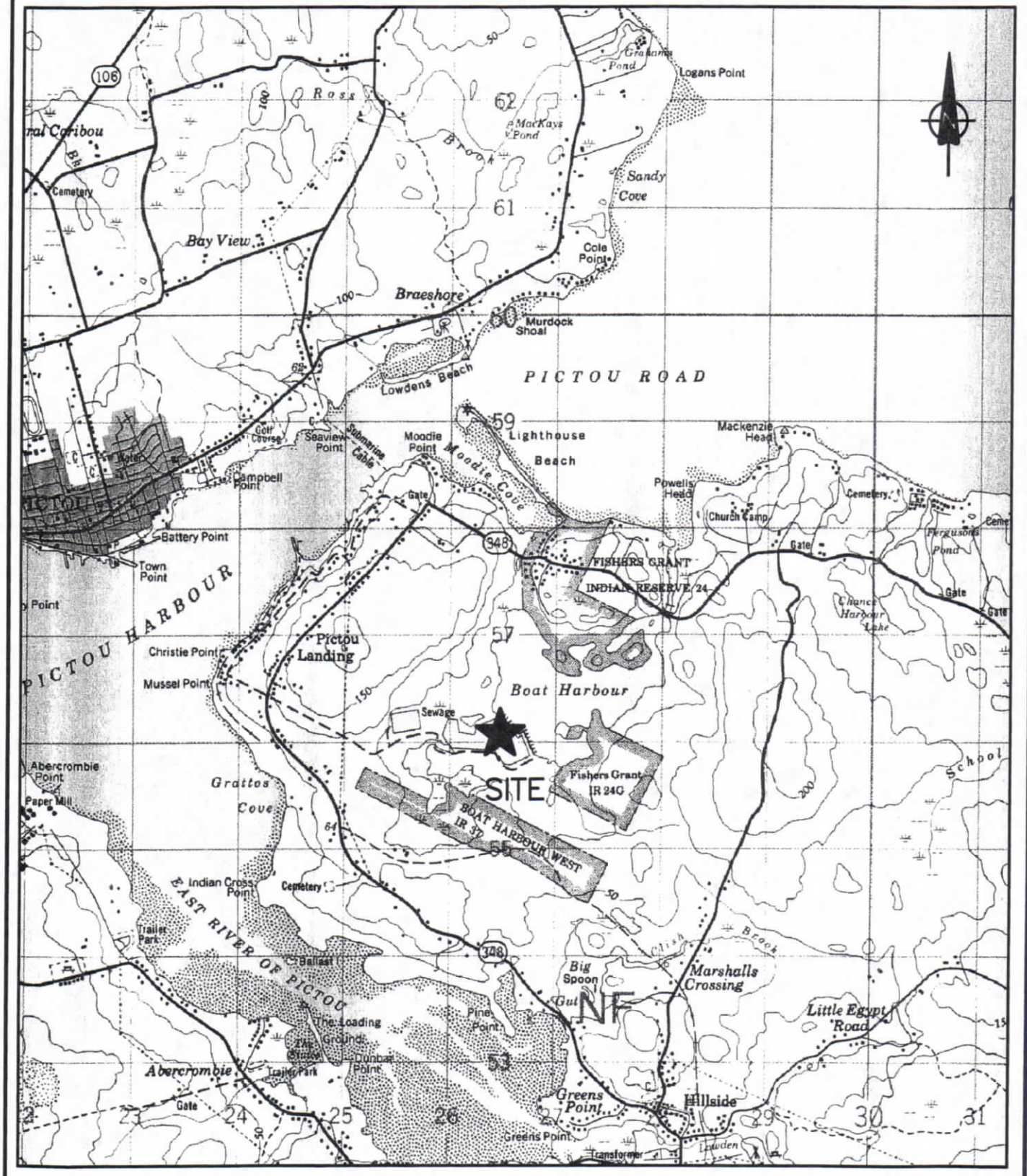
APPENDIX A

FIGURE AND DRAWINGS



GENERAL SITE LOCATION AND TOPOGRAPHY

SCALE 1:50,000

Stantec

121411647

FIGURE 1

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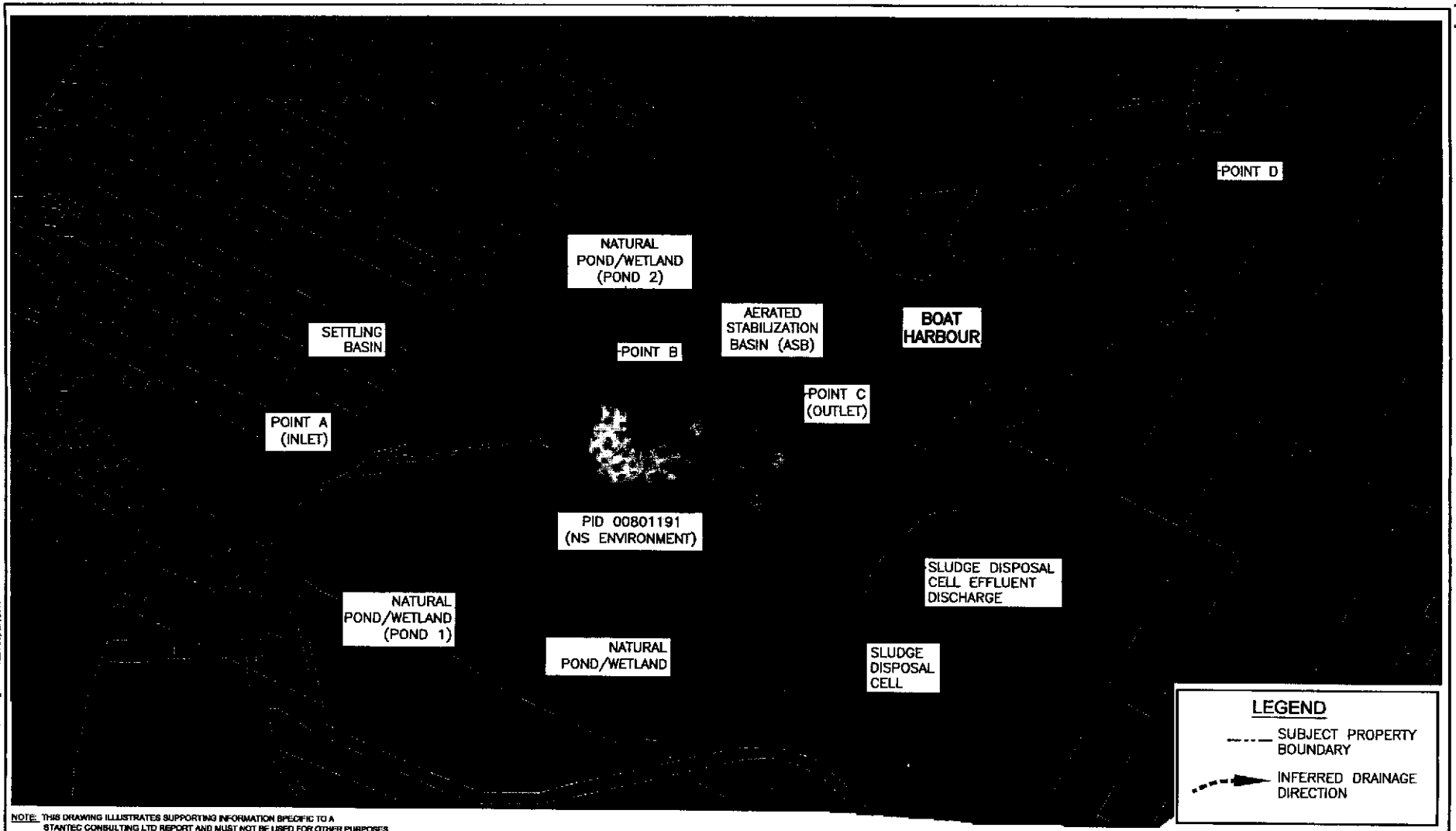

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Reference: PROPERTY BOUNDARIES ARE FROM SERVICE NOVA SCOTIA AND MUNICIPAL AFFAIRS PROPERTY RESOURCES AND ARE APPROXIMATE. BACK GROUND IMAGE IS FROM GOOGLE EARTH AND IS APPROXIMATE	Job No.: 121411647 Scale: 1:12,500 Date: 2011/09/27 Dsn. By: SJT App'd By:	Client: NORTHERN PULP Site Address: SIMPSONS ROAD, PICTOU LANDING, PICTOU COUNTY, NS	Project: HYDROGEOLOGICAL AND HYDROLOGICAL EVALUATION OF BOAT HARBOUR TREATMENT FACILITY	Drawing Title: SITE PLAN	Dwg. No.: 1

Stantec

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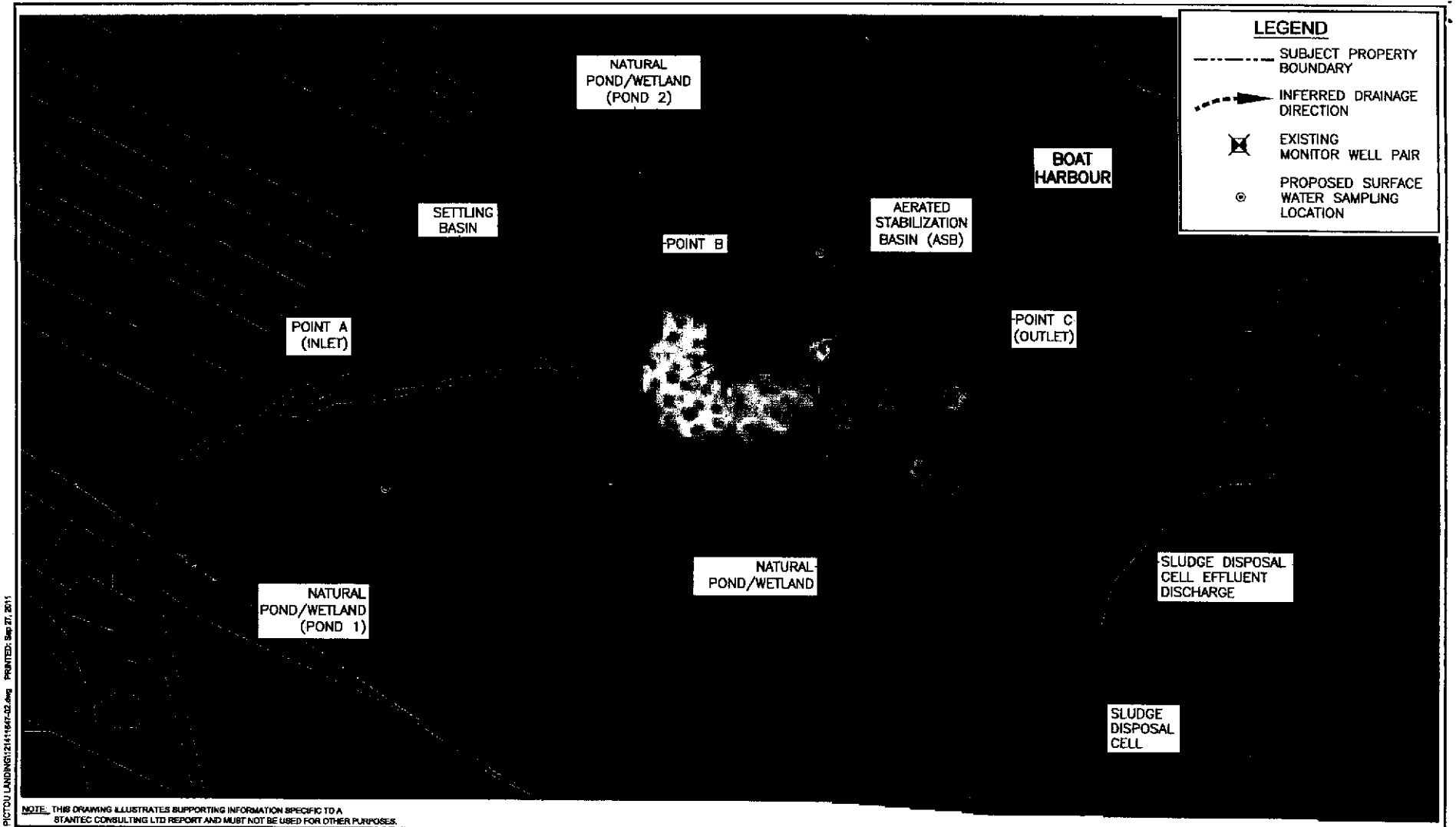

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