Henvey Inlet Wind LP

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Henvey Inlet Wind Energy Centre

Hydrogeological Assessment and Effects Assessment

Final Draft

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AECOM: 2012-01-06

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Executive Summary

Henvey Inlet Wind LP (HIW), a limited partnership between Pattern Renewable Holdings Canada ULC and Nigig Power Corporation, is proposing to construct the Henvey Inlet Wind Energy Centre (HIWEC) on the Henvey Inlet First Nation Reserve No. 2 (HIFN I.R. #2) in Ontario, Canada. HIW retained AECOM Canada Ltd. (AECOM) to conduct a desktop study to provide a high-level characterization of existing geological and hydrogeologic conditions and to identify potential effects to the geophysical environment (soil and groundwater) through construction and installation of the HIWEC. Potential water taking requirements during the construction, operation and decommissioning of the HIWEC was inferred from available secondary source data.

The HIWEC study area is situated within the western portion of the Central Gneiss Belt, which comprises the southwestern part of the Grenville Province of the Canadian Shield. The Central Gneiss Belt is composed of a complex suite of strongly foliated gneissic and migmatitic rocks of Early to Middle Proterozoic age (Kor, 1991). Very little overburden is present within the HIWEC study area. Exposed, frequently weathered and fractured bedrock accounts for much of the surficial geology, with the remainder being characterized by organic deposits which accumulated in low-lying areas and bedrock valleys as well as a bedrock-drift complex consisting of a thin, discontinuous veneer of glaciolacustrine sand and/or gravel, isolated occurrences of ice-contact stratified sands and gravels, and of loose, stony glacial till (OGS, 2003).

Surficial geology and bedrock geology of the Canadian Shield provides a foundation to characterize the general hydrostratigraphy of the HIWEC study area. Within the Canadian Shield, two (2) separate groundwater systems are identified: i) a shallow, freshwater system that extends to at least 150 m depth, and ii) a deep saline system that extends down hundreds of metres (Singer and Cheng, 2002; Thorne and Gascoyne, 1993). Groundwater within the shallow freshwater system of the Canadian Shield serves as a source of drinking water for many residents within the Canadian Shield. The exposed bedrock of the Central Gneiss Belt within the region is highly fractured within the upper 10 to 20 m (Sykes *et al.*, 2009; Ecoplans Limited, 2007), making it an aquifer unit and highly susceptible to contamination from surface sources. Overburden deposits, such as the glaciolacustrine sands are also considered aquifer units however, these units are thin and discontinuous and thus are not considered to be significant, although they may be hydraulically connected with the underlying Precambrian bedrock aquifer (Singer and Cheng, 2002).

The primary aquifer within the HIWEC study area is within the upper fractured bedrock. A detailed door-to-door water well survey was performed on June 8th and 9th, 2015. The purpose of the well survey was to collect hydrogeological data and well construction details for actively used groundwater supply wells within the 1,000 m search area radius to the east and south of the HIFN I.R. #2 boundary and bounded by Key River to the north and Georgian Bay to the west. The 1,000 m search area radium was not extended to the north of the HIFN I.R. #2 boundary as hydrogeological impacts are not anticipated across the Key River. Results of the well survey indicate the presence of 18 private groundwater supply wells, of which 20 private residences source water. Four (4) property owners/tenants share a communal well located on Bekanon Road and one residence has two wells located on the property. Of the 18 wells identified, six (6) shallow dug wells, presumably completed in overburden, were identified. The remaining 12 wells were drilled wells most likely completed in bedrock.

Groundwater takings for the purposes of providing dry working conditions during wind turbine generator (WTG) foundation construction, collector line installation, road construction and dust suppression may be required during construction of the HIWEC. Water requirements for the purpose of dust suppression are expected to have peak water demands up to 40,000 litres per day (L/day). The proposed source of water for dust suppression may be a local surface water intake, excluding federally regulated waters (Georgian Bay, Henvey Inlet and Key River), or new groundwater supply wells located at the Transformer Station Area (TSA) and the Operations and Maintenance

(O&M) building which will be needed for operations. Up to approximately 120,000 L/day of water may be required during drilling operations to facilitate the installation of rock anchors as part of the WTG foundation construction. The proposed source of water for drilling water may be one or more future new groundwater supply wells located at both TSA and O&M building locations. Dewatering of WTG foundation excavations may also be required to maintain a dry work environment, resulting in a maximum daily dewatering rate of approximately 387,000 L at each WTG foundation excavation which encounters the groundwater table. During operation of the HIWEC, it is expected that full time employees will regularly use the O&M building. Non-potable water taking during operation will be limited to regular personnel requirements, which are expected to be approximately 4,500 L/day and are not expected to exceed 50,000 L/day. Facilities that will provide this non-potable water will require the construction of one or more new well(s) at the O&M building.

Presently, subsurface geotechnical and hydrogeological investigations have not been performed within the HIWEC study area to confirm depth to the water table and hydrogeological properties at each WTG location. The calculation of anticipated groundwater dewatering rates is required as part of typical provincial requirements and therefore has been determined based on secondary source information available during this desktop assessment.

This Executive Summary provides a summary of the findings detailed in the following report and is not intended to be a stand-alone document.

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1. Introduction

Henvey Inlet Wind LP (HIW), a limited partnership between Pattern Renewable Holdings Canada ULC and Nigig Power Corporation, is proposing to construct the Henvey Inlet Wind Energy Centre (HIWEC) on the Henvey Inlet First Nation Reserve No. 2 (HIFN I.R. #2) in Ontario, Canada.

This Hydrogeological Assessment and Effects Assessment was prepared in accordance with the HIFN EA Guidance requirements, which has regard to provincial and federal processes for similar undertakings.

This desktop study was conducted to provide a high-level characterization of existing geological and hydrogeologic conditions and to identify potential effects to groundwater through construction and installation of the HIWEC. Subsurface stratigraphy and general groundwater usage within the HIWEC study area was interpreted from available secondary source data including:

- Quaternary geological mapping from the Ministry of Northern Development and Mines (MNDM);
- Bedrock geological mapping from Ontario Geological Survey (OGS);
- Ministry of the Environment and Climate Change (MOECC) Water Well Records;
- Geology terrain mapping from the OGS;
- Geotechnical borehole data from the Oil, Gas and Salt Resource Library and;
- Various groundwater study reports prepared by AECOM and URS for the Highway 69 expansion project.

2. Existing Conditions

2.1 Topography and Physiography

The HIWEC study area lies within the Georgian Bay Fringe physiographic region, as defined by Chapman and Putnam (1984). The Georgian Bay Fringe is characterized by a gentle plain that inclines gradually from the shoreline of Georgian Bay to the Algonquin Highlands, the region that runs approximately north-south along its eastern boundary. Although relief within the Georgian Bay Fringe is generally considered to be low (i.e., less than about 15 m), numerous bare rock knobs and ridges occur which rise above the local ground topography. The character of the land surface across the region is dictated by the irregular bedrock surface that underlies a thin, discontinuous blanket of overburden. Steep-walled valleys and bedrock-controlled features are observed to trend generally northeast – southwest and are dictated by the fault and fracture network prevalent in the bedrock. Ground elevations within the HIWEC study area generally decline in a southwest direction from a topographic high of approximately 213 m Above Sea Level (mASL) in the southeast portion of the HIWEC study area to a low of about 169 mASL in the northeast and along the shoreline of Georgian Bay (**Figure 1**).

2.2 Geological Setting

2.2.1 Bedrock Geology

The HIWEC study area is situated within the western portion of the Central Gneiss Belt, which comprises the southwestern part of the Grenville Province of the Canadian Shield. The Grenville Front Tectonic Zone lies to the north of the HIWEC study area, and the Central Metasedimentary Belt lies to the south. The Central Gneiss Belt is composed of a complex suite of strongly foliated gneissic and migmatitic rocks of Early to Middle Proterozoic age (Kor, 1991). The Central Gneiss Belt has been further divided into separate lithotectonic domains and sub-domains, each separated by zones of intense metamorphism and based on distinct changes in geological, geophysical, and structural characteristics (Kor, 1991, Davidson *et al.*, 1982). The HIWEC study area is located within the Britt Domain which occupies the eastern shoreline of Georgian Bay north of Parry Sound. The Britt Domain is characterized by a complex of highly deformed layered, migmatitic gneisses of granitic to granodioritic composition that range from pinkish-grey to greyish white in colour and exhibit strong foliation (Bright, 1989). Mineral assemblages correspond to that of the mid- to upper amphibolites facies (Davidson and Morgan, 1981). Biotite gneiss and quartzofeldspathic gneiss are also present. These units are intruded by metamorphosed felsic to intermediate plutonic rocks consisting of massive to foliated monzogranitic to granitic orthogneiss, and a sequence of mafic dikes composed of amphibolite and gabbroic orthogneiss. The suite of metamorphic rocks within the area is intruded by late, unmetamorphosed pegmatitic granite dykes (Bright, 1989).

The HIWEC study area is situated over a folded assemblage of gneissic rocks of the Key Harbour Gneiss Association and intermediate to felsic intrusives (Culshaw *et al.*, 2004a). The Key Harbour Gneiss Association is mapped within the central portion of the HIWEC study area and is characterized by intermediate to felsic leucocratic gneiss, and layered metasedimentary rocks of pink to grey quartz-feldspar-biotite paragneiss. Rocks of the Key Harbour Gneiss Association within the HIWEC study area are mapped as a single unit in **Figure 2** due to their similarity in age and generally more mafic composition when compared to the younger, more felsic intrusives.

A later suite of intermediate to felsic intrusive rocks is mapped throughout the HIWEC study area, and becomes more prevalent in the western half of the HIWEC study area. These are characterized by weakly foliated to gneissic grey-coloured hornblende-biotite granodiorite, locally containing potassium feldspar megacrysts, minor tonalite, pink granite, and grey granodiorite (Culshaw *et al.*, 2004b).

2.2.2 Overburden Geology

Very little overburden is present within the HIWEC study area. Exposed, frequently weathered and fractured bedrock accounts for much of the surficial geology, with the remainder being characterized by organic deposits which accumulated in low-lying areas and bedrock valleys as well as a bedrock-drift complex consisting of a thin, discontinuous veneer of glaciolacustrine sand and/or gravel, isolated occurrences of ice-contact stratified sands and gravels, and of loose, stony glacial till (OGS, 2003) (**Figure 3**). Where present, the thickness of the overburden generally is less than about 1 m, however, with slightly thicker accumulations of up to 3 m being found in bedrock hollows, topographic lows, and on the lee-side of bedrock knobs in relation to the direction of glacial ice-flow.

The past glacial history of the region is better described through observations of erosional bedrock features such as striae, chattermarks, and roches moutonees. The deposited drift and bedrock erosional features represent the final Late Wisconsinan glacial advance and retreat (Kor, 1989). The following is a description of the quaternary geological deposits found within the HIWEC study area:

Ice-Contact Stratified Deposits and Till

Ice-contact stratified deposits occur in a narrow linear bedrock-controlled valley in the northeastern portion of the HIWEC study area (**Figure 3**). This deposit is described by Kor (1989) as rippled, cross-bedded, medium- to coarse-grained sands and fine gravels that are interbedded with loose stony diamict flows.

The till is of a loose sandy to silty sand texture and contains sub-angular clasts derived from local rock types. This deposit was observed by Kor (1989) in protected bedrock hollows and was associated with the ice-contact stratified deposits. Kor (1989) suggests this till may have been more extensively deposited, but was removed by glacial meltwaters.

Glaciolacustrine Deposits

Glaciolacustrine sands and gravels were deposited during a time when the HIWEC study area was submerged by glacial Lake Algonquin. Thicker, more continuous deposits of glaciolacustrine sediments are mapped within the eastern portion of the HIWEC study area and along the existing Highway 69 corridor to the east. These deposits are generally characterized by a coarsening-upward sequence of laminated silts and clays overlain by stratified sand and some gravel, having a maximum thickness of about 4 m within the HIWEC study area (Kor, 1989). Glaciolacustrine sands and gravels are also present within east-west trending narrow bedrock valleys throughout the Parry Sound region.

Glaciofluvial Deposits

Glaciofluvial deposits do not occur within the HIWEC study area in any mappable quantities. Minor amounts of sand and gravel were observed overlying glaciolacustrine deposits, indicating drainage during phases of glacial lake decline (Kor, 1989).

Recent Deposits

Recent deposits, swamps and organic deposits are common within the HIWEC study area and are present in low-lying areas and bedrock hollows. These areas commonly exhibit poor drainage and associated marsh-like characteristics.

2.3 Hydrogeological Setting

Surficial geology and bedrock geology of the Canadian Shield provides a foundation to characterize the general hydrostratigraphy of the HIWEC study area. Hydrostratigraphy is the classification of various major stratigraphic units into aquifers and aquitards, with some simplification or combination of units with similar properties. Previous groundwater resource studies provide a generalized framework to characterize groundwater resources, flow and quality within the HIWEC study area. A review of available secondary source information was used in this investigation, including:

- Hydrogeological Assessment Study – Highway 69 Magnetawan prepared by AECOM (2013); and
- Hydrogeological Assessment Study – Highway 69, G.W.P. 5404-05-11 Hydrogeological Assessment Study Henvey Inlet First Nation (French River Reserve No.13 and Henvey Inlet Reserve No.2), Townships of Mowat and Henvey District of Parry Sound and Municipality of Killarney Ontario by URS (2014).

2.3.1 Hydrostratigraphy

Within the Canadian Shield, two (2) separate groundwater systems are identified: i) a shallow, freshwater system that extends to at least 150 m depth, and ii) a deep saline system that extends down hundreds of metres (Singer and Cheng, 2002; Thorne and Gascoyne, 1993). Groundwater within the shallow freshwater system of the Canadian Shield serves as a source of drinking water for many residents within the Canadian Shield. Geological materials that host and transmit groundwater can be subdivided into two distinct groups based on their ability to allow groundwater movement; namely aquifers and aquitards. Aquifers are classically defined as a geological unit permeable enough to permit a useable supply of water to be extracted, and aquitards are relatively impermeable units that inhibit groundwater movement. The exposed bedrock of the Central Gneiss Belt within the region is highly fractured within the upper 10 to 20 m (Sykes *et al.*, 2009; Ecoplans Limited, 2007), making it an aquifer unit. It is the secondary permeability created by these fractures that dictate the ease at which groundwater is able to move through the bedrock aquifer, and the intensity and distribution of fractures determines the total porosity, hydraulic conductivity, and infiltration rate within the Precambrian bedrock aquifer (Singer and Cheng, 2002).

Within the HIWEC study area, the pattern of fractures in the bedrock aquifer allows for movement of groundwater, however, this secondary permeability generally decreases with depth (Sykes *et al.* 2009). Overburden deposits, such as the glaciolacustrine sands are also considered aquifer units however, as mentioned in **Section 2.2.2**; these units are thin and discontinuous and thus are not considered to be significant, although they may be hydraulically connected with the underlying Precambrian bedrock aquifer (Singer and Cheng, 2002). The primary aquifer within the HIWEC study area is the upper fractured bedrock.

The fundamental characteristics of fractured rock aquifers are the extreme variability in hydraulic properties, such as hydraulic conductivity and flow direction. In a fractured rock setting, groundwater flows may be extremely high through discrete fractures or faults, creating a defined flow zone. In a purely fractured media, such as in crystalline bedrock environments, groundwater flow in the host rock between these fractures and faults is extremely low and is considered a confining unit.

2.3.2 Water Well Survey

An inventory of private water wells (i.e., domestic, commercial, industrial, etc.) was performed within a radius of approximately 1,000 m from the HIFN I.R. #2 boundary, by means of searching the Ministry of the Environment and Climate Change (MOECC) Water Well Database. The northern limit of the water well survey area was truncated at the Key River as this feature would serve as a hydrogeological divide between the HIFN I.R. #2 boundary and those lands to the north. Results are shown in **Figure 3**, along with the primary use of each well. A total of 28

MOECC water well records were located within the 1,000 m search area radius, of which only six (6) are located within the HIFN I.R. #2 boundary. A review of the water well records indicates that the majority (88%) of wells are completed in bedrock and range in depth between about 3.1 and 79.2 m. Two (2) wells located are reported to be completed in overburden material (sand) and are located on the north side of Key River, outside of the HIFN I.R. #2 boundary.

As shown in **Table 1**, available MOECC well records indicate that 61% of groundwater use within the 1,000 m search area radius is for domestic purposes, followed by commercial use (11%), and public and municipal supply use (11%). Approximately 18% of MOECC water well records specified the primary use as 'Not Used' or 'Monitoring and Test Hole', which indicates those wells are not used as a groundwater supply.

Table 1. Summary of MOECC Water Well Records

Primary Well Use	Number
Commercial	3
Domestic	17
Monitoring and Test Hole	3
Municipal	1
Not Used	2
Public	2
Total	**28**

2.3.2.1 Water Well Survey Results

A detailed door-to-door water well survey was performed by AECOM on June 8th and 9th, 2015. The purpose of the well survey was to collect hydrogeological data and well construction details for actively used groundwater supply wells within the 1,000 m search area radius to the east and south of the HIFN I.R. #2 boundary and bounded by Georgian Bay to the west and Key River to the north as previously mentioned. The 1,000 m search area radium was not extended to the north of the HIFN I.R. #2 boundary as hydrogeological impacts are not anticipated across the Key River. The well survey was performed from publically accessed roads and/or by boat along Henvey Inlet and Key River. The well survey included a detailed questionnaire regarding pertinent water well information such as: contact information; well location; past water quality concerns; well construction details; well depth; pump setting details; historic and current water usage; and water treatment system details. In instances where the property owner was not available at the time of our survey, an information package, including a brief covering letter, a copy of the survey form and a pre-addressed and stamped envelope for return mailing to AECOM, was left at the front door. A sample copy of the survey information package is provided in **Appendix A**.

During the survey, a total of fifty one (51) private residences were identified. Of those 51 residences, 15 property owners/tenants were interviewed, and 26 were not available at the time of our attendance. As noted previously, an information package was left in a highly visible location at the front door at each location where the property owner was not home. Ten (10) property owners/tenants were unable to provide information about their water supply or did not wish to participate in the well survey. One (1) property owner/tenant responded to the information package left at the property. **Figure 4** illustrates the private residences in which a well survey was conducted.

Results of the well survey indicate the presence of 18 private groundwater supply wells, of which 20 private residences source water. Four (4) property owners/tenants share a communal well located on Bekanon Road and one residence has two wells located on the property. Of the 18 wells identified, six (6) shallow dug wells, presumably completed in overburden, were identified. The remaining 12 wells were drilled wells most likely completed in bedrock. Results of the survey are summarized and included in **Appendix A** and illustrated on **Figure 4**.

2.3.3 Aquifer Properties

2.3.3.1 Groundwater Levels

Groundwater levels within the HIWEC study area have been interpreted from information collected during the water well survey conducted by AECOM in June 2015 and from information presented in a Hydrogeological Assessment Report prepared by URS (2014) for the HIWEC study area.

During the well survey, three (3) property owners/tenants provided permission for AECOM to obtain a groundwater level measurement from their well. Results of this investigation indicate shallow groundwater levels of less than 2 metres below ground surface (mbgs), exists within the shallow bedrock and / or overburden sediments in the vicinity of Bekanon Road.

In the fall of 2013, URS installed a total of four (4) groundwater monitoring well nests within the HIWEC study area. Each nest included one (1) shallow overburden well and one (1) deep bedrock well. The shallow overburden monitoring wells were completed to a depth ranging from 2.4 m to 6.1 m. Bedrock monitoring wells have a total depth ranging from 4.6 m to 15.3 m. Water level measurements were collected from each well in November 2013 and May 2014. Groundwater levels within the overburden sediments range from 0.19 mbgs to 3.58 mbgs. Groundwater levels within the shallow bedrock monitoring wells, with a total depth of less than 10 m, range from 0.02 m above ground surface to 2.02 mbgs. Artesian groundwater conditions were observed in one (1) bedrock monitoring well in the vicinity of Bekanon Road, approximately 500 m west of Highway 69. Borehole logs and well location map provided in **Appendix B**.

A summary of groundwater levels is provided in **Table 2**.

Table 2. Groundwater Level Summary

Well Location	Water Level (mbgs) June 2014	Water Level (mbgs)[1] November 2013	Water Level (mbgs)[1] May 2014
Private Water Wells			
2344 Highway 69	14.83	14.68	13.72
2336 Highway 69	-	9.23	9.17
2 Groundhog Lane	-	4.76	4.29
10 Groundhog Lane	-	13.34	12.94
52 Bekanon Road	-	1.44	-
49 Bekanon Road	-	0.89	0.84
87 Bekanon Road	1.27 (Dug) 1.61 (Drilled)	0.46 (Dug) 0.85 (Drilled)	0.69 (Dug) 0.58 (Drilled)
170 Bekanon Road	0.80	0.18	0.17
URS Groundwater Monitoring Wells			
OMW-10	-	3.58	1.65
BMW-10	-	1.86	3.02
OMW-11	-	0.19	0.29
BMW-11	-	1.06	1.24
OMW-13	-	1.37	0.61
BMW-13	-	1.98	2.02
OMW-14	-	0.80	0.89
BMW-14	-	1.36	-0.02 (Artesian)

Notes: (1) Source: "Highway 69, G.W.P. 5404-05-00 Hydrogeological Assessment Study" by URS (2014)

2.3.3.2 Hydraulic Conductivity

Hydraulic conductivity is a measure of the relative ability of water to move through a geologic material and can be used to determine potential groundwater inflow rates into construction excavations. Higher values of hydraulic conductivity indicate that the geologic material can convey large quantities of groundwater and therefore higher groundwater dewatering rates are anticipated. Conversely, lower values of hydraulic conductivity typically equate to lower groundwater dewatering requirements.

Hydraulic conductivity values have been estimated from information presented in the "Hydrogeological Assessment Study" reports for Highway 69 within the Henvey Inlet Reserve No. 2 (URS, 2014) and the Magnetawan First Nation Reserve No. 1 (MFN), located approximately 9 km south of the HIWEC study area (AECOM, 2013). Surficial geology and bedrock geology within the MFN is similar to that found within the HIWEC study area and therefore hydrogeological properties of the shallow bedrock aquifer are expected to be comparable. Single well response tests were conducted on four (4) groundwater monitoring wells completed in the shallow bedrock aquifer installed within the MFN study area resulting in the determination of hydraulic conductivities ranging from about 4×10^{-7} to 8×10^{-4} m/s (AECOM, 2013). It is interpreted that hydraulic conductivity generally decreases with depth and therefore higher hydraulic conductivities are anticipated with shallower depths and greater bedrock weathering. Single well response tests (pumping tests) were conducted on private water wells within the HIWEC study area by URS (2014). Based on these results, the mean hydraulic conductivity was determined to be approximately 5×10^{-6} m/s. Since the wind turbine generator (WTG) foundations will be installed at a shallow depth, where the potential for bedrock weathering and fracturing is greatest, shallow dug and / or drilled wells located within the HIWEC study area are considered the most representative of conditions encountered during foundation excavation. A mean hydraulic conductivity of 2.5×10^{-5} m/s was calculated for shallow dug or drilled wells located along Bekanon Road and Highway 69 and is assumed to be representative of shallow bedrock aquifer conditions across the HIWEC study area.

2.3.4 Groundwater Recharge and Discharge

Recharge is the term used to describe the downward movement of water within the subsurface, that is, from the ground surface toward the water table. Discharge is defined as the movement of groundwater such that the water table intersects the ground surface. Within the Canadian Shield, recharge and downward groundwater movement typically occurs in topographically high regions, such as the Algonquin Highlands to the east of the HIWEC study area or more locally on bedrock knobs and ridges. Discharge and upward groundwater flow occurs in topographic lows, such as Henvey Inlet or within bedrock valleys and isolated topographic depressions between bedrock knobs (**Figure 1**). Throughflow, sub-parallel to ground surface, occurs in areas of low topographic relief at moderate elevations (Sykes *et al.*, 2009). A significant component of the HIWEC study area can be classified as a recharge area due to the dense, interconnected fracture network that exists at surface.

Water table elevation for the HIWEC study area was interpolated from topographic information and validated by groundwater level information provided in the URS (2014) Hydrogeological Assessment Report. For the purpose of this desktop study, the water table is assumed to be directly connected to local surface water features within the HIWEC study area. By means of a GIS mapping technique, a water table elevation map was prepared using surface water elevation as a point source for water table elevation information (**Figure 5**). The resulting water table elevation map indicates a potential groundwater discharge zone in the vicinity of Henvey Inlet and within the western portion of the HIWEC study area. Groundwater seeps and springs were observed during the ecological field investigation by AECOM and locations are presented on **Figure 5**.

2.3.5 Groundwater Flow

Groundwater flow is the result of differences in hydraulic head or, simply stated, water table elevation, from one location to another. Regional groundwater flows from east to west into Georgian Bay. Topographic lows, such as river valleys, can have local effects on the rate and direction of groundwater movement. Groundwater flowpaths frequently bend into river valleys and isolated topographic depressions; examples within the HIWEC study area include Henvey Inlet, Key River, and some of the deeper bedrock hollows and valleys within the lowlands.

Water table contours have been shown to subtly reflect the topographic contours in the region, emphasizing the influence of topography on the shallow groundwater flow system. As illustrated in **Figure 5**, groundwater flow within the HIWEC study area is primarily from east to west, except within the central portion of the study area, where groundwater likely flows towards Henvey Inlet.

2.3.6 Aquifer Susceptibility

Aquifer susceptibility is the ability of an aquifer to accept and transmit contamination introduced to the environment from the surface. The degree of aquifer susceptibility is controlled by the depth to the water table and the permeability of surficial sediments. Generally, overburden deposits of sand and gravel and exposed bedrock aquifers are highly susceptible to surficial contamination.

The dominant aquifer within the HIWEC study area is the Precambrian bedrock. The bedrock aquifer is most susceptible to contamination where the bedrock is exposed at surface or beneath a thin veneer of overburden and is highly fractured. The rate of groundwater contamination and transmission of contamination through the aquifer is controlled by the hydraulic conductivity overburden (if present) and bedrock, in conjunction with the density of fractures in the vicinity of a contaminant release site.

2.3.7 Wellhead Protection Areas

There are no wellhead protection areas within the HIWEC study area.

3. Water Taking Assessment

3.1 Temporary Water Takings and Construction Considerations

An important environmental effect to consider is the potential for the HIWEC to interfere with existing uses of a water resource. Groundwater takings for the purposes of providing dry working conditions during WTG foundation construction, collector line installation, road construction and dust suppression may be required during construction of the HIWEC. Any water taking conducted during the construction phase of the HIWEC is subject to the HIFN EA Guidance requirements which have regard to both provincial and federal requirements for similar projects

3.1.1 Construction Operation Water Takings

During the construction phase of the HIWEC, water may be required to support WTG construction (i.e., dust suppression and drilling fluids). Water requirements for the purpose of dust suppression are expected to have peak water demands up to 40,000 L/day. The proposed source of water for dust suppression may be a local surface water intake, excluding federally regulated waters (Georgian Bay, Henvey Inlet and Key River), or one or more new groundwater supply well located at both Transformer Station Area (TSA) and Operations and Maintenance (O&M) building locations. Water may be required during drilling operations to facilitate the installation of rock anchors as part of the WTG foundation construction. At this point in time, construction methodologies and WTG construction sequencing have not been finalized. Estimates for water requirements for the construction of WTG foundations have been estimated based on the assumption that ten (10) WTG foundations will be constructed simultaneously, with three (3) drill rigs operating at each location. Approximately 4,000 L of water will be required to facilitate one (1) rock anchor installation, resulting in a daily water requirement for the HIWEC of approximately 120,000 L/day. Actual daily demands will vary based on day-to-day operations and will typically be lower in volume than the estimated peak volume. The proposed source of water for general construction use will be one or more future groundwater supply well(s) located at both TSA and O&M building locations.

3.1.2 Groundwater Dewatering Requirements

Review of existing secondary source information provided by the Ontario Geological Survey and through the analysis of local MOECC water well records indicates that groundwater takings for the purpose of WTG foundation dewatering is expected to occur at WTG locations where the water table is expected to be less than 4 m from ground surface. Comparing groundwater elevation (**Figure 4**) and ground surface elevation (**Figure 1**) by means of a GIS mapping technique the approximate depth to the water table within the HIWEC study area was determined (**Figure 6**). For the purposes of this investigation, WTGs located in areas where the water table is less than 4 m from ground surface is expected to require groundwater taking during the construction of the WTG foundation to maintain a dry working environment. Based on these results, it is anticipated that 68 WTG locations are located in areas where the groundwater table is anticipated to be less than 4 m below ground surface. A complete list of WTGs with potential groundwater taking requirements is presented below in **Table 3**.

Table 3. WTG Locations with Anticipated Groundwater Dewatering Requirements

WTG ID		Easting	Northing
WTG	**1**	521148	5079966
WTG	**2**	521552	5079430
WTG	**3**	523121	5079906
WTG	**4**	523527	5079507
WTG	**5**	523801	5078989

Table 3. WTG Locations with Anticipated Groundwater Dewatering Requirements

WTG ID		Easting	Northing
WTG	**6**	521973	5079961
WTG	**7**	523640	5078449
WTG	**8**	524642	5078218
WTG	**9**	523962	5078048
WTG	**11**	524059	5079914
WTG	**12**	524488	5079598
WTG	**13**	525248	5077957
WTG	**14**	525350	5078487
WTG	**19**	525953	5079724
WTG	**20**	525928	5080964
WTG	**25**	527321	5079969
WTG	**26**	527595	5079486
WTG	**31**	529460	5079461
WTG	**36**	525504	5074920
WTG	**39**	527748	5075446
WTG	**40**	526809	5076303
WTG	**45**	528144	5075012
WTG	**46**	526496	5074549
WTG	**48**	528808	5074717
WTG	**50**	529449	5075542
WTG	**51**	529849	5075135
WTG	**54**	528366	5075731
WTG	**61**	529719	5076776
WTG	**62**	530238	5077263
WTG	**63**	530918	5077495
WTG	**64**	531242	5077109
WTG	**65**	531753	5076474
WTG	**66**	531737	5075913
WTG	**67**	531023	5075433
WTG	**68**	530276	5076631
WTG	**69**	530021	5076110
WTG	**70**	530420	5075594
WTG	**71**	527426	5074203
WTG	**72**	525316	5079601
WTG	**73**	526881	5081217
WTG	**75**	527944	5080517
WTG	**77**	522324	5075471
WTG	**80**	522549	5075033
WTG	**82**	524586	5074970
WTG	**83**	524646	5074504
WTG	**84**	525161	5074143
WTG	**86**	526833	5073848
WTG	**88**	527405	5073568
WTG	**89**	527686	5073119
WTG	**92**	522423	5079763
WTG	**93**	522721	5079382
WTG	**94**	523022	5078984
WTG	**95**	523993	5077407
WTG	**98**	526051	5078399
WTG	**99**	526639	5078778
WTG	**100**	527943	5078628
WTG	**101**	526026	5079213
WTG	**102**	524600	5078918
WTG	**103**	522710	5074574
WTG	**105**	531016	5076400
WTG	**106**	529122	5075994

Table 3. WTG Locations with Anticipated Groundwater Dewatering Requirements

WTG ID		Easting	Northing
WTG	**108**	527349	5074679
WTG	**110**	524205	5078567
WTG	**111**	526947	5079256
WTG	**115**	525916	5075226
WTG	**117**	530703	5077008
WTG	**118**	526776	5080715
WTG	**122**	529137	5076532

Presently, subsurface geotechnical and hydrogeological investigations have not yet been performed within the HIWEC study area to confirm depth to the water table and hydrogeological properties at the above locations. The calculation of anticipated groundwater dewatering rates and durations is required in accordance with the HIFN EA Guidance requirements and therefore will be determined based on secondary source information available during this desktop assessment.

3.1.2.1 Preliminary Design Parameters

The exact design for the HIWEC turbine foundations will be finalized during the detailed design phase. The following information is based on a WTG foundation that is anticipated to be similar to the HIWEC WTG foundation design and are appended to this report for reference (**Appendix C**). An excavation of approximately 10.0 m wide by 13.0 m long will extend to an approximate depth of 2.0 mbgs in bedrock to prepare for the installation of an 8 m wide octagonal shaped concrete WTG foundation and transformer pad. Excavation depths will vary based on site topography and have been assumed to be on average 2 mbgs as a conservative measure. In areas where organic material (peat and / or muck) is present at surface it is assumed the organic material will be removed to bedrock and that the foundation will be constructed in or on bedrock. Rock anchors will also be drilled to a depth of approximately 13.0 m into bedrock. In certain instances, it is assumed that the groundwater table will be lowered approximately 1.0 m below the base of the planned excavation (3.0 mbgs) to facilitate construction. As a conservative measure, pre-construction water table depths are assumed to be equivalent to the ground surface for all identified WTGs in **Table 3**. Design parameters for the WTG foundation construction are summarized below in **Table 4**.

Table 4. Summary of Design Parameters for WTG Foundation Construction

Parameter	Value
Excavation Length	13.0 m
Excavation Width	10.0 m
Excavation Depth	2.0 m
Assumed Depth to Groundwater Table	0 mbgs
Required Water Table Drawdown	3.0 m

As specific conditions dictate, dewatering will be required to draw the groundwater level in the WTG foundation excavation to a depth of approximately 3.0 m below the present static level (ground surface). Sump pumping dewatering methods will be used to achieve the required drawdown and to maintain a dry work area. The sump pump may need to operate 24 hours a day, 7 days a week, until the construction of the WTG foundation is complete.

3.1.2.2 Estimated Dewatering Rates

Groundwater inflow to the WTG foundation excavation area was calculated using the approach for radial flow to an unconfined aquifer, as presented in Powers *et al.,* 2007. This calculation methodology is considered representative of equilibrium or long-term, steady-state conditions, and first requires that the dewatering radius of influence be calculated. The radius of influence is equivalent to the radial distance away from the excavation at which dewatering no longer causes temporary water table drawdown. The following equation provides the (equivalent) radius of influence, assuming radial flow to a well, after an empirical relationship developed by Sichardt and Kryieleis (1930):

$$R_o = 3000(H-h)\sqrt{K}$$

Where: H = pre-construction saturated aquifer thickness (20.0 m)
h = post-construction saturated aquifer thickness (17.0 m)
K = hydraulic conductivity (2.5×10^{-5} m/s)

A pre-construction saturated aquifer thickness value of 20.0 m was estimated based on the observed depth of weathering in crystalline bedrock (AECOM, 2013). The hydraulic conductivity (K) value used in the equation above was determined based on single well response testing. Using the noted parameters, an R_o value of approximately 45.0 m was calculated.

The calculation of equivalent well radius (r_s) differs based on excavation geometry (Powers *et al.*, 2007). Thus, assuming a semi-square excavation area 13.0 m long by 10.0 m wide for a total of 130 m^2, r_s is calculated as follows:

$$r_s = \sqrt{\frac{ab}{\pi}}$$

Where: r_s = equivalent radius (m)
a = excavation length (13.0 m)
b = excavation width (10.0 m)

Using the noted parameters, an r_s value of approximately 6.4 m was determined.

Using the R_o and r_s values determined above, along with previously defined H, h and K values, the dewatering rate (Q), or the steady-state groundwater inflow for the saturated portion of the excavation was estimated using the following numerical solution for unconfined aquifers (Powers *et al.*, 2007).

$$Q = \frac{\pi K (H^2 - h^2)}{\ln(\frac{R_o}{r_s})}$$

Where: Q = groundwater inflow (m^3/s)
K = hydraulic conductivity (2.5×10^{-5} m/s)
H = pre-construction saturated aquifer thickness (20.0 m)
h = post construction saturated aquifer thickness (17.0 m)
R_o = radius of influence (45.0 m)
r_s = equivalent radius (6.4 m)

The calculation of groundwater inflow assumes that drawdown is occurring in an unconfined aquifer composed of homogeneous sediments. Report **Section 2** describes the complex heterogeneous surficial geology present in the vicinity of the site. Based on this disagreement between field conditions and the assumption implicit in the mathematics, the results computed herein are considered conservative.

The equation above estimates horizontal inflow into the excavation area. Vertical inflow is assumed to be negligible based on the shallow nature of the excavation and the general lack of vertical fracturing in crystalline bedrock.

Using the parameters outlined above, a typical daily dewatering rate of approximately 387,000 L is calculated. It is recommended that a 3 times Factor of Safety (F_s) be applied to this value for a maximum daily taking of 1,162,000 L. This recommendation is based on a number of factors that could cause the daily dewatering rate required to maintain dry working conditions to be above the typical daily rate. It should be expected that surface runoff or shallow infiltration, caused by spring freshet and / or precipitation events, will add water to the excavation area, thus requiring dewatering. The equation addresses steady-state conditions; it does not account for the volume of water that is stored in the rock fractures and would be drained during advanced dewatering or during the excavation process.

3.2 Long Term Water Takings and Operation Considerations

During operation of the HIWEC, it is expected that full time employees will regularly use the O&M building. Non-potable water taking during operation will be limited to regular personnel requirements, which are expected to be approximately 4,500 L/day and are not expected to exceed 50,000 L/day. Facilities that will provide this non-potable water will require the construction of one or more new well(s) at the O&M building.

3.3 Water Conservation

Long-term water conservation measures are not anticipated for the proposed short-term water taking. The pumped water will remain within the same watershed as it travels from discharge point to ultimate receiving body.

4. Assessment of Impacts and Monitoring

The following section describes how the HIWEC could result in potential environmental effects to geology and groundwater during the construction, operation and decommissioning phases of the HIWEC. Potential environmental impacts, mitigation measures, residual effects, monitoring and contingency measures associated with potential effects to geology and groundwater are described in **Table 5** for the construction / decommissioning phase of the HIWEC. Once site specific geotechnical information is available and a detailed groundwater taking assessment is complete for each WTG foundation location, site specific effects will be assessed based on calculated groundwater dewatering rates and predicted dewatering zones of influence.

4.1 Construction and Decommissioning Phase

4.1.1 Geology (Soil and Terrain)

Potential effects on soils and terrain during construction and decommissioning of the HIWEC could include:

- Reduction in soil capability (quality) from admixing, compaction and rutting risk, and erosion;
- Reduction in soil thickness and change in soil distribution from wind and water erosion and soil handling;
- Changes to soil and/or rock instability (rock falls, landslides, geological hazards) due to changes in topography; and

Construction activities (e.g., excavation, use of heavy equipment, stockpiling of cleared materials, and dewatering discharge) have the potential to cause changes in soil quality through processes such as admixing, soil compaction and rutting, and erosion leading to an alteration of soil capability. Although topsoil is thin and / or not present at many locations throughout the study area, there will be an opportunity to salvage topsoil in some areas and admixing of strippings and subsoil could occur during construction if soil handling occurs during wet or thawed ground conditions. Mixing of stripping material with spoil piles could occur during site preparation if adequate separation of the piles is not ensured. General construction activities such as vehicle and machinery operation and concrete truck rinsing also have the potential to change soil quality through minor contaminant releases.

Inadequate stripping of topsoil and upper subsoil, or careless stockpiling can cause changes to soil thickness and quantity from soil loss. Reduced soil thickness can lead to reduced soil productivity resulting from reduced medium for plant growth. Reduced soil thickness also can negatively affect soil fertility status, and rooting zone. Degradation of soil structure may occur due to compaction if traffic and handling activities are completed when the soils are wet. Soil exposure during construction and reclamation might also lead to increased wind and water erosion risk.

Increased areas of impervious surfaces from construction areas may result in a change in direction, quantity and rate of surface runoff. Inadequate control of surface runoff from construction areas and dewatering discharge has the potential to cause soil erosion resulting in a soil loss. Effects of water erosion on soil include changes in soil quality, structure, stability, and texture. Removal of fine-textured particles in the soil can result in a textural change, affecting the infiltration / percolation and water-holding capacity and making it more susceptible to drought conditions (Ritter, 2012). Effects of soil erosion often have corresponding impacts to receiving waterbodies and/or wetlands as soils redistribute to these features.

General construction activities such as vehicle and machinery operation and concrete truck rinsing have the potential to change soil quality through minor contaminant releases. Spills consisting of materials that constitute a contaminant may affect soils and will therefore have to be managed.

Blasting of bedrock during construction has the potential to change topography and therefore increase the risk for rock slope instability. Changes in topography may also result in the alteration of surface water drainage patterns at or near blast sites.

4.1.2 Groundwater

Potential effects on groundwater during construction and decommissioning of the HIWEC could include:

- Changes in groundwater quantity;
- Changes in groundwater quality; and
- Change in groundwater flow patterns.

Construction activities such as dewatering, water taking activities, and the creation of impervious surfaces have the potential to change groundwater quantity resulting in decreases in baseflow to watercourses, groundwater discharge to wetlands, yield of private water wells, and groundwater flow patterns. Where dewatering occurs, local water table elevations will be temporarily lowered during construction. These effects are typically confined to the Zone of Influence (ZOI) from dewatering activities and are temporary in nature. Private water wells located within the dewatering ZOI, where groundwater levels have been lowered to facilitate construction, have the potential to be effected temporarily by lower well yields and/or changes in water quality. A reduction in well yield and/or water quality may result in the inability to use the well as a potable water source. Groundwater taking activities may also result in a decrease in groundwater contribution to groundwater-dependent natural features (i.e., wetlands, watercourses, ponds and lakes) resulting in declines in surface water levels / flow and potential loss of habitat. Estimates of water taking quantities and related dewatering ZOI have not been calculated due to insufficient data available at the present time, and will therefore be deferred to the detailed design stage.

Blasting of bedrock that might be required to support construction of the HIWEC also has the potential to change groundwater quantity. In rare cases, vibrations from blasting in bedrock can alter the fracture geometry, open new fractures, change the aperture of existing fractures, or permanently change local groundwater flow patterns. Groundwater quality may also be affected through agitation of subsurface conditions and the potential release of fine particulate and/or soluble substances. In the event a groundwater supply well is located within the area where ground vibration results from blasting activities, groundwater supply wells may become physically damaged and result in a reduction in well yield and/or water quality.

Construction dewatering has the potential to change groundwater quality in areas of substantial groundwater recharge through the release of contaminated construction dewatering discharge. When not mitigated effectively, groundwater discharge activities also may result in significant erosion and deposition of soils along the discharge path. Elevated suspended solids and potential release of contaminants to the receiving water body may occur as a result.

General construction activities such as vehicle and machinery operation and concrete truck rinsing have the potential to change groundwater quality through minor contaminant releases. Spills consisting of materials that constitute a contaminant may affect groundwater and will therefore have to be managed.

Table 5. Potential Effects, Mitigation Measures, Residual Effects and Recommended Monitoring for Geology and Groundwater During Construction and Decommissioning Phase

VEC	Project Activity	Potential Environmental Effects	Proposed Mitigation Measures	Residual Environmental Effects
Soils and Terrain	• Site preparation • Construction of access roads and laydown areas • Transportation of equipment and materials • Foundation excavation and construction • WTG installation • Collector system and transmission line installation • Installation of TSs • Power connection and commissioning • Power disconnection and decommissioning • Transportation of materials • Disassembly and removal of collector system components • WTG and / or tower disassembly and removal • Disassembly and removal of O&M building infrastructure • Decommissioning completion	*Changes to soil quality* • Reduction in soil quality due to mixing of topsoil and subsoils.	• Strip and store topsoil (where present) from temporary work areas separately from subsoils and maintain for reclamation use after construction. • Where topsoil quality has been compromised, import topsoil for reclamation activities (according to the Restoration Plan).	• *Residual effect on soil quality* • Potential reduction in soil quality due to mixing of topsoil and subsoils would be minimized following mitigation; however, some mixing of topsoil and subsoil may still occur.
		Changes to soil quality • Reduction in soil quality due to accidental release of contaminants during construction, heavy equipment and vehicle use, excavation, and concrete truck rinsing, etc.	• Develop and implement a Spill Prevention and Response Plan outlining steps to prevent and contain any chemicals and to avoid soil contamination. This plan will include, for example: ▪ In the event of a contaminant spill all work will stop in the immediate area until the spill is cleaned up. ▪ Spill control and containment equipment/materials shall be readily available on site. ▪ Protocols for access to additional spill clean-up materials if needed. ▪ Contaminated materials to be handled in accordance with relevant federal and provincial guidelines and standards. ▪ Including the use of Material Safety Data Sheets (MSDS) which provides information on proper handling of chemicals readily available for the types of chemicals that will be used on-site. ▪ Proper training of construction staff on associated emergency response plan and spill clean-up procedures. ▪ Spills to be cleaned up as soon as possible, with contaminated soils removed to a licenced disposal site, if required. ▪ Materials contained in spill clean-up kits are restocked as necessary. ▪ Any soil encountered during excavation that has visual staining or odours, or contains rubble, debris, cinders or other visual evidence of impacts to be analyzed to determine its quality in order to identify the appropriate disposal method. ▪ To include reporting procedures to meet federal, provincial and local requirements (e.g., reporting spills and verification of clean-up), emergency contact and project management phone numbers. • Apply the following general mitigation measures to avoid soil contamination: ▪ Ensure machinery is maintained free of fluid leaks. ▪ Site maintenance, vehicle maintenance, vehicle washing and refuelling to be done on spill pads in specified areas at least 30 m away from wetlands and/or waterbodies. ▪ Store any stockpiled materials at least 30 m away wetlands and/or waterbodies. ▪ Store any potential contaminants (e.g., oil, fuels and chemicals) in designated areas using secondary containment, where necessary. • Ensure that concrete in construction is used in accordance with relevant provincial guidelines and standards. • Undertake waste management in accordance with relevant federal and provincial guidelines and standards and construction site to be kept clear of garbage and debris. • Ensure that wash water used for the cleaning of cement construction materials does not come in contact with the ground. Deposit waste water in a concrete washout container that allows evaporation and hardening for easier disposal or recover and recycle wash water back into cement truck.	• *Residual effect on soil quality* • Potential reduction in soil quality due to accidental release of contaminants would be minimized following mitigation; however, a minor reduction in soil quality may remain due to limitation in current spill clean-up processes.
		Changes to soil quantity and quality • Reduction in soil quantity and quality due to the release of construction dewatering discharge resulting in erosion and sedimentation.	• If dewatering of excavations is required, implement mitigation such as the use of splash pads, discharge diffusers, filter bags, sediment basins or similar measures (if required and as appropriate) at discharge locations to ensure that any water discharged to the natural environment does not result in scouring, erosion or physical alteration of the streams channel or banks. • Leave a layer of vegetation intact between the outfall and receiving waterbody to provide additional water dispersion and entrapment of suspended solids, if discharge is to a waterbody and/or wetland, where feasible. • Ensure that any overland discharge complies with previous mitigation for erosion and sedimentation included with "*Reduction in soil quality and quantity due to erosion, sedimentation and compaction resulting from excavation, use of heavy equipment and stockpiling of cleared materials.*" under the **Soils and Terrain** VEC.	• *No residual effects* • No reduction in soil quantity and quality due to the release of construction dewatering discharge provided recommended mitigation is implemented.
		Changes to soil quantity and quality • Reduction in soil quality and/or quantity due to erosion, sedimentation and compaction resulting from excavation, use of heavy equipment on exposed soils and stockpiling of cleared materials.	• Develop and implement an Erosion and Sediment Control Plan. • Utilize erosion blankets, sediment control fencing, straw bale etc. for construction activities in areas where there is erosion and sedimentation potential near a wetland, woodland or waterbody. • Utilize sediment logs (compost filter sock) in areas where bedrock is exposed at surface or trenching and securing of erosion control fencing is not possible. • Maintain undisturbed buffer strips greater than 30 m in width around watercourses, where possible, except where access roads approach water crossings. • Store stockpiled material at least 30 m from a wetland or waterbody.	• *Residual effects on soil quality and soil quantity* • Potential reduction in soil quality due to erosion and sedimentation would be minimized through the implementation of an Erosion and Sediment Control plan; however, disturbance to soils within construction areas cannot be avoided and a residual reduction in soil quality and quantity in these areas may remain.

Table 5. Potential Effects, Mitigation Measures, Residual Effects and Recommended Monitoring for Geology and Groundwater During Construction and Decommissioning Phase

VEC	Project Activity	Potential Environmental Effects	Proposed Mitigation Measures	Residual Environmental Effects
			• Monitor to ensure erosion and sedimentation control measures are in good repair and properly functioning prior to conducting daily work and re-install or repair as required prior to commencing daily construction activities for the duration of construction/decommissioning activity . • Minimize the size of cleared areas to limit the area of exposed soil. • Re-vegetate or stabilize exposed sites as soon as possible following disturbance using species native to the area to limit the duration of soil exposure. • Divert access road runoff through drainage ditches directed into vegetated areas or through environmental protection measures (such as sediment traps, rock flow check dams, sediment barriers etc.) to ensure that exposed soils or road materials are not transported into waterbodies or wetlands. Ditches >5% in slope may require lining with appropriate sized rip rap to protect against erosion and also slow the flow velocity. • Grade disturbed / remediated slopes or stockpiles to a stable angle to avoid slope instability and reduce erosion. • Grade soil stockpiles by mechanical means to compact the soil and limit the erosion. Tracks of machinery should be perpendicular to the slope of the pile to reduce the flow velocity of rainfall over the stockpile. • Identify unstable rock structures and sensitive soils through field investigation prior to construction. If any areas of concern are identified, design modifications may be implemented (as required) to minimize potential erosion, settlement, slope instability, foundation failure or rock fall hazards as a result of construction. • Keep all equipment within identified work areas to minimize disturbance of adjacent soils. • Restrict construction equipment to designated controlled vehicle access routes to minimize the potential for soil compaction and to minimize vehicle traffic on exposed and/or sensitive soils.	• Potential reduction in soil quality and/or quantity due to compaction and removal of soils within construction areas would be minimized provided recommended mitigation is implemented; however the potential for removal and compaction of soils within construction areas may remain.
		Changes to rock and soil slope stability • Disturbance to topography, including rock and soil instability due to blasting.	• Undertake blasting operations in accordance with relevant federal and provincial guidelines and standards. • Investigate alternative rock-excavating techniques (i.e., mechanical means) where possible. • Develop and implement a Blasting Plan that includes standard BMPs to minimize extent of adverse noise, vibration and slope instability from blasting, including: ▪ Follow proper drilling, explosive handling and loading procedures; ▪ Implement safe handling and storage procedures for all material, including soluble substances used for blasting; ▪ Use blasting mats over top of holes to minimize scattering of blast debris around the area; ▪ Reduce blasting footprint to the extent possible; ▪ Ensure the order of firing is correct to minimize the frequency of blasts; ▪ Remove all blasting debris and other associated equipment / products from the blast area. • Identify unstable rock structures through field investigations prior to construction. If any areas of concern are identified, design modifications may be implemented (as required) to minimize potential erosion, settlement, slope instability, foundation failure or rock fall hazards as a result of construction.	• *Residual effect on topography* • Potential disturbance to rock and soil stability, due to blasting would be minimized through the development and implementation of a Blasting Plan, however, permanent disturbance to topography would remain in areas of road cuts and WTG laydown areas.
Groundwater	• Site preparation • Construction of access roads and laydown areas • Transportation of equipment and materials • Foundation excavation and construction • WTG installation • Collector system and transmission line installation • Installation of TSs • Construction completion • Power connection and commissioning • Power disconnection and decommissioning • Transportation of Materials • Disassembly and removal of collector system components • WTG and / or tower disassembly and removal	*Changes to groundwater quantity* • Reduction in groundwater recharge quantities due to increases in impervious surfaces.	• Minimize paved surfaces and design roads to promote groundwater infiltration. • Implement groundwater infiltration techniques to the maximum extent possible. Examples include: ▪ releasing water to vegetated areas; ▪ lining ditches with permeable material (rather than clay, for example); and, ▪ groundwater should remain on site and not disposed of off-site (unless contaminated). • Where possible, direct groundwater discharge water to natural infiltration systems.	• *No residual effects* • No reduction in groundwater recharge quantities anticipated provided recommended infiltration techniques and measures are implemented; however, the creation of impervious surface is not completely avoidable and therefore some reduction in groundwater recharge may remain.
		Changes to groundwater quantity • Reduction in groundwater quantity resulting in changes in groundwater flow patterns and yield of private water wells, as a result of temporary construction dewatering and water taking activities.	• Conduct a Detailed Water Taking Assessment for WTG foundations and new water supply well locations based on geotechnical investigation results to determine anticipated groundwater taking quantities, groundwater quality and predicted zone of influence (ZOI) prior to construction. Based on this assessment site-specific mitigation measures and a monitoring program for groundwater dependent natural features and private wells within the anticipated ZOI will be provided. • Limit duration of dewatering to as short a time frame as possible. • Limit dewatering quantities by implementing targeted groundwater cut-offs (i.e., slurry trench walls) where possible. • Construct new water supply wells according to regulatory standards and be operated in a manner to conserve water (i.e., excessive water taking is avoided).	• *Residual effect on groundwater quantity* • Potential reduction in groundwater quantity resulting in changes in groundwater flow patterns and yield of private water wells would be minimized provided the recommended mitigation measures are implemented; however, a reduction in groundwater quantity may not be avoided within the ZOI of dewatering activities, but will likely be temporary and have no long term residual effects.
		Changes to groundwater quality • Reduction in groundwater quality due to the accidental release of contaminated construction dewatering discharge in areas of	• Develop and implement a Construction Dewatering Discharge Plan describing appropriate areas and methods for discharge. • If dewatering of excavations is required and is expected to exceed 50,000 L/day, sample discharge water daily during the days the water is discharged and tested for suspended sediments. The company	• *Residual effect on groundwater quality* • Potential reduction in groundwater quality due to the accidental release of contaminated construction dewatering discharge in areas of substantial groundwater recharge would be minimized

Table 5. Potential Effects, Mitigation Measures, Residual Effects and Recommended Monitoring for Geology and Groundwater During Construction and Decommissioning Phase

VEC	Project Activity	Potential Environmental Effects	Proposed Mitigation Measures	Residual Environmental Effects
	• Disassembly and removal of O&M building infrastructure • Decommissioning Completion	substantial groundwater recharge	shall not discharge turbid water and will comply with protocols in the Canadian Council of Ministers of the Environment (CCME) "Canadian Water Quality Guidelines for the Protection of Aquatic Life: Total Particulate Matter", which includes requirements for measuring suspended sediments, and the Provincial Water Quality Objectives (PWQO). • The Contractor shall implement appropriate measures (e.g., geosock or similar device) to reduce the amount of sediment released. • Dispose of any contaminated waste material generated from construction activities off-site by authorized and approved haulers and receivers. Where feasible, leave a layer of vegetation intact between the outfall and receiving waterbody to provide additional water dispersion and entrapment of suspended solids. • Ensure that no direct discharge to Georgian Bay, Key River, Henvey Inlet or any surface water feature outside the HIWEC will occur without acquiring applicable approvals. • Ensure that any overland discharge complies with previous mitigation for erosion and sedimentation included with "*Reduction in soil quality and quantity due to erosion, sedimentation and compaction resulting from excavation, use of heavy equipment and stockpiling of cleared materials*." under the **Soils and Terrain** VEC. • Should groundwater dewatering activities be expected to exceed 50,000 L/day, implement the following measures : ▪ Surround inlet pump head with clear stone and filter fabric. ▪ Regulate the discharge rate to ensure there is no flooding in the receiving water body and that no soil erosion is caused that impacts the receiving water body.	following mitigation; however, residual contaminants may remain in some areas of the HIWEC.
		Changes to groundwater quality and quantity • Reduction in groundwater quality (turbidity), quantity and physical damage to groundwater supply wells due to agitation of the subsurface during construction blasting (including potential release of soluble substances used during blasting) and pile driving.	• Undertake blasting operations and pile driving in accordance with relevant federal and provincial guidelines and standards. • Develop and implement a Blasting Plan that includes standard BMPs to minimize extent of adverse noise and vibration from blasting (Also refer to mitigation measures for "*Disturbance to topography, including rock and soil instability, due to blasting*." Under the **Soils and Terrain** VEC for a list of proposed blasting BMPs). • In the event an impact to a private water well is detected the well owner will be provided with a potable supply of water and maintain the supply until water quality conditions are comparable to baseline conditions. In the event water quality does not recover to baseline conditions, the impacted well will be modified (i.e., deepened) or a new well be constructed that is sufficient to provide the resident with a potable supply of water similar in quantity and quality of baseline conditions.	• *Residual effect on groundwater quality and quantity* • Potential reduction in groundwater quality (turbidity) and quantity would be minimized through the development and implementation of a Blasting Plan; however, potential disturbance to the subsurface resulting in a temporary reduction in groundwater quality and/or quantity may remain. • Physical damage to groundwater supply wells would be compensated for through implementation of mitigation.
		Changes to groundwater quality • Reduction in groundwater quality due to accidental contaminant spills from vehicle and machinery operation, and concrete truck rinsing.	• Develop and implement a Spill Prevention and Response Plan outlining steps to prevent and contain any chemicals or to avoid contamination of adjacent waterbodies and train staff on associated procedures. • Apply the following general mitigation measures to avoid soil or water contamination: ▪ Ensure machinery is maintained free of fluid leaks. ▪ Site maintenance, vehicle maintenance, vehicle washing and refuelling to be done in specified areas at least 30 m away from wetlands, woodlands or waterbodies. ▪ Store any stockpiled materials at least 30 m away from wetlands, woodlands or waterbodies. ▪ Store any potential contaminants (e.g., oil, fuels and chemicals) in designated areas using secondary containment, where necessary. • Also refer to mitigation measures for "*Reduction in soil quality due accidental release of contaminants during construction, heavy equipment and vehicle use, excavation, and concrete truck rinsing, etc*" under the **Soil and Terrain** VEC for additional proposed mitigation measures. • Ensure that wash water used for the cleaning of cement construction materials does not come in contact with the ground. Deposit waste water in a concrete washout container that allows evaporation and hardening for easier disposal or recover and recycle wash water back into cement truck. • In the event of a contaminant release that has potential to cause harm to an individual if consumed, the spill exceeds 100 L in volume and is located less than 500 m from a private water well, the potentially affected well(s) will be included in a well monitoring program that includes water quality sampling for the suspected contaminant. In the event an impact to a private water well is detected the well owner will be provided with a potable supply of water and maintain the supply until water quality conditions are comparable to baseline conditions. In the event water quality does not recover to baseline conditions, the impacted well will be modified (i.e., deepened) or a new well be constructed that is sufficient to provide the resident with a potable supply of water similar in quantity and quality of baseline conditions.	• *Residual effect on groundwater quality* • Potential reduction in groundwater quality due to accidental contaminant spills from vehicle and machinery operation, and concrete truck rinsing would be minimized provided a Spill Prevention and Response Plan is developed and implemented; however, residual contaminants may remain in some areas of the HIWEC.

Note: A 'spill' is defined as an unintentional release or discharge of a contaminant that has potential to cause harm to the natural environment.

4.2 Operation Phase

The following section describes how the HIWEC could result in potential environmental effects to geology and groundwater. Potential environmental impacts, mitigation measures, residual effects, monitoring and contingency measures associated with geology and groundwater are described in **Table 6** for the operational phase of the HIWEC.

4.2.1 Geology (Soil and Terrain)

General operations activities such as vehicle and machinery use have the potential to change soil quality through minor contaminant releases and soil compaction and rutting. Spills consisting of materials that constitute a contaminant may affect soils and therefore will have to be managed.

No other effects on soils and terrain are anticipated during operations, as vegetation clearing will be kept to a minimum and the use of pesticides or herbicides are prohibited.

4.2.2 Groundwater

Potential effects on groundwater during operation of the HIWEC could include:

- Changes in groundwater quantity
- Changes in groundwater quality

General operations activities such as vehicle and machinery operation have the potential to change groundwater quality through minor contaminant releases. Spills consisting of materials that constitute a contaminant may affect groundwater and will therefore have to be managed.

The creation of impervious surfaces (e.g., WTG foundations, access roads, and buildings) has the potential to reduce groundwater quantity through a minor reduction in groundwater recharge. There is a greater potential to affect groundwater quantity through a reduction in recharge in areas where coarse-textured glaciolacustrine deposits of sand and/or gravel exist at surface due to the limited extent and depth of these deposits. Private water wells drawing water from surficial sand deposits were identified within the HIWEC study area. HIWEC infrastructure has been sited so as to not intercept these deposits, and therefore no adverse effects to private water wells due to a reduction in groundwater recharge are expected to occur.

Water taking activities during the operational phase will be restricted to quantities not exceeding 50,000 L/day and confined to the Transformer Station Area and Operation and Maintenance Building, located more than 3 km from any known actively used private water well. Adverse effects to local groundwater users (landowners) and natural ecological features are not anticipated due to the operation of groundwater supply wells at such low rates. Therefore, no adverse environmental impacts are expected to occur during operation of the proposed groundwater supply well(s).

Table 6. Potential Effects, Mitigation Measures, Residual Effects and Recommended Monitoring for Geology and Groundwater during Operation Phase

VEC	Project Activity	Potential Environmental Effects	Proposed Mitigation Measures	Residual Environmental Effects
Soils and Terrain	• WTG, collector system/on-reserve transmission , road and crossing repair / maintenance • Environmental Monitoring	*Changes to soil quality* • Reduction in soil quality due accidental release of contaminants during operation, etc.	• Develop and implement a Spill Prevention and Response Plan outlining steps to prevent and contain any chemicals and to avoid soil contamination. This plan will include, for example: ▪ Protocols for access to spill control and containment equipment/materials (e.g., ensure that spill control and containment equipment/materials are readily available on site and additional spill clean-up materials will be available if needed, restock materials contained in spill clean-up kits as necessary). ▪ Protocols for handling contaminated materials (i.e., to be handled in accordance with relevant federal and provincial guidelines and standards). ▪ Material Safety Data Sheets (MSDS) which provides information on proper handling of chemicals readily available for the types of chemicals that will be used on-site. ▪ Training requirements for operational staff on associated emergency response plan and spill clean-up procedures. ▪ Protocols for cleaning up spills (i.e., clean up spills as soon as possible, with contaminated soils removed to a licenced disposal site, if required; analyze any soil encountered during operation that has visual staining or odours, or contains rubble, debris, cinders or other visual evidence of impacts to determine its quality in order to identify the appropriate disposal method). ▪ Reporting procedures to meet federal, provincial and local requirements (e.g., reporting spills and verification of clean-up), emergency contact and project management phone numbers. • Apply the following general mitigation measures to avoid soil contamination: ▪ Ensure machinery is maintained free of fluid leaks. ▪ Site maintenance, vehicle maintenance, vehicle washing and refuelling to be done on spill pads in specified areas at least 30 m away from wetlands and/or waterbodies. ▪ Store any stockpiled materials at least 30 m away from wetlands and/or waterbodies. ▪ Store any potential contaminants (e.g., oil, fuels and chemicals) in designated areas using secondary containment, where necessary. ▪ All potentially hazardous materials to be stored in containment sites within the Operations and Maintenance Building, within berms where possible. ▪ Keep ROW for access roads, collector lines /on-reserve transmission lines and WTGs clear of garbage and debris.	• *Residual effect on soil quality* • Potential reduction in soil quality due to accidental release of contaminants during operation would be minimized following implementation of mitigation measures; however, residual contaminants may remain in some areas of the HIWEC.
Groundwater	• Physical presence of WTG and roads	*Changes to groundwater quantity* • Reduction in groundwater recharge quantities due to increases in impervious surfaces (e.g., WTG foundations, access roads and buildings) and changes to infiltration and surface runoff patterns	• Apply mitigation measures to increase groundwater infiltration, as described in the **Construction and Decommissioning Effects and Mitigation Table 5** during the design and construction phase.	• *Residual effect on groundwater quantity* • Potential reduction in groundwater recharge quantities due to increases in impervious surfaces and changes to infiltration and surface runoff patterns would be minimized following implementation of mitigation measures; however, the creation of impervious surface (i.e., paved parking lots, compressed gravel roads, WTG foundations and buildings) is not completely avoidable and therefore some reduction in groundwater recharge will remain.
	• WTG, collector system/on-reserve transmission , road and crossing repair / maintenance • Environmental monitoring	*Changes to groundwater quality* • Reduction in groundwater quality due to accidental contaminant spills, vehicle and machinery operation during operation.	• Develop and implement a Spill Prevention and Response Plan outlining steps to prevent and contain any chemicals or to avoid contamination of adjacent waterbodies and train staff on associated procedures. • Apply the following general mitigation measures to avoid soil and/or water contamination: ▪ Ensure machinery is maintained free of fluid leaks. ▪ Site maintenance, vehicle maintenance, vehicle washing and refuelling to be done in specified areas at least 30 m away from wetlands, woodlands and or waterbodies. ▪ Store any stockpiled materials at least 30 m away from wetlands and/or waterbodies. ▪ Store any potential contaminants (e.g., oil, fuels and chemicals) in designated areas using secondary containment, where necessary. • Also refer to mitigation measures for "Reduction in soil quality due accidental release of contaminants during operation, etc." for additional proposed mitigation measures.	• *Residual effect on groundwater quality* • Potential reduction in groundwater quality due to accidental contaminant spills, vehicle and machinery operation during operation would be minimized through the implementation of a Spill Prevention and Response Plan and other mitigation measures; however, residual contaminants may remain in some areas of the HIWEC.

Note: A 'spill' is defined as an unintentional release or discharge of a contaminant that has potential to cause harm to the natural environment.

5. Conclusions and Recommendations

This Hydrogeological Assessment and Effects Assessment was completed for the intended purpose of characterizing the local physical and groundwater setting, assessing potential dewatering requirements for construction, assess possible impacts to local water wells and groundwater dependant environmental features, and to recommend appropriate mitigation measures, as required. This report provides a summary, interpretation and discussion of the assessment results, in sufficient content and detail similar to that of a technical support document in support of provincial permitting requirements.

Field borehole logs, monitoring well installations, private water well sampling and geotechnical investigations were previously completed by URS (now AECOM) as part of a hydrogeological investigation for the Highway 69 expansion project. The results of that investigation program were relied upon by AECOM for this assessment. AECOM has assumed that the information provided was factual and accurate. Judgement has been used by AECOM in the interpretation of the field information provided, however it is recognized that subsurface physical and chemical characteristics may vary between or beyond borehole locations given the variability observed in local geological and hydrogeological conditions.

As a site-specific hydrogeological investigation has not yet been completed to confirm groundwater conditions at each turbine foundation location there is a potential for groundwater dewatering rates at each WTG to differ from estimated quantities provided herein, since water taking requirements are dependent on site-specific hydrogeological characteristics of the bedrock and/or soil, depth of required excavation and the depth of groundwater (relative to the excavation extent). It is recommended that a Detailed Water Taking Assessment be performed once site-specific geotechnical and hydrogeological information becomes available to determine the anticipated groundwater taking requirements and associated potential Zone of Influence (ZOI) for each WTG location. Based on results of the Detailed Water Taking Assessment, a monitoring plan and site-specific mitigation measures for groundwater dependent natural features and private wells can be provided.

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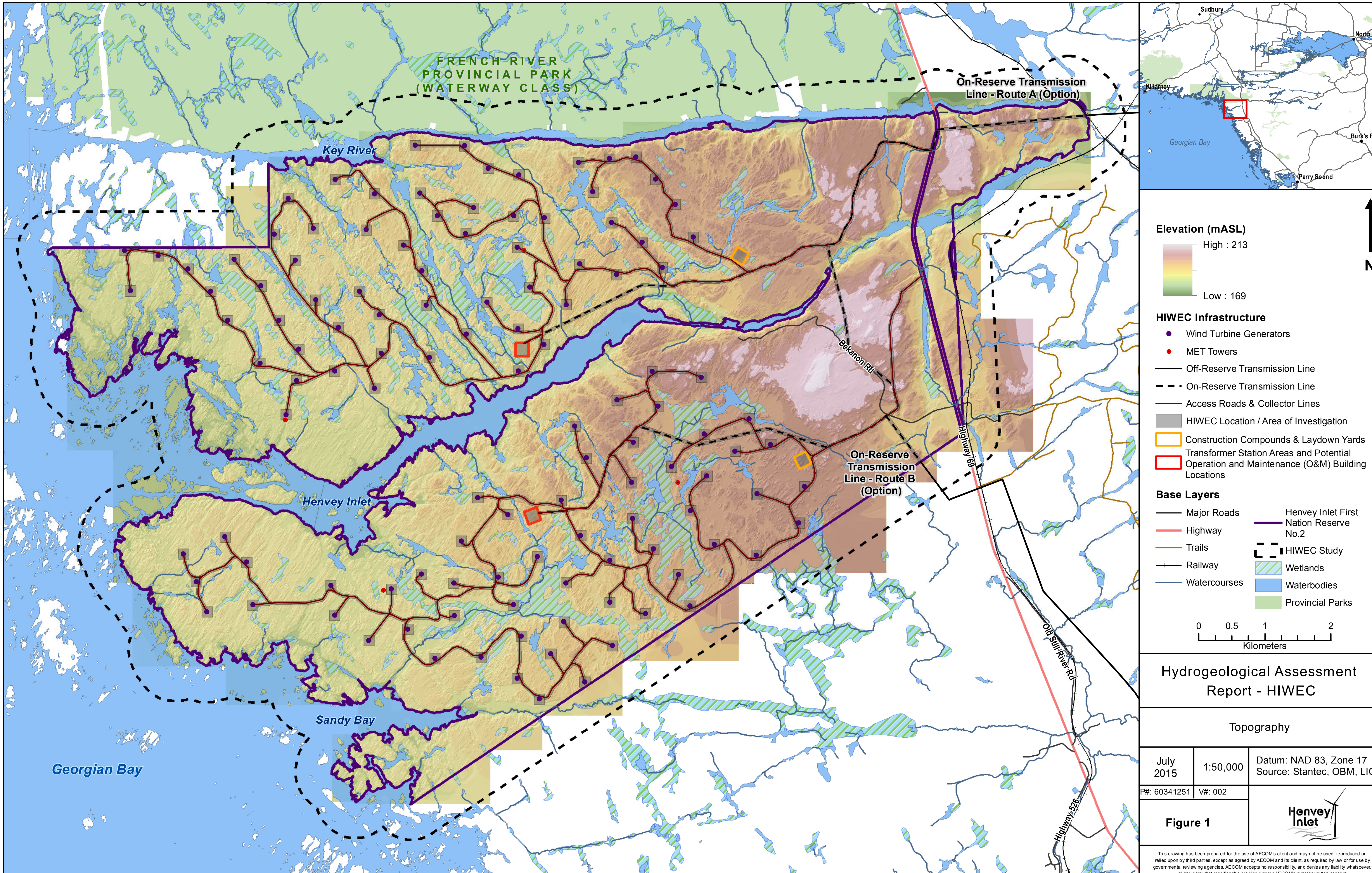
Figures



FRENCH RIVER PROVINCIAL PARK (WATERWAY CLASS)
Key River
Henvey Inlet
Sandy Bay
Georgian Bay
On-Reserve Transmission Line - Route A (Option)
On-Reserve Transmission Line - Route B (Option)
Bekanon Rd
Highway 69
Old Still River Rd
Highway 526
Sudbury
North Bay
Killarney
Georgian Bay
Burk's Falls
Parry Sound
N
Elevation (mASL)
High : 213
Low : 169
HIWEC Infrastructure
Wind Turbine Generators
MET Towers
Off-Reserve Transmission Line
On-Reserve Transmission Line
Access Roads & Collector Lines
HIWEC Location / Area of Investigation
Construction Compounds & Laydown Yards
Transformer Station Areas and Potential Operation and Maintenance (O&M) Building Locations
Base Layers
Major Roads
Highway
Trails
Railway
Watercourses
Henvey Inlet First Nation Reserve No.2
HIWEC Study
Wetlands
Waterbodies
Provincial Parks
0 0.5 1 2
Kilometers
Hydrogeological Assessment Report - HIWEC
Topography
July 2015
1:50,000
Datum: NAD 83, Zone 17
Source: Stantec, OBM, LIO
P#: 60341251
V#: 002
Figure 1
Henvey Inlet
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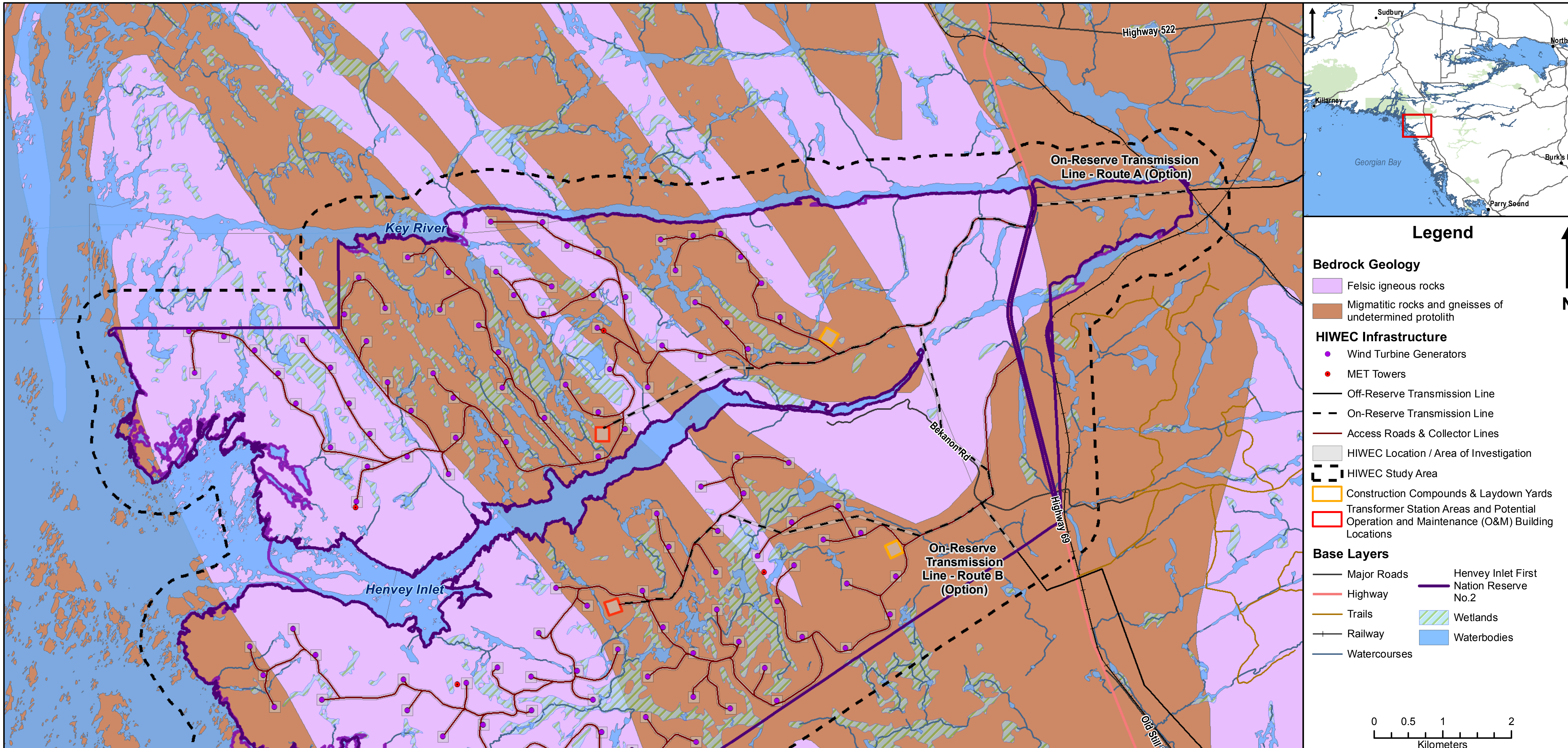

Hydrogeological Assessment Report - HIWEC

Bedrock Geology

September 2015	1:55,000	Datum: NAD 83, Zone 17 Source: Stantec, OBM, LIO
P#: 60341251	V#: 002	

Figure 2

Henvey Inlet

Map location: P:\60333000 Henvy Inlet\900-Work\920-929 (GIS-Graphics)\Design\FINAL REPORT\HydrogeologicalAssessment\HydroAssessment_BedrockGeology.mxd
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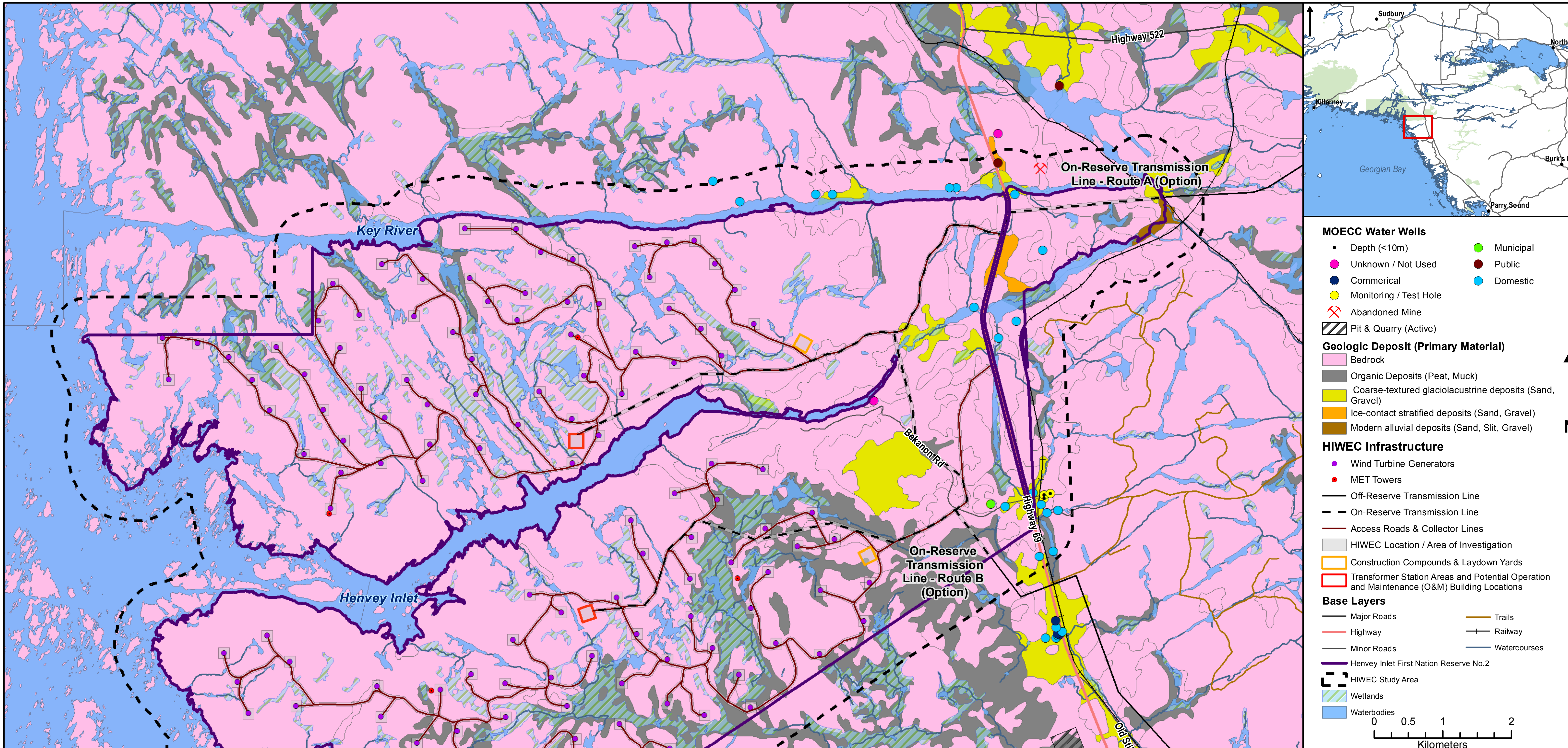

Hydrogeological Assessment Report - HIWEC

Surficial Geology and MOECC Water Wells

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Figure 3

Henvey Inlet

Map location: P:\60333000 Henvy Inlet\900-Work\920-929 (GIS-Graphics)\Design\FINAL REPORT\Hydrogeological Assessment\HydroAssessment_SurficialGeology_WW_20150909.mxd
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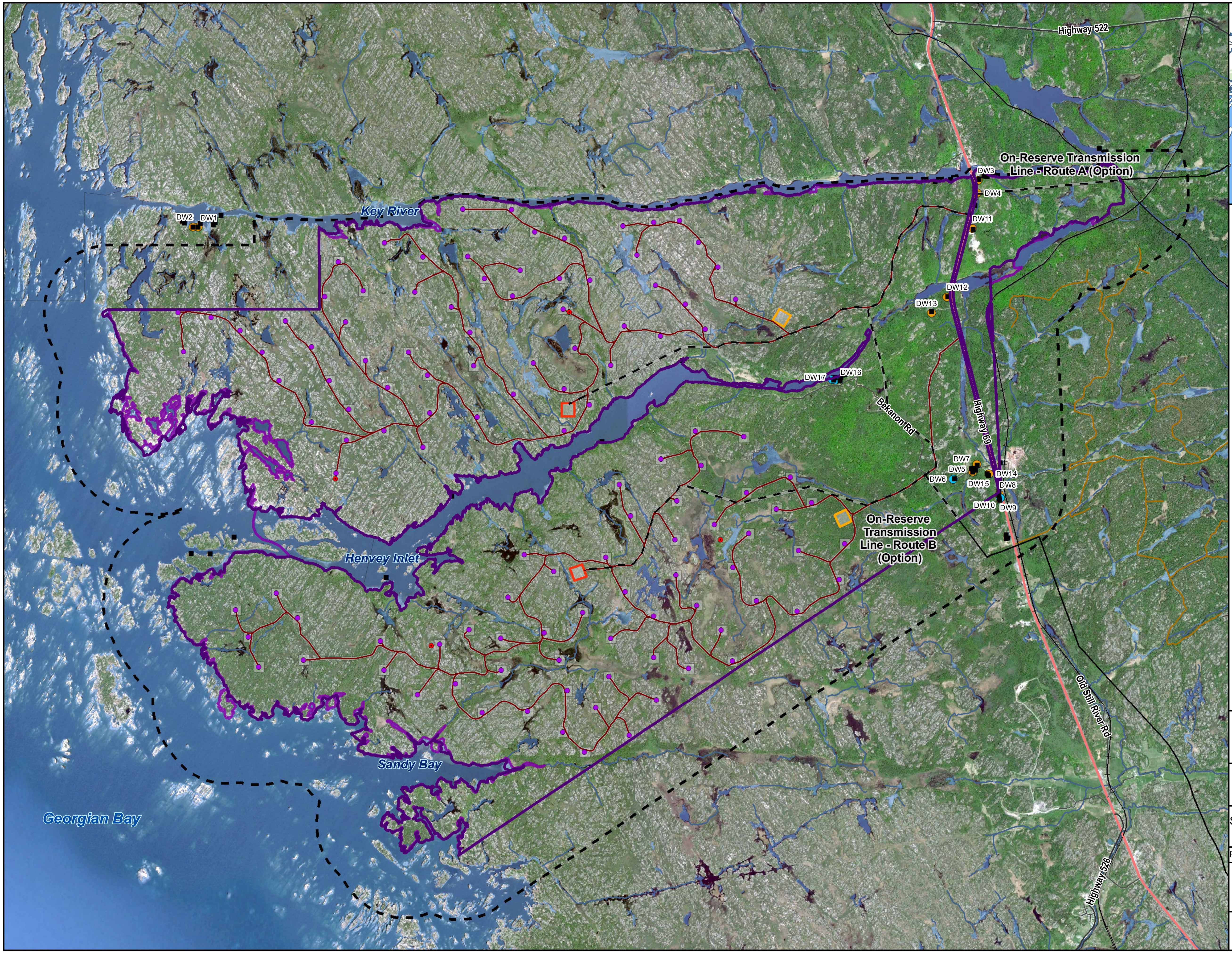

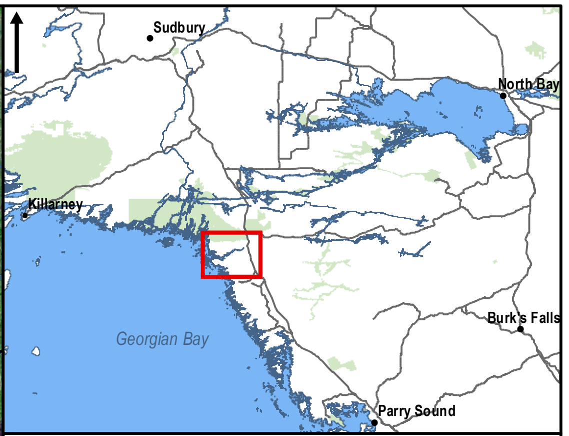

N

Results of Water Well Survey
- Residential Properties Surveyed
- Drilled Water Wells
- Dug Water Wells

HIWEC Infrastructure
- Wind Turbine Generators
- MET Towers
- Off-Reserve Transmission Line
- On-Reserve Transmission Line
- Access Roads & Collector Lines
- HIWEC Location / Area of Investigation
- Water Well Survey Radius
- Construction Compounds and Laydown Yards
- Transformer Station Areas and Potential Operation and Maintenance (O&M) Building Locations

Base Layers
- Major Roads
- Highway
- Trails
- Railway
- Watercourses
- Henvey Inlet First Nation Reserve No. 2
- Waterbodies

0 0.5 1 2
Kilometers

Hydrogeological Assessment Report - HIWEC

Private Water Supplies

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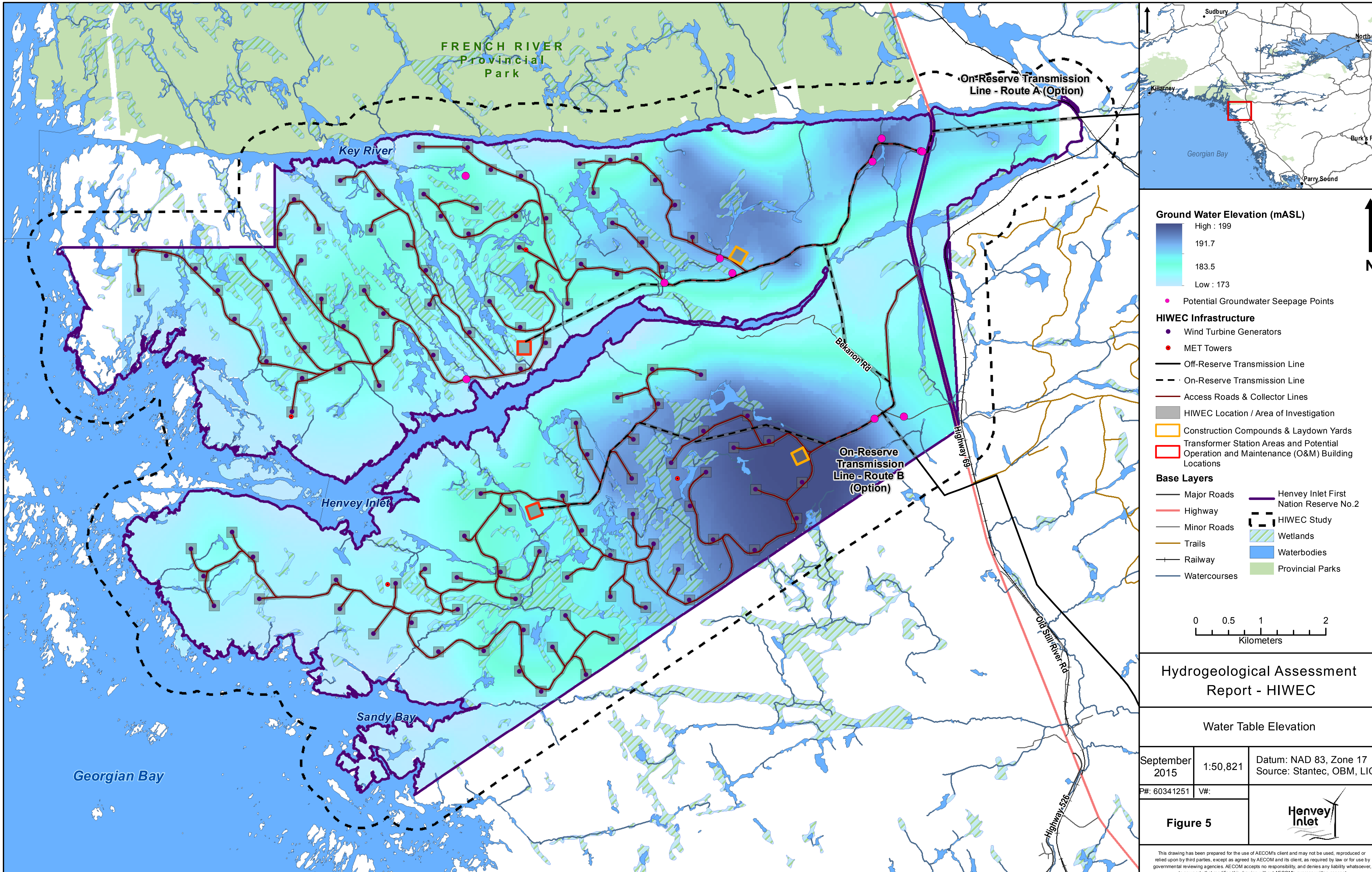
P#: 60341251	V#: 002	

Figure 4



Hydrogeological Assessment Report - HIWEC

Water Table Elevation

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P#: 60341251	V#:	

Figure 5

Henvey Inlet

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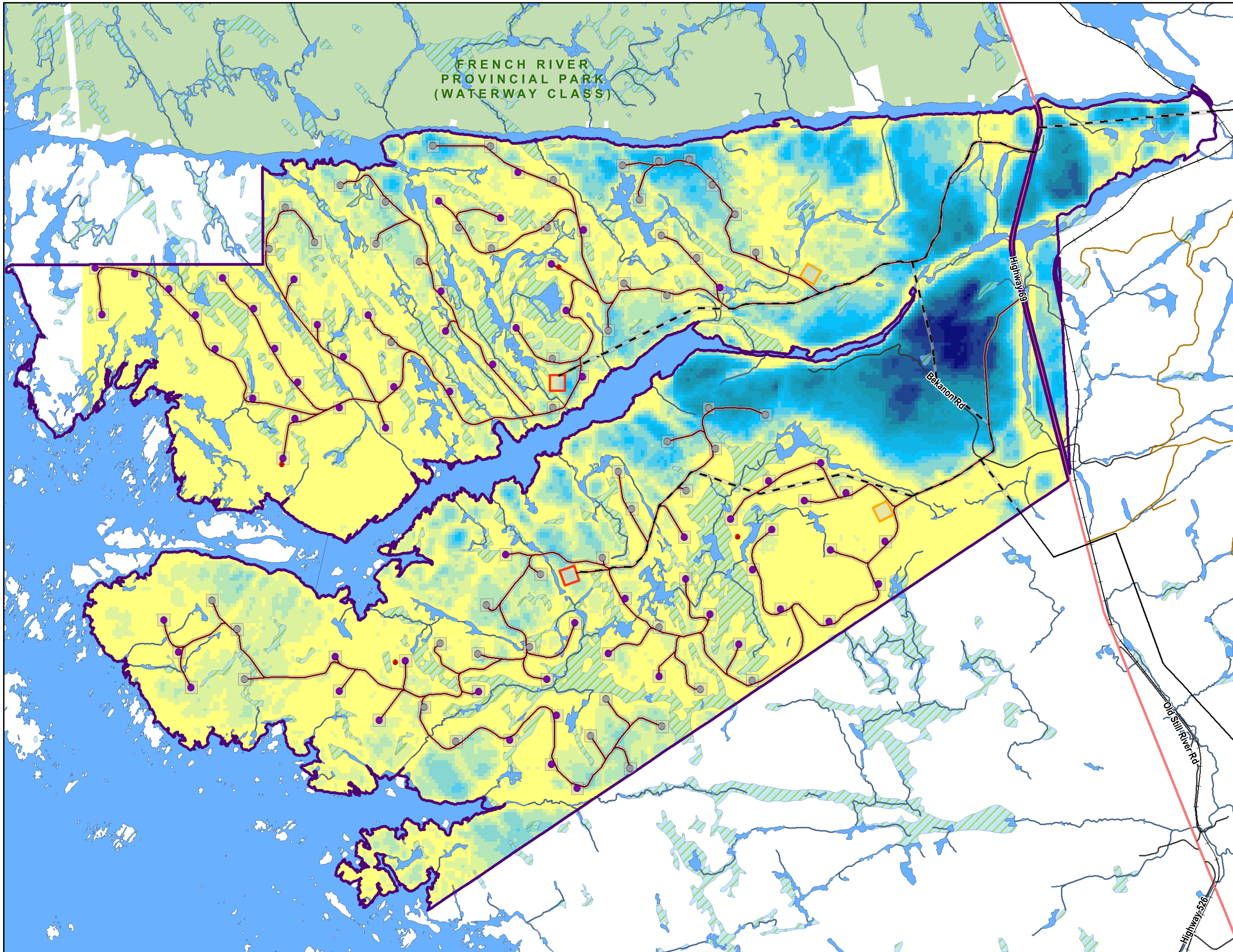

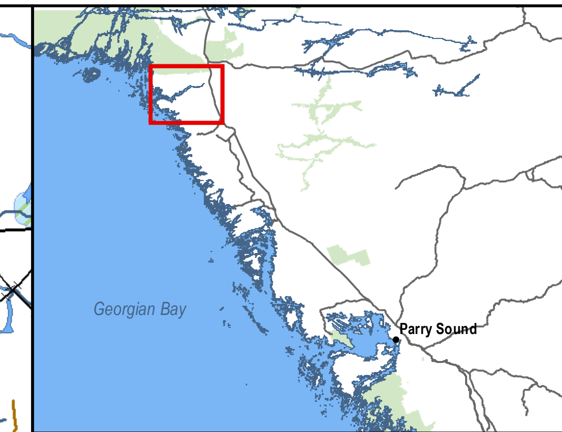

N

Depth to Ground Water (m)

33
16
4
0

HIWEC Infrastructure
Wind Turbine Generators

- No Potential for Groundwater Dewatering Requirements
- Potential Groundwater Dewatering Requirements
- MET Towers
- Off-Reserve Transmission Line
- On-Reserve Transmission Line
- Access Roads & Collector Lines
- HIWEC Location / Area of Investigation
- Construction Compounds & Laydown Yards
- Transformer Station Areas/Potential Operation/Maintenance (O&M) Building Locations

Base Layers

- Major Roads
- Highway
- Trails
- Railway
- Watercourses
- Henvey Inlet First Nation Reserve No.2
- Wetlands
- Waterbodies
- Provincial Parks

0 0.5 1 2
Kilometers

Henvey Inlet Wind Energy Centre

Depth to Ground Water

September 2015	1:47,000	Datum: NAD 83, Zone 17 Source: Stantec, OBM, LIO

P#: 60333000 V#:

Figure 6

Henvey Inlet

Map location: F:\AECOM-Work\60333000 - Henvey Wind\Design\Baseline Report (Feb 2015)\Baseline_GWDepth.mxd
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Appendix A

Sample Water Well Survey Package

AECOM
105 Commerce Valley Drive West, Floor 7 905 886 7022 tel
Markham, ON, Canada L3T 7W3 905 886 9494 fax
www.aecom.com

June 2015

Dear Homeowner/Resident:

Project No: 60341251

Regarding: Henvey Inlet Wind Energy Centre Water Well Survey

Henvey Inlet Wind LP (“HIW”), a limited partnership between Nigig Power Corporation and Pattern Renewable Holdings Canada ULC, is proposing to construct a wind energy centre in the vicinity of your residence. The project is referred to as the Henvey Inlet Wind Energy Centre (the “HIWEC”). As part of the HIWEC, AECOM Canada Ltd. (AECOM) is completing a Water Well Survey to identify current water well users within 1,000 m of the Henvey Inlet First Nation Reserve No.2 boundary. The information obtained by the Water Well Survey will provide a better understanding of existing local groundwater use, as well as identify potential mitigation measures that may be warranted as it relates to this undertaking.

At this time, AECOM will ask you a few questions about your well and water use. Should you be unable to respond to the survey at this time AECOM will provide you with a copy of the survey form and a pre-stamped and addressed envelope. We respectfully ask that you fill out the survey form to the best of your knowledge and mail it back to us in the provided envelope.

Following receipt of the completed water well survey form, an AECOM representative may contact you to schedule a voluntary interview that would be conducted at your property. During the interview, a water level measurement and a water quality sample also would be collected from your well (with your permission) and the condition of your well will be documented with photographs and other physical measurements. Based on the results of this survey, and with your permission, the water level in your well may potentially be monitored during construction dewatering activities.

You should understand that you are under no obligation to participate in this well survey. However, there is no cost to the property owner for having this testing done, and the water level and well condition information will be provided to the well owner.

Should you have any questions regarding the Water Well Survey please do not hesitate to contact myself, Erin Wilson, at 905-747-7466 or via email to Erin.Wilson@aecom.com.

Sincerely,
AECOM Canada Ltd.

Erin Wilson, B.Sc.
Environmental Scientist
Erin.Wilson@aecom.com

EW\JAM:mm
Attach: Water Well Survey

AECOM
105 Commerce Valley Drive West, Floor 7
Markham, ON, Canada L3T 7W3
905 886 7022 tel / 905 886 9494 fax
www.aecom.com

Water Well Survey Form

Henvey Inlet Wind Energy Centre

Well #:	
MOE #:	

Contact Information:

Name: ______ **Telephone (Bus.):** ______

Address: ______ **(Home):** ______

Person Interviewed: ______ **Residence (Y/N):** ______

Date: ______ **Time:** ______

Name(s) of Previous Owners: *(if different from above)* ______

How long has the owner operated or lived on this property? ______

Is there a water well located on the property? *No:*____ *Yes:*____ **Is the well currently used for water supply purposes?** *No:*____ *Yes:*____

If you have answered yes to the above questions please proceed to the following sections.

Occupant of Property Served by Well: (if other than owner)

Name: ______ **Telephone (Bus.):** ______

Address: ______ **(Home):** ______

How long has the occupant operated or lived on this property? ______

Well Construction Details:

Date Constructed: ______ **Use (i.e., domestic, irrigation):** ______ **Contractor:** ______

Type (drilled or dug): ______ **Diameter:** ______ **Well Depth:** ______

Is well accessible for direct sampling (Y/N)? ______ **Is it buried (Y/N)?** ______ **Is the well sealed shut (Y/N)?** ______

Screen Length (drilled wells): ______ **Depth of top of screen:** ______ **Bedrock well (Y/N)?** ______

Well Testing History:

Has the owner ever tested for bacteria (Y/N)? ______ **How often is the well sampled for bacteria?** ______

Where is the sample collected from? ______ **When was the last sample collected?** ______

Have any bacteriological exceedances been detected (Y/N)? ______ **What parameters exceeded Provincial Criteria?** ______

What actions were taken to correct the problem? ______

Have there been any other problems with the well (i.e., increased silt content, odour, change in taste, etc.)? ______

Describe: ______

What do you think was the likely cause? ______

What actions were taken to correct the problem? ______

Well Water Levels:

Has the owner even taken a water level from the well (Y/N)? ______ **When?** ______ **Level:** ______

What was the original water level depth as measured by the Drilling Contractor? ______

Does the well ever go dry (Y/N)? ______ **When was the last time the well went dry?** ______

Pumping Equipment:

Pump Type: ☐ *Suicide-lift* *(e.g., Jet Pump in basement)* ☐ *Submersible Pump* *(pump located down well)* ☐ *Other* **Horsepower:** ______ **Age:** ______

Depth of Pump Intake Setting: ______ *(Original)* ______ *(Present)* **Pumping Rate (L/min or GPM):** ______

Storage Tank (Y/N): ______ *Type:* ______ *Capacity:* ______ *Cistern (Y/N):* ______

Do you have a: ☐ *Chlorinator* ☐ *Water Softener* ☐ *UV Filter* ☐ *Charcoal Filter* ☐ *RO Filter* ☐ *Other*

Water Use:
Domestic: *No:* ______ *Yes:* ______
Livestock: *No:* ______ *Yes:* ______ *No. of Livestock:* ______
Lawn Watering: *No:* ______ *Yes:* ______ *Other:* ______

Any high water use equipment *(e.g., pool, hot tub, irrigation system, etc.)?* ______

Sewage Disposal: (relative to front of house)

Type of Sewage Disposal: ☐ *Septic Tank - Bed* ☐ *Municipal Service* ☐ *Other* **Distance of Septic Bed to Well:** ____________

Septic Bed is located: ☐ *North of House* ☐ *South of House* ☐ *East side of House* ☐ *West side of House*

Well is located : ☐ *North of House* ☐ *South of House* ☐ *East side of House* ☐ *West side of House*

Select Option that describes where the Well is generally located from Septic Bed: ☐ *Uphill* ☐ *Downhill* ☐ *Same Grade*

Well Maintenance:

Have you ever had your well cleaned (Y/N)? ____________ **Deepened (Y/N)?** ____________ **Silt Removed (Y/N)?** ____________

If so, why? ____

Outline briefly any previous repairs or changes in pumping equipment, and dates: ____________________________

Location Sketch: (location of house, septic, well etc.)

Does homeowner grant permission to obtain a groundwater quality sample and a groundwater level by a qualified AECOM representative? **Yes** ☐ **No** ☐

Signature: ____________________________

Water Well Survey Results

Henvey Inlet Wind Energy Centre

AECOM

Coordinate Location of House/Dwelling		Resident Interviewed?	Survey Complete?	Well Observed?		Water Level	Coordinate Location of Well		Well ID	Address/Location	Comments
Northing	Easting	(Y/N/RR/LP)	(Y/N)	(Y/N)	Type	(mBtop)	Northing	Easting			
533391	5082087	N/A	N	N	-	-				Boat Access - Key River	Vacant property, dock not present, house present
533149	5082058	LP	N	N	-	-				Boat Access - Key River	Dock and house present, not vacant, homeowner not present, left package
522129	5081544	LP	N	N	-	-				Boat Access - Key River - Off Reserve - #2325	McKinney's House - dock present, homeowner not present, left package
522037	5081470	LP	N	N	-	-				Boat Access - Key River - Off Reserve - #2329	House and dock present, surface water intake observed
522038	5081433	LP	N	N	-	-				Boat Access - Key River - Off Reserve - #2333	House and dock present, surface water intake observed
522013	5081398	LP	N	N	-	-				Boat Access - Key River - Off Reserve - #2337	House and dock present, surface water intake observed
521811	5081416	LP	N	N	-	-				Boat Access - Key River - Off Reserve - #2383	House and dock present, surface water intake not observed
521771	5081359	LP	N	Y	Drilled	-	521771	5081359	DW1	Boat Access - Key River - Off Reserve - #2383	Kolsar Property, house and dock present, surface water intake observed, 4" water supply well observed
521696	5081363	LP	N	Y	Drilled	-	521696	5081363	DW2	Boat Access - Key River - Off Reserve - #2411	House and dock present, surface water intake observed, 4" water supply well observed
521564	5081420	LP	N	N	-	-				Boat Access - Key River - Off Reserve - #2425	House and dock present, surface water intake observed
521532	5081448	LP	N	N	-	-				Boat Access - Key River - Off Reserve - #2431	House and dock present, surface water intake observed
535690	5082573	LP	N	N	-	-				Boat Access - Key River - Off Reserve	House and dock present, surface water intake not observed
533826	5082094	LP	N	Y	Drilled	-	533813	5082083	DW3	Milton Lane - Hwy 69 - Joe's rental property	House present, currently occupied by Joe for project, 2 wells drilled less than 1 week ago. Both wells approximately 200' deep and completed in bedrock.
534050	5082199	Y	N	N	-	-				5 Milton Lane - cottage rental	No well, surface water intake from Key River.
533955	5082133	LP	N	N	-	-				52 Milton Lane - cottage rental	House and dock present, surface water intake observed
533935	5082144	LP	N	N	-	-				40 Milton Lane - cottage rental	House and dock present, surface water intake observed
533904	5082147	LP	Y	N	-	-				26 Milton Lane - cottage rental	Well is not used for water supply purposes. No other information provided.
533768	5081695	Y	Y	Y	Drilled	14.83	533805	5081883	DW4	2344 Hwy 69	Drilled well observed, approx. 222' deep in bedrock. Water quality poor - salty taste. Well has never gone dry. Well located more than 100 m from house down lane.
533729	5077583	Y	Y	Y	Drilled & Dug	1.27 (drilled) 1.61 (dug)	533735	5077598	DW5	87 Beckanon Road	Drilled well and dug well observed. E-coli in drilled well - resident not drinking. Resident drinking water from dug well located on property. Both wells in poor condition with well caps not sealed or covered. Well has never gone dry.
533450	5077474	Y	Y	Y	Dug	0.8	533434	5077473	DW6	170 Beckanon Road	Dug well observed, unknown depth. Small 1.5" hole on lid for access. Well has never gone dry.
533740	5077636	RR	N	Y	Public Drilled	Pumphouse Locked - No Access	533797	5077700	DW7	62 Beckanon Road	Water supply from communal well located at 52 Beckanon Road in pump house. Resident not interviewed.
533798	5077685	N	N	Y	Public Drilled	Pumphouse Locked - No Access	533797	5077700	DW7	52 Beckanon Road	Water supply from communal well located at 52 Beckanon Road in pump house. Resident not interviewed.
533772	5077609	N	N	Y	Public Drilled	Pumphouse Locked - No Access	533797	5077700	DW7	65 Beckanon Road	Water supply from communal well located at 52 Beckanon Road in pump house. Resident not interviewed.
533714	5077629	N	N	Y	Public Drilled	Pumphouse Locked - No Access	533797	5077700	DW7	72 Beckanon Road	Water supply from communal well located at 52 Beckanon Road in pump house. Resident not interviewed.
534158	5077724	N	N	N	-	-				19 Beckanon Road	Muskoka Timber property - spoke with previous owner at 1390 Hwy 69 - wells decommissioned and not used - water supplied by truck/bottles.
534139	5077295	N	N	N	-	-				Hwy 69 North of 1398 Hwy 69	
534135	5077217	Y	Y	Y	Drilled	Buried - No access	534145	5077230	DW8	1390 Hwy 69	Two wells on property, only one is used. Well is buried under soil and not accessible. Water quality good - no exceedances detected previously and well has never gone dry. Owner indicated the well is a flowing well at the time of completion.
534149	5077151	RR	N	Y	Dug	-	534155	5077182	DW9	1378 Hwy 69	Resident refused to participate. No survey conducted
534144	5077169	LP	N	Y	Dug	-	534155	5077182	DW10	1388 Hwy 69	Trailer - maybe a dwelling.
534279	5076565	LP	N	N	-	-				1090 Hwy 69 - #5	Three houses with shared driveway off of Hwy 69. No well observed. Nobody home - left package.
534249	5076608	LP	N	N	-	-				1090 Hwy 69 - #6	Three houses with shared driveway off of Hwy 69. No well observed. Nobody home - left package.
534249	5076556	LP	N	N	-	-				1090 Hwy 69 - #7	Three houses with shared driveway off of Hwy 69. No well observed. Nobody home - left package.
533739	5081326	Y	Y	Y	Drilled	-	533726	5081339	DW11	2336 Hwy 69	Drilled well observed, unknown depth. Well is capped but not sealed with a low stick up. Water quality is poor - exceedances for bacteriological parameters previous tested, sulphur smell, high iron, hard water. Well has never gone dry.
533346	5080288	Y	Y	Y	Drilled	-	533331	5080282	DW12	2 Groundhog Corner Lane	Drilled well observed, unknown depth (resident thinks 16'). Water quality is poor - exceedances for bacteriological parameters previously tested. Well has never gone dry.
533098	5080054	Y	Y	Y	Drilled	-	533097	5080030	DW13	10 Groundhog Corner Lane	Drilled well observed, unknown depth. Water quality is poor - exceedances for bacteriological parameters previously tested. Well has never gone dry.
533955	5077555	N	N	Y	Drilled	-	533986	5077552	DW14	49 Beckanon Road, #A	Drilled well observed, located inside dug well. Possible shared well with two houses. Houses vacant. Bear observed near property, no water level taken.

Water Well Survey Results
Henvey Inlet Wind Energy Centre

AECOM

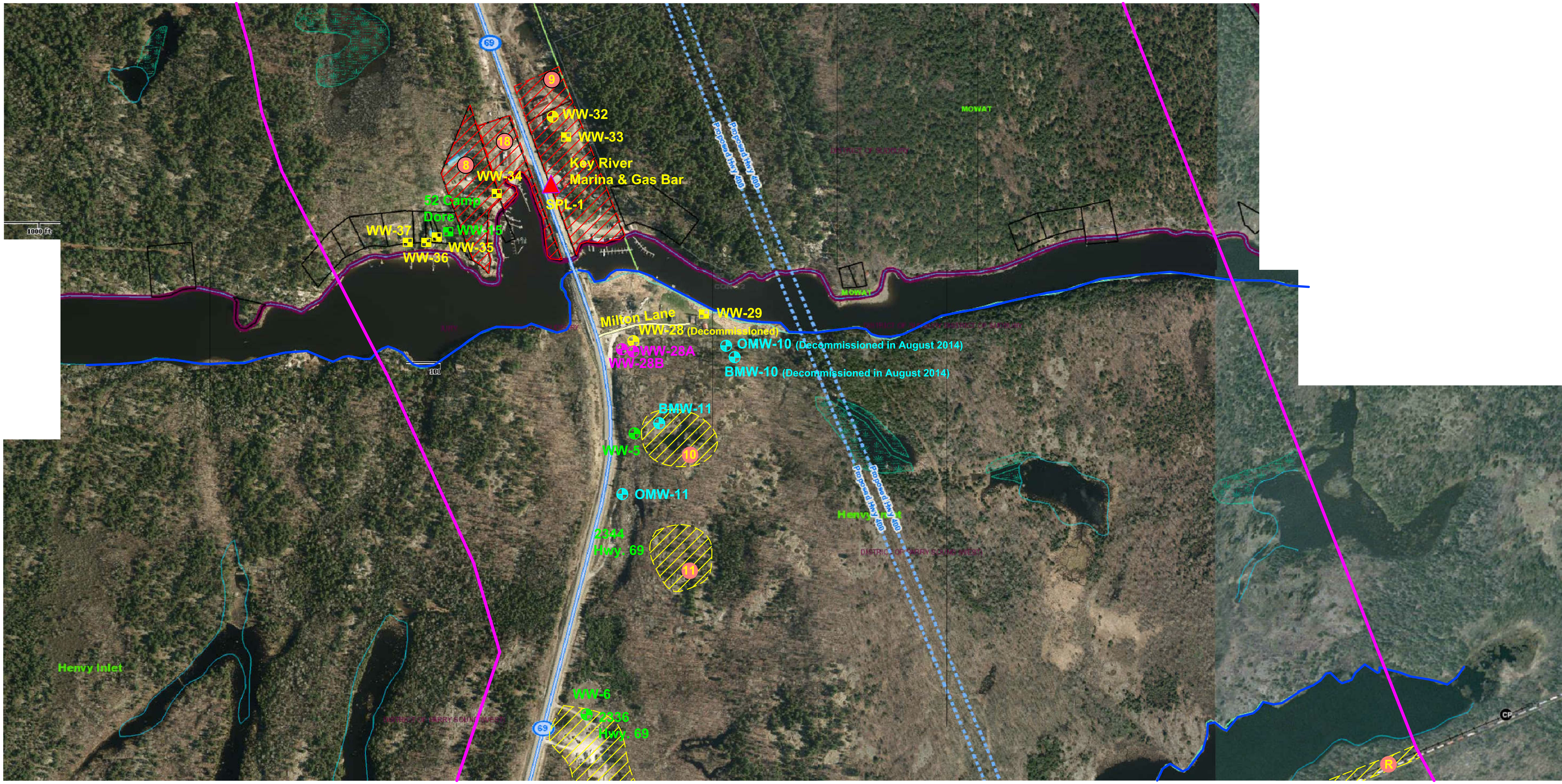
Coordinate Location of House/Dwelling		Resident Interviewed?	Survey Complete?	Well Observed?		Water Level	Coordinate Location of Well		Well ID	Address/Location	Comments
Northing	Easting	(Y/N/RR/LP)	(Y/N)	(Y/N)	Type	(mBtop)	Northing	Easting			
533973	5077527	N	N	Y	Drilled	-	533986	5077552	DW15	49 Beckanon Road, #B	Drilled well observed, located inside dug well. Possible shared well with two houses. Houses vacant. Bear observed near property, no water level taken.
529256	5079303	Y	Y	N	-	-				Boat Access - Henvey Inlet - Joe's Son	No well, surface water intake from Henvey Inlet. Interviewed Joe.
528010	5078048	Y	N	N	-	-				Boat Access - Henvey Inlet - Joe's House	No well, surface water intake from Henvey Inlet. Interviewed Joe.
525692	5077215	Y	N	N	-	-				Boat Access - Henvey Inlet - Joe's Brother	No well, surface water intake from Henvey Inlet. Interviewed Joe.
524680	5075952	LP	N	N	-	-				Boat Access - Henvey Inlet	House and dock present, surface water intake observed
522330	5076573	Y	N	N	-	-				Boat Access - Henvey Inlet	House and dock present, surface water intake observed
521671	5076322	LP	N	N						Boat Access - Henvey Inlet	House and dock present, surface water intake observed
521962	5076315	LP	N	N						Boat Access - Henvey Inlet	House and dock present, surface water intake observed
531684	5078989	LP	N	N	-	-				Beckanon Road - Leased Cottage	Abe and Helen Venderwelle - No surface water intake observed.
531606	5079033	Y	Y	Y	Dug	-	531615	5078999	DW16	Beckanon Road - Leased Cottage	House and dock present, dug well observed with screen and wood lid. Did not remove lid due to poor condition. Water quality good with exception of occasional suphur smell. Well has gone dry previously.
531590	5078998	LP	N	Y	Dug		531568	5079006	DW17	Beckanon Road - Leased Cottage	House and dock present, dug well observed with screen and wood lid. Did not remove lid due to poor condition. Possibly spring fed (heard water flowing in well)
531701	5079038	LP	N	N	-	-				Beckanon Road - Leased Cottage	House and dock present, surface water intake not observed, well not observed.
531725	5079074	Y	N	N	-	-				Beckanon Road - Leased Cottage	House and dock present, surface water intake from spring/creek located behind property.
531780	5079139	Y	N	N	-	-				Beckanon Road - Leased Cottage	House and dock present, surface water intake probably from spring/creek located behind property.
531760	5079085	LP	N	N	-	-				Beckanon Road - Leased Cottage	House and dock present, surface water intake from spring/creek located behind property.

Notes:

Resident Interviewed: Y-Yes, N-No, RR-Resident Refused, LP-Left Survey Package

Appendix B

URS Groundwater Monitor Location Map and Borehole Logs



Approximate Study Area Limit	Henvey Inlet First Nation Reserve #2 Boundary
Approximate Spill Location	
High Contamination Potential	URS ID#
Medium Contamination Potential	Railway Properties
WW-5 Existing Drilled Water Wells Monitored by URS	WW-33 Existing Dug Water Wells Not Monitored by URS
OMW-10 BMW-10 Overburden (OMW) and Bedrock (BMW) Groundwater Monitoring Wells by URS, Oct.-Nov. 2013	WW-32 Existing Drilled Water Wells Not Monitored by URS
WW-28A WW-28B New Drinking Water Wells Observed in August 2014	WW-15 Existing Dug Water Wells Monitored by URS

Map Source: WPSGN http://www.wpsgn.ca/iFLEX/nfl/index.html

Title of Drawing: **DETAILED SITE CONDITIONS**
HYDROGEOLOGICAL ASSESSMENT STUDY

Site: Highway 69, G.W.P. 5404–05–00
Henvey Inlet First Nation
Townships of Mowat and Henvey, Ontario

Client: ONTARIO MINISTRY OF TRANSPORTATION

URS
4th Floor, 30 Leek Crescent
Richmond Hill, Ontario
Tel:905-882-4401
Fax:905-882-4399

Scale: metres 0 200 400

DATE:	PROJECT NO.:	DRAWN BY:	REVISION NO.:	DRAWING NO.:
October 2014	G.W.P. 5404-05-00	CZ	0	FIGURE 2: MAP 14

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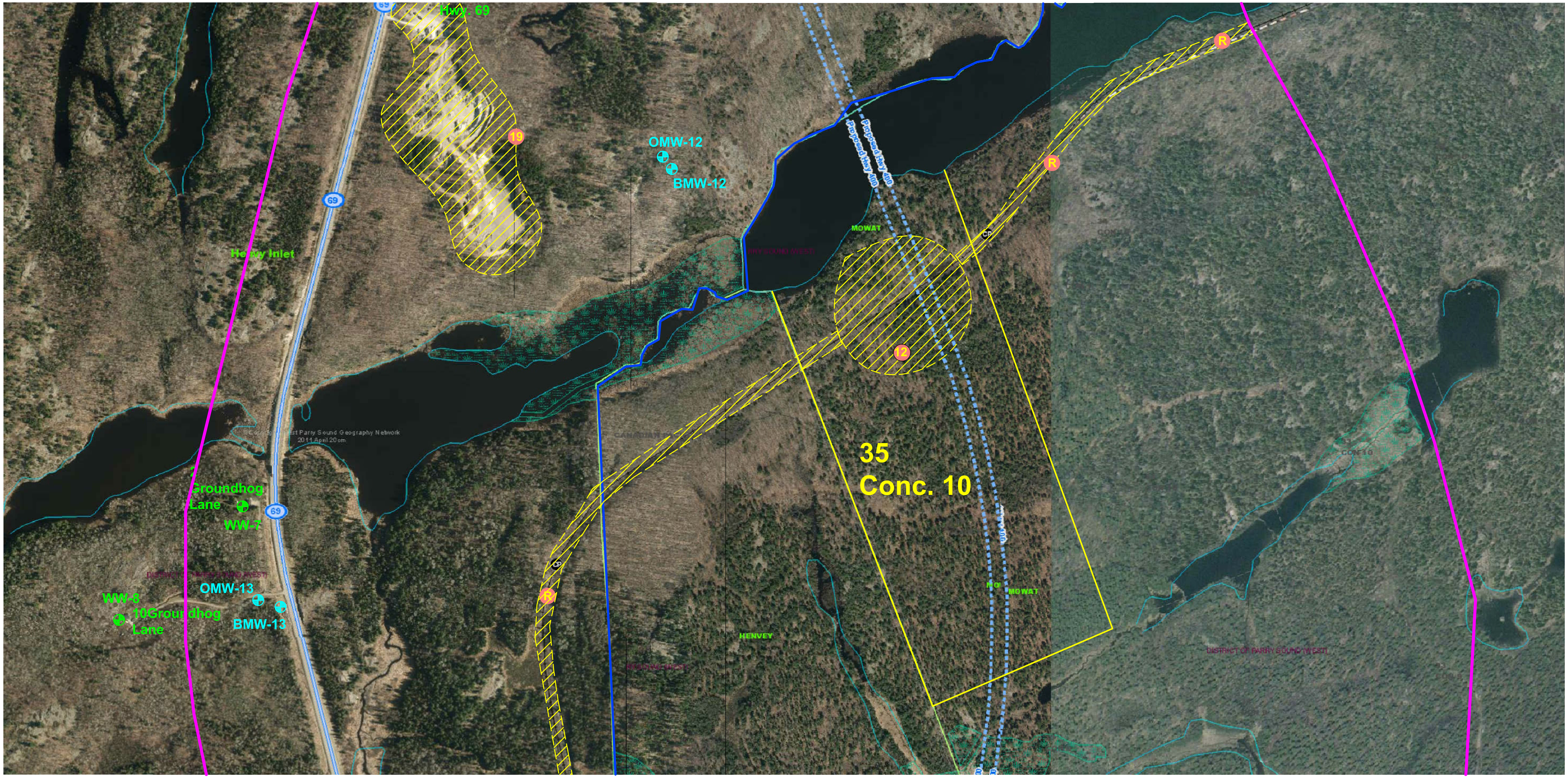


Approximate Study Area Limit

Henvey Inlet First Nation Reserve #2 Boundary

Lot/Concession Boundary

Medium Contamination Potential

12 URS ID#

R Railway Properties

WW-7 Existing Drilled Water Wells Monitored by URS

OMW-13 BMW-13 Overburden (OMW) and Bedrock (BMW) Groundwater Monitoring Wells by URS, Oct.-Nov. 2013

Map Source: WPSGN http://www.wpsgn.ca/iFLEX/nfi/index.html

Title of Drawing:	**DETAILED SITE CONDITIONS** *HYDROGEOLOGICAL ASSESSMENT STUDY*
Site:	Highway 69, G.W.P. 5404-05-00 Henvey Inlet First Nation Townships of Mowat and Henvey, Ontario
Client:	ONTARIO MINISTRY OF TRANSPORTATION

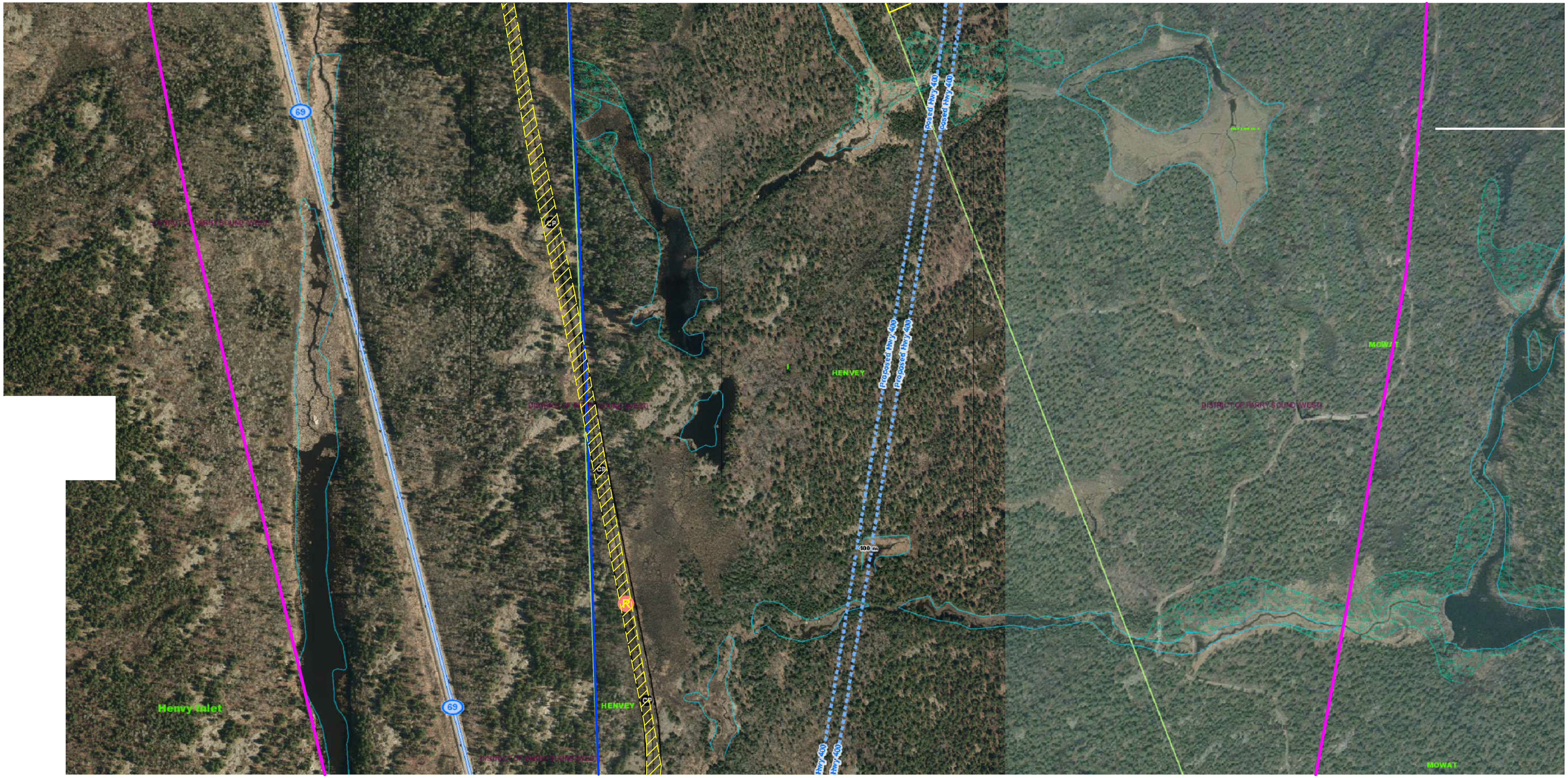
URS

4th Floor, 30 Leek Crescent
Richmond Hill, Ontario
Tel:905-882-4401
Fax:905-882-4399

Scale: metres 0 200 400

DATE:	PROJECT NO.:	DRAWN BY:	REVISION NO.:	DRAWING NO.:
October 2014	G.W.P. 5404-05-00	CZ	0	FIGURE 2: MAP 15

FILE NAME: C:\Users\chloe_zhang\Desktop\Hwy 69 Figures Oct 2014\Figures\Figure 1.2 Final Report Oct 2014.dwg



Approximate Study Area Limit

Henvey Inlet First Nation Reserve #2 Boundary

Medium Contamination Potential

Railway Properties

Map Source: WPSGN http://www.wpsgn.ca/iFLEX/nfi/index.html

Title of Drawing:	**DETAILED SITE CONDITIONS** *HYDROGEOLOGICAL ASSESSMENT STUDY*
Site:	Highway 69, G.W.P. 5404–05–00 Henvey Inlet First Nation Townships of Mowat and Henvey, Ontario
Client:	ONTARIO MINISTRY OF TRANSPORTATION

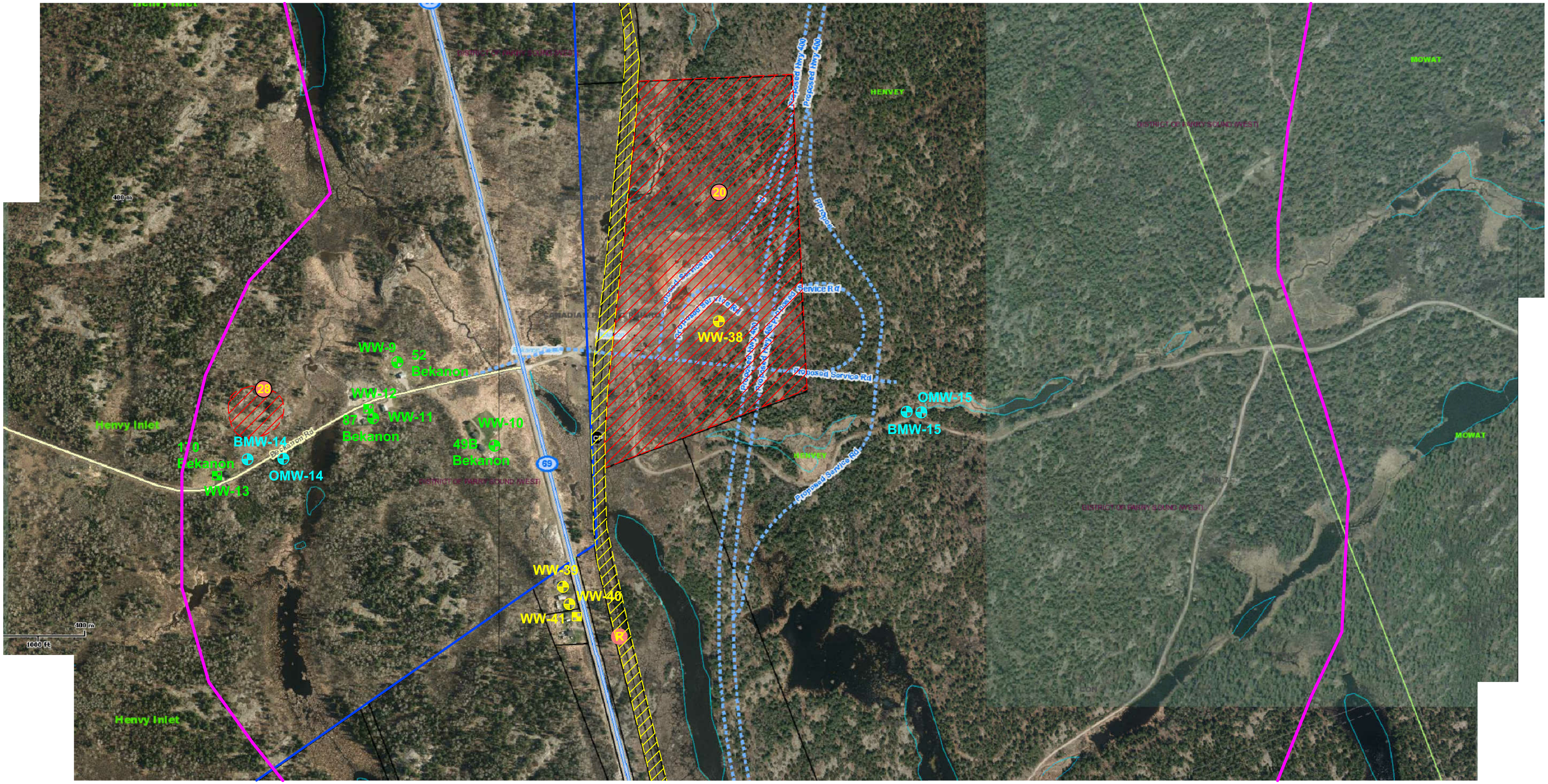
URS

4th Floor, 30 Leek Crescent
Richmond Hill, Ontario
Tel:905-882-4401
Fax:905-882-4399

Scale: metres 0 200 400

DATE:	PROJECT NO.:	DRAWN BY:	REVISION NO.:	DRAWING NO.:
October 2014	G.W.P. 5404-05-00	CZ	0	FIGURE 2: MAP 16

FILE NAME: C:\Users\chloe_zhang\Desktop\Hwy 69 Figures Oct 2014\Figures\Figure 1,2 Final Report Oct 2014.dwg



Approximate Study Area Limit

Henvey Inlet First Nation Reserve #2 Boundary

28 URS ID#

WW-41 Existing Dug Water Wells Not Monitored by URS

High Contamination Potential

R Railway Properties

WW-13 Existing Dug Water Wells Monitored by URS

WW-9 Existing Drilled Water Wells Monitored by URS

Medium Contamination Potential

WW-38 Existing Drilled Water Wells Not Monitored by URS

OMW-14 BMW-14 Overburden (OMW) and Bedrock (BMW) Groundwater Monitoring Wells by URS, Oct.-Nov. 2013

Map Source: WPSGN http://www.wpsgn.ca/iFLEX/nfi/index.html

Title of Drawing: **DETAILED SITE CONDITIONS**
HYDROGEOLOGICAL ASSESSMENT STUDY

Site: Highway 69, G.W.P. 5404–05–00
Henvey Inlet First Nation
Townships of Mowat and Henvey, Ontario

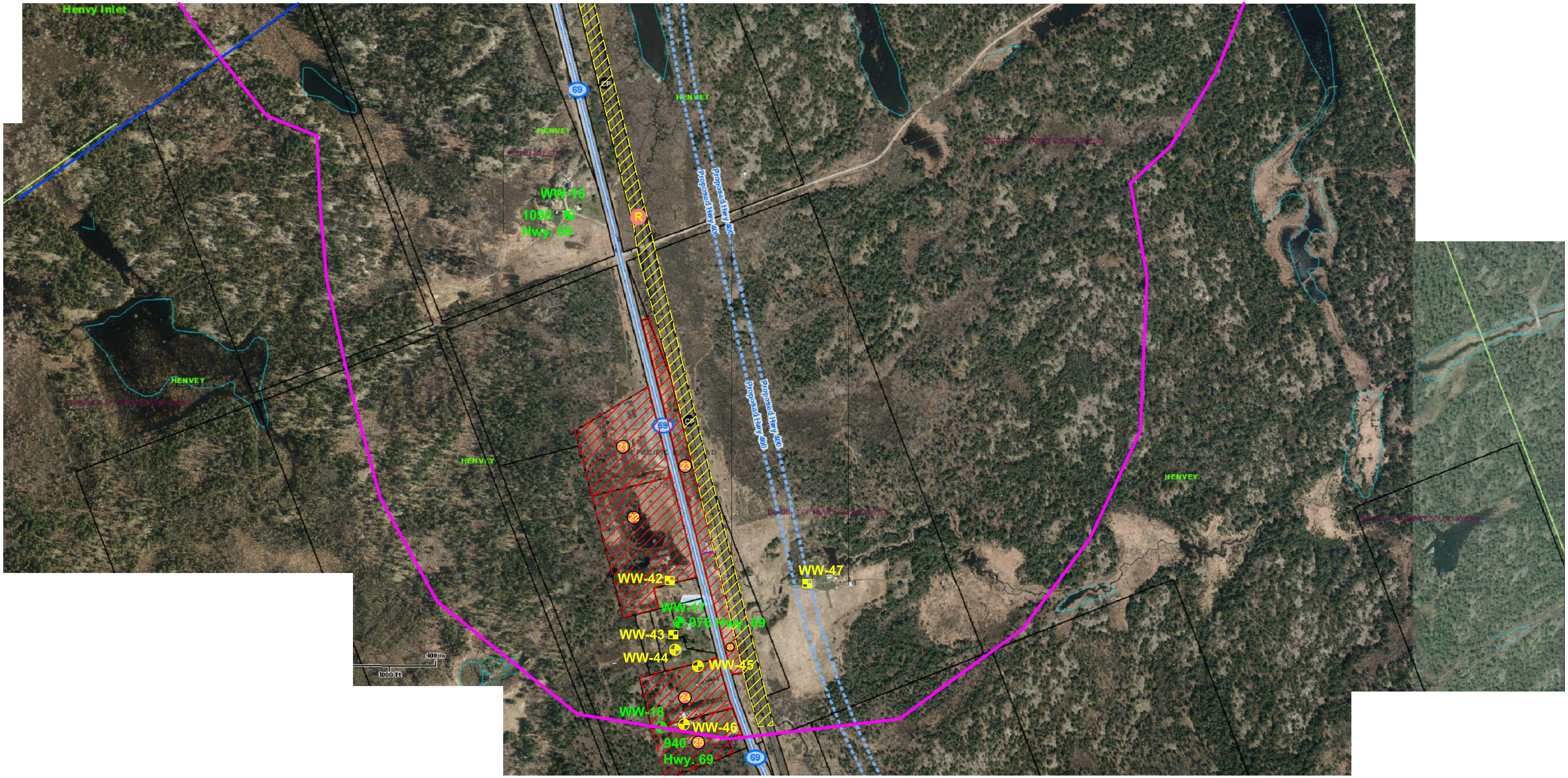
Client: ONTARIO MINISTRY OF TRANSPORTATION

URS
4th Floor, 30 Leek Crescent
Richmond Hill, Ontario
Tel:905-882-4401
Fax:905-882-4399

Scale: metres 0 200 400

DATE:	PROJECT NO.:	DRAWN BY:	REVISION NO.:	DRAWING NO.:
October 2014	G.W.P. 5404-05-00	CZ	0	FIGURE 2: MAP 17

FILE NAME: C:\Users\chloe_zhang\Desktop\Hwy 69 Figures Oct 2014\Figures\Figure 1,2 Final Report Oct 2014.dwg



Approximate Study Area Limit

Henvey Inlet First Nation Reserve #2 Boundary

21 URS ID#

R Railway Properties

High Contamination Potential

Medium Contamination Potential

WW-45 Existing Drilled Water Wells Not Monitored by URS

WW-43 Existing Dug Water Wells Not Monitored by URS

WW-16 Existing Dug Water Wells Monitored by URS

WW-18 Existing Drilled Water Wells Monitored by URS

Map Source: WPSGN http://www.wpsgn.ca/iFLEX/nfi/index.html

Title of Drawing: **DETAILED SITE CONDITIONS**
HYDROGEOLOGICAL ASSESSMENT STUDY

Site: Highway 69, G.W.P. 5404-05-00
Henvey Inlet First Nation
Townships of Mowat and Henvey, Ontario

Client: ONTARIO MINISTRY OF TRANSPORTATION

URS

4th Floor, 30 Leek Crescent
Richmond Hill, Ontario
Tel:905-882-4401
Fax:905-882-4399

Scale: metres 0 200 400

DATE:	PROJECT NO.:	DRAWN BY:	REVISION NO.:	DRAWING NO.:
October 2014	G.W.P. 5404-05-00	CZ	0	FIGURE 2: MAP 18

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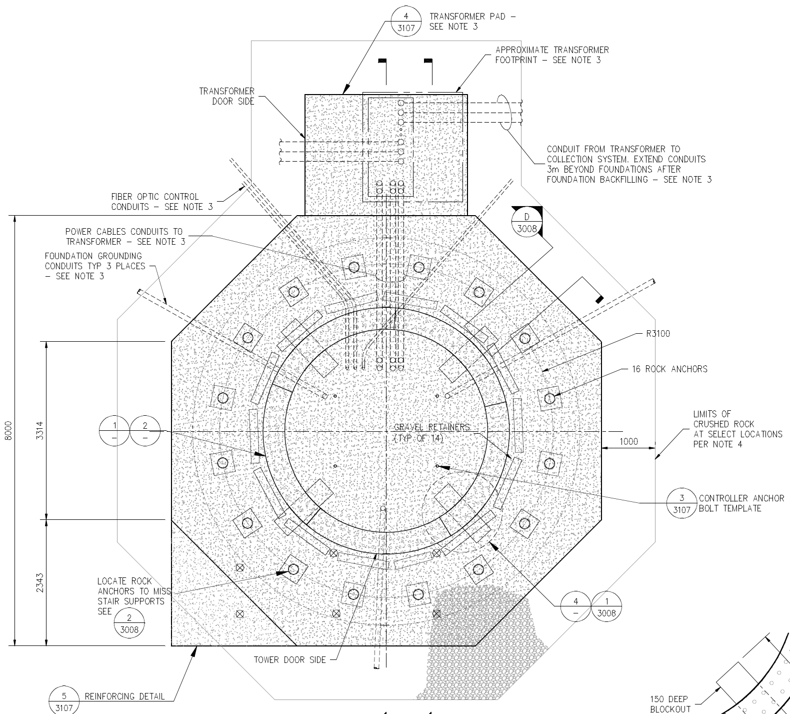
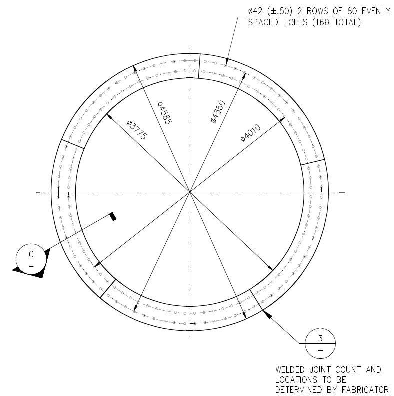
Appendix C

Detailed Design Drawings



PLAN: TURBINE FOUNDATION

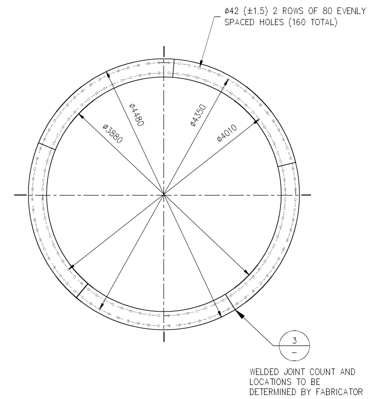
SCALE: 1:450



1 DETAIL: TEMPLATE RING

SCALE: 1:40

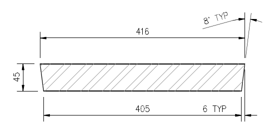
MATERIAL: 44W STEEL
SIZE: 405 (WIDE) x 45 (THICK) SEE SECTION A FOR VERTICAL LOCATION



2 DETAIL: EMBEDMENT RING

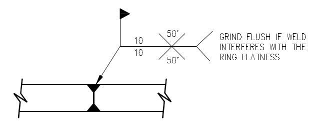
SCALE: 1:40

MATERIAL: 50A STEEL
SIZE: 300 WIDE x 35 THICK



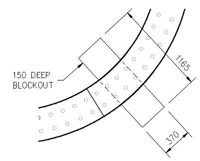
C SECTION: TEMPLATE RING

SCALE: NONE



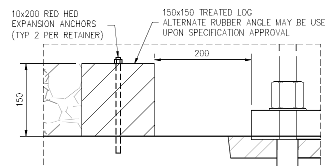
3 DETAIL: TYPICAL WELD FOR RINGS

Scale: NONE

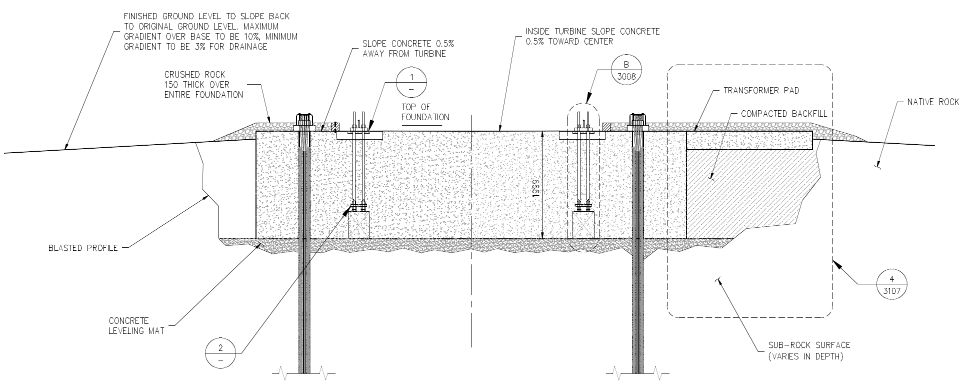


4 DETAIL: BLOCKOUT

SCALE: NONE

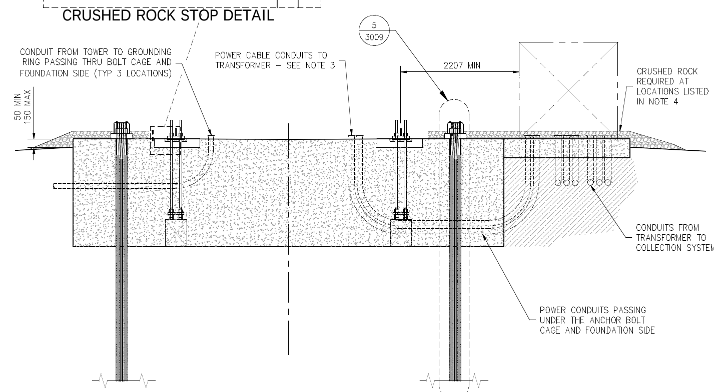


CRUSHED ROCK STOP DETAIL



A SECTION: FOUNDATION AND TYPICAL GRADING

SCALE: 1:450



B SECTION: TYPICAL CONDUIT ROUTING

SCALE: 1:450

NOTES:

1. FOR EMBEDMENT AND TEMPLATE RING USE E70 ELECTRODE (70,000 PSI TENSILE STRENGTH) FOR ANY WELDED JOINTS ON THE A36 STEEL PLATE.
2. CONTRACTOR TO SUPPLY 3 FLAME CUT LIFTING EYES PER RING TO BE SHIPPED LOOSE AND WELDED IN PLACE ON SITE.
3. COORDINATE ALL CONDUIT LAYOUTS AND GROUNDING REQUIREMENTS WITH ELECTRICAL DRAWING (01682D4203). ANY DISCREPANCIES OR CHANGES SHALL BE REPORTED TO AND APPROVED BY RES ENGINEERS.
4. CRUSHED ROCK REQUIRED AT TURBINE LOCATION T35.

AS BUILT CONDITION NOTES:

1. TWO UNUSED CONDUITS CUT FLUSH WITH TOP OF THE BACKFILL AT T1, T6, T7, T9, T11, T14, T18, T20, T24, T26, T29, T40 AND T41.
2. TWO UNUSED CONDUITS CUT FLUSH WITH TOP OF CONCRETE AND TOP 6" TO 12" FILLED WITH CONCRETE OR GROUT AT T16, T31, T33, T35, AND T36.

RECORD DRAWING

ISSUE	DRAWN	DSGN	APPD	DATE	REVISION NOTES
6	PC	LG/MC	JBH	113011	RECORD DRAWINGS
5	DM	LG/MC	JBH	042511	REMOVED DOWELS FROM PADS
4	DM	LG/MC	JBH	082010	STAIR PAD/CRUSHED ROCK LOCATIONS
3	DM	LG/MC	JBH	080510	ADDED CRUSHED ROCK
2	DM	LG/MC	JBH	072310	REVISED REBAR
1	DM	LG/MC	JBH	070710	REVISED DETAILS
0	DM	LG/MC	JBH	070110	ISSUE FOR CONSTRUCTION

LAYOUT DWG N/A — T-LAYOUT NO. N/A

DRAWING NUMBER 01682D3007

COORDS N/A

PURPOSE FOR RECORD

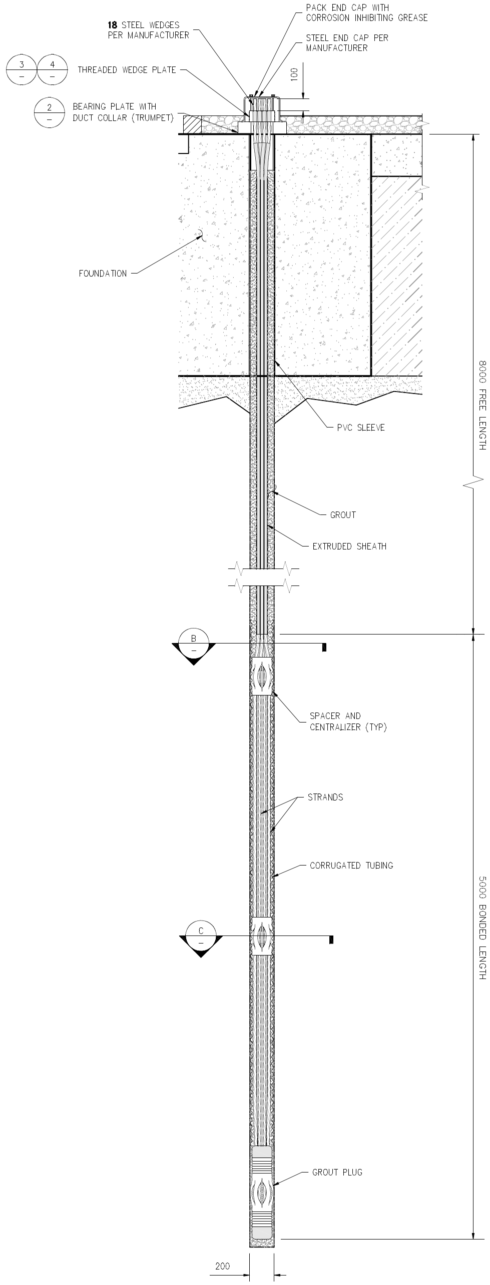
SCALE AS NOTED — ORIGINAL PLOT SIZE A1

PROJECT TITLE
ONTARIO – GREENWICH WIND FARM

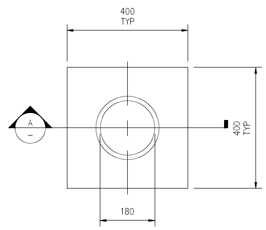
DRAWING TITLE
TURBINE FOUNDATION PLAN VIEW & DETAILS SIEMENS 2.3MW

FIELD DEVIATIONS FROM THIS DESIGN ARE NOT PERMITTED WITHOUT DOCUMENTATION THROUGH A TEF (TECHNICAL ENQUIRY FORM) APPROVED BY THE ENGINEER.

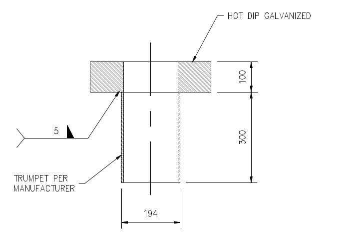
PREPARED BY:
RES CANADA CONSTRUCTION GP
300 LEO PARISEAU, SUITE 2516
MONTREAL, QUEBEC H2X 4B3
TEL +1 514 525 2113
FAX +1 514 524 9669



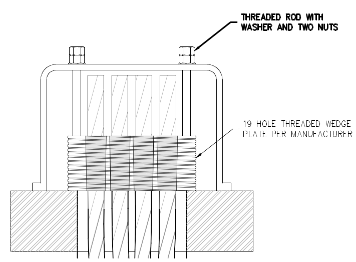
1 DETAIL: ROCK ANCHOR (TYP OF 16)
Scale: 1:20



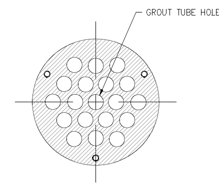
2 DETAIL: BEARING PLATE
Scale: 1:8



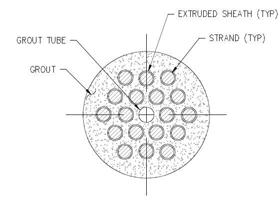
A SECTION: BEARING PLATE WITH TRUMPET
Scale: 1:8



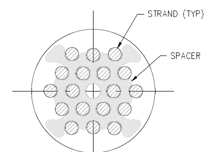
4 DETAIL: THREADED WEDGE PLATE
Scale: 1:4



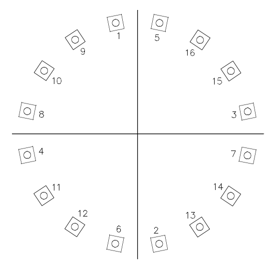
3 DETAIL: THREADED WEDGE PLATE
Scale: 1:4



B SECTION: STRANDS
Scale: 1:4



C SECTION: SPACER
Scale: 1:4



5 ROCK ANCHOR TIGHTENING SEQUENCE
Scale: N/A

NOTES:

1. ALL DIMENSIONS ARE IN MM UNLESS OTHERWISE STATED.
2. ROCK ANCHORS SHALL BE PTI, TYPE I CORROSION PROTECTION.
3. ROCK ANCHOR INSTALLATION SEQUENCE IS AS FOLLOWS:

A. UPON COMPLEATION OF CAP CONSTRUCTION AND BACK FILING.
B. DRILL ROCK ANCHOR TO APPROPRIATE DEPTH (SEE DETAIL 1).
C. CLEAN HOLE FROM ALL DEBRIS UPON COMPLETION OF DRILLING. HOLES OPEN FOR LONGER THAN 8 TO 12 HOURS SHOULD BE RE-CLEANED PRIOR TO INSERTION OF THE TENDON AND GROUTING.
D. ALL STRANDS SHALL HAVE SMOOTH PVC BOND BREAKER WITH GROUT SEAL AT THE UNBONDED ZONE. PVC CENTRALIZERS AND GROUT TUBE SHALL BE ADDED TO STRAND ANCHORS.
E. INSTALL 18 STEEL STRAND ROCK ANCHOR SYSTEM (SEE DETAILS 3 & 4). SHOP DRAWINGS TO BE SUBMITTED TO RES ENGINEERING BEFORE WORK IS TO TAKE PLACE.
F. GROUT ALL ANCHORS TO THE FULL LENGTH FROM THE BOTTOM UP (SEE DETAIL 1).
G. WHEN GROUT REACHES 40MPa OR 5 DAYS TENSION ALL ANCHORS.

H. DESIGN ROCK ANCHOR POST-TENSION LOAD SHALL BE 2775kN WITH TOLERANCE OF ±50kN.

SEE DETAIL 5 FOR ROCK ANCHOR TENSIONING SEQUENCE.

4. ALL DRILLING AND GROUTING SHALL BE IN ACCORDANCE WITH THE POST TENSIONING INSTITUTE (PTI).

RECORD DRAWING

ISSUE	DRAWN	DSGN	APPD	DATE	REVISION NOTES
6	PC	LG/MC	JBH	113011	RECORD DRAWINGS
5	DM	LG/MC	JBH	042511	REMOVED DOWELS FROM PADS
4	DM	LG/MC	JBH	082010	STAIR PAD/CRUSHED ROCK LOCATIONS
3	DM	LG/MC	JBH	080510	ADDED CRUSHED ROCK
2	DM	LG/MC	JBH	072310	REVISED REBAR
1	DM	LG/MC	JBH	070710	REVISED DETAILS
0	DM	LG/MC	JBH	070110	ISSUE FOR CONSTRUCTION

LAYOUT DWG N/A
T-LAYOUT NO. N/A

DRAWING NUMBER 01682D3009

COORDS N/A

PURPOSE FOR RECORD

SCALE AS NOTED
ORIGINAL PLOT SIZE A1

PROJECT TITLE
ONTARIO – GREENWICH WIND FARM

DRAWING TITLE
TURBINE FOUNDATION
ROCK ANCHOR DETAILS
SIEMENS 2.3MW

FIELD DEVIATIONS FROM THIS DESIGN ARE NOT PERMITTED WITHOUT DOCUMENTATION THROUGH A TEF (TECHNICAL ENQUIRY FORM) APPROVED BY THE ENGINEER.

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