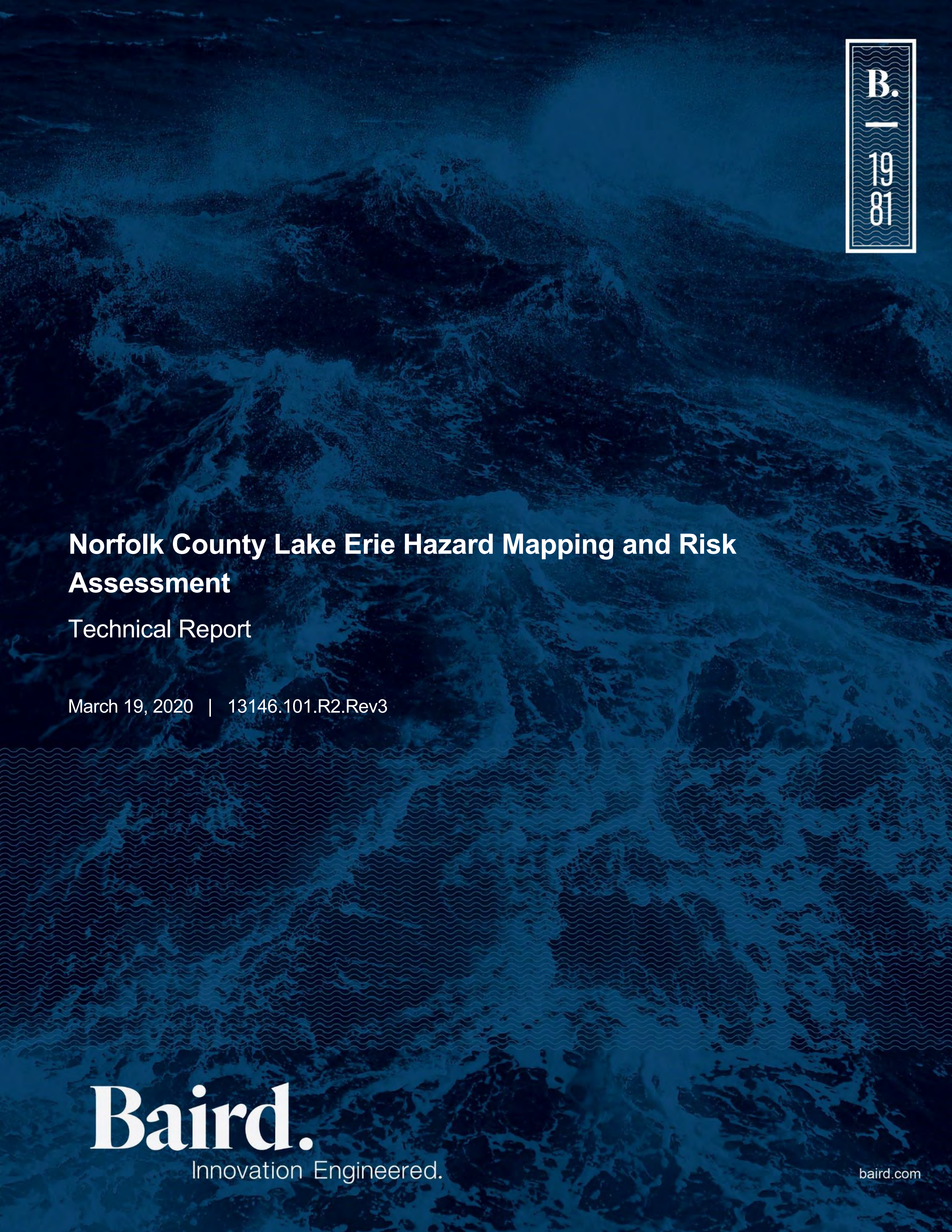

Norfolk County Lake Erie Hazard Mapping and Risk Assessment

Technical Report

March 19, 2020 | 13146.101.R2.Rev3

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Norfolk County Lake Erie Hazard Mapping and Risk Assessment

Technical Report

Prepared for:

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On behalf of Norfolk County

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13146.101.R2.Rev3

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Revision	Date	Status	Comments	Prepared	Reviewed	Approved
Rev A	2019 10 15	Draft	Prelim – not for review	SKL/JDW	FJLD	FJLD
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Rev 3	2020 03 19	Final		SKL/JDW	FJLD	FJLD

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Tables

Figures

1. Introduction

The Long Point Region Conservation Authority (LPRCA), on behalf of Norfolk County retained Baird & Associates with geotechnical sub-consultant Terraprobe Inc. to undertake the Norfolk County Lake Erie Hazard Mapping project. This report describes the technical studies undertaken to update the Lake Erie hazard mapping for Norfolk County.

Norfolk County has 135 km of Lake Erie shoreline, with approximately 65 to 70 km included in this project to be mapped. The project shoreline is shown in Figure 1.1. The lakeshore area is comprised predominantly of agricultural lands with strip residential developments bisected by the lakeshore roads. There are designated tourist residential nodes that consist of a mix of seasonal and year round developments. Some of these major nodes include Long Point, Port Rowan, St. Williams, Turkey Point, Normandale, Port Ryerse and Port Dover. There are also many seasonal trailer parks and campgrounds within the lakeshore area. In addition to these privately owned facilities, there are several Provincial Parks, Conservation Areas and other public facilities.

Previous shoreline hazard mapping for the County within LPRCA jurisdictions was prepared in the late 1980s. Since completion of this work, the provincial technical guidance has been updated (2001), and there have been legislative changes, including an updated Provincial Policy Statement (2014) under the Planning Act, and new regulations under the Conservation Authorities Act.

This report summarizes the technical analyses undertaken to update the Lake Erie shoreline flooding, erosion, and dynamic beach hazard mapping within Norfolk County. The mapping, provided under separate cover, supports land use planning and permitting decisions in at-risk communities such as Port Dover, Long Point, Turkey Point and other shoreline areas within the County. Updates to conservation authority shoreline management plan was outside the scope of the project.

The technical information for this project may also support flood and erosion-related response and mitigation planning. Updates to a risk assessment for shoreline flooding, including estimates of damage potential, are provided under separate cover.

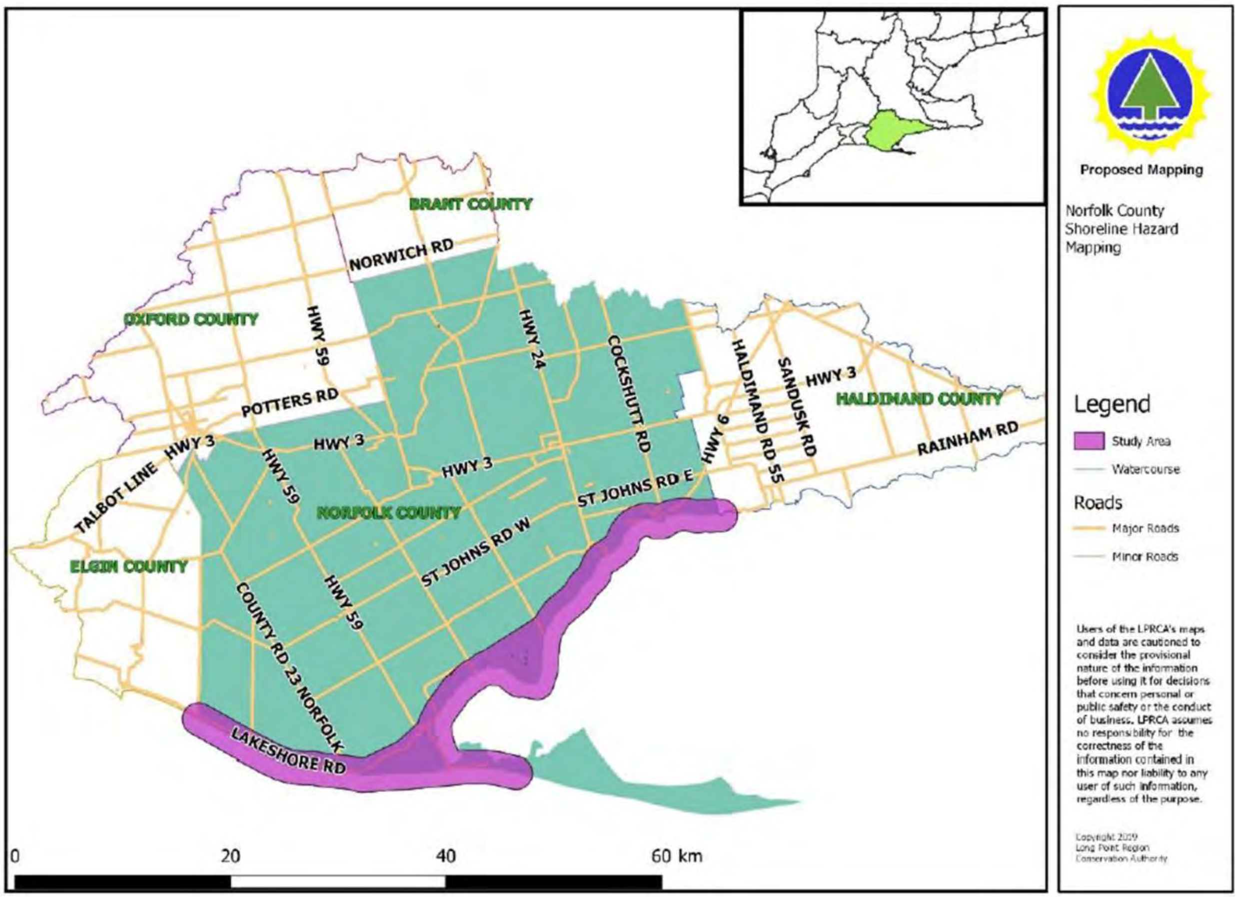


Figure 1.1: Map showing study area, Norfolk County, and LPRCA boundaries

2. Previous Technical Studies

Key technical studies and data, relevant to the development of the Haldimand County Lake Erie hazard mapping are summarized in this section.

2.1 Policies for the Administration of Ontario Regulations 178/06

Ontario Regulation 97/04 stipulates the criteria by which each Conservation Authority must establish its updated regulated area or 'Regulation Limit'. The Province of Ontario subsequently enacted Regulation 178/06, requiring the Conservation Authority (CA) to regulate areas that are river or stream valleys, wetlands and other areas where development could interfere with the hydrologic function of a wetland, adjacent or close to the shoreline of Great Lakes-St. Lawrence System and inland lakes that may be affected by flooding, erosion or dynamic beach hazards. The Regulated Area represents the greatest extent of the combined hazards plus a prescribed allowance as set out in the Regulation.

LPRCA developed Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation (received by the Board of Directors Oct. 4, 2017) for guiding decisions regarding the outcome of applications made under the Regulations, to ensure a consistent, timely and fair approach to the review of applications, staff recommendations and CA decisions, to achieve efficient and effective use and allocation of available resources.

2.2 Shoreline Management Plans

Shoreline Management Plan. Long Point Region Conservation Authority (Philpott Associates, 1989) is the current shoreline management plan for the Long Point Region CA. It presents the methodologies used in 1989 to delineate the flood, erosion and dynamic beach hazards. This document predates MNR (2001a), which provides technical direction on the methodologies to be used when delineating the natural hazard limits. Philpott (1989) describes the flood hazard as the "100-year uprush limit"; the erosion hazard as 100 times the AARR plus a stable slope allowance; and the dynamic beach as the landward limit of the cohesionless beach deposit. Limited detail on mapping methodologies is provided. Since that time, additional data has become available and approaches to delineating the hazards have advanced.

2.3 Norfolk County Official Plan

The Norfolk County Official Plan (2006) was adopted by Norfolk County Council on May 9, 2006, and the most recent Five Year Review was adopted by Council on January 31, 2018. It was approved by the Ministry of Municipal Affairs and Housing in 2008 and the most recent Five-Year Review was approved on October 5, 2018. The document is the official land use planning tool used to manage growth and development within the county to the year 2036. It also provides the link through which the Provincial Policy is implemented into the local context.

The Official Plan recognizes the natural hazards and identifies Norfolk County's commitment to the protection of life and property by respecting natural and man-made hazards. It states that new development shall only take place in areas which are not susceptible to hazards, while recognizing that there are certain areas of the County where extensive development has taken place within Hazard Lands. The hazard mapping that will be updated during this project is referenced in the Official Plan.

2.4 Technical Direction

Technical Guide for Great Lakes - St. Lawrence River System

In 2001, the Ministry of Natural Resources (now the Ontario Ministry of Natural Resources and Forestry (MNRF)) released the Technical Guide for the Great Lakes – St. Lawrence River System and Large Inland Lakes (MNR, 2001a). This guide provides the technical basis and procedures for establishing the hazard limits for flooding, erosion, and dynamic beaches in Ontario as well as options for addressing the hazards.

Understanding Natural Hazards

The Ontario Ministry of Natural Resources (now the Ontario Ministry of Natural Resources and Forestry) also prepared Understanding Natural Hazards (MNR, 2001b) to assist the public and planning authorities with explanation of the Natural Hazard Policies (3.1) of the Provincial Policy Statement of the Planning Act. This publication updates and replaces the older Natural Hazards Training Manual (from 1997). This document is also referenced when addressing natural hazard concerns.

Great Lakes System Flood Levels and Water Related Hazards

This document was developed by the Ontario Ministry of Natural Resources (1989) to assist Conservation Authorities in delineating shoreline hazard areas. It includes a combined probability analysis of Great Lakes water levels, considering monthly mean water levels and surge. Water levels are presented for the 100-year return period event, as well as other return periods. While this document is referenced in the Technical Guide (MNR, 2001a), for use in calculating hazard limits, it does not consider the almost 30 years of water level data collected since 1989. Water level data including the most recent available data was analyzed for this study and was used to estimate the 100-year flood level, as well as extreme water levels for other return periods (5, 25, 50, 200 year instantaneous flood levels). These values are compared with the values presented in MNR (1989) in Section 6.1.

3. Data

3.1 Aerial Imagery

The 2015 Southwestern Ontario Orthophotography Project (SWOOP) acquired aerial imagery at 20 cm resolution through the Government of Ontario's Imagery Acquisition Strategy that provides Land Information Ontario (LIO) with a mandate to collect and refresh imagery for southern Ontario on a five-year cycle. Data was collected between 12 April and 23 May 2015. This dataset is consistent across the entire study area of Norfolk County. The imagery provides a visual reference for ground features such as the delineation of shore protection structures, indications of shoreline substrate, and was used as a base layer for the 1:2,000-scale mapping developed for this study.

3.2 Elevation

The elevation data utilized for this project is the 2017 Lake Erie Watershed LiDAR dataset, collected as part of the Ontario Government's LiDAR Digital Terrain Model (2016-2018) LIO Dataset. The Airborne Topographic LiDAR (ATL) was acquired through a collaborative partnership between the Ministry of Natural Resources and Forestry (MNRF), the Ministry of Agriculture, Food and Rural Affairs (OMAFRA) and a private contractor. It was collected in March to May 2017 and October to December 2017. The LiDAR Digital Terrain Model (DTM) is a 50 cm resolution raster representing the bare-earth terrain derived from a classified LiDAR point cloud, which has been hydro-flattened using water body breaklines. This dataset provides complete coverage of the study limits of the Norfolk County Lake Erie hazard mapping.

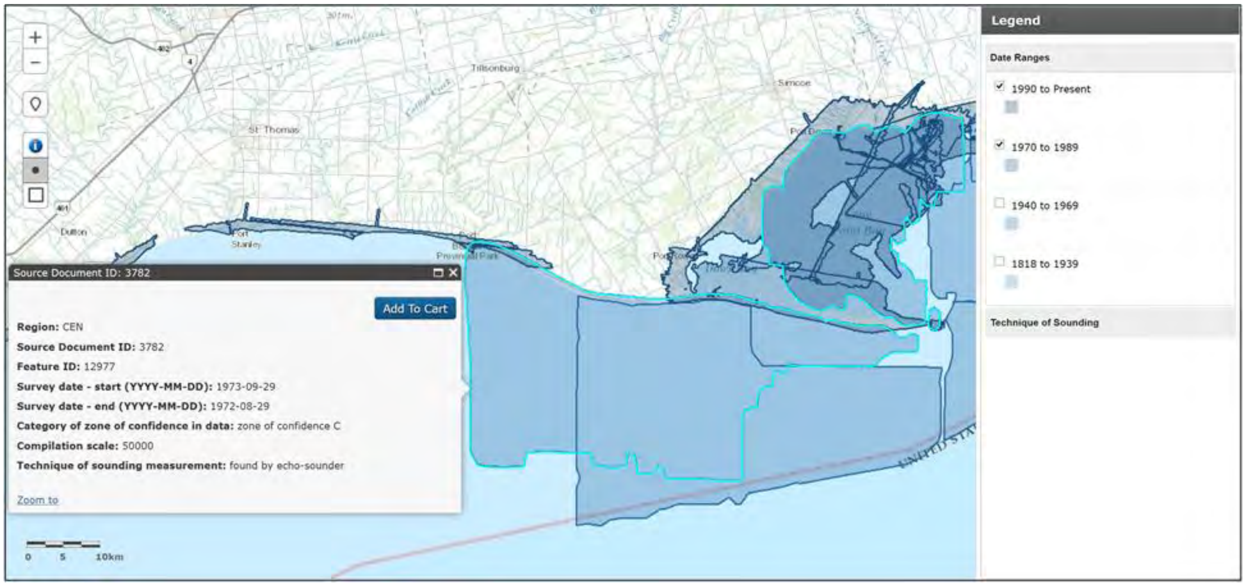
The elevation dataset provides elevation surfaces for calculating flooding and erosion hazards, including profiles extracted for slope stability analysis, and was also used to provide contours as cartographic elements that are included in the 1:2,000-scale series of maps.

3.3 Bathymetry

Bathymetry data from various sources were assembled to develop the best available combined dataset for the study area. In the area north of Long Point, the Government of Canada Department of Fisheries and Oceans (DFO) collected bathymetry using an airborne bathymetry sensor. The survey was completed between 19 April and 19 June 2018. As a result of water clarity issues during the acquisition flights, this dataset did not extend further south.

For the areas south and west of Long Point, a dataset compiled by the US National Oceanographic and Atmospheric Administration (NOAA) National Geophysical Data Center's Marine Geology and Geophysics Division (NGDC/MGG), the NOAA Great Lakes Environmental Research Laboratory (GLERL) and the Canadian Hydrographic Service (CHS). This product includes various data sets, collected over different years but primarily 1972-1973 as shown in Figure 3.1.

To fill data gaps offshore of long Point Village, a bathymetric survey was completed by Monteith & Sutherland Limited in August 2019. The area surveyed is shown in Figure 3.2. Data were collected along 35 lines spaced at 200 m intervals, running perpendicular to shore over the 7 km by 2 km area. Three check lines were run parallel to shore. A topographic survey was completed from wading depth to the back of beach at 1 km intervals, coincident with the bathymetric survey lines. All data were reduced to NAD83 UTM Zone 17 horizontal datum and IGLD1985 vertical datum.



Region: CEN

Source Document ID: 3782

Feature ID: 12977

Survey date - start (YYYY-MM-DD): 1973-09-29

Survey date - end (YYYY-MM-DD): 1972-08-29

Category of zone of confidence in data: zone of confidence C

Compilation scale: 50000

Technique of sounding measurement: found by echo-sounder

Figure 3.1: CHS Hydrographic Survey Coverage South and West of Long Point

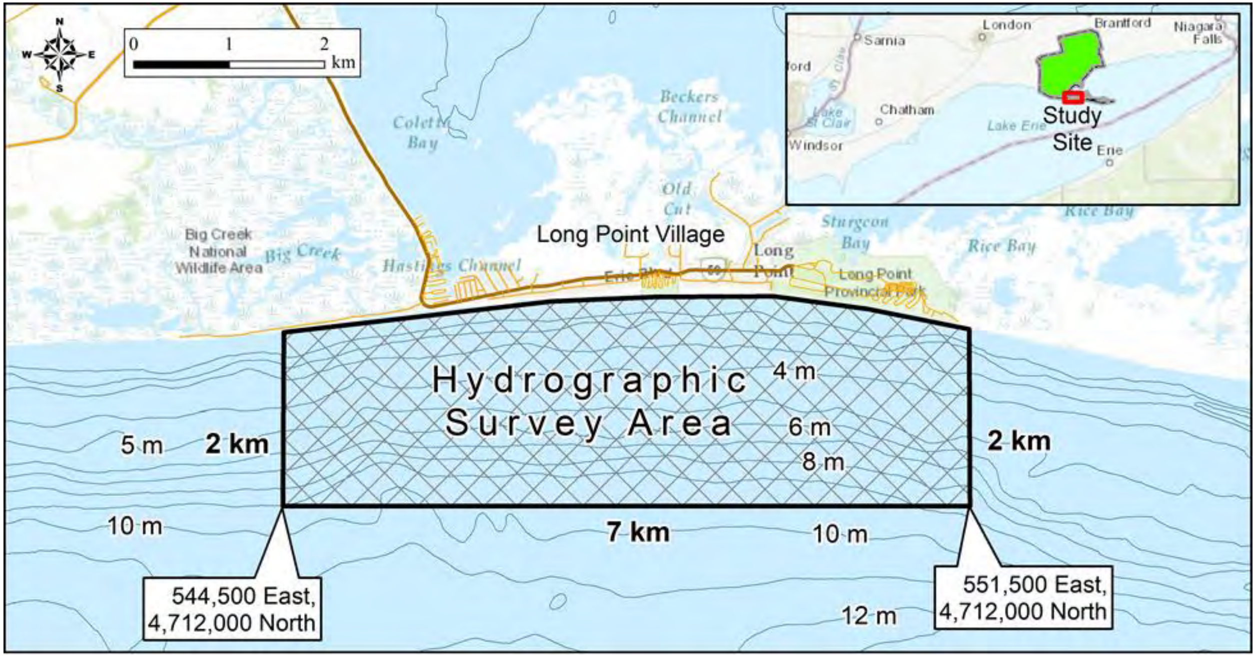


Figure 3.2: Map showing Area of 2019 Bathymetric Survey by Monteith & Sutherland

3.4 Water Levels

Lake Erie water levels were obtained from the Department of Fisheries and Oceans (DFO) Marine Environmental Data Service (MEDS). Permanent gauging stations are maintained at Port Stanley (to the west) and Port Dover (east side) of Norfolk County. A summary of the available hourly water level data is provided in Table 3.1.

Table 3.1: Summary of Lake Erie water level gauges near Norfolk County

Station Name	Station Number	Date Range of Hourly Data	Status
Port Stanley	12400	June 6, 1926 to present	Permanent
Port Dover	12710	November 1, 1961 to present	Permanent

3.5 Waves

Wave hindcast data were obtained from the US Army Corps of Engineers Wave Information Study (WIS). The wave hindcast consists of an hourly time series of modelled wave height, period, and direction at offshore locations where the waves are unaffected by the water depth. Approximately 30 output points are located offshore of the Norfolk County shoreline (see Figure 3.3). The hindcast extends from January 1, 1979 to December 31, 2014.

Figure 3.3: Wave hindcast output points from the US Army Corps of Engineers Wave Information Study

The offshore wave conditions were transformed to the Norfolk County nearshore region to assess wave uprush as discussed in Section 6.2.

3.6 Geotechnical

The background data available for the slope stability analysis includes:

- Visual observations from site visits undertaken in April and May 2019.
- Terraprobe reports from the areas Port Stanley, Port Bruce and Nanticoke.
- Geotechnical data received from LPRCA.
- Locally available geotechnical boreholes from the Ministry of Energy, Northern Development and Mines.
- Locally available quaternary geology from the Ministry of Energy, Northern Development and Mines.
- Locally available surficial geology from the Ministry of Energy, Northern Development and Mines.
- Locally available well records from the Government of Ontario.
- LiDAR data of the shoreline described in Section 3.2

These data sets are discussed in further detail in Appendix A.

4. Defining the Natural Hazards

4.1 Overview of Shoreline Hazards

The Provincial Policy Statement (PPS) provides policy direction on matters of provincial interest related to land use planning and development. Hazardous lands are defined in the PPS, (MMAH, 2014) as “property or lands that could be unsafe for development due to naturally occurring processes.” Along shorelines of the Great Lakes – St. Lawrence River System, this means the land, including that covered by water between the international boundary where applicable, and the furthest landward extent of the flooding hazard, erosion hazard, or dynamic beach hazard limits.

The technical basis and methodologies for defining and applying the hazard limits for flooding, erosion, and dynamic beaches are provided by the Technical Guide for Flooding, Erosion and Dynamic Beaches, Great Lakes – St. Lawrence River System and Large Inland Lakes (MNR, 2001a). The basic procedures outlined in the Technical Guide (MNR, 2001a) with some modifications have been included in subsequent documents, such as Ontario Regulation 97/04 (“Generic Regulation”) and Guidelines for Developing Schedules of Regulated Areas (Conservation Ontario, 2005). The methodologies outlined in MNR (2001a) have been used on this project.

It is important to note, as outlined in the Technical Guide (MNR, 2001a), that the regulated hazard limits are generally to be mapped based on the assumption of no shoreline protection works in place. The clearly stated intent is that the mapped flooding, erosion, and dynamic beach hazard limits are to represent the underlying ambient nature of the natural shoreline hazard and should not be modified by the presence of existing or proposed shoreline protection. The most landward limit of the Flooding, Erosion and Dynamic Beach hazards is utilized in determining the regulated area along the Haldimand County shoreline.

4.2 Flooding Hazard

The flooding hazard limit is defined as the 100-year flood level plus an allowance for wave uprush and other water-related hazards, as depicted graphically in Figure 4.1.

The 100-year flood level is the sum of the static water level plus storm surge with a combined 1% probability of being equalled or exceeded in a given year. This means that on average it has a one percent probability of occurring in any given year. The 100-year flood levels as defined by MNR (1989) and listed in Section 6.1 were used to map the flooding hazard for this project.

When shorelines are exposed to wave action, wave uprush and overtopping occur driving water above the 100-year water level. Other water-related hazards may include ship generated waves and ice. Site specific studies may be used to assess the allowance for wave uprush and water related hazards. The Technical Guide (MNR, 2001a) requires a flooding allowance of 15 m, measured horizontally from the location of the 100-year flood level, as shown in Figure 4.1, if a study using accepted engineering, and scientific principles is not undertaken. Wave uprush was calculated on a reach basis for this study, as presented in Section 6.2.

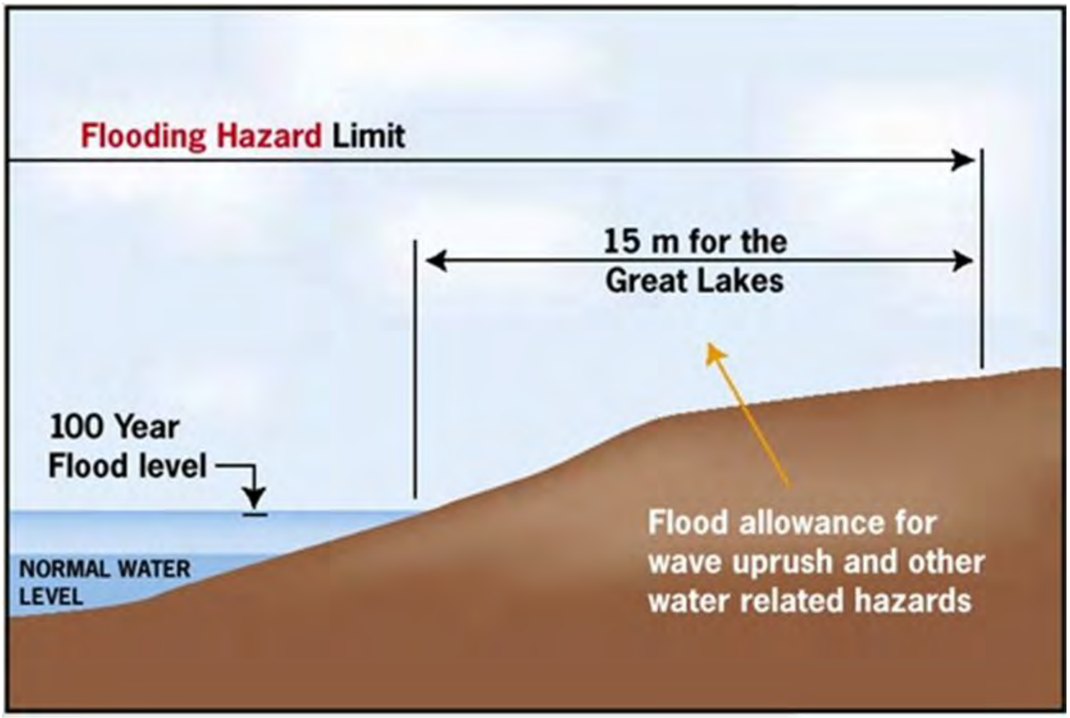


Figure 4.1: Flooding hazard limit for the Great Lakes (from MNR, 2001a)

4.3 Erosion Hazard

The erosion hazard limit is calculated as the sum of the stable slope allowance, plus the 100-year erosion allowance. Figure 4.2 shows the erosion hazard limit as defined in the Technical Guide (MNR, 2001a) and Understanding Natural Hazards (MNR, 2001b).

The approach used in Ontario Regulation 97/04 is similar, but the recession allowance is applied first and then the stable slope allowance is applied. The stable slope allowance was applied first for this study, because the stable slope line is used to identify lands and infrastructure in an imminent high risk zone.

The stable slope allowance is a horizontal allowance measured landward from the toe of the bluff or bank. It is dependent on soil characteristics and groundwater conditions. In the absence of a site-specific study, a stable slope allowance of three times the bluff height may be used. The bluff heights are calculated as the vertical change in elevation from the toe of bluff to the top of bluff. For this study, the stable slope allowance was determined on a reach basis, for representative profiles, and a geotechnical analysis of slope stability was undertaken as described in Section 6.4.

The erosion allowance is the distance the shoreline would erode in 100 years from present. It is calculated as 100 times the average annual recession rate (AARR) as shown in Figure 4.2. For this study, the AARR was calculated based on a comparison of historical aerial imagery where sufficient data existed (see Section 6.5). In the absence of a minimum 35 years of reliable data, a 30-metre erosion allowance is used (as shown in Figure 4.3). This is also applied in areas where the shoreline has been protected and an erosion allowance cannot be determined.

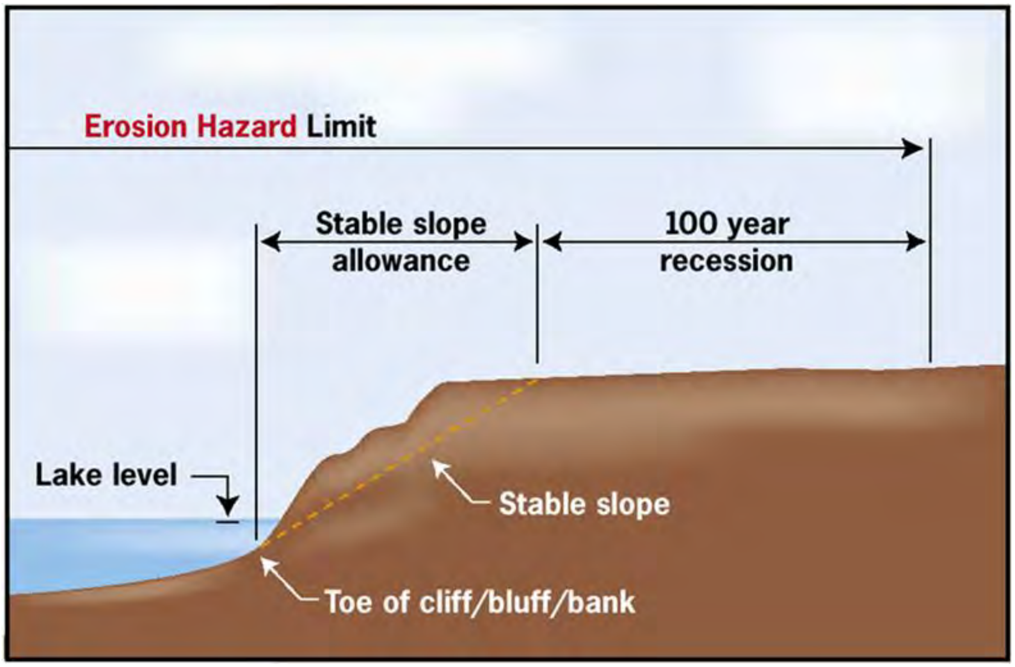


Figure 4.2: Erosion hazard limit defined with reliable recession data (from MNR, 2001a)

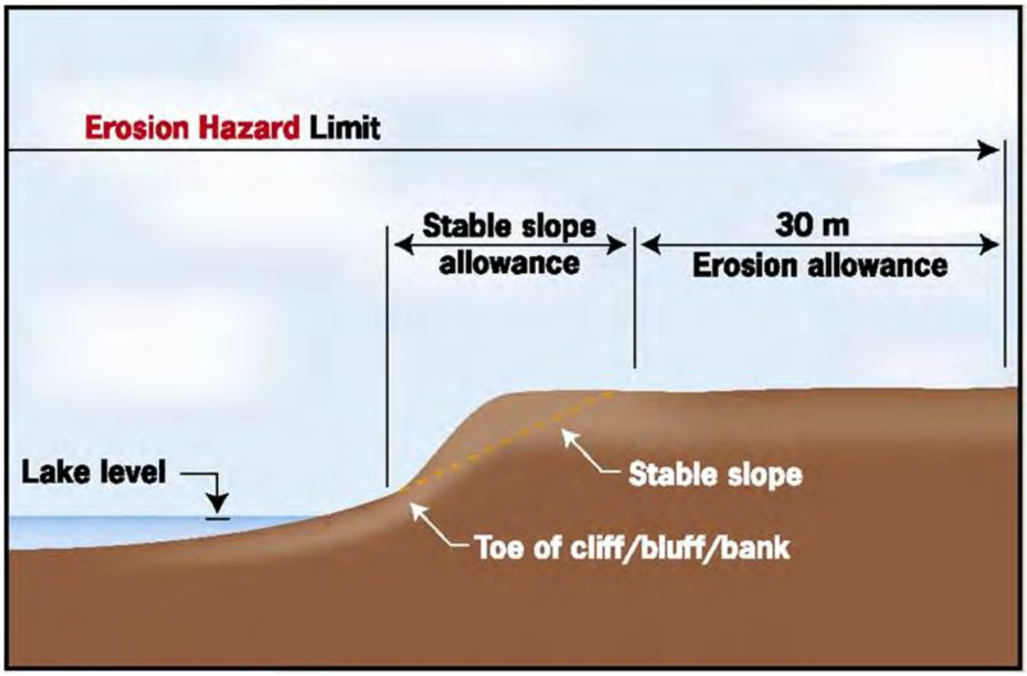


Figure 4.3: Erosion hazard limit defined where reliable recession data not available (from MNR, 2001a)

4.4 Dynamic Beach Hazard

Assessment of the dynamic beach hazard involves the calculation of the cumulative impacts of the flooding hazard, an erosion allowance, and a dynamic beach allowance.

The dynamic beach hazard is only applied where: a beach or dune deposit exists landward of the water line; the beach or dune deposits overlying bedrock or cohesive material are equal to or greater than 0.3 m in thickness, 10 m in width, and 100 m in length along shoreline; and the fetch is more than 5 km (MNR, 2001a).

The dynamic beach hazard limit is defined as the landward limit of the flooding hazard (100-year flood level plus a flood allowance for wave uprush and other water related hazards), plus a 30 m dynamic beach allowance or a distance determined by an accepted coastal study (see Figure 4.4). If the dynamic beach is backed by an eroding bluff, the definition of the erosion hazard is applied to the bluff feature.

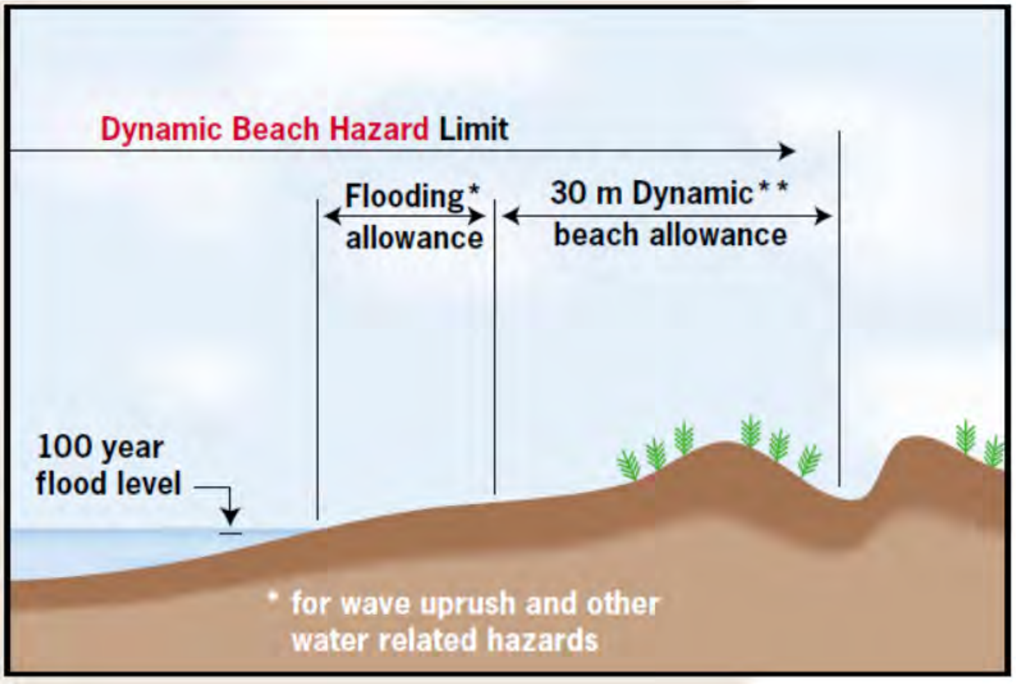


Figure 4.4: Dynamic beach hazard limit (from MNR, 2001a)

5. Shoreline Reaches

The shoreline was divided into reaches to support the mapping of the natural hazards (flood, erosion, and dynamic beach). Shoreline reaches are segments of shoreline having relatively uniform physical characteristics (MNR, 2001a). In establishing the reaches, the following factors were considered: shoreline type, controlling nearshore substrate, surficial nearshore substrate, and shoreline exposure and planform. Reaches defined by the Conservation Authority (CA) for previous mapping were used as a starting point and then refined. The reaches used for the mapping are shown in Figure 5.1 and summarized in Table 5.1 including: reach number, general location, brief description of the shoreline, and approximate reach length. The hazard mapping, provided under separate cover, shows reach boundaries at higher resolution (1:2000).

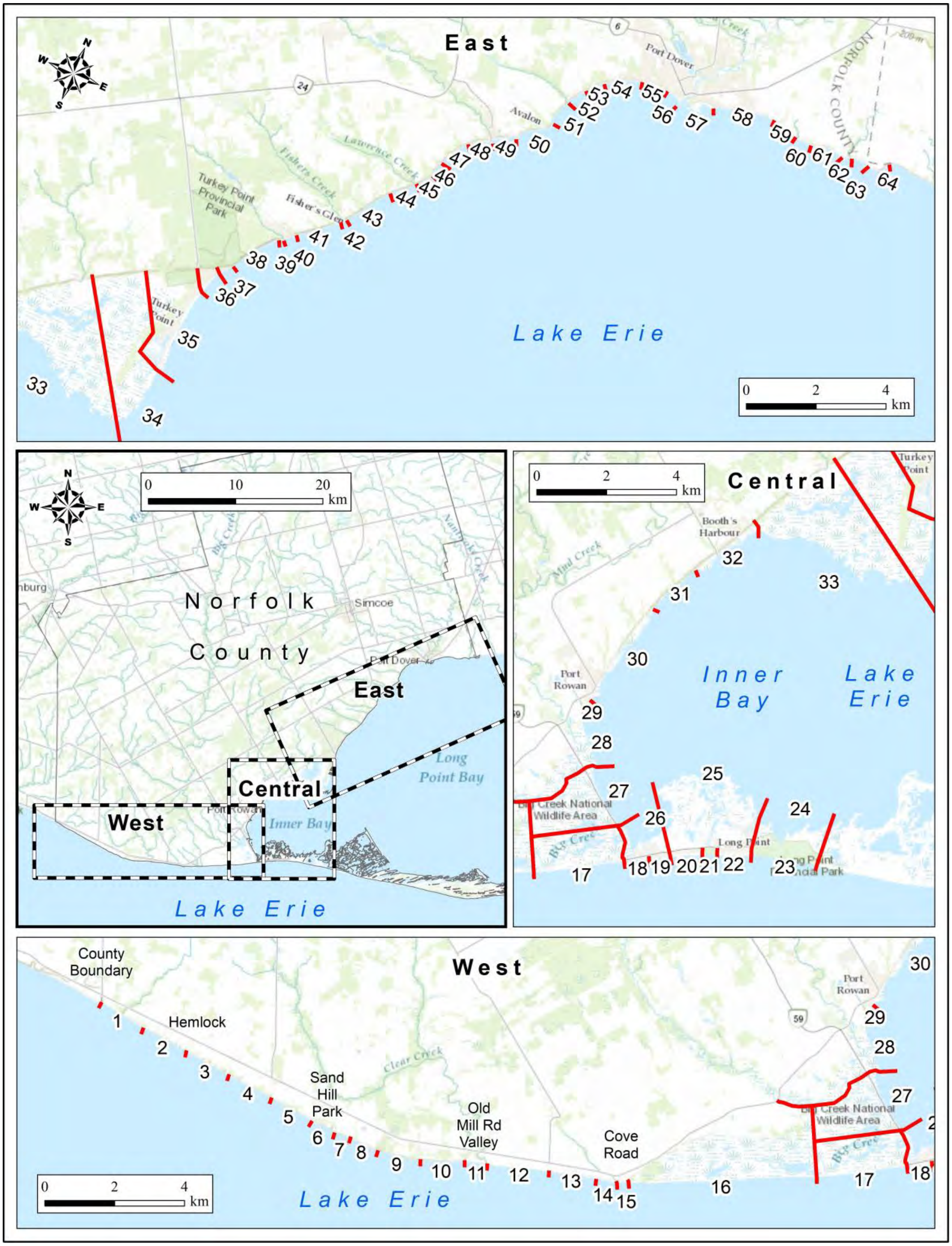


Figure 5.1: Reaches used for natural hazard delineation on Lake Erie, Norfolk County

Table 5.1: Reaches with location, description, and length

Reach #	Location (Approximate)	Description	Length (m)
1	County Boundary-Elgin Road 55 to North Road	Eroding bluff, ~25 m height	1400
2	North Road to 1st Concession ENR	Eroding bluff, ~30 m height	1400
3	1st Concession ENR to 2nd Concession ENR	Eroding bluff, ~30 m height	1380
4	2nd Concession ENR to County Road 28	Eroding bluff, ~25 m height	1390
5	County Road 28 to Sand Hill Park	Eroding bluff, ~25 m height	1300
6	Sand Hill Park	Eroding bluff and sand dune, up to 50 m height	750
7	East of Sand Hill Park	Eroding bluff, ~25 m height	480
8	East of 5th Concession Road ENR	Eroding bluff, ~up to 30 m height	870
9	Concession Lake Road South Side, Lots 14 & 15	Eroding bluff, ~25 m height	1280
10	Lots 16 & 17	Eroding bluff, ~20 m height	1275
11	Valley of Old Mill Road	Eroding lowland, 2-7 m height	640
12	Lots 19-21, West of Houghton First Baptist Church	Eroding bluff, ~15 m height	1780
13	East of Houghton First Baptist Church to Gore Road	Eroding bluff, ~10 m height	1360
14	Gore Road to creek	Eroding bluff, ~8 m height	620
15	Cove Road	Eroding bluff, ~6 m height	340
16	Big Creek wetland area	Dynamic beach	5385
17	Hastings Drive	Dynamic beach	2620
18	Long Point Community, West of Harmony Lane	Dynamic beach	710

Reach #	Location (Approximate)	Description	Length (m)
19	Long Point Community, East of Harmony Lane to 81 Woodstock Avenue	Dynamic beach	630
20	Long Point Community, 81 Woodstock Ave. to Cottonwood Campground	Dynamic beach	890
21	Long Point Provincial Park, Cottonwood Campground	Dynamic beach	430
22	Long Point Community, Beach Avenue and Sandy Lane	Dynamic beach	960
23	Long Point Provincial Park	Dynamic beach	1870
24	Long Point Provincial Park, north shore	Marsh, dynamic beach	1960
25	Long Point, north shore	Marsh, dynamic beach	3550
26	Long Point north shore, Coletta Bay, Teal to Amy Avenues, marinas along Long Point Road	Marsh, dynamic beach, marinas	2670
27	Long Point Causeway south of Big Creek	Marsh	1680
28	Long Point Causeway north of Big Creek	Marsh	1400
29	South of Port Rowan	Vegetated 8 m bank	500
30	Port Rowan and North, Bayview Harbour Marina, Shady Aker's Marina, to marina at 340 Front Street	Marsh	3220
31	380 to 648 Front Street	Vegetated bank ~ 20 m+, no marsh	1500
32	Booth's Harbour	Marsh	2030
33	Turkey Point marsh facing south to Inner Bay	Marsh	5260
34	Turkey Point marsh facing east to Long Point Bay	Marsh	2380
35	Turkey Point, MacDonald Turkey Point Marina entrance North to Turkey Point Road	Dynamic Beach	2600

Reach #	Location (Approximate)	Description	Length (m)
36	Turkey Point, Turkey Point Road North to Old Hill Road	Dynamic Beach	700
37	Turkey Point, Old Hill Road North to Turkey Point Provincial Park Golf Course	Armoured shoreline	450
38	Turkey Point Provincial Park Golf Course, Ryerson Camp East to 122 Hill Lane	Eroding Bank, ~ 33 to 44 m	1440
39	Normandale, 37 to 42 Mill Lane	Armoured shoreline	160
40	Normandale, East of Normandale Creek to 220 Hillside Avenue	Armoured shoreline	380
41	Between Normandale and Fishers Glen	Eroding bank, ~ 18 m t	1330
42	Fishers Glen	Beach on either side of creek	220
43	North of Fishers Glen, Triple C Bible Camp, to gully East of 2740 Front Road	Eroding bank, ~ 23 to 27 m	1430
44	West of Lawrence Creek	Eroding bank, ~ 23 m	810
45	East of Lawrence Creek, 2916 and 2960 Front Road	Eroding bank, ~ 18 m	600
46	2960 and 3016 Front Road	Eroding bank, ~ 20 m, can’t measure recession because of bank regrading and forest cover	480
47	3053 Front Road, Norfolk Conservation Area, 490 Ryerse Boulevard	Eroding bank, ~ 16 m	810
48	Port Ryerse, 500 Ryerse Boulevard to Young Creek	Fillet beach	700
49	Port Ryerse, East of Young Creek to point	Eroding bank, ~ 18 m, mostly armoured	660
50	Point on 6 Evans Street to Avalon Lane	Eroding bank, ~ 18 m height	1320
51	184 Gilbert Road and West half of 422 Radical Road	Eroding bank, ~ 20 m	720
52	To 18 Blueline Road	Eroding bank, ~ 20 m	530

Reach #	Location (Approximate)	Description	Length (m)
53	18 Blueline Road to 544 Radical Road	Eroding bank, ~ 20 m	540
54	574 Radical Road (Shore Acres Park) to 615 Nelson Street	Extensive shore protection, bank ~ 14 to 18 m	1020
55	Water Treatment Plant at 603 Nelson Street, East to Regent Street	Extensive shore protection	720
56	Port Dover beach	Fillet beach	450
57	Port Dover marina	Marina with armourstone breakwall	1310
58	East of marina, from Ontario Street to 232 New Lakeshore Road	Extensive shore protection, bank ~ 12 to 15 m	1720
59	256 New Lakeshore Road to 342 New Lakeshore Road	Extensive shore protection, bank ~ 13 m	760
60	358 to 404 New Lakeshore Road	Extensive shore protection, bank ~ 12 m	540
61	418 New Lakeshore Road to 538 New Lakeshore Road	Extensive shore protection, bank ~ 10 to 12 m	900
62	544 New Lakeshore Road, including Faurie's Creek	Rocky headland, bank ~ 10 m	360
63	572 New Lakeshore Road to 12 Ramona Crescent	Extensive shore protection, bank ~ 8 to 12 m	480
64	14 Ramona Crescent to 82 Old Lakeshore Road (County Boundary)	Rocky headland, bank ~ 12 m	750

6. Technical Analyses

6.1 100-Year Flood Level

Return period water levels for locations on the Great Lakes were developed by the Ontario Ministry of Natural Resources (MNR, 1989). The return period water level estimates in MNR (1989) were developed for static lake levels (i.e. monthly mean levels), storm surge, and all combinations of static lake levels and storm surge. The statistical analyses were conducted using the HYDSTAT software package developed by MNR (1982). The report defines the 100-year flood level, which is the still-water level (or peak instantaneous water level) having a 1% annual chance of being equalled or exceeded. The still-water level is equivalent to the hourly water level.

Unless otherwise noted, all water levels are reported in IGLD85. Datum conversions are listed in Table 6.1. The conversion from IGLD85 to CGVD2013 is based on the NRCan Benchmark Station Reports.

Table 6.1: Datum conversions for Port Dover and Port Stanley

Datum	**Port Dover** **NRCAN Benchmark MMDCCXXX**	**Port Stanley** **NRCAN Benchmark 75U2001**
IGLD1955	175.627	175.574
IGLD1985	175.797	175.764
CGVD28	175.793	175.740
CGVD2013	175.341	175.293

6.1.1 Static Water Levels

In MNR (1989), the historical monthly mean lake levels from 1900 to 1988 were adjusted to the constant set of conditions existing after about 1960 (regulation conditions, diversions, etc.) to form a consistent basis of comparison. The “Basis of Comparison” Lake Erie water levels are shown in Figure 6.1 with the measured water levels (1918-2018).

Considering that an additional 30 years of data has been measured since 1988, and recognizing the 1970s to 1990s were a period of higher water levels in the Great Lakes, Baird updated the static water level return periods for Port Dover and Port Stanley using only the measured data corresponding to the period of hourly water level measurements (January 1962 to June 2019). This is a conservative approach (i.e. errs on the side of higher extreme lake levels). In June 2019, Lake Erie reached its highest monthly mean lake level ever recorded. The preliminary mean monthly water level for June 2019 (175.14 m IGLD85) was included in the Extreme Value Analysis. The data set includes 58 years of water level measurements under conditions (flow regulation, diversions, dredging, etc.) similar to the present.

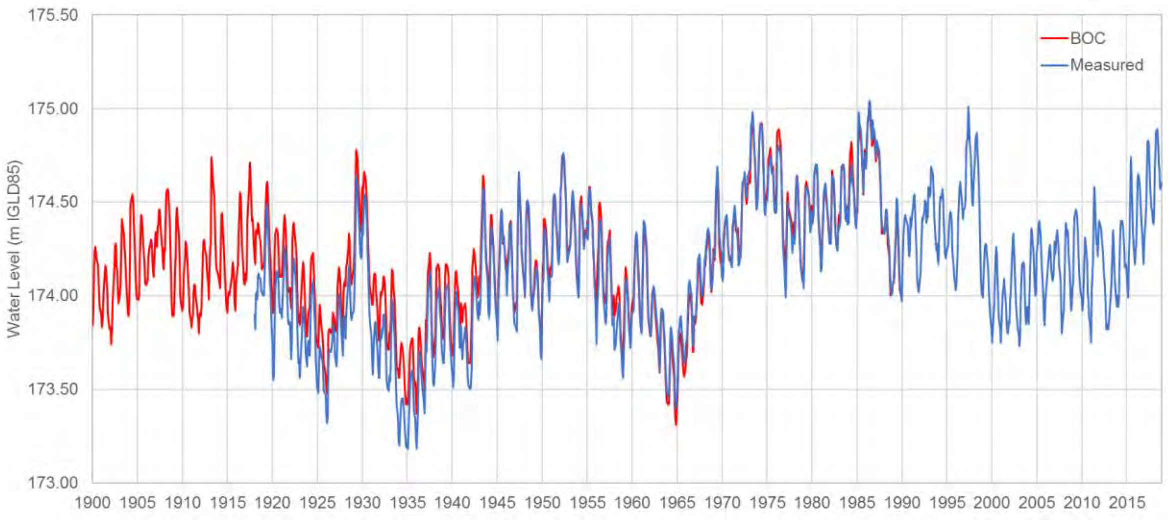


Figure 6.1: Lake Erie measured and "Basis of Comparison (BOC)" monthly water levels

6.1.2 Surge Levels

Storm surge (or wind setup) was calculated in MNR (1989) by subtracting the mean monthly water level from the hourly water level measurements. A computer model was used to estimate storm surges for locations between gauge stations.

Baird updated the storm surge analysis using the 58 years of hourly water level data (1962-2019). In the analysis, static water levels were calculated using a Gaussian-weighted 30-day moving average filter to eliminate the stairstep effect between months. Surge was calculated by subtracting the hourly water level measurements from the "smoothed" static water level. Hourly water levels, calculated static levels, and calculated surges for Port Dover are shown in Figure 6.2.

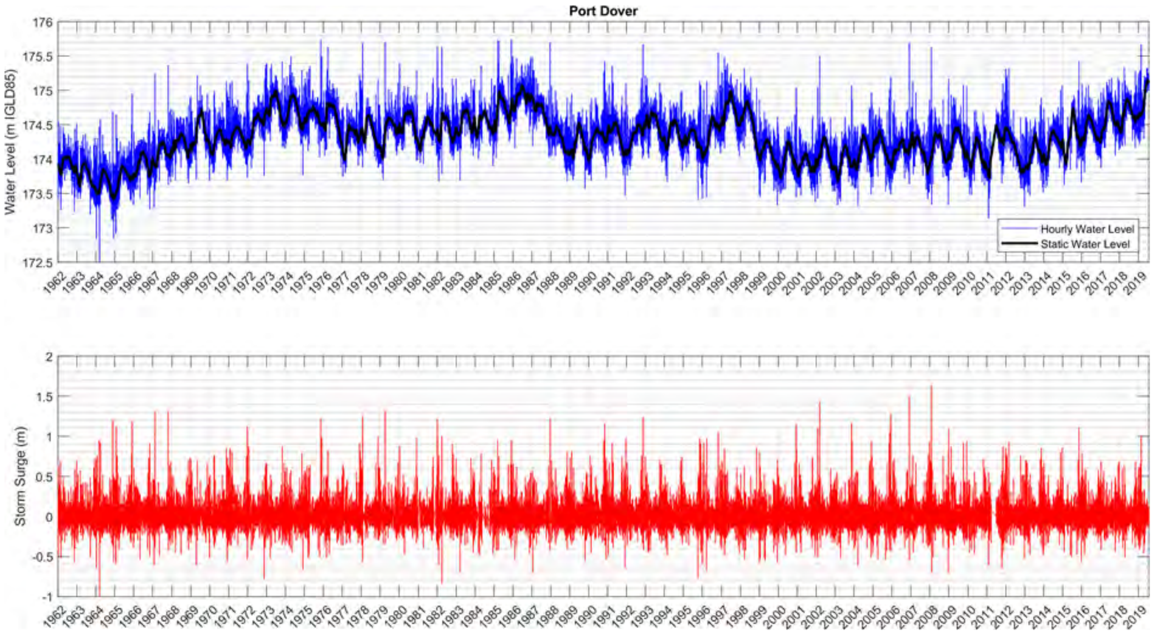


Figure 6.2: Hourly and static water level and calculated surge at Port Dover January 1962 to July 2019

Considering that surges are driven by independent storm events, a peak-over-threshold analysis was used to identify the largest surge events in the dataset. Using this method, more than one surge event can be identified per year. A listing of the largest surge events at Port Dover and Port Stanley is provided in Table 6.1. Port Dover is subject to larger surges than Port Stanley. The largest surge on record at Port Dover occurred on January 30, 2008.

Table 6.2: Listing of largest surge events at Port Dover and Port Stanley January 1962 to June 2019

Rank	Port Dover			Port Stanley		
	Date	Surge (m)	Water level (m IGLD85)	Date	Surge (m)	Water level (m IGLD85)
1	2008-01-30 08:00	1.63	175.63	1978-01-26 13:00	0.81	175.16
2	2006-12-01 19:00	1.50	175.69	1987-12-15 21:00	0.71	175.12
3	2002-03-10 00:00	1.44	175.50	1964-03-05 12:00	0.63	174.16
4	1967-02-16 07:00	1.31	175.24	2000-12-12 9:00	0.56	174.42
5	1967-10-27 20:00	1.31	175.37	1985-12-02 8:00	0.54	175.33

6.1.3 Return Period Water Levels

The HYDSTAT software package was used to estimate the return period static water levels, surge levels, and joint probability of static water levels and storm surge (still-water levels). The input data consisted of the annual maximum monthly water levels for 1962 to June 2019 and the 58 largest surges over this period. In June 2019, Lake Erie reached its highest recorded monthly mean lake level. The Log-Pearson Type 3 distribution, which was the best fitting distribution, was selected in the analyses.

The existing (MNR, 1989) and updated return period water levels for Port Dover and Port Stanley are summarized in Table 6.3 and Table 6.4 respectively. The updated 100-year still-water levels are within 5 cm of the levels in MNR (1989). Following review and discussion with the Project Team, LPRCA decided to maintain the existing 100-year flood levels and the 100-year flood level used in the Norfolk County hazard mapping is therefore as defined in MNR (1989).

Table 6.3: Port Dover return period water levels

Study	Water Level	Return Period Water Level (m and m IGLD85)						
		2 year	5 year	10 year	25 year	50 year	100 year	200 year
OMNR (1989)	Static	174.35	174.59	174.72	174.84	174.93	175.00	175.06
	Surge	1.15	1.32	1.42	1.52	1.59	1.66	1.72
	Stillwater	175.50	175.79	175.94	176.10	176.20	**176.30**	176.38
Baird (2019)	Static	174.53	174.77	174.89	175.01	175.09	175.16	175.22
	Surge	1.01	1.17	1.28	1.43	1.55	1.67	1.81
	Stillwater	175.56	175.85	175.99	176.15	176.25	**176.34**	176.42
Difference	Stillwater	0.06	0.06	0.05	0.05	0.05	**0.04**	0.04

Table 6.4: Port Stanley return period water levels

Study	Water Level	Return Period Water Level (m and m IGLD85)						
		2 year	5 year	10 year	25 year	50 year	100 year	200 year
OMNR (1989)	Static	174.37	174.61	174.74	174.86	174.95	175.02	175.08
	Surge	0.40	0.53	0.63	0.75	0.85	0.96	1.07
	Stillwater	174.79	175.06	175.20	175.36	175.45	**175.54**	175.63
Baird (2019)	Static	174.53	174.77	174.89	175.01	175.09	175.16	175.22
	Surge	0.37	0.45	0.51	0.61	0.70	0.80	0.92
	Stillwater	174.92	175.17	175.30	175.43	175.51	**175.59**	175.65
Difference	Stillwater	0.13	0.11	0.10	0.07	0.06	**0.05**	0.02

The 100-year flood levels for Port Dover and Port Stanley used to define the stillwater levels in the Norfolk County hazard mapping are summarized in Table 6.5. The 100-year flood levels were defined for each reach using a linear interpolation between the 100-year flood levels at Port Dover and Port Stanley adjusted to CGVD2013 datum. The values used in the mapping are discussed further in Section 7.1.

Table 6.5: 100-year flood levels at Port Dover and Port Stanley used for flood hazard mapping

Gauge Location	100-year Flood Level (m IGLD85)	100-year Flood Level (m CGVD2013)
Port Dover	176.30	175.84
Port Stanley	175.54	175.07

6.2 Wave Uprush

Wave uprush (runup), wave overtopping, and the inland extent of overtopping waves were calculated for each of the 64 shoreline reaches using a representative shoreline profile for each reach. The analysis used the 100-year flood level with the 20-year wave condition as per MNR (2001a). The definition sketch for wave uprush is shown in Figure 6.3. In this figure, “R” is the wave runup height for threshold extension of slope, “F” is the freeboard height; and “Ls” is the maximum distance that an overtopping wave is predicted to travel inland. The distance “Ls” is proportional to the excess runup (R minus F) and the wave period. The wave uprush allowance is equal to the horizontal extent of the wave runup on the slope measured from the 100-year flood level plus the distance “Ls”.

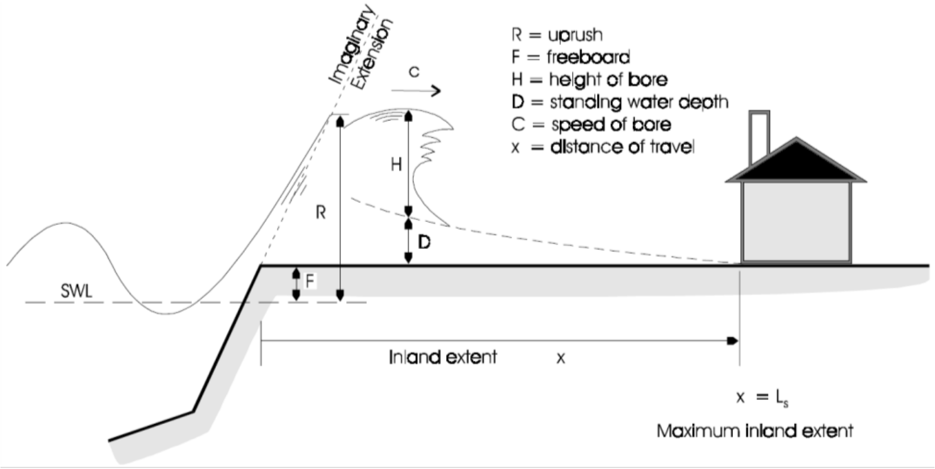


Figure 6.3: Definition sketch of wave uprush over low bluff (from MNR, 2001a)

6.2.1 Nearshore Wave Modelling

The two-dimensional spectral wave model, MIKE21 SW, was used to transform the offshore "deep water" wave conditions from the US Army Corps of Engineers (USACE) Wave Information Study (WIS) to the Norfolk County shoreline. The WIS hindcast consists of hourly wave data for 1979-2014. The nearshore wave model bathymetry was developed using a gridded bathymetric dataset of Lake Erie from NOAA and Canadian Hydrographic Service (CHS) and the 2019 bathymetry collected by Monteith & Sutherland at Long Point as part of this project. The 2018 CHS bathymetric LiDAR was not used for the nearshore wave modelling due to the incomplete coverage of the study area and level of effort required to merge the datasets (ensuring smooth transitions between datasets). However, the CHS bathymetric LiDAR was used for the shoreline profiles to estimate the wave uprush.

The model domain extends approximately 7 km east and 7 km west of Norfolk County and the offshore boundary was selected to coincide with the WIS output points. The model mesh is composed of approximately 245,000 triangular elements which vary in size from 250 m at the offshore boundary to 50 m at the nearshore. The model mesh, bathymetry, and WIS output points are shown in Figure 6.4.

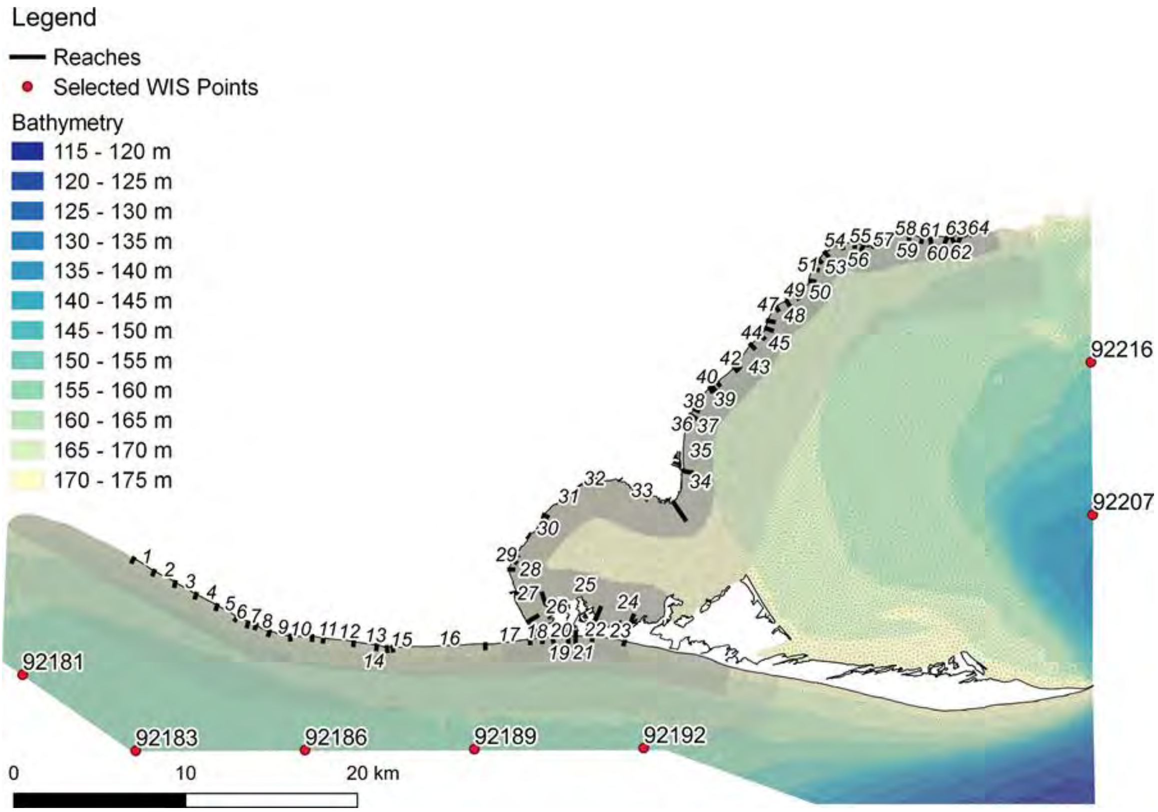


Figure 6.4: MIKE21 Spectral Wave model of the Norfolk County shoreline

The nearshore wave model was run using spatially varying water levels corresponding to the 100-year flood levels at Port Dover and Port Stanley (interpolated over the model domain) and the 20-year offshore wave conditions at the WIS output points. The 20-year offshore wave heights varied between 6.4 m at the westernmost WIS point and 4.0 m at the easternmost WIS point. A series of model runs were carried out using the range of wave heights, periods, and directions that corresponded to the 20-year wave condition at the seven WIS output points. Wind conditions were examined for the selected storm events, and an onshore wind of 25 to 28 m/s was applied in the model runs.

An output point was defined at each of the 64 shoreline profiles (reaches), approximately 200 m from the shoreline. The wave direction vectors were examined for each of the model runs to determine the envelope of nearshore output points influenced by the particular model run (combination of wave height, period, and direction for a particular WIS output point). For example, Profiles 16-23 are influenced by the WIS output points 92186 and 92189 shown in Figure 6.5. The 20-year wave condition at each of the profile locations was selected as the maximum wave condition from the series of corresponding model runs.

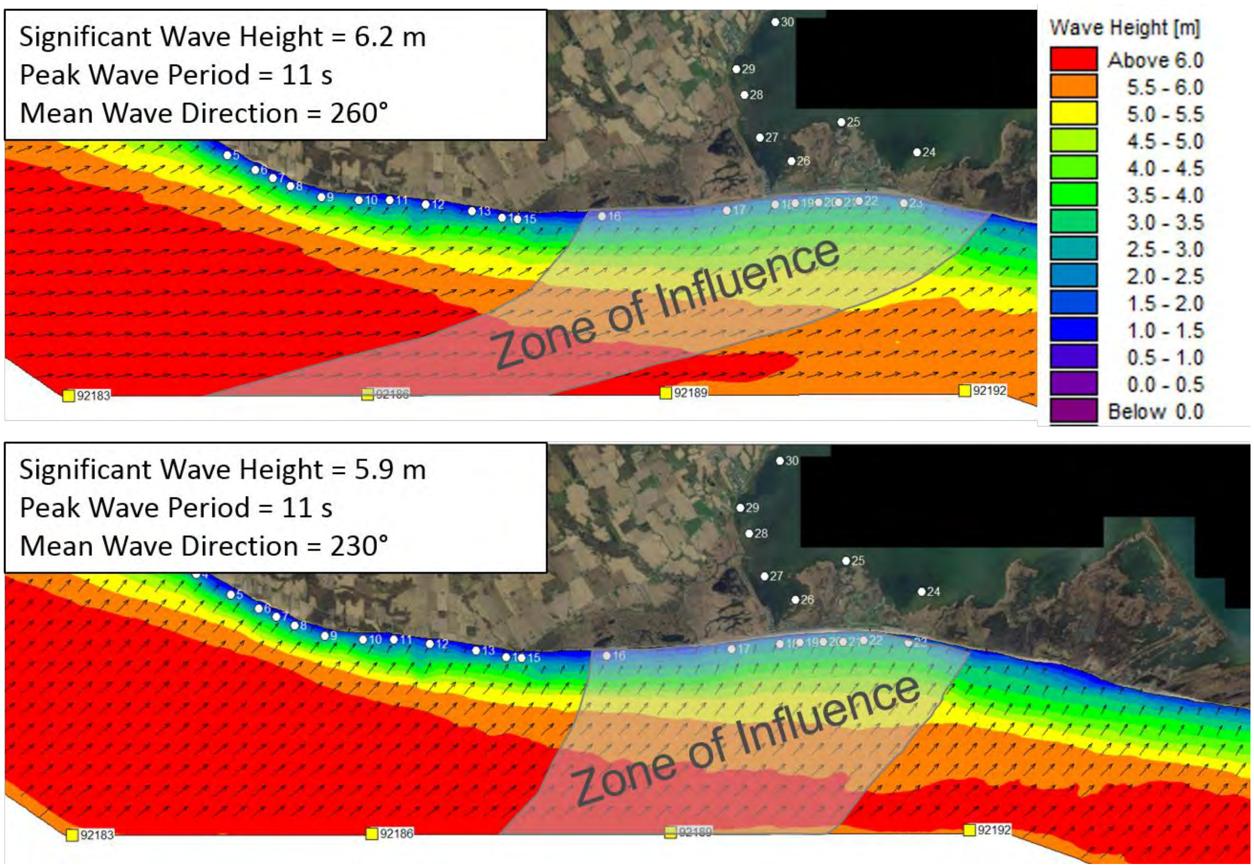


Figure 6.5: Example of nearshore wave modelling and selection of model runs for reach locations

6.2.2 Wave Uprush Analysis

Wave uprush (runup) elevations and horizontal distances were calculated for each reach using a representative shoreline profile. The shoreline profiles were extracted from a high-resolution merged dataset (listed in order of priority for use in developing) of the 2017 SWOOP LiDAR, 2018 DFO bathymetric LiDAR and the NOAA/CHS Lake Erie bathymetry. At Long Point, the profiles were developed from the 2019 Monteith & Sutherland survey and 2017 SWOOP LiDAR. The profiles were schematized to define the nearshore lakebed slope, water depth at the toe of slope, lower slope, beach berm (if applicable), upper slope, and crest height. Wave runup elevations were calculated for each profile using the empirical equations in the EurOtop overtopping manual (Van der Meer et al., 2018) for the 100-year flood level, 20-year wave conditions (from the nearshore wave modelling), and schematized shoreline profile.

An example of the wave runup elevation and corresponding horizontal runup distance on a high bluff is shown in Figure 6.6. In this example, the wave runup is 5.0 m above the 100-year flood level, and the corresponding horizontal runup distance is 8 m.

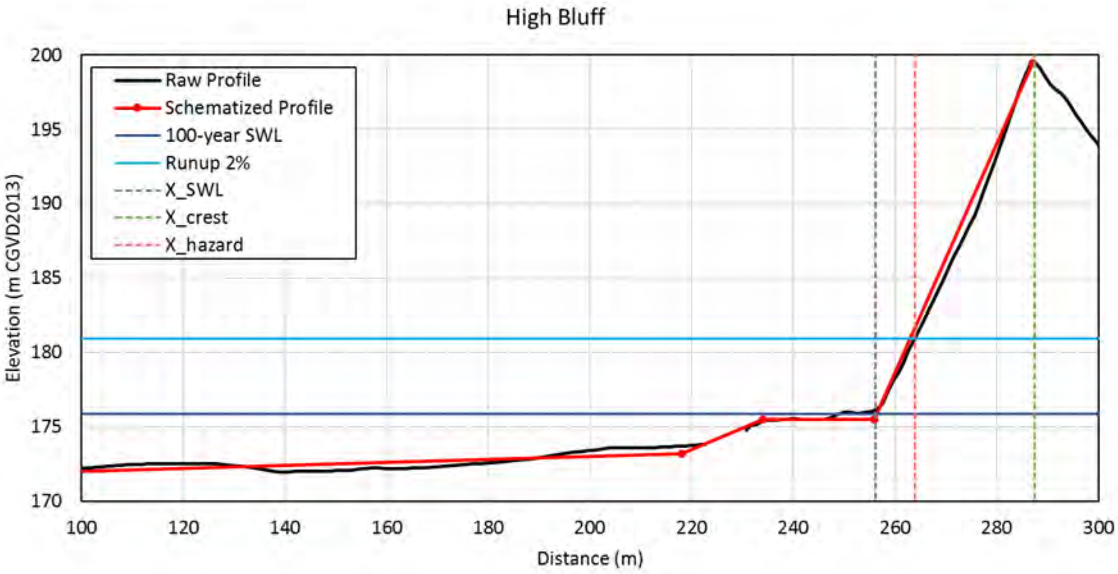


Figure 6.6: Example of wave uprush on a high bluff

An example of wave runup on a low bluff is shown in Figure 6.7. In this example, the wave runup is 4.5 m above the 100-year flood level, which exceeds the height of the bluff by 3.6 m.

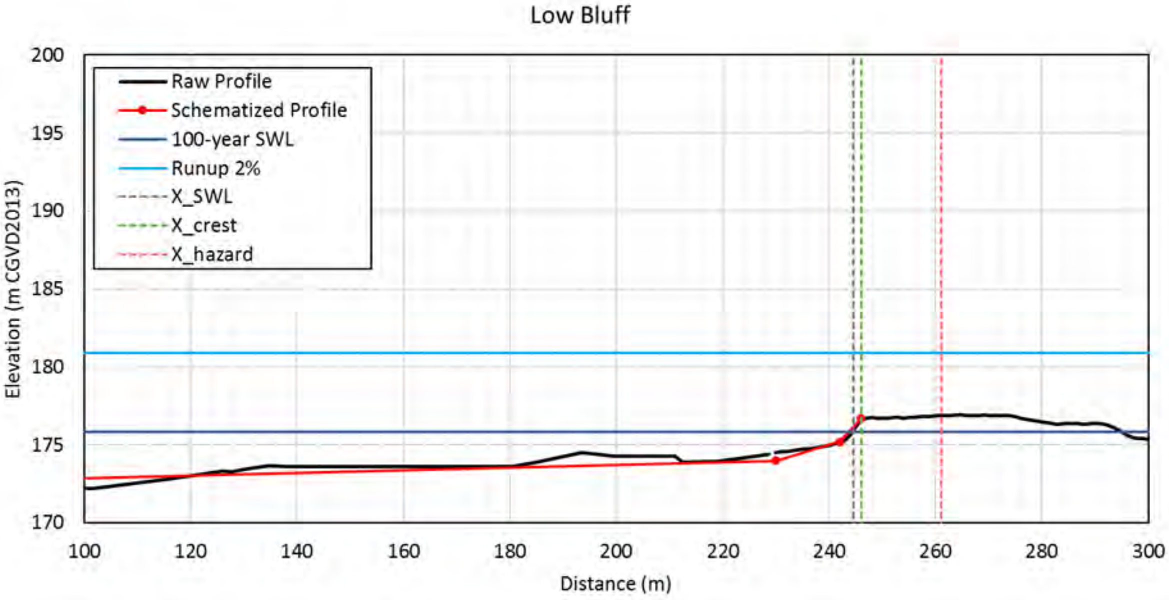


Figure 6.7: Example of wave uprush on a low bluff

When the wave runup exceeds the height of the bluff, the inland extent of the overtopping wave is then calculated according to the Cox-Machemehl equation (Eq. 1), as presented in MNR (2001a) and shown in Figure 6.3.

$$L_s = \frac{T\sqrt{g}}{5}(R-F)^{1/2}$$

where:

Ls = horizontal extent of wave uprush measured from the slope crest
T = wave period
g = acceleration due to gravity
R = wave runup
F = freeboard

In the example shown in Figure 6.7, the horizontal extent of wave uprush is 17 m (4 m horizontally on the slope and 13 m from the slope crest to the distance Ls).

6.3 Ice Impacts

A risk assessment of ice ride-up/piling was conducted for the Norfolk County Lake Erie shoreline. This phenomenon is also sometimes called an ice shove, ice surge, or ice tsunami in newspapers and local media.

MNR (2001a) describes the process as being caused by onshore winds and waves. The wind and wave action help to break up the ice into smaller floes, providing the conditions needed for ice piling (MNR, 2001a). Onshore winds drive the ice floes into the shoreline, which then pile-up under their own momentum. Generally, ice piling does not cause serious damage to beaches, bulkheads, and riprap revetments (MNR, 2001a). However, shore perpendicular structures (e.g. groynes, dock walls, piers, etc.), buildings, and other infrastructure may be significantly damaged by ice piling. MNR (2001a) notes that local experience with the impacts of ice piling is the best guide to help define the extent of the ice hazard.

A photograph of the February 25, 2019 ice pile-up event at Fort Erie, Ontario (east of Norfolk County) is shown in Figure 6.8. No historical ice pile-up events of this magnitude were identified by the project team for Norfolk County.

Figure 6.8: Ice pile-up along Lake Erie shoreline in Fort Erie, Ontario during Feb 25, 2019 (Mazza, 2019)

This section of the report includes a review of historical ice pile-up events in Norfolk County, shoreline conditions vulnerable to ride-up/pile-up processes, and evaluation of the risk of ice pile-up for the 64 shoreline reaches in Haldimand County.

6.3.1 Historical Ice Pile-up Events

A literature review was conducted to understand the historical risk of ice damage along the Norfolk County shoreline, and to obtain information or reports of past occurrences. From the literature review, and consultation with representatives of LPRCA and Norfolk County, it appears Norfolk County has historically had low impact due to ice pile-up.

Anecdotal information obtained during the literature review and consultation indicated that occasional ice jams can occur at the mouth of the Lynn River at Port Dover, with resulting backwater effects. Flooding in this area occurred during the February 25, 2019 storm where high water levels in the Lynn River floated large chunks of ice over the banks, trapping at least one person inside their home who required rescue by local firefighters (Port Dover Maple Leaf, 2019).

During this same storm event, strong winds and high lake levels resulted in ice piling and slush deposits onto roads near Walker St. Beach in Port Dover, and Willow Beach Lane in Simcoe (Figure 6.9). At Port Dover, the ice migrated landward up to approximately 50 m from shore near Walker St. Beach and resulted in minor damage to structures and infrastructure. The pile-up that occurred in Port Dover was in the form of large ice sheets that were pushed ashore, as opposed to large piles of broken ice rubble (such as in Figure 6.8).

Figure 6.9: Ice pile-up along Walker St. in Port Dover, at The Beach House looking East (Sonnenberg, 2019)

Additional information obtained from LPRCA indicates that ice tends to build up every year along the shoreline on the south side of Long Point due to strong winds, although no significant damages have been reported in this area due to ice. Ice spray can occur during winter months when the lake is not completely frozen, or ice has been broken up by wave action. This combined with winds, results in the spray from waves icing structures along the shoreline.

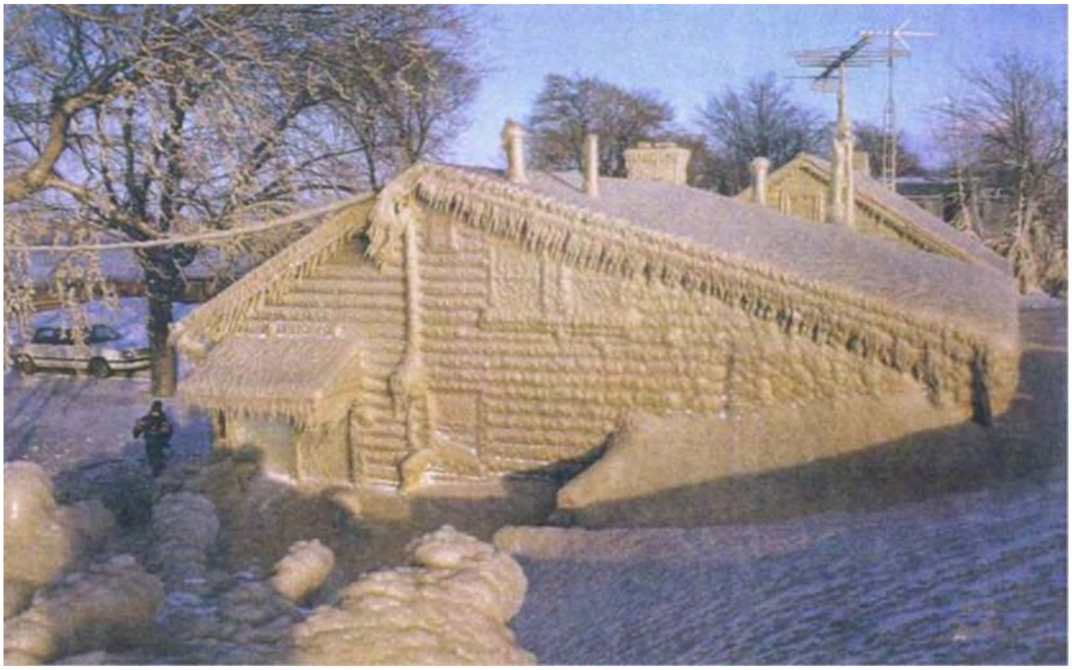


Figure 6.10: Example of Lake Erie ice spray on Erie Shore Drive (from LTVCA, date unknown)

In general, the literature review indicates that ice pile-up events are not frequent along the Norfolk County shoreline. Ice piling is more common along the Niagara County shore of Lake Erie, where ice pile-up events have occurred in 2014, 2018, and 2019 (see Figure 6.8). In addition to Fort Erie (located east of Norfolk County), Erieau and Wheatley (located west of Norfolk County) have also experienced significant ice piling in the past and are indicated as areas prone to ice piling in Figure 6.11 (from MNR, 2001a).

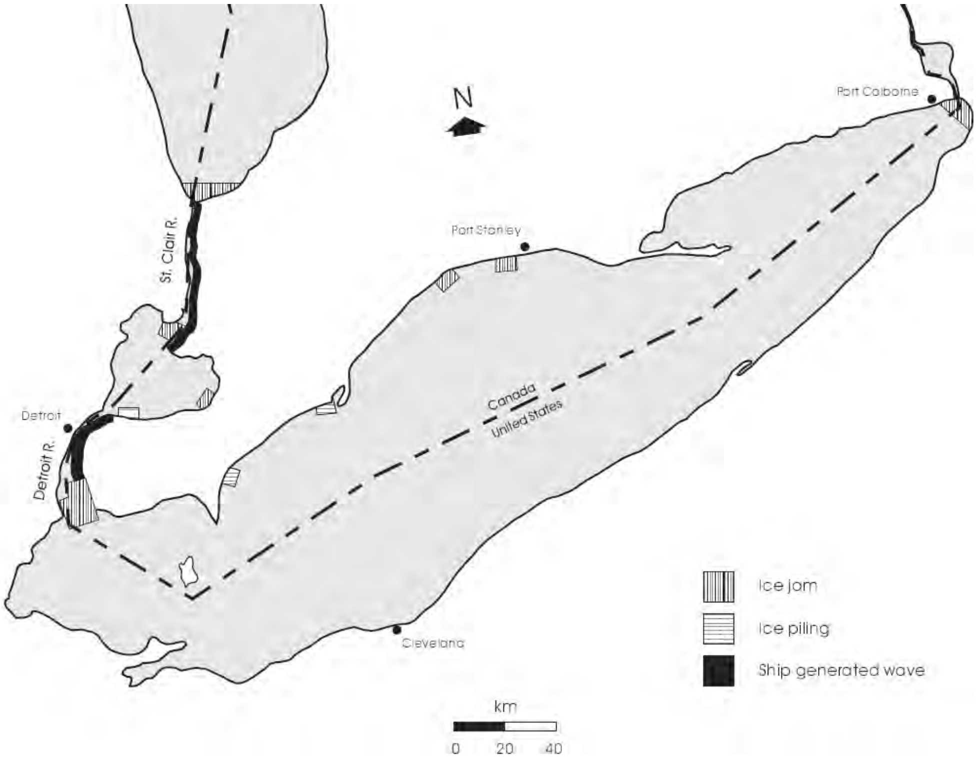


Figure 6.11: Ontario locations on Lake Erie vulnerable to ice piling (MNR, 2001a)

6.3.2 Shoreline Conditions Vulnerable to Ice Ride-up/Pile-up

Ice ride-up tends to occur in places where the water is relatively deep, and the shore is relatively low and flat. Canadian experience on the Great Lakes and St. Lawrence River indicate that slopes of 2H:1V or steeper above the water line and about 4H:1V or flatter below the water line tend to limit ice pileup and damage (MacIntosh et al., 1995; Danys, 1979). The steeper slopes above the water line tend to contain the amount of ice ride-up/pile-up, and flatter slopes below the water line, or berms, will cause the ice to ground on the lakebed rather than pileup on the shoreline (MNR, 2001a).

6.3.3 Shoreline Risk Assessment

The risk of ice ride-up/pile-up was evaluated for the 64 shoreline reaches in Norfolk County based on the height of the shoreline bluff, shoreline orientation, above water slope, and below water slope. The open-water fetch distance for all reaches is sufficient for ice piling to occur.

The risk of ice ride-up/pile-up was estimated for each reach using the following criteria:

1. Freeboard Risk Factor:
    - 100% risk of ice ride-up when the bluff is at the same elevation as the 100-year flood level,
    - 0% risk of ice ride-up when the bluff is 3 m above the 100-year flood level.
2. Azimuth Risk Factor:
    - 100% risk of ice ride-up when the wind is perpendicular to the shoreline and onshore,
    - 0% risk of ice ride-up when the wind is parallel to the shoreline or offshore.
3. Lower Slope Risk Factor:

  - 100% risk of ice ride-up when the below water slope is 2H:1V or steeper,
  - 0% risk of ice ride-up when the below water slope is 4H:1V or flatter.
4. Upper Slope Risk Factor:
  - 100% risk of ice ride-up when the above water slope is 4H:1V or flatter,
  - 0% risk of ice ride-up when the above water slope is 2H:1V or steeper.

The risk factors were assessed using the reach profiles developed for the wave uprush estimates. The 100-year flood level was used for the freeboard risk factor estimates and is representative of a high-water condition that could occur during an ice pile-up event. Three metres was selected as a reasonable bluff height that would contain/limit the landward progression of an ice pile-up event.

The azimuth (shoreline orientation) risk factor was calculated using the 40-year wind/wave hindcast for all wind occurrences over 10 m/s.

Based on information obtained from the literature review in relatively similar conditions to what is experience along Norfolk County's shoreline (MacIntosh et al., 1995), both the lower and upper slopes of each reach profile were considered independently. For the lower slope, 2H:1V or steeper tends to promote the ice ride-up process, while slopes 4H:1V or milder will tend to promote grounding of the ice sheet and prevent ice ride-up. If the ice sheet is able to reach the upper slope, an upper slope of 2H:1V or steeper tends to prevent the ice from riding up the beach, while 4H:1V or milder will not. The slopes were considered with the associated bounds, and risk factors were calculated for each.

Given the limited information available on the quantification of different parameters and their influence on the overall ice ride-up process, minimum and maximum bounds were chosen for each parameter based on information obtained from the literature review, and a linear interpolation was done in between these bounds (see Figure 6.12).

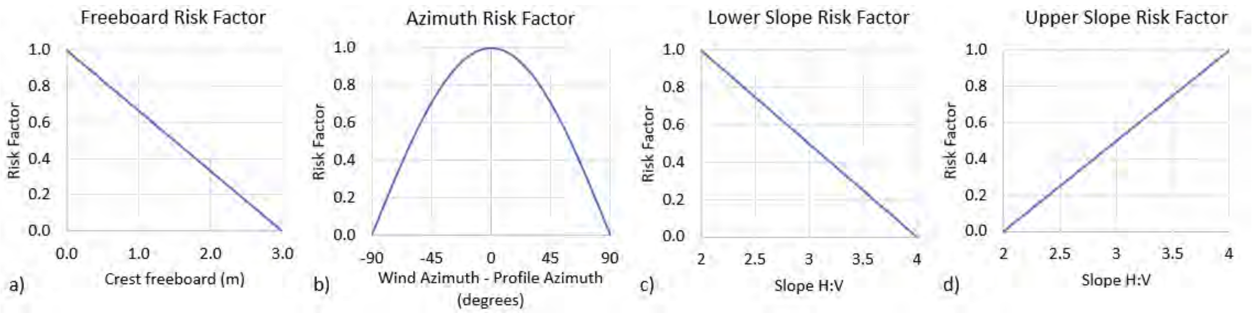


Figure 6.12: Functions used to estimate ice ride-up/pile-up risk factors

A combined Risk Factor (CRF) was calculated based on a weighted average using the equation below.

CRF = (Freeboard RF + Azimuth RF + 0.5* Lower RF + 0.5* Upper RF) / 3

Each reach was then classified as low, medium or high risk for ice ride=up/pile-up as follows: low (CRF<0.33); medium (0.33<CRF<0.66); or high (>0.66). Irrespective of the calculated CRF value, the combined risk of ice ride-up/pile-up was set to "low" for reaches when either of the following conditions were met:

- Height of the shoreline bluff greater than 3 m above the 100-year flood level, or
- Above water slope 2H:1V or steeper and below water slope 4H:1V or flatter.

Table 6.6 summarizes the resulting classifications for each reach along the Norfolk County Shoreline.

Table 6.6: Ice risk classification by reach

Risk of Ice Ride-up	Reaches
Low	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 23, 28, 29, 31, 32, 38, 39, 41, 42, 43, 44, 45, 46, 47, 49, 50, 51, 52, 53, 54, 55, 58, 59, 60, 61, 62, 63, 64
Medium	17, 18, 19, 20, 21, 22, 24, 25, 26, 27, 30, 33, 34, 35, 36, 37, 40, 48, 56, 57
High	none

6.4 Geotechnical Analysis of Stable Slope

The Stable Slope Allowance used to determine the Erosion Hazard Limit (as defined in Section 4.3) is a horizontal allowance measured landward from the toe of the bluff, equivalent to three times the bluff height, or as determined through a study using accepted geotechnical principles (MNR, 2001a). For this project, a study was undertaken by Terraprobe Inc. to determine the stable slope allowance. The complete geotechnical report is provided in Appendix A, and the findings are summarized in this section.

The shoreline generally comprises sand and silt rythmites, glaciolacustrine silt and clay, glacial till, sand dunes, sand beaches, talus and limestone bedrock. Active retrogressive slope failures were observed along some reaches, particularly at the west end of the study area. Stretches of shoreline are protected with armourstone, concrete retaining walls, steel sheet pile, and ad hoc protection. The shoreline at Long Point and Turkey Point includes dynamic beaches and marshes, with no slope at the shoreline.

The stable slope analysis was based on a review of publicly available subsurface information, existing Terraprobe reports for the area, and a detailed visual slope inspection. Cross-sections were developed from the 2017 LiDAR data at 40 representative locations with a focus on the reaches where the Erosion Hazard governs (see Figure 6.13). The subsurface conditions including general stratigraphy were assessed based on publicly available information and visual observations during the site visits. The water table was estimated from well records and site observations of seepage from the slope face.

An engineering analysis of slope stability was completed for each of the 40 locations. The analysis was conducted utilizing computer software (Slide 8.016, released July 23, 2018, developed by Rocscience Inc.) and several standard methods of limit equilibrium analysis (Bishop, Janbu, Morgenstern/Price, and Spencer). These methods of analysis allow the calculation of Factors of Safety for hypothetical or assumed slip surfaces through the slope. The analysis method is used to assess potential for movements of large masses of soil over a specific slip surface which can be curved or circular, or noncircular.

For a specific slip surface, the Factor of Safety is defined as the ratio of the available soil strength resisting movement, divided by the gravitational forces tending to cause movement. A Factor of Safety of 1.0 represents a “limiting equilibrium” condition where the slope is at a point of pending failure since the soil resistance is equal to forces tending to cause movement. It is usual to require a Factor of Safety greater than one (1) to ensure stability of the slope. The typical Factor of Safety used for engineering design of slopes for stability ranges from about 1.3 to 1.5 for developments situated close to the slope crest. For active land use, the MNR Policy Guidelines allow a minimum Factor of Safety of 1.4 to 1.5 for slope stability and a Factor of Safety of 1.5 was used for this study.

The computed factors of safety for the sections analyzed indicated that the majority (23 of 40 sections) have a factor of safety of less than 1.5, which is considered inadequate and unacceptable for long-term planning purposes. An additional setback from the existing top of slope will be required to achieve a long-term stable inclination. Ten (10) of these sections have a factor of safety of less than 1.0. Seventeen (17) of the sections have a factor of safety of 1.5 or greater.

The stable slope was determined for each section considering soil type and available data. The soil type of each section is composed of assumed earth fill, surficial sand, silt and clay, and/or glacial till. The stable slope inclinations for each of the reaches analyzed are listed in Table 6.7, along with the primary soil type. Recommended stable slope inclinations based on interpolation, are also provided for the remaining reaches. Where the slope is earth fill and/or surficial sand, a value of 3H:1V was used. Additional information on slope height, inclination and existing Factor of Safety (FS) are provided in Appendix A.

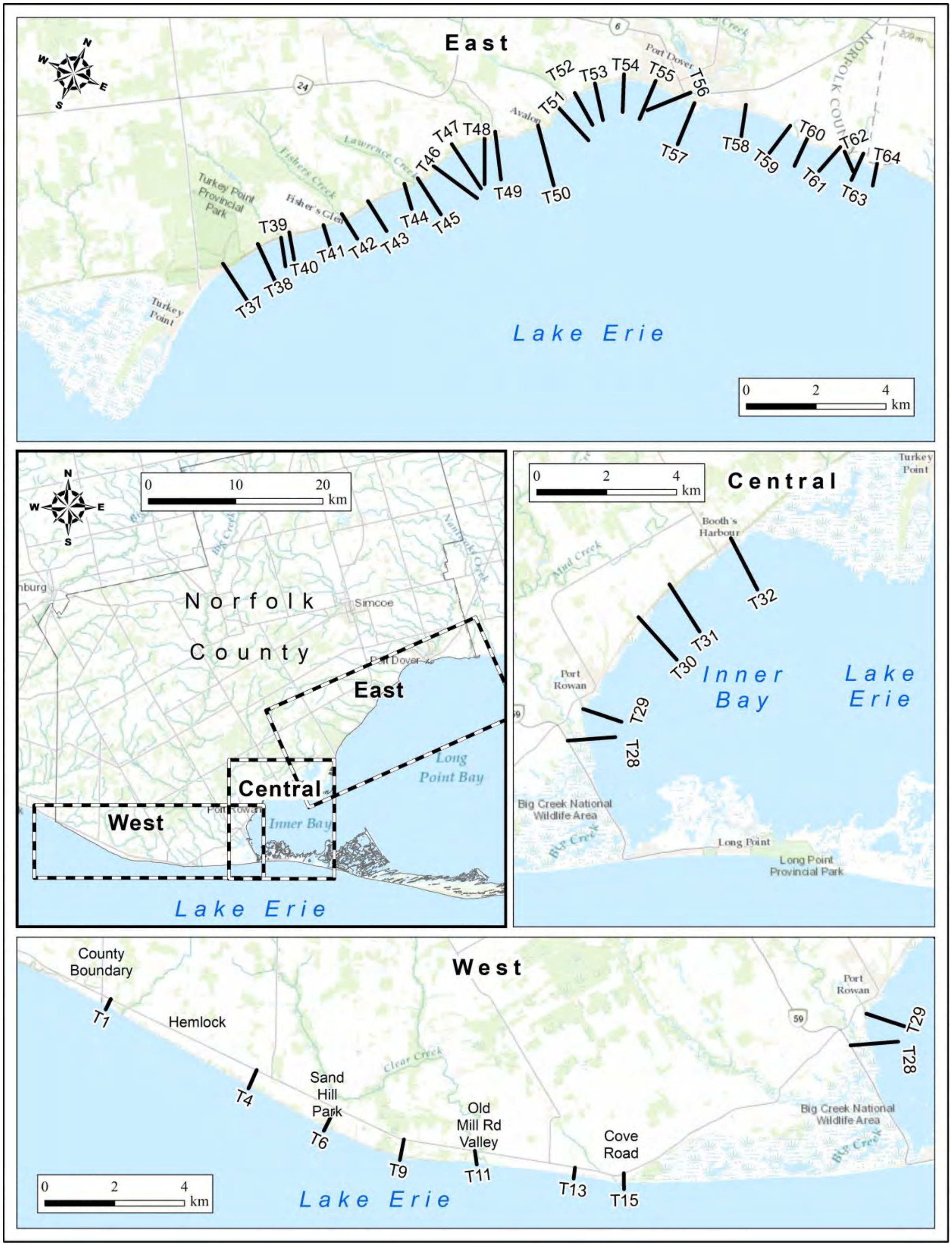


Figure 6.13: Map showing reaches and locations where a stable slope analysis was completed

Table 6.7: Stable slope inclinations for each of the cross sections based on the primary soil type

Reach	Stable Slope Section	Primary Soil Type	Stable Slope Inclination (Horizontal:Vertical)
1	T01	Sand, Silt Rhythmites Silt and Clay	2.5H:1V (above Elev. 178.8 m) 2.3H:1V (below Elev. 178.8 m)
2	use T01		
3	use T04		
4	T04	Sand Sand Rhythmite	2.5H:1V (above Elev. 198.3 m) 2.0H:1V (below Elev. 198.3 m)
5	use T04		
6	T06	Sand Sand Rhythmite	2.5H:1V (above Elev. 198.9 m) 2.0H:1V (below Elev. 198.9 m)
7	use T06		
8	use T09		
9	T09	Sand Clayey Silt Till	2.5H:1V (above Elev. 195.0 m) 2.3H:1V (below Elev. 195.0 m)
10	use T09		
11	T11	Sand Clayey Silt Till	2.5H:1V (above Elev. 179.9 m) 2.3H:1V (below Elev. 179.9 m)
12	use T13		
13	T13	Sand Rhythmite Clayey Silt Till	2.0H:1V (below Elev. 179.3 m) 2.3H:1V (below Elev. 179.3 m)
14	use T15		
15	T15	Silt and Clay	2.3H:1V
16 to 27	No bluff, stable slope not applicable.		
28	T28	Sand	2.5H:1V
29	T29	Silt and Clay	2.3H:1V
30	T30	Silt and Clay Clayey Silt Till	2.3H:1V
31	T31	Silt and Clay Clayey Silt Till	2.3H:1V 2.3H:1V
32	T32	Silt and Clay Clayey Silt Till	2.3H:1V 2.3H:1V
33	use T32		
34	use T32		
35	use T37		
36	use T37		

Reach	Stable Slope Section	Primary Soil Type	Stable Slope Inclination (Horizontal:Vertical)
37	T37	Sand Silt and Clay Sand Rhythmite	2.5H:1V (above 208.5 m) 2.3H:1V (208.5 - 203.5 m) 2.0H:1V (below 203.5 m)
38	T38	Sand Silt and Clay Sand Rhythmite	2.5H:1V (above 204.0 m) 2.3H:1V (204.0 – 201.0 m) 2.0H:1V (below 201.0 m)
39	T39	Sand Silt and Clay Sand Rhythmite	2.5H:1V (above 188.5 m) 2.3H:1V (188.5 – 183.5 m) 2.0H:1V (below 183.5 m)
40	T40	Silt and Clay Sand Rhythmite	2.3H:1V (above 181.1 m) 2.0H:1V (below 181.1 m)
41	T41	Silt and Clay Sand Rhythmite	2.3H:1V (above 196.1 m) 2.0H:1V (below 196.1 m)
42	T42	Sand Rhythmite	2.0H:1V
43	T43	Silt and Clay Sand Rhythmite	2.3H:1V (above 193.0 m) 2.0H:1V (below 193.0 m)
44	T44	Silt and Clay Sand Rhythmite	2.3H:1V (above 190.7 m) 2.0H:1V (below 190.7 m)
45	T45	Silt and Clay Sand Rhythmite	2.3H:1V (above 186.9 m) 2.0H:1V (below 186.9 m)
46	T46	Silt and Clay Sand Rhythmite	2.3H:1V (above 185.2 m) 2.0H:1V (below 185.2 m)
47	T47	Silt and Clay	2.3H:1V
48	T48	Silt and Clay	2.3H:1V
49	T49	Silt and Clay	2.3H:1V
50	T50	Silt and Clay	2.3H:1V
51	T51	Silt and Clay	2.3H:1V
52	T52	Silt and Clay	2.3H:1V
53	T53	Silt and Clay	2.3H:1V
54	T54	Silt and Clay	2.3H:1V
55	T55	Silt and Clay	2.3H:1V
56	T56	Sand	2.5H:1V
57	T57	Sand	2.5H:1V
58	T58	Silt and Clay	2.3H:1V
59	T59	Silt and Clay	2.3H:1V
60	T60	Silt and Clay	2.3H:1V
61	T61	Silt and Clay	2.3H:1V

Reach	Stable Slope Section	Primary Soil Type	Stable Slope Inclination (Horizontal:Vertical)
62	T62	Silt and Clay	2.3H:1V
63	T63	Silt and Clay	2.3H:1V
64	T64	Silt and Clay	2.3H:1V

6.5 Average Annual Recession Rate (AARR)

The Average Annual Recession Rate (AARR) is used to delineate the Erosion Hazard, as defined in Section 4.3. The Technical Guide (MNR, 2001a) identifies the use of historic aerial photographs extending over long periods of time as a good indicator of future recession/erosion rates. Specifically, it is recommended that at least 35 years of sound recession information for the unprotected shoreline should exist to calculate an AARR.

The 2017 LiDAR data and the 2015 aerial imagery (described in Section 3.2) were used as a basis of comparison with historical imagery to estimate the AARR. The bank toe and crest lines were manually digitized in GIS, providing a good estimate of the existing bluff conditions upon which to estimate the future erosion setback. The elevation difference between the toe and crest was calculated at representative profiles in each reach to establish the bluff height.

Historic aerial imagery for Norfolk County was provided by LPRCA. This included aerial photographs from 1955, 1964, 1978 and 1985, but with most analysis completed using the imagery from 1955 and 1964, with the more recent imagery providing a visual reference. When compared to the current 2015 aerial imagery, these aerial photos provide temporal change over periods ranging from 51 to 60 years.

The oldest historic aerial photographs would provide the longest temporal period to measure a more accurate long-term recession rate, but there are other factors to consider when selecting aerial photographs for shoreline change analysis including: photographic scale, lake water level, quality of the prints, time of year such that vegetation cover does not obscure ground features, type of photographic film (black and white, colour, near infrared), and other factors. Figure 6.14 is a map showing the selected historic aerial photographs reviewed for estimating the AARR.

For both the historic aerial photographs and the 2015/2017 dataset, a reference top of bank feature was digitized where the shoreline was unprotected and a change in top of bank location could be identified. The change in top of bank location was measured using a series of parallel transects at 5 metre spacing. Figure 6.15 is a map showing an example of these transects at an unprotected shoreline in Reach 4, near Norfolk County Road 28. The transects used to estimate shoreline change are shown on the maps provided in Appendix B. Measurements of shoreline change are tabulated in Table 6.8, for the reaches where an AARR could be established. The recession rate was determined based on the mean of the transect recessions in each reach plus one standard deviation (S.D.). The historic imagery date, temporal period of comparison, number of transects measured, average recession, standard deviation and AARR plus 1 S.D. are tabulated in Table 6.8. These values were used for mapping the Erosion Allowance as described in Section 7.1.2.

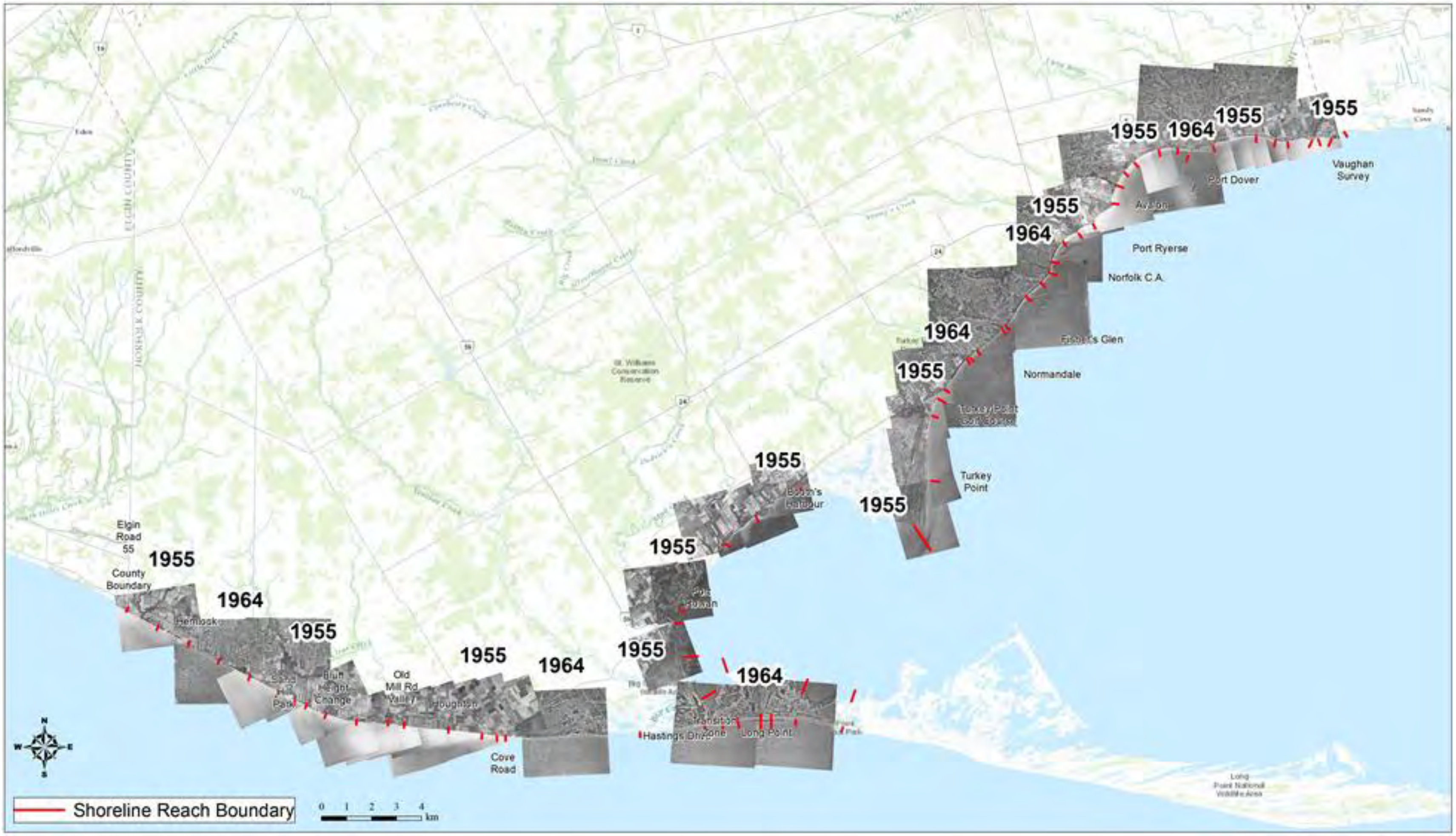


Figure 6.14: Map of selected historic aerial photographs used to estimate the AARR

Figure 6.15: Example map of transects where change in top of bank location was measured at unprotected shoreline, to estimate the AARR

Table 6.8: Summary of calculated shoreline change and AARR for reaches where AARR was measured

Reach	Historic Year	Temporal Period	Transect Count	Average Recession (m)	1 S.D. (m)	Average + 1 S.D. (m)	AARR + 1 S.D. (m/yr)
1	1955	62	211	177.0	50.1	227.1	3.66
2	1955	62	230	149.1	46.8	195.9	3.16
3	1964	53	269	94.6	27.9	122.4	2.31
4	1964	53	274	118.7	23.1	141.8	2.68
5	1964	53	262	95.9	14.0	109.9	2.07
6	1964	53	61	104.0	10.0	114.0	2.15
7	1955	62	95	109.1	16.5	125.6	2.03
8	1955	62	165	116.1	12.9	129.1	2.08
9	1955	62	234	103.0	11.0	114.1	1.84
10	1955	62	179	128.0	21.9	149.9	2.42
11	1955	62	22	188.2	3.1	191.4	3.09
12	1955	62	318	143.5	8.3	151.9	2.45
13	1955	62	263	83.2	19.2	102.4	1.65
14	1955	62	81	42.9	11.8	54.7	0.88
15	1955	62	20	44.7	5.0	49.7	0.80
38	1964	53	59	13.5	3.7	17.2	0.32
41	1964	53	78	9.5	4.1	13.6	0.26
43	1964	53	114	16.7	4.9	21.6	0.41
44	1964	53	50	7.4	3.5	10.9	0.21
45	1964	53	31	10.2	6.0	16.2	0.31
47	1964	53	56	15.0	5.9	20.9	0.40
49	1955	62	24	40.8	3.7	44.5	0.72
50	1955	62	41	23.8	8.1	31.9	0.51
51	1955	62	24	7.6	2.0	9.7	0.16
52	1964	53	62	17.9	6.5	24.5	0.46
53	1964	53	46	25.7	11.4	37.1	0.70

6.6 Climate Change

The Ontario Climate Consortium and Ontario Ministry of Natural Resources and Forestry published a climate change synthesis report for the Great Lakes basin in 2015 (McDermid et al., 2015). The report draws on over 70 scientific studies published since 2010 for the Great Lakes basin. The report outlines the anticipated climate change impacts, evidence, uncertainty, and agreement between studies in language that this accessible to the general public. Findings from the synthesis report will be referred to throughout this section as it reflects the current state of climate change science for the Great Lakes basin.

6.6.1 Projected Climate Change Impacts

The impacts of climate change in the Great Lakes are uncertain and are likely to remain uncertain even as climate change science advances. The uncertainty is related to the complexity of the hydrological conditions in the Great Lakes basin including their long-term cyclic nature (precipitation, evapotranspiration, runoff, etc.), the difficulties in modelling the conditions, and predicting future green house gas levels which will depend on human actions and behaviours.

Future water levels will be most affected by changes in air temperature and precipitation. Over the past 60 years, average annual air temperatures have increased and are predicted to continue increasing. The increase in air temperature is expected to result in lower water levels due to increased evapotranspiration. The past 60 years have also been slightly wetter than the historical average and annual precipitation is predicted to increase over the next century. However, the increase in air temperature is predicted to be more significant than the increase in precipitation, resulting in overall drier conditions and lower lake levels (McDermid et al., 2015).

The natural variability in water supplies is likely more significant than the anticipated climate change impacts on water levels in the Great Lakes. Long-term (decadal) fluctuations in water supplies have been measured since 1860 and are believed to be driven by large-scale atmospheric and oceanic circulation patterns such as the Atlantic Multidecadal Oscillation (Hanrahan et al., 2014; Watras et al., 2014). These large-scale anomalies affect air temperature, moisture availability, and precipitation. The natural variation in monthly mean water levels is approximately 2 m for Lake Erie.

The terms, “confidence” and “uncertainty” are used extensively in climate change literature. In general, confidence relates to the amount, quality, and agreement of the evidence, and uncertainty relates to the magnitude of the unknowns. In McDermid et al. (2015) the various studies were reviewed by a cross-section of climate change researchers and information on each topic was evaluated and ranked as low, medium or high confidence based on the agreement among available studies; type, amount, and quality of the evidence; and limitations of the research.

Uncertainty in future projections is also related to the challenges of predicting future human behaviour related to future green house gas levels (scenario uncertainty), and model imperfection. Climate models use mathematical equations to represent complex processes between the atmosphere, earth surface, and human and natural systems. Model uncertainty is related to our understanding of those systems and the accuracy of the model results.

A summary of projected climate change impacts on factors affecting Lake Erie water levels is provided in Table 6.9. The various factors are discussed in detail in the following sections.

Table 6.9: Projected impacts of climate change in the Great Lakes Basin (adapted from McDermid et al., 2015)

Theme	General Projections	Trend	Confidence
Air Temperature	• 1.5 to 7 °C increase by the 2080s depending on climate scenario model used. • Greater increases in the winter.	Increase	High evidence High agreement
Precipitation	• 20% increase in annual precipitation across the Great Lakes Basin by 2080s under the highest emission scenario. • Increases in rainfall, decreases in snowfall. • Increased spring precipitation, decreased summer precipitation. • More frequent extreme rain events.	Increase	High evidence Medium agreement
Drought	• Increases in frequency and extent of drought.	Increase	Low evidence High agreement
Wind	• Increased wind gust events.	Increase	Low evidence Low agreement
Water Temperature	• 0.9 to 6.7 °C increase in surface water temperature by the 2080s. • 42-90 day increase in ice free season.	Increase	High evidence Low agreement
Water Levels	• Water levels in the Great Lakes naturally fluctuate by up to 1.5m. • Long-term water levels in the Great Lakes peaked in the 1980s and have been decreasing since. • Projections of future lake water levels vary; however, they generally suggest fluctuations around lower mean water levels. • Lower water levels are due to several factors including warmer air temperatures, increased evaporation and evapotranspiration, drought, and changes in precipitation patterns.	Decrease	High evidence Low agreement
Ice	• Projected decreases in ice cover duration, ice thickness, and ice extent. • Increased mid-winter thaws, changing river ice dynamics.	Decrease	Medium evidence High agreement
Flood	• Increases in flood severity and frequency.	Increase	Medium evidence Medium agreement

Air Temperature

There is high confidence that air temperatures in the Great Lakes basin have risen in the past 60 years and will continue to rise in the future. Average annual air temperatures have risen by up to 2°C and are predicted to continue to rise regardless of the emissions scenario (Lofgren et al., 2002; Hayhoe et al., 2010; McKenney et al., 2011). The largest temperature increases have occurred and are projected to occur in the winter and spring (McKenney et al. 2011), resulting in more winter rainfall (less snowfall), less ice cover (more evaporation), and also affecting the timing of the spring freshet. Higher air temperatures in the summer and fall are projected to result in increased evaporation and plant transpiration (collectively evapotranspiration).

Precipitation

There is medium to high confidence that the Great Lakes basin is in a period of slightly wetter weather. Future projections indicate that annual precipitation will increase by up to 20% across the Great Lakes basin (Lofgren et al., 2002; McKenney et al., 2011).

Rising air temperatures are expected to result in a higher percentage of precipitation falling as rain, and less as snow. Snowfall losses of up to 48% are projected for the Great Lakes basin by the end of the century (Notaro et al., 2014). The projected increase in winter rainfall and decline in snowpack is expected to affect the timing and magnitude of the spring freshet.

Rainfall amounts are projected to increase in the spring and decline in the summer (Kling et al., 2003; Hayhoe et al., 2010). The resulting shifts in the timing of precipitation and snowmelt could present challenges for lake regulation, though this is less relevant for Lake Erie.

Heavy rainfalls are twice as frequent as a century ago and are projected to become more frequent in the future (Changnon and Kunkel, 2006; Kling et al., 2003). Heavy rainfalls are more of a concern for flood-prone urban and riverine areas.

Drought

There is moderate confidence that the Great Lakes basin has been and will become more vulnerable to drought (Bonsal et al., 2011). Air temperature and evapotranspiration are projected to increase in the summer while precipitation is predicted to decline.

Wind/Storminess

There is low confidence in projections of future wind speeds and wind patterns. It is believed that warmer air and water temperatures in the Great Lakes may increase atmospheric turbulence, resulting in higher wind speeds in the lower atmosphere (Austin and Colman, 2007; Desai et al., 2009; Huff et al., 2014). However, other studies such as Yao et al. (2012), project a decrease in wind speeds in the Great Lakes Basin by the year 2100. Cheng et al. (2012) projected that wind gusts will become at least 10% more frequent by the end of the century.

Water Temperature

There is moderate confidence that surface water temperatures in the Great Lakes basin have risen in the past century and will continue to rise in the future. The high evidence and low agreement for this topic indicates that there is considerable variability between studies. The increase in water temperature is projected to result in less ice cover (duration and extent), resulting in increased evaporation from the lake surface.

Water Levels

McDermid et al. (2015) reports moderate confidence that water levels in the Great Lakes peaked in the 1980s, declined, and will continue to decline in the future. This seems to ignore longer term variations in water levels prior to 1980, and water levels reached record highs on Lake Erie in 2019. Masking climate change impacts are the much larger natural (decadal) cycles of high and low water supplies.

Projections indicate that future mean water levels will be similar or slightly lower due to higher evapotranspiration rates, and changes is precipitation patterns (Mortsch et al., 2003; Hayhoe et al., 2010; Lofgren et al., 2002; McKenney et al., 2011; Angel and Kunkel, 2010; MacKay and Seglenieks, 2013). Some earlier studies, which predicted more severe water level declines, are believed to have overestimated evapotranspiration rates (Lofgren et al., 2011). Emerging research using an energy balance approach to evapotranspiration suggest that declines, and possibly increases, in water levels will be modest.

Ice

There is moderate to high confidence that ice cover in the Great Lakes is decreasing and that mid-winter thaws are becoming more frequent. A decrease in the duration and extent of the ice cover will result in increased evaporation from the lake surface. The greatest evaporation losses on the Great Lakes occur in the fall and winter when cold, dry air blows over the warmer lakes (Mortsch et al., 2003). Mid-winter thaws may pose challenges for river ice management.

The extent of ice cover on the Great Lakes decreased 71% between 1973 and 2010 (Wang et al., 2012) and the ice cover period decreased by 1 to 2 months over the past century (McDermid et al., 2015). Ice protects the shoreline and prevents erosion during winter storms. Therefore, a reduction in the ice-in period will render shorelines more susceptible to extreme storm events (Mortsch et al. 2003). Baird (2019) describes wave modeling undertaken on Lake Erie to examine the impact of future ice regimes on wave climatology. It was found that wave energy along the Chatham-Kent shoreline at the west end of Lake Erie would increase by 150% to 200% if lake ice disappears in the future.

Flood

There is medium confidence that summer floods will become more frequent and more severe and that spring floods will become less severe in the Great Lakes basin. Spring runoff is projected to decline due to the predicted decrease in snowfall (Notaro et al., 2014; Shaw and Riha, 2011). However, extreme rainfall events are projected to become more frequent in the future. These changes are likely to result in less frequent riverine flooding (smaller freshets), and more frequent urban (pluvial) flooding.

6.6.2 Summary

The latest climate change research related to precipitation, evaporation, snow and ice cover, and storminess in the Great Lakes basin was reviewed to assess potential future changes to static water levels, storm surge, waves and sediment processes in the study area.

Over the past 60 years, the Great Lakes basin has become warmer and has been slightly wetter (than the long-term average). Air temperature and precipitation are projected to increase in the future, with water levels in the Great Lakes remaining similar or slightly decreasing (McDermid et al., 2015). The uncertainty in water level projections is related to the relative roles of evapotranspiration and precipitation. It is likely that the impacts of climate change on static water levels will be less than the natural variability of Lake Erie.

Snowfall and ice cover in the Great Lakes-St. Lawrence River basin are projected to decrease resulting in an earlier and smaller spring freshet (Kling et al., 2003) and increased evaporation from the lake surface in the winter. In addition, predicted reduced ice cover will result in increased wave energy, which in turn would result in higher erosion rates and sediment transport rates. Increased exposure to surge could also be expected as a result on reduced ice cover.

Wind gusts, although expected to increase slightly over the next century, are anticipated to have a lesser impact on storm surge and waves.

7. Mapping

7.1 Hazard Mapping

The 2015 SWOOP imagery was used to prepare the base maps for the hazard mapping. The flood, erosion and dynamic beach hazard limits were mapped as described below.

7.1.1 Flooding Hazard Mapping

The Flood Hazard Limit is the 100-year flood level plus an allowance for wave uprush as defined in MNR (2001a) and described in Section 4.2.

The 100-year flood level was established based on analyses described in Section 6.1. The 100-year flood levels were defined for each reach using a linear interpolation between the 100-year flood levels at Port Dover and Port Stanley adjusted to CGVD2013 datum. The flood levels were rounded to the nearest 0.1 m increment as summarized in Table 7.1 . The location of the 100-year flood level was mapped using the 2017 elevation datasets, which are of sufficient scale and accuracy to locate the flood elevation.

Table 7.1: Summary of 100-year flood levels used to map the flooding hazard

Reach No.	MNR (1989) Reach Name	100-year flood level (CGVD2013)
1-9	E-11 Hemlock	175.4
10-15	E-12 Clear Creek	175.5
16-17	E-13 Erie View	175.7
18-23	E-14 Long Point Park	175.9
24-57	E-17 Port Dover (Long Point Bay)	175.9
58-64	E-18 Nanticoke	176.0

The horizontal wave uprush allowance includes both the wave runup on the shoreline slope and the inland extent of overtopping waves. Wave uprush was established based on the analyses described in Section 6.2. The mapped wave uprush is based on the calculated horizontal extent of wave uprush measured from the 100-year flood level, except in cases where it was clear that wave uprush would not exceed the top of bluff elevation. In these cases, the wave uprush allowance was plotted at the calculated uprush elevation, on the bluff slope.

The average calculated horizontal wave uprush was 12.1 m for the 21 profiles with wave overtopping, with a minimum value of 1 m and maximum value of 24 m. All values less than 15 m were mapped as 15 m due to possible variability in wave exposure, nearshore slope, water depth at the toe, and bluff height within a reach. Approximately 40% of the reaches with wave overtopping have a wave uprush allowance greater than 15 m.

The 100 year flood level and allowance for wave uprush values used to map the Flooding Hazard are listed on a reach basis in Appendix C. While the vertical uprush elevation is listed in the table, this value should not be used to establish floodproofing elevations. Floodproofing is discussed further in Section 8.1 and in MNR (2001a, Appendix A7.1).

7.1.2 Erosion Hazard Mapping

The Erosion Hazard Limit is the stable slope allowance plus the erosion allowance as defined in MNR (2001a) and described in Section 4.3.

The stable slope allowance was defined on a reach basis, using a geotechnical study, as summarized in Section 6.4 and described in detail in Appendix A. For those reaches where a stable slope was not defined by a geotechnical study, the stable slope was interpolated from adjacent reaches. The stable slope allowance was calculated by multiplying the stable slope inclination by representative bluff heights within the reach. The stable slope allowance was measured inland from the delineated toe of bluff and mapped. Where the stable slope allowance plotted lakeward of the existing top of bluff, an adjustment was made, and the stable slope allowance was moved inland to the top of bluff. The stable slope allowance values used in the mapping are listed in Appendix C.

Where erosion could be measured using the historical shoreline comparison, the erosion allowance was calculated from the values presented in Section 6.5. The AARR + 1 S.D. was multiplied by 100, representing the 100-year planning horizon as specified in MNR (2001a). The erosion allowance was measured inshore from the stable slope allowance and mapped. Where erosion was not measured, due to the presence of shore protection along the reach or difficulty in delineating a bluff crest, an erosion allowance of 30 m was assumed, consistent with MNR (2001a). In locations where the shoreline was protected by marsh and the historical aerial imagery comparison indicated no discernible shoreline change, an erosion allowance of 10 m was used. An example is Reach 30, east of Port Rowan.

For marsh and dynamic beach shorelines, a toe of bluff could not be defined, and it was therefore not possible to map the erosion hazard. Along these shorelines, the flood and dynamic beach hazards govern. The erosion allowance values used in the mapping are listed in Appendix C.

At reach boundaries, the Erosion Hazard Limit changes from one reach to the next and no transition was applied. This may result in a discontinuity at reach boundaries.

7.1.3 Dynamic Beach Hazard Mapping

The dynamic beach hazard limit is the landward limit of the flooding hazard (100-year flood level plus a flood allowance for wave uprush and other water related hazards), plus a 30 m dynamic beach allowance or a distance determined by an accepted coastal study as defined in MNR (2001a) and described in Section 4.4. For this project, the dynamic beach allowance was defined as the greater of 30 m or the back (lower side) of the first dune. Where the beach is backed by a bluff or substantial roadway within the dynamic beach allowance, an adjustment was made, consistent with MNR (2001a). The dynamic beach was mapped as described above.

7.1.4 Establishing Hazard Limits Onsite

It is understood that the Hazard Limits will be measured onsite, in response to site specific development applications. While the mapping provides a visual representation of the hazard limits on a reach basis, a more accurate assessment should be determined onsite using information provided in this report. For example, representative bluff heights was used to establish the stable slope allowance within a given reach, however bluff height varies along the reach and adjustments may be required. In addition, where shorelines are eroding, the hazard limit will need to be adjusted inland in response to erosion occurring after the date of the data used for mapping.

7.2 Flood Depth Mapping for Flood Preparedness

Mapping was developed to identify areas that would be rendered inaccessible to people and vehicles due to water depth and wave uprush conditions during the 100-year flood. Roads located within the Flooding Hazard (100-year flood level plus an allowance for wave uprush) were identified. Water depths on the roads were then mapped at 0.3 m intervals for the 100-year flood level. Roads located in the wave uprush zone are also indicated on the maps. Roads in the wave uprush zone will be exposed to moving water. Velocities within the wave uprush zone vary temporally and spatially and cannot be readily defined as is typically done for river flooding.

The mapping is presented in Appendix D. The mapping informs the National Disaster Mitigation Program, Risk Assessment Information Template (NDMP-RAIT) that was updated for this study and is provided under separate cover.

7.2.1 Vehicular Access/Egress

Ingress and egress from an area by the most "typical" automobiles will be halted by flood depths above 0.3 to 0.4 m (MNR, 2002). This is generally consistent with MNR (2001a), which references a depth limit of 0.3 - 0.5 m. This is the typical depth of key electrical components, which fail when submerged, preventing vehicle egress. A typical North American car would not be significantly affected by flood velocities up to about 4.5 m/s providing that flood depths are less than 0.3 m (MNR, 2002).

In Norfolk County, emergency responders make decisions about vehicle access on a case by case basis. In general, emergency vehicles will not access a road where flooding exceeds 0.3 m, the lines on the road are not visible, or the road is exposed to wave uprush.

7.2.2 Pedestrian Access/Egress

MNR (2002) provides technical considerations for pedestrian access/egress during flooding. This document pertains to river and stream systems flooding but it is also relevant for Lake Erie flooding. Hazard to life is linked to the depth of the flood waters and the velocity of flow. A product of depth and velocity less than or equal to 0.4 m^2/s defines a low risk hazard, providing that the depth does not exceed 0.8 m and velocity does not exceed 1.7 m/s (MNR, 2001a).

For stagnant backwater areas (i.e., zero flow velocity), depths in excess of about 1 m are sufficient to float young children, and depths above 1.4 m are sufficient to float teenage children and many adults. Even shallower depths can pose a risk. In shallow areas, velocities in excess of about 1.8 m/s pose a threat to the stability of many individuals (MNR, 2001a). In areas exposed to wave uprush, the combination of flood depth and velocities may be sufficient to pose danger to pedestrians. In areas subject to direct wave action, the maximum depth of flooding to define a low risk hazard is 0.25 m.

8. Recommendations for Flooding and Erosion Prevention and Protection

This section provides general recommendations for flooding and erosion prevention and protection. Consultation with a coastal engineer is recommended as conditions will vary from reach to reach, and within a shoreline reach. The reader is referred to the Technical Guide for Great Lakes – St. Lawrence River System (MNR, 2001a) for further information. A permit from the Conservation Authority is required for any work undertaken within the Regulation Limit and other permits may also be required.

Shoreline management approaches can be classified as prevention or protection. Prevention is normally achieved through planning of land use and the regulation of development within the hazard limits. Prevention approaches are generally considered the most environmentally sound and cost-effective means of ensuring that buildings and structures are not susceptible to hazards. Protection approaches involve engineered methods for protecting development located within hazard susceptible shoreline areas. Where protection works are constructed, they are to be combined with an appropriate hazard allowance.

Prevention is generally considered to be the preferred approach. However, it is recognized that prevention is not always practicable, particularly for existing development. This section provides an overview of the floodproofing and protection works standards as they can be applied along the Lake Erie shoreline of Norfolk County.

8.1 Floodproofing Standard

Floodproofing is generally defined as a combination of structural changes and/or adjustments incorporated into the basic design and/or construction or alteration of individual buildings, structures or properties subject to flooding hazards so as to reduce the risk of flood damages, including wave uprush and other water related hazards. Floodproofing and flood protection works can only reduce the risk and/or lessen the damage to properties. No measure will prevent all damages due to flooding. Where it has been determined that development and site alteration could possibly be located within the less hazardous portion of the flooding hazard, the floodproofing standard should be applied. The minimum floodproofing standard is as follows: development and site alteration is to be protected from flooding, as a minimum, to an elevation equal to the sum of the 100-year static water level plus the 100-year surge plus a vertical flood allowance for wave uprush and other water related hazards. The 100-year static water level plus the 100-year surge is listed by reach in Appendix C. The vertical flood allowance for wave uprush varies with shoreline conditions and is determined on a site specific basis. Some example wave uprush values for selected shoreline conditions are listed in Appendix C. It is recommended that a minimum freeboard of 0.3 m be added to these elevations as a factor of safety to compensate for factors that may increase flood heights and uncertainties inherent in determining flood frequencies and flood elevations (ASCE/SEI, 2014). The flood proofing elevation should be determined by a Professional Engineer with experience in flood proofing.

Floodproofing measures that could be incorporated into the design of new buildings and retrofit of existing buildings is described in Part 7 of the Technical Guide (OMNR, 2001). Examples include elevating buildings on posts, piers, walls, pilings or engineered fill; elevating electrical equipment and utilities above the expected flood levels; using watertight closures for doors and windows; and using flood resistant materials. The guide describes “dry floodproofing” as measures that prevent the entry of floodwater into a building, and “wet floodproofing” as measures that minimize the impact of flooding. Dry floodproofing is usually accomplished by elevating the building above the floodproofing standard elevation, and is the most desirable measure for residential buildings. It may not be feasible or desirable to elevate certain non-residential buildings (e.g. garages, boathouses, sheds, warehouses, etc.) above the floodproofing standard elevation. Wet floodproofing measures such as the use of flood resistant building materials and elevating contents and utilities can lessen the impact of flooding and improve the clean up and recovery time for non-residential buildings.

Table 8.1 identifies the buildings that are most vulnerable to flooding from Lake Erie. The building location and other information can be obtained from the building inventory geodatabase using the unique Building ID (provided in the RAIT deliverable). The minimum ground elevation along the perimeter of the building and the estimated first floor elevation is provided in the table. The first floor elevation is estimated to be 0.2 m above ground for commercial and institutional buildings, and 0.7 m above ground for residential buildings.

Table 8.1: List of buildings most vulnerable to flooding

Building ID	Building Use	Reach	Minimum Ground Elevation (m CGVD2013)	Estimated First Floor Elevation (m CGVD2013)
1776	residential	25	173.16	173.86
6246	residential	35	173.16	173.86
66256	commercial	26	173.16	173.36
70192	commercial	25	173.16	173.36
24331	commercial	56	173.29	173.49
2807	residential	26	173.36	174.06
2813	residential	26	173.36	174.06
1402	commercial	25	173.89	174.09
1747	residential	25	173.91	174.61
7287	residential	35	173.93	174.63
7336	residential	35	174.02	174.72
7255	residential	35	174.03	174.73
21378	residential	28	174.05	174.75
21380	residential	28	174.05	174.75
21381	residential	28	174.05	174.75
7230	residential	35	174.08	174.78
7319	residential	35	174.11	174.81
7256	residential	35	174.16	174.86
7248	residential	35	174.22	174.92
6238	residential	35	174.27	174.97
7179	residential	37	174.29	174.99
1767	residential	25	174.33	175.03
7229	residential	35	174.34	175.04
1267	residential	25	174.38	175.08
66631	residential	25	174.38	175.08
49509	commercial	56	174.39	174.59
46010	institutional	56	174.44	174.64
21386	residential	28	174.45	175.15
69757	residential	35	174.46	175.16
69758	residential	35	174.46	175.16
2138	residential	25	174.48	175.18
43261	residential	40	174.48	175.18
7257	residential	35	174.49	175.19
1419	residential	25	174.50	175.20
27669	residential	57	174.50	175.20

Building ID	Building Use	Reach	Minimum Ground Elevation (m CGVD2013)	Estimated First Floor Elevation (m CGVD2013)
65277	residential	35	174.53	175.23
27656	residential	57	174.54	175.24
2485	residential	26	174.55	175.25
1414	residential	25	174.58	175.28
1411	residential	25	174.59	175.29
2179	residential	25	174.59	175.29
2433	residential	26	174.60	175.30
49510	commercial	56	174.60	174.80
69754	residential	26	174.60	175.30
69760	residential	35	174.60	175.30
27668	residential	57	174.61	175.31
62669	residential	34	174.61	175.31
27655	commercial	57	174.62	174.82
71035	commercial	32	174.62	174.82
1763	residential	25	174.63	175.33

8.2 Protection Works Standard

By definition (PPS, Section 6.0 Definitions), protection works standards “means the combination of non-structural or structural works and allowances for slope stability and flooding/erosion to reduce the damages caused by flooding hazards, erosion hazards and other water-related hazards, and to allow access for their maintenance and repair” (PPS 2014). The Technical Guide (MNR 2001a), developed in support of the PPS, outlines specific guidelines for the protection works standard including protection works, the stable slope allowance and the erosion hazard allowance.

The three key elements of the protection works standard are described in the Technical Guide (MNR 2001a) as follows:

- Protection works should be of sound, durable construction and be designed by a qualified coastal engineer according to accepted practice;
- Protection works should be used in conjunction with appropriate stable slope and hazard allowances; and
- There must be access to the protection works for suitable equipment for future rehabilitation, replacement or repairs.

8.3 Shore Protection

This section describes some alternative shore protection measures that may be considered along the Norfolk County shoreline. Shore protection should be designed on a site specific basis by a coastal engineer. Permits are required for the construction of shore protection including an assessment to confirm there will be no negative impacts on adjacent properties.

8.3.1 Armourstone Revetment

Armourstone revetments are sloped shore parallel structures with a protective layer of large "armour" stones that are built to prevent the direct attack of waves on the toe of a bluff (see Figure 8.1). These structures rely on the mass of the armour stones to withstand the forces of the waves. As waves impact the structure, energy is dissipated as the water moves over the rough, permeable sloped face of the structure, and through the voids between the armour stones. The land behind the structure is thus protected from the erosional stress that results from wave attack.

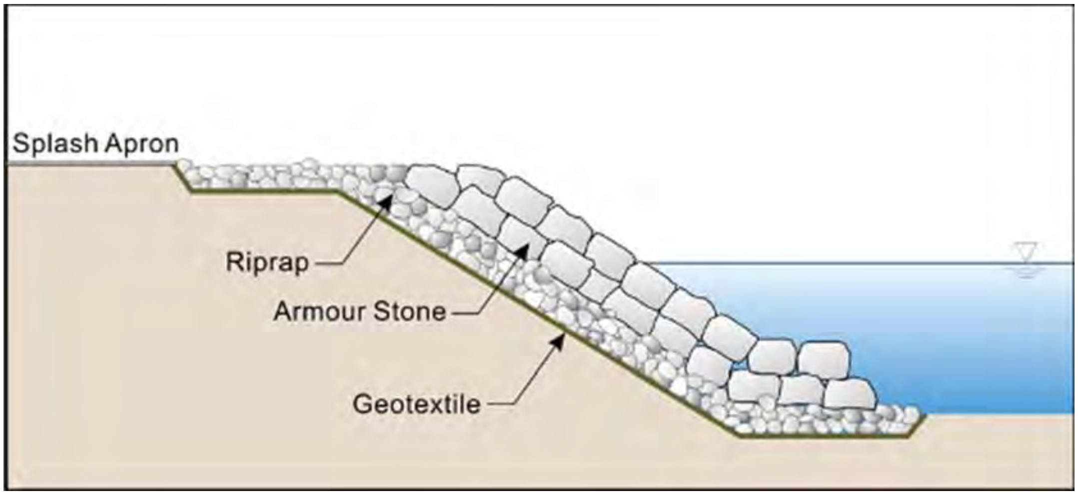


Figure 8.1: Schematic showing typical armourstone revetment section

Armour stone revetments have advantages over many other forms of shore protection, because they are flexible, can accommodate some settlement and do not generally fail catastrophically. The use of larger armour stones and/or a higher crest elevation will provide a stable structure which protects the backshore under more severe conditions. This type of structure can be designed to accommodate the ongoing erosion of the lakebed, thus providing long term protection to the backshore.

Revetments, like any other shore protection structure, have a number of disadvantages that make them inappropriate for some conditions. Revetments may severely limit access to the beach and water, and do not increase the amount of recreational space. Beach or water access must often be provided by staircases or ramps located intermittently along the shoreline. Access along the beach may also be obstructed. Another disadvantage of revetments is that the structure does not encourage beach development, and may in fact increase scour in front of the structure as a result of wave reflection at the structure. If the lakebed erodes, higher waves may be able to reach the structure, further eroding the bottom and possibly undermining the structure. Flanking can be an issue at the termination of the structure, particularly if the adjacent property is not protected and is eroding at a high rate.

Key design features for the armour stone revetment include: sound, good quality, durable armour stone with sufficient size to resist wave action and ice; sufficient crest elevation to protect against wave overtopping; riprap underlayer; and geotextile filter to prevent loss of backfill. The armour stone size is dependent on the wave height, the inclination of the revetment slope and placement (i.e., degree of “interlocking”). Typically, the individual armour stones in an armour stone have a mass of 3 to 5 tonnes for a single layer of armour; slightly smaller stones could be used with flatter slopes or double layers. A qualified coastal engineer should design the revetment. A double layer of armour provides more “reserve capacity” (i.e., damage to a double layer armour revetment is more progressive than damage to a single layer).

8.3.2 Seawalls

Seawalls are vertical, sloped, curved or stepped shore parallel walls that function in a very similar manner to a revetment (see Figure 8.2). They are typically made of steel sheet piles or concrete (pre-cast or cast-in-place) and are placed to protect the toe of a bluff from wave attack.

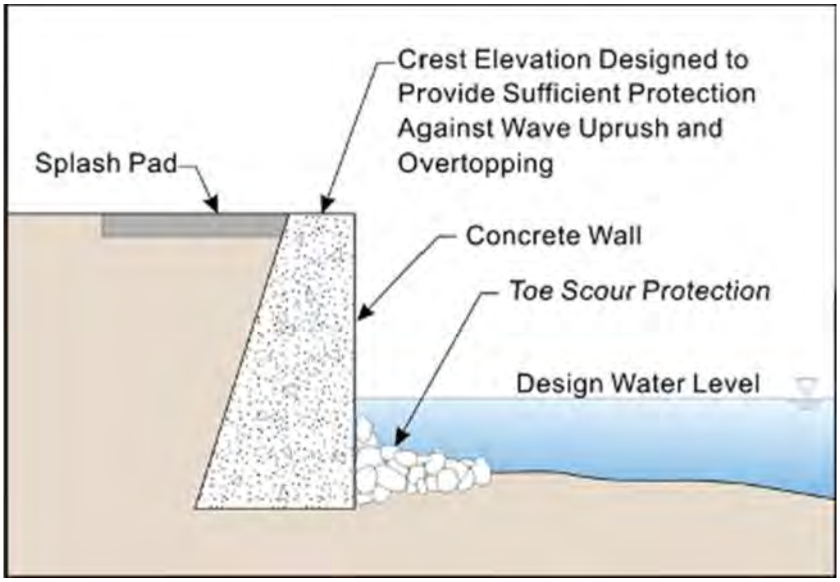


Figure 8.2: Schematic showing concrete seawall section

Some property owners consider seawalls to be more aesthetically pleasing than revetments for a number of reasons. Seawalls allow people to be closer to the water and/or beach than an armour stone revetment. It is also easier to incorporate stairs or ramps for access to the water. Seawalls also require less width than a revetment, possibly making construction feasible in some areas with a steep backshore where a sloped structure might require large amounts of earth moving.

However, seawalls are rigid structures and do not accommodate settlement. In addition, seawalls, due to their steep (often vertical), impermeable and generally smooth face, cause more wave reflection, resulting in increased scour and the risk of undermining at the toe of the structure. Because of this, seawalls may fail catastrophically if not designed correctly. Seawalls also require higher crest elevations than revetments to provide a similar level of protection against wave overtopping.

8.4 Critical Warning Levels

Being aware of risks is an important part of flood preparedness. LPRCA provides information to the public, including critical warning levels for flooding. Communities along Lake Erie are susceptible to flooding due to storm surge, which can be exacerbated by high water levels. Water levels along the shoreline can change in a matter of hours and areas can become flooded. The situation can be further exacerbated by wave action. During flooding events, there is a heightened risk of shoreline flooding, beach submersion, crawl space and septic system inundation and wave-driven erosion along some reaches of Lake Erie.

LPRCA monitors water levels and flood warnings posted on the Ontario Ministry of Natural Resources and Forestry (MNRF) Surface water Monitoring Centre's web site https://www.ontario.ca/law-and-safety/flood-forecasting-and-warning-program#section-3. Data published on this site is based on the Great Lakes Storm Surge Operational System (GLSSOS) developed for OMNRF. The system uses real time water level and meteorological data and the Danish Hydraulics Institute MIKE21 model to provide 48 hour forecasts with time series plots of water level, wave height, mean wave direction and peak wave period at selected locations on the Great Lakes. The locations nearest to Norfolk County are Port Stanley, Long Point and Port Colborne.

LPRCA issues flood warnings based on the five stages shown in Figure 8.3. The figure also shows the probability of the water levels associated with the stages. Flood levels at the east end of the County are higher than at the west end of the County. For example, the 100-year return period flood level corresponds to a Stage 2 flood level at the west end of Norfolk County (Hemlock) and a Stage 4 flood level at the east end (Port Dover).

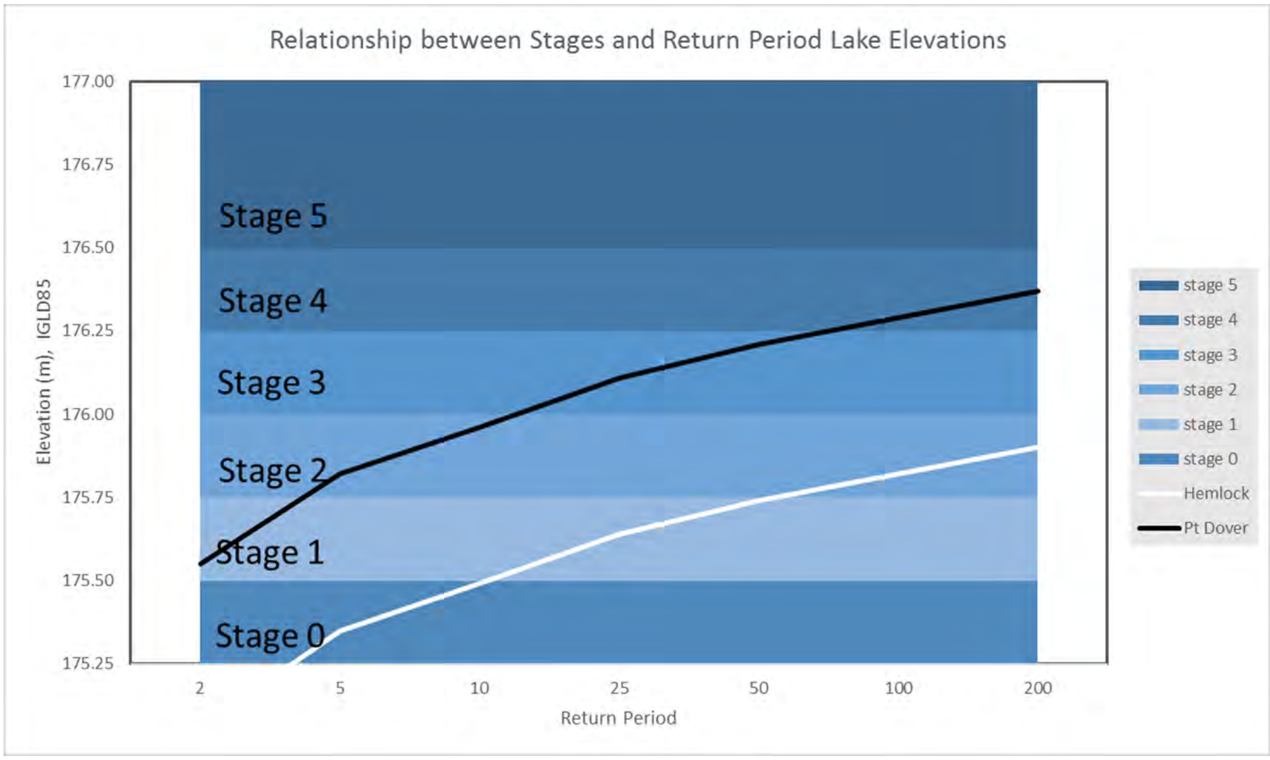


Figure 8.3: Relationship between Norfolk County Lake Erie flood warning stages and return period

A meeting was held with emergency responders from the County on January 20, 2020 to discuss issues related to emergency response and updates the National Disaster Mitigation Program Risk Assessment Information Template (NDMP RAIT) completed for this project. Based on that meeting, it is our recommendation that the current flood warning stages be maintained. The flood warnings are well understood by emergency responders and the correlation with probabilities of exceedance shown in Figure 8.3 provides additional context.

LPRCA issues flood warning messages based on the data provided by the MNRF. The municipalities and media including newspapers and radio (CD989, Easy 101, Country 1510) are notified. Flood warning messages are also posted on social media including Facebook and Twitter. Norfolk County also issues the flood warnings to their social media platforms.

8.5 Emergency Access/Egress

The Technical Guide (MNR, 2001a) discusses access/egress with respect to development located within the flooding hazard and development that may be isolated from access/egress during flooding events. It is not desirable to have development isolated during the flood conditions because roads and escape routes are not passable. Flooding characteristics that must be considered when evaluating ingress/egress include:

- Depth of expected flooding and, in shoreline areas, height of wave crests.
- Velocity of flood waters and waves.
- Frequency of flooding, which is the amount of time between occurrences of damaging floods.
- Duration of flooding, which affects the length of time access/egress may be impacted.
- Rate of rise, which indicates how rapidly water depth increases during flooding. This determines warning time before a flood, which will influence the need for access routes (ingress/egress) to be elevated above floodwaters.
- Ice and debris, which can block access/egress, and may damage roads and bridges.

Mapping for flood preparedness is discussed in Section 7.2 and specific locations are identified, where access/egress may be disrupted during flooding events. Additional information on access/egress and emergency access planning is provided in the National Disaster Mitigation Plan, Risk Assessment Information Template (NDMP RAIT), prepared for Norfolk County for this project, and provided under separate cover. Mapping developed for the NDMP RAIT, showing flood depths during the 100-year return period event is provided in Appendix E for those reaches where roads and buildings are flooded. The mapping shows that 55 km of road is flooded during this event, including roads in the wave uprush zone. Table 8.2 identifies roads that are vulnerable to flooding from Lake Erie, the lowest elevation along the centreline of the road, and the corresponding Flood Warning Stage used by the County and Conservation Authorities.

Table 8.2: List of roads most vulnerable to flooding

Road Name	Reach	Elevation (m CGVD2013)	Elevation (m IGLD1985)	Flood Warning Stage
Erie Boulevard	23	174.4	174.9	0
Highway 59	18	174.4	174.9	0
Clubhouse Road	35	174.4	174.9	0
Ferris Street	35	174.4	174.9	0
Hastings Drive	17	174.7	175.1	0
Bay Side Drive West	30	174.7	175.2	0
Sea Queen Road	29	174.7	175.2	0
Old Cut Boulevard	21	174.7	175.2	0
Cedar Drive	36	174.7	175.2	0
River Drive	56	174.7	175.2	0
Erie Boulevard	18	174.8	175.2	0
Ordnance Avenue	35	174.8	175.3	1
Highway 59	27	174.9	175.3	1
Bay Side Drive East	30	174.9	175.4	1
Port Dover - No Name 2	56	174.9	175.4	1
Willow Beach Lane	48	174.9	175.4	1
Walker Street	56	174.9	175.4	1

Road Name	Reach	Elevation (m CGVD2013)	Elevation (m IGLD1985)	Flood Warning Stage
Harbour Street	56	174.9	175.4	1
Erie Boulevard	21	175.0	175.4	1
Drew Williamson Boulevard	56	175.2	175.7	1
Port Dover - No Name 1	56	175.5	176.0	3

8.6 Protection of Municipal Infrastructure

When municipal structures are located within the hazard limits, a more detailed assessment of the risks may be warranted. A number of these structures, by their very nature are located within the hazard limits (e.g. water intake, bridges, drains, culverts, treatment and conveyance structures) and protection works are often required. Public parks are often located along the waterfront and some investment may be warranted to protect these public spaces, if the impacts can be mitigated.

Where municipal infrastructure is concerned, public safety, minimizing risks to life, property damage, adverse environmental impacts and social disruption are paramount. Ecological, geomorphological and socioeconomic elements must be considered. In addition, public access, recreation and aesthetics may be considerations.

There are areas where protection works may be inappropriate and unacceptable as they would not meet all of the requirements defined in the Technical Guide (MNR, 2001a). These areas may include, but are not limited to: locations where the active erosion of the site provides an essential sediment source for downdrift beaches; sites where the proposed protection works would result in unacceptable environmental impacts (i.e., adjacent wetland or fish habitat is significantly impacted); areas where the protection works create or aggravate hazards at updrift/downdrift properties (i.e., groynes trapping or deflecting alongshore sediment transport resulting in a significantly reduced quantity of sediment on beaches at adjacent properties thus increasing hazards).

Special consideration is required for roads located within the hazard limits. These roads may be used for access/egress and may become unusable during flooding events, or as a result of erosion. Examples in Norfolk County are discussed in Section 7.2. For roads at risk due to erosion, the recommendations for shore protection provided in Section 8.3 are applicable. As an alternative, it may be necessary to relocate roads.

For roads at risk due to flooding, mitigation measures include raising the road elevation, emergency access such as constructing temporary gravel roads and permanently relocating roads. As a planning tool, the County may wish to identify priority road segments where it may be possible to secure easements along the rear property lines for future road alignments.

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Appendix A

Terraprobe Slope Stability Analysis Report

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLOPE STABILITY STUDY
LAKE ERIE SHORELINE OF NORFOLK COUNTY
EAST OF PORT BURWELL TO EAST OF PORT DOVER
NORFOLK COUNTY, ONTARIO

Prepared For: W.F. Baird & Associates Coastal Engineers Ltd.
1267 Cornwall Road, Suite 100
Oakville, Ontario
L6J 7T5

Attention: Fiona Duckett

File No. 1-19-0230-01
October 15, 2019

Distribution of Report:
1 Copy - W.F. Baird & Associates Coastal Engineers Ltd.
1 Copy - Terraprobe Inc., Brampton Office

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1.0 THE PROJECT

Terraprobe was retained by W.F. Baird & Associates Coastal Engineers Ltd. to conduct a detailed slope stability study and erosion risk assessment for 70 kilometers of the Lake Erie shoreline in Norfolk County, Ontario. The subject slope along the shoreline is up to 50 ±m in height. The tableland is generally occupied by agricultural land, residential properties, conservation land, or municipal roadways. A site location plan is provided as Figure 1.

This slope stability study and erosion risk assessment has been prepared for the purposes of establishing the stable slope allowance at a county scale. Site specific studies are recommended. The stable slope allowance is used for mapping the Erosion Hazard.

This report encompasses a review of publicly available subsurface information, knowledge of the subsurface conditions in the area, and a detailed visual slope inspection to establish existing conditions. The scope of work also includes a detailed slope stability analysis. Based on these studies, this report provides geotechnical engineering recommendations pertaining to the site including the stable slope allowance for the slope along the north shoreline of Lake Erie in Norfolk County.

2.0 SITE & PROJECT DESCRIPTION

The study area includes approximately 70 km of shoreline along Lake Erie's north shore, from east of Port Burwell to east of Port Dover, in Norfolk County, Ontario. The tableland is generally flat. There are bluff type slopes along the shoreline with heights up to 50 ±m. These slopes are vegetated to bare, with inclinations near vertical in some locations. The stratigraphy of the shoreline generally comprises sand and silt rhythmites, glaciolacustrine silt and clay, glacial till, sand dunes, beaches or talus, or visible limestone bedrock. Some areas, especially at the west end of the study area, are currently experiencing active retrogressive slope failures. In Reaches 15 to 27 and Reaches 33 to 36 the shoreline consists of dynamic beaches and wetlands, with no slope at the shoreline.

Terraprobe completed a slope stability study for a total of 40 out of 64 reaches delineated by Baird. The study area has been divided by Terraprobe into four areas (Area A to D). The areas are described in the table below.

Area Label	Reaches	Limits
A	1 to 15	east of Port Burwell to Long Point
B	28 to 32	Long Point to Turkey Point
C	37 to 46	Turkey Point to Port Ryerse
D	47 to 64	Port Ryerse to east of Port Dover

Areas are groups of reaches that are in close proximity to each other. Areas C and D are grouped based on similar geology. The stratigraphy and recommendations can be interpolated between sections by transitioning approximately halfway between adjacent sections.

Baird provided Terraprobe with cross sections created from LiDAR data of the entire study area in .xlsx format that included 0.50 m contours. The vertical datum of the dataset is CGVD2013. The LiDAR data provided was used and relied on as factual in preparation of this report. The cross-section locations are shown on Appendix A and the detailed sections are provided in Appendix F.

Jory Hunter, EIT, of Terraprobe carried out a site and detailed slope inspection on May 13th, 2019. Jason Crowder, P.Eng., also inspected the slope in April 2019. The MNR Slope Stability Rating Chart was completed during the inspection (included in Appendix D). The slope ratings are summarized in the table below.

Area	Slope Rating Value	Slope Rating
A	40-68	Moderate
B	29-42	Slight to Moderate
C	36-68	Moderate
D	32-64	Slight to Moderate

3.0 SUBSURFACE INFORMATION

3.1 Stratigraphy

Boreholes were not advanced as part of this scope of work. Terraprobe inferred the subsurface conditions based on a desk top study including a review of publicly available subsurface information and knowledge of the subsurface conditions in the area. A detailed visual slope inspection was also conducted.

The Ministry of Northern Development and Mines (MNDM) has publicly available subsurface information including geotechnical boreholes (Appendix A) and surficial geology (Figure 2). The Ontario Geological Survey (OGS) completed a report on the geological setting of the study area ("Quaternary Geology Long Point – Port Burwell Area", by the Ontario Geological Survey, Report 298, dated 1998). The government of Ontario (MECP) has publicly available well records for wells drilled in the study area. The locations of the well records used for the study are in Appendix A, and the well records are included in Appendix B. This information was used to determine the general stratigraphy encountered in the study area.

Terraprobe relied on visual observation during the visual slope inspection to confirm the subsurface conditions within the study area. Photographs are included in Appendix C, with the photograph locations in Appendix A. The photographs in the appendix consist of photos taken by Terraprobe during the visual slope inspections and drone photos taken by Baird and provided to Terraprobe. Some cross-section locations were not accessible during the visual slope inspection and were not captured in the drone photos, and therefore, photographs of these sections are not included in the photo appendix.

A summary of the stratigraphy at each of the cross sections can be seen in the table below.

Area	Section #	Geotechnical Borehole ID from MNDM	Geotechnical Borehole Description from MNDM	Surficial Geology from MNDM	Well Record ID	Well Record Soil Description	OGS Report (1998)
A	T01	700205	fine sand	sand, gravel, minor silt and clay	4400509	sand, wet at 18', grey at 23' (water table 5 m	sand over silt and clay
	T04	700200	fine to medium sand, with silt	sand, gravel, minor silt and	4402323	sand, grey at 22', wet at 33'	sand
	T06	700199	fine to medium sand	sand, gravel, minor silt and	7040191	sand, grey at 40', clay at 69'	sand
	T09	700213	fine to medium sand, with silt	sand, gravel, minor silt and	4405425	sand, wet at 14', clay at 16' (wet	glacial till
	T11	n/a	n/a	older alluvial, silt till	4403644	sandy clay, clay at 15'	glacial till
	T13	n/a	n/a	silt and clay, till	n/a	n/a	sand over glacial till
	T15	n/a	n/a	silt and clay, sand	4401217	grey clay	silt and clay
B	T28	n/a	n/a	organics, silt and clay below	4401219	red clay	n/a
	T29	n/a	n/a	organics, silt and clay below	n/a	n/a	n/a
	T30	n/a	n/a	silt and clay, older alluvial,	7245585	clay, grey at 12'	n/a
	T31	n/a	n/a	silt and clay, and till	4403847	clay, limestone at 271'	n/a
	T32	n/a	n/a	sand, clay and silt, till	4403849	clay, grey at 110', limestone	n/a
C	T37	n/a	n/a	sand, silt and clay	7277004	sand	sand, silt and clay, sand
	T38	n/a	n/a	sand	4400014	clay over sand, wet at 56', clay	sand, silt and clay, sand
	T39	n/a	n/a	older alluvial	4400032	sand, grey at 9', clay at 14', sand	sand, silt and clay, sand
	T40	n/a	n/a	older alluvial	4403786	clay, wet sand at 25'	silt and clay over sand
	T41	n/a	n/a	silt and clay, sand	n/a	n/a	silt and clay over sand
	T42	n/a	n/a	sand, older alluvial	4403453	sand, wet with clay at 45', shale	silt and clay over sand
	T43	n/a	n/a	silt and clay, sand	4407014	clay, silt at 65', clay at 160',	silt and clay over sand
	T44	n/a	n/a	silt and clay, sand, till	n/a	n/a	silt and clay over sand
	T45	n/a	n/a	silt and clay, sand, till	n/a	n/a	silt and clay over sand
	T46	700012	clay, silt, sand	silt and clay, sand, till	n/a	n/a	silt and clay over sand

Area	Section #	Geotechnical Borehole ID from MNDM	Geotechnical Borehole Description from MNDM	Surficial Geology from MNDM	Well Record ID	Well Record Soil Description	OGS Report (1998)
D	T47	700011	clay and silt	silt and clay	4401911	clay, wet at 35'	silt and clay
	T48	n/a	n/a	silt and clay, sand	4401920	clay, rock at 63'	n/a
	T49	700014	silt, clay, fine sand, till below	silt and clay, sand, older	4404399	sand, with clay at 12', clay with	n/a
	T50	700015	silt, clay, fine sand, till below	silt and clay, sand	4404450	sand, clay at 20', rock at 110'	n/a
	T51	700016	silt, clay, fine sand, till below	silt and clay, sand, till	7219033	sand, silt till at 14', silt and sand	n/a
	T52	700010	clay and silt	silt and clay, sand	4407319	clay , silt at 65', clay and gravel	n/a
	T53	700013	clay and silt	silt and clay, sand	4402638	clay, grey at 30', sand and clay at	n/a
	T54	700017	clay and silt	silt and clay, sand	7269445	silt and clay	n/a
	T55	700019	clay, silt, fine sand	silt and clay, sand	7264341	clay	n/a
	T56	n/a	n/a	silt and clay, sand	7237775	fill	n/a
	T57	700020	clay, silt, fine sand	silt and clay, man made	n/a	n/a	n/a
	T58	700009	clay and silt	silt and clay, sand	7287720	silt and clay with gravel	n/a
	T59	700023	clay and silt	silt and clay, sand	4401948	clay, limestone at 92'	n/a
	T60	700008	clay and silt, limestone below	silt and clay, sand, limestone	4403709	clay, flint at 35', wet sand and	n/a
	T61	700000	clay, silt, pebbles	silt and clay, sand, limestone	4403431	clay, limestone at 54'	n/a
	T62	n/a	n/a	silt and clay, sand, limestone	n/a	n/a	n/a
	T63	n/a	n/a	silt and clay, sand, limestone	7234652	clay and silt	n/a
	T64	700001	clay and silt, limestone below	silt and clay, sand, limestone	4402577	clay, gravel at 46', limestone at	n/a

3.2 Ground Water

Installing ground water monitoring wells was not part of the scope of work. Static water levels recorded on the well records are included in the table below. Due to the proximity of Lake Erie, the water table along the shoreline is assumed to be hydraulically connected to the lake. The water table was estimated with this information and from observations of seepage at the slope face.

Area	Section #	Well Record ID	Well Record Static Water Level (ft) (depth below grade)	Well Record Static Water Level (m) (depth below grade)
A	T01	4400509	18	5.5
	T04	4402323	10	3.0
	T06	7040191	134	41

Area	Section #	Well Record ID	Well Record Static Water Level (ft) (depth below grade)	Well Record Static Water Level (m) (depth below grade)
A	T09	4405425	16	4.9
	T11	4403644	15	4.6
	T13	n/a	n/a	n/a
	T15	4401217	n/a	n/a
B	T28	4401219	n/a	n/a
	T29	n/a	n/a	n/a
	T30	7245585	n/a	n/a
	T31	4403847	n/a	n/a
	T32	4403849	62	18.9
C	T37	7277004	n/a	n/a
	T38	4400014	93	28.3
	T39	4400032	2	0.6
	T40	4403786	19	5.8
	T41	n/a	n/a	n/a
	T42	4403453	n/a	n/a
	T43	4407014	71	21.6
	T44	n/a	n/a	n/a
	T45	n/a	n/a	n/a
	T46	n/a	n/a	n/a
D	T47	4401911	50	15.2
	T48	4401920	0	0
	T49	4404399	0	0
	T50	4404450	30	9.1
	T51	7219033	31	9.4
	T52	4407319	55	16.8
	T53	4402638	55	16.8
	T54	7269445	40	12.2
	T55	7264341	n/a	n/a
	T56	7237775	n/a	n/a
	T57	n/a	n/a	n/a
	T58	7287720	n/a	n/a
	T59	4401948	45	13.7
	T60	4403709	20	6.1
	T61	4403431	35	10.7
	T62	n/a	n/a	n/a
	T63	7234652	n/a	n/a

Area	Section #	Well Record ID	Well Record Static Water Level (ft) (depth below grade)	Well Record Static Water Level (m) (depth below grade)
D	T64	4402577	46	14.0

3.3 Visual Slope Inspections

A detailed visual slope inspection of the slope area from the crest to the toe was conducted by Jory Hunter of Terraprobe on May 13, 2019. Jason Crowder of Terraprobe also inspected the slope in April 2019. General information pertaining to the existing slope features such as slope profile, slope drainage, water course features, vegetation cover, buildings in the vicinity of the slope, erosion features, and slope slide features were obtained during the inspection. A summary of the visual slope inspection is presented below. Photographs taken during the inspections are included as Appendix C. The locations of the features discussed below are shown on the Cross-sections, Photographs, and Site Features plan in Appendix A. Some cross-section locations were not accessible during the visual slope inspection and were not captured in the drone photos, and therefore, photographs of these sections are not included in the photo appendix.

The tableland is generally flat, and is occupied by agricultural land, residential properties, conservation land, or municipal roadways. The shoreline generally comprises sand and silt rhythmites, glaciolacustrine silt and clay, glacial till, sand dunes, beaches or talus, or visible limestone bedrock. The slope and bluff along the shoreline are on average 20 ±m in height and up to 50 ±m in height.

Where there are dwellings in the tableland there may be drainage over the slope. Drainage pipes were observed on the slope face in Area B at Section 32, with outlets on the lower slope face.

The tableland is generally vegetated with grass, shrubs, young to mature trees, or is occupied by agricultural land. The slope face is either forested, vegetated with grass, or bare. Where there are bluffs (in parts of Areas A, C, and D), seepage is sometimes visible through the slope face from multiple levels, including well above the slope toe.

At the west end of Area A, seepage is apparent through the bluff face and natural pipes are visible along the sand and silt boundary. The bluffs in this area are generally 20 to 50 m in height with a wide range of slope inclinations, and are in state of active retrogressive slope failure. There is talus accumulation at the toe of the slope.

Area B is located between Long Point and Turkey Point. The slope at Area B is generally vegetated, up to 26 ±m in height, sloped at 1.7H:1V or flatter, with agricultural land or residential property in the tableland. There are two marinas at the toe of slope. North of the shoreline along the road into one of the marinas (at Section T32) there are leaning trees with loss of ground at the top of slope and bulging ground at the toe slope, with sediment accumulation on the roadway, which may indicate movement and potential instability.

The slope along Area C and D is generally around 20 ±m in height to up to 50 ±m in height with a wide range of slope inclinations, and vegetated, with some isolated areas experiencing active retrogressive slope failure. There are residential properties in the tableland in close proximity to the slope crest. At Section T39, the slope is oversteepened and bare with seepage through the slope face. There are dwellings in the tableland at the slope crest which are at risk due to slope failure.

Other areas where there are dwellings in close proximity to the slope crest where active failure is occurring are summarized in the table below.

Area	Closest Section	Description
C	T38 – T39	dwellings in close proximity to oversteepened, bare, and actively failing slope face
C	T39	dwellings in close proximity to oversteepened, bare, and actively failing slope face
C	east of T42	dwellings in close proximity to oversteepened, bare, and actively failing slope face
D	T47	trailers in close proximity to oversteepened, bare, and actively failing slope face

A summary of the visual observations across the study area is shown below.

Area	Sections	General Slope Height (±m)	General Slope Inclination	Exposed Soil	Features
A	1 to 15	7 to 49	steeper than 1.0H:1V to 2.3H:1V	cohesionless **sands and silts** overlying cohesive **glacial till** and glaciolacustrine **silt and clay**	• Agricultural land, dwellings, and municipal roadways • Slope is bare, oversteepened and actively failing • Seepage and natural piping through the slope face • Generally sand talus at the toe of slope
B	28 to 32	2 to 25	flatter than 4.0H:1V to 1.7H:1V	cohesive **silt and clay** overlying cohesive **glacial till**	• Agricultural land, dwellings, and municipal roadways in the tableland • Slope face forested with shrubs and trees, landscaped with grass • Lake Erie directly at the toe of slope, marinas at the toe of slope
C	37 to 46	7 to 40	steeper than 1.0H:1V to 3.0H:1V	cohesive **silt and clay** overlying very dense **sand**	• Agricultural land, dwellings, and municipal roadways in the tableland • Slope face is bare and oversteepened or forested with shrubs and trees, landscaped with grass • There is sand beach or talus at the toe of slope • Dwellings are sometimes present along the toe of slope
D	47 to 64	2 to 23	steeper than 1.0H:1V to flatter than 3.0H:1V	cohesive **silt and clay**	• Agricultural land, dwellings, and municipal roadways in the tableland • Slope face is generally forested with shrubs and trees, or landscaped with grass, some areas bare and oversteepened • At the east end of the study area there is limestone at the shoreline

4.0 SLOPE STABILITY ANALYSIS

4.1 Existing Conditions

A detailed engineering analysis of slope stability was carried out on the subject slope as shown in plan as Appendix A, and in profile in Appendix F. The analysis was completed using the LiDAR data provided by Baird. Terraprobe has assumed for the present purposes that this factual data represents the existing slope conditions.

The analysis was conducted utilizing computer software (Slide 8.016, released July 23, 2018, developed by Rocscience Inc.) and several standard methods of limit equilibrium analysis (Bishop, Janbu, Morgenstern/Price, and Spencer). These methods of analysis allow the calculation of Factors of Safety for hypothetical or assumed slip surfaces through the slope. The analysis method is used to assess potential for movements of large masses of soil over a specific slip surface which can be curved or circular, or non-circular. The analysis involves dividing the sliding mass into many thin slices and calculating the forces on each slice. The normal and shear forces acting on the sides and base of each slice are calculated. It is an iterative process that converges on a solution. An example analysis is provided as Appendix E, which shows the critical slip surface, the slices, and the inter-slice forces, as well as pertinent aspects of the slope stability output.

For a specific slip surface, the Factor of Safety is defined as the ratio of the available soil strength resisting movement, divided by the gravitational forces tending to cause movement. The Factor of Safety of 1.0 represents a “limiting equilibrium” condition where the slope is at a point of pending failure since the soil resistance is equal to forces tending to cause movement. It is usual to require a Factor of Safety greater than one (1) to ensure stability of the slope. The typical Factor of Safety used for engineering design of slopes for stability ranges from about 1.3 to 1.5 for developments situated close to the slope crest. The most common design guidelines are based on a 1.5 minimum Factor of Safety.

Each analysis was carried out by preparing a model of the slope geometry and subsurface conditions, and analyzing numerous different slip surfaces through the slope in search of the minimum or critical Factor of Safety for specific conditions. The pertinent data obtained from topographic plan, slope profiles, slope mapping, and the borehole information, were input for the slope stability analysis. Many calculations were carried out to examine the Factor of Safety for varying depths of potential slip surfaces. Circular and non-circular surfaces were both analyzed and circular surfaces were found to govern.

The average soil properties utilized for the soil strata in the slope stability analysis were assessed from information secured from the boreholes, publicly available information, and visual inspection. The average soil properties are based on effective stress analysis for long-term slope stability, and are summarized in the table below. These soil properties are considered conservative; the soils on site are likely stronger. Short-term effects such as negative pore water pressures within unsaturated soils can increase the stability of a slope, and have been conservatively omitted. The presence of limestone (east end of Area D) at the shoreline has been conservatively omitted.

Material	Unit Weight (kN/m^3)	Cohesion (kPa)	Internal Friction Angle (deg.)
Sand	18.5	0	30
Silt Rhythmites	21	2	34
Silt and Clay	21	6	30
Sand Rhythmites	20	0	38
Sand Talus	18.5	0	30
Clayey Silt Till	21	8	32
Toe Wall	22	impenetrable	impenetrable

The Lake Erie water level used in the slope stability analysis is at Elev. 173.2 m.

The results of the slope stability analysis of the existing conditions are provided in Appendix F, and are summarized in the table below.

Area	Section #	Height from section (m)	Existing Inclination from section	Existing FS	Critical (circular) Slip Surface Description
A	T01	25.5 ±m	0.6H:1V (upper slope) 1.3H:1V (lower slope)	<1.0 (upper slope) 1.0 (lower slope) 1.3 (overall)	Surfaces pass through the mid to lower slope profile
	T04	28.5 ±m	0.8H:1V (overall)	<1.0 (overall)	Surfaces pass through the mid to lower slope profile
	T06	49.0 ±m	1.4H:1V (overall)	<1.0 (upper slope) 1.0 (lower slope)	Surfaces pass through the lower slope profile
	T09	23.9 ±m	2.0H:1V (upper slope) 0.7H:1V (lower slope)	<1.0 (lower slope) 1.3 (overall)	Surfaces pass through the lower slope profile
	T11	7.7 ±m	2.3H:1V (overall)	1.8 (overall)	Surfaces pass under the toe wall
	T13	11 ±m	1.3H:1V (upper slope) 0.8H:1V (lower slope)	<1.0 (overall)	Surfaces pass through the lower slope profile
	T15	7.3 ±m	1.7H:1V (overall)	1.4 (overall)	Surfaces pass under the toe wall
B	T28	< 5 m	flatter than 4.0H:1V	2.3 (overall)	Surfaces pass through the lower slope profile
	T29	8.7 ±m	3.8H:1V (overall)	2.1 (overall)	Surfaces pass under the toe wall
	T30	15.8 ±m	2.1H:1V (overall)	1.5 (overall)	Surfaces pass through the toe of slope
	T31	24.3 ±m	1.7H:1V (overall)	1.2 (overall)	Surfaces pass through the toe of slope
	T32	25.6 ±m	2.5H:1V (overall)	1.6 (overall)	Surfaces pass through the toe of slope
C	T37	39.8 ±m	1.3H:1V (overall)	1.1 (overall)	Surfaces pass through the mid-slope profile

Area	Section #	Height from section (m)	Existing Inclination from section	Existing FS	Critical (circular) Slip Surface Description
C	T38	34.9 ±m	1.1H:1V (upper slope) 1.9H:1V (lower slope)	<1.0 (overall)	Surfaces pass through the mid-slope profile
	T39	23.4 ±m	1.0H:1V (upper slope) 1.5H:1V (lower slope)	<1.0 (overall)	Surfaces pass through the lower slope profile
	T40	10.4 ±m	1.7H:1V (upper slope) 0.6H:1V (lower slope)	1.1 (overall)	Surfaces pass through the toe of slope
	T41	28.2 ±m	1.1H:1V (overall)	<1.0 (overall)	Surfaces pass through the toe of slope
	T42	7.4 ±m	1.7H:1V (overall)	1.4 (overall)	Surfaces pass through the toe of slope
	T43	25.7 ±m	1.2H:1V (overall)	<1.0 (overall)	Surfaces pass through the lower slope profile
	T44	23.6 ±m	2.1H:1V (overall)	1.4 (overall)	Surfaces pass through the toe of slope
	T45	19.2 ±m	1.9H:1V (upper slope) 0.8H:1V (mid-slope)	<1.0 (overall)	Surfaces pass through the mid slope profile
	T46	21.2 ±m	3.0H:1V (overall)	1.9 (overall)	Surfaces pass under the toe wall
D	T47	18.3 ±m	2.2H:1V (overall)	1.4 (overall)	Surfaces pass through the toe of slope
	T48	16.3 ±m	2.5H:1V (overall)	1.5 (overall)	Surfaces pass through the toe of slope
	T49	13.4 ±m	1.0H:1V (upper slope) 2.7H:1V (lower slope)	1.3 (overall)	Surfaces pass through the toe of slope
	T50	19.9 ±m	1.5H:1V (overall)	1.1 (overall)	Surfaces pass through the toe of slope
	T51	20.9 ±m	3.5H:1V (overall)	1.6 (overall)	Surfaces pass through the toe of slope
	T52	21.9 ±m	2.3H:1V (upper slope) 1.6H:1V (mid-slope) 1.0H:1V (lower slope)	1.2 (overall)	Surfaces pass through the toe of slope
	T53	18.2 ±m	5.2H:1V (upper slope) 3.2H:1V (lower slope)	1.9 (overall)	Surfaces pass through the toe of slope
	T54	15.8 ±m	1.3H:1V (overall)	1.2 (overall)	Surfaces pass through the lower slope profile
	T55	13.1 ±m	2.1H:1V (overall)	1.4 (overall)	Surfaces pass through the toe of slope
	T56	less than 2 m	0.9H:1V (overall)	1.5 (overall)	Surfaces pass through the toe of slope
	T57	2.4 ±m	1.8H:1V (upper slope) 0.9H:1V (lower slope)	1.5 (overall)	Surfaces pass through the toe of slope
	T58	14.7 ±m	2.1H:1V (overall)	1.4 (overall)	Surfaces pass through the toe of slope
	T59	13.6 ±m	2.3H:1V (overall)	1.7 (overall)	Surfaces pass under the toe wall
	T60	13.1 ±m	2.5H:1V (overall)	1.5 (overall)	Surfaces pass under the toe wall
	T61	10.5 ±m	3.4H:1V (overall)	2.1 (overall)	Surfaces pass through the toe of slope
	T62	10.0 ±m	2.2H:1V (overall)	1.5 (overall)	Surfaces pass through the toe of slope
	T63	8.9 ±m	3.0H:1V (overall)	1.9 (overall)	Surfaces pass through the toe of slope
	T64	11.2 ±m	2.6H:1V (overall)	1.5 (overall)	Surfaces pass through the toe of slope

Circular surfaces were found to govern for the existing conditions, with critical slip surfaces generally passing through the lower slope profile. The results indicate that the majority of the site (23 out of 40 sections) have factors of safety of less than 1.5. Ten (10) of these sections have factors of safety of less than 1.0. Seventeen (17) of the cross sections have factors of safety of 1.5 or greater.

In Area A, Sections T1, T4, T6, and T13 are bare and oversteepened and have minimum factors of safety of less than 1.0. These sections are considered unstable. Sections T9, T11, and T15 are vegetated with shallower inclinations. Sections T9 and T15 have minimum factors of safety of 1.3 to 1.4 and are marginally stable, and Section T11 has a factor of safety of 1.8 and is stable.

In Area B, all the sections in this section are vegetated with inclinations of 1.7H:1V or flatter. The minimum factors of safety are greater than or equal to 1.5 and considered stable along this section. Section T31 has a factor of safety of 1.2 and is considered marginally stable.

In Area C, Sections T37, T40, T42, T44 and T46 are vegetated and have inclinations of 1.3H:1V to 3.0H:1V. Some of these sections have dwellings at the toe of slope. The minimum factors of safety are 1.1 to 1.4 and marginally stable, except for T46 which is stable with a factor of safety of 1.9. Sections T38, T39, T41, T43, and T45 are bare with factors of safety of less than 1.0 and are therefore considered unstable.

In Area D, Sections T48, T51, T53, T56, T57, T59, T60, T61, T62, T63, and T64 are vegetated with factors of safety greater than 1.5, and are therefore considered stable. Sections T47, T49, T50, T52, T54, T55 and T58 are vegetated to bare and sometimes oversteepened with factors of safety of 1.1 to 1.4, and are considered marginally stable.

4.2 Stable Inclination Setback

For active land use, the MNR Policy Guidelines allow a minimum Factor of Safety of 1.3 to 1.5 for slope stability, as follows.

TYPE	LAND-USES	DESIGN MINIMUM FACTOR OF SAFETY
A	PASSIVE: no buildings near slope; farm field, bush, forest, timberland, woods, wasteland, badlands, tundra	1.1
B	LIGHT: no habitable structures near slope; recreational parks, golf courses, buried small utilities, tile beds, barns, garages, swimming pools, sheds, satellite dishes, dog houses	1.20 to 1.30
C	ACTIVE: habitable or occupied structures near slopes; residential, commercial, and industrial buildings, retaining walls, storage/warehousing of non-hazardous substances	1.30 to 1.50
D	INFRASTRUCTURE and PUBLIC USE: public use structures and buildings (i.e. hospitals, schools, stadiums), cemeteries, bridges, high voltage power transmission lines, towers, storage/warehousing of hazardous materials, waste management areas	1.40 to 1.50

Based on the MNR policy guidelines, the LTSSC analysis was conducted using a Factor of Safety of 1.5 (“$LTSSC_{1.5}$”, for habitable or occupied structures near slopes). The computed minimum factors of safety are as low as less than 1.0, with critical (circular) slip surfaces generally passing through the lower slope profile. Therefore, the minimum factors of safety obtained under existing conditions in 23 of the 40 section locations are considered inadequate and unacceptable for long-term planning purposes. An additional setback from the existing top of slope will be required to achieve a long-term stable inclination.

4.2.1 Stable Slope Inclination

Based on the soil type of the subject section (as described in Section 3.0 and shown in Appendix F), the subject slope is either composed of sand and silt rhythmites, glaciolacustrine silt and clay, glacial till, sand dunes, beaches or talus, or visible limestone bedrock. A number of representative trial stabilized slope profiles were analysed to obtain the required factor of safety.

Terraprobe referred to the following documents for the policies in the study area:

- Long Point Region Conservation Authority, “Policies for the Administration of the Development, Interference with Wetlands, and Alterations to Shorelines and Watercourses Regulation, Ontario Regulation 178/06”, dated October 4, 2017.

A number of representative trial stabilized slope profiles were analyzed to obtain a minimum factor of safety for global stability of 1.5 (shown in Appendix G) for normal ground water conditions and temporary and infrequent high-water table conditions.

The stable slope inclinations are shown in profile in Appendix G, and summarized in the table below.

Soil Type	Stable Slope Inclinations for: Normal Ground Water Table (FS = 1.5) Temporary and Infrequent High Ground Water Table (FS = 1.3)
Sand	2.5H:1V
Silt Rhythmites	2.5H:1V
Silt and Clay	2.3H:1V
Sand Rhythmites	2.0H:1V
Clayey Silt Till	2.3H:1V

In addition to a stable slope inclination setback, an erosion allowance (to be provided by Baird) should be applied to determine the long-term stable slope crest position.

The following table provides the stable slope inclinations for each of the cross sections based on the primary soil type. The assumed geological contact between units and corresponding change in stable slope inclination for each cross section is also noted. The stratigraphy and recommendations can be interpolated between sections by transitioning approximately halfway between adjacent sections.

Area	Section #	Primary Soil Type	Stable Inclination
A	T01	Sand, Silt Rhythmites	2.5H:1V (above Elev. 178.8 m)
		Silt and Clay	2.3H:1V (below Elev. 178.8 m)
	T04	Sand	2.5H:1V (above Elev. 198.3 m)
		Sand Rhythmite	2.0H:1V (below Elev. 198.3 m)
	T06	Sand	2.5H:1V (above Elev. 198.9 m)
		Sand Rhythmite	2.0H:1V (below Elev. 198.9 m)
	T09	Sand	2.5H:1V (above Elev. 195.0 m)
		Clayey Silt Till	2.3H:1V (below Elev. 195.0 m)
	T11	Sand	2.5H:1V (above Elev. 179.9 m)
		Clayey Silt Till	2.3H:1V (below Elev. 179.9 m)
	T13	Sand Rhythmite	2.0H:1V (above Elev. 179.3 m)
		Clayey Silt Till	2.3H:1V (below Elev. 179.3 m)
	T15	Silt and Clay	2.3H:1V
B	T28	Sand	2.5H:1V
	T29	Silt and Clay	2.3H:1V
	T30	Silt and Clay	2.3H:1V
		Clayey Silt Till	
	T31	Silt and Clay	2.3H:1V
	T31	Clayey Silt Till	2.3H:1V
	T32	Silt and Clay	2.3H:1V

Area	Section #	Primary Soil Type	Stable Inclination
B		Clayey Silt Till	
C	T37	Sand	2.5H:1V (above 208.5 m)
		Silt and Clay	2.3H:1V (208.5 - 203.5 m)
		Sand Rhythmite	2.0H:1V (below 203.5 m)
	T38	Sand	2.5H:1V (above 204.0 m)
		Silt and Clay	2.3H:1V (204.0 – 201.0 m)
		Sand Rhythmite	2.0H:1V (below 201.0 m)
	T39	Sand	2.5H:1V (above 188.5 m)
		Silt and Clay	2.3H:1V (188.5 – 183.5 m)
		Sand Rhythmite	2.0H:1V (below 183.5 m)
	T40	Silt and Clay	2.3H:1V (above 181.1 m)
		Sand Rhythmite	2.0H:1V (below 181.1 m)
	T41	Silt and Clay	2.3H:1V (above 196.1 m)
		Sand Rhythmite	2.0H:1V (below 196.1 m)
	T42	Sand Rhythmite	2.0H:1V
	T43	Silt and Clay	2.3H:1V (above 193.0 m)
		Sand Rhythmite	2.0H:1V (below 193.0 m)
	T44	Silt and Clay	2.3H:1V (above 190.7 m)
		Sand Rhythmite	2.0H:1V (below 190.7 m)
	T45	Silt and Clay	2.3H:1V (above 186.9 m)
		Sand Rhythmite	2.0H:1V (below 186.9 m)
	T46	Silt and Clay	2.3H:1V (above 185.2 m)
		Sand Rhythmite	2.0H:1V (below 185.2 m)
D	T47	Silt and Clay	2.3H:1V
	T48	Silt and Clay	2.3H:1V
	T49	Silt and Clay	2.3H:1V
	T50	Silt and Clay	2.3H:1V
	T51	Silt and Clay	2.3H:1V
	T52	Silt and Clay	2.3H:1V
	T53	Silt and Clay	2.3H:1V
	T54	Silt and Clay	2.3H:1V
	T55	Silt and Clay	2.3H:1V
	T56	Sand	2.5H:1V
	T57	Sand	2.5H:1V
	T58	Silt and Clay	2.3H:1V
	T59	Silt and Clay	2.3H:1V
	T60	Silt and Clay	2.3H:1V
	T61	Silt and Clay	2.3H:1V
	T62	Silt and Clay	2.3H:1V
	T63	Silt and Clay	2.3H:1V
	T64	Silt and Clay	2.3H:1V

The stratigraphy and stable slope inclinations can be interpolated between sections by transitioning approximately halfway between adjacent sections.

5.0 SUMMARY AND CLOSURE

This report encompasses a slope stability and erosion risk assessment for the purpose of establishing the Stable Slope Inclinations at a county scale. Site specific studies are recommended. The stable slope allowance is used for mapping the Erosion Hazard.

The study area is along the north shoreline of Lake Erie in Norfolk County (east of Port Burwell to east of Port Dover, Ontario). Lake Erie shoreline of Norfolk County, in Norfolk County, Ontario. The subject slope along the shoreline is up to 50 ±m in height. The tableland is generally occupied by agricultural land, residential properties, conservation land, or municipal roadways. Lake Erie is present approximately at the toe of slope. The scope of work includes a detailed visual slope inspection to review the existing slope conditions and a detailed slope stability analysis.

Based on the detailed slope stability analysis, the existing slope generally has a minimum Factor of Safety of less than 1.5, and is not considered stable for long-term planning purposes. Some areas are in a state of active retrogressive failure. Minimum Factors of Safety of 1.5 for normal ground water and temporary elevated ground water conditions are achieved with a stable slope inclination of 2.5H:1V in the sand and silt rhythmite, 2.3H:1V in the glaciolacustrine silt and clay and glacial till, and 2.0H:1V in the sand rhythmite. To determine the Long-Term Stable Slope Crest, an erosion allowance must be applied. MNR guidelines require that developments, dwellings, buildings, or other structures have an additional setback for planning purposes.

There are some dwellings in close proximity to the slope crest where there was limited access to the slope, mainly in Area C; see Section 3.3 for specific locations. These dwellings are within the stable slope allowance, and a more detailed site-specific analysis outside of this scope of work is recommended.

West of the study area, around Godby Road to Stafford Road, there are large gullies that formed by eroding inland rapidly, exceeding the surrounding erosion rates. These gullies may form in the west end of the study area, especially around Hemlock, Ontario, where v-shaped retrogressive failures were observed.

In general, any site development and construction activities should be conducted in a manner which does not result in surface erosion of the slope. In particular, site grading and drainage should be designed to prevent direct concentrated or channelized surface runoff from flowing directly over the slope. Water drainage from down-spouts, sumps, road drainage, and the like should not be permitted to flow over the slope.

This report is prepared for the express use of W.F. Baird & Associates Coastal Engineers Ltd. and the client, Long Point Region Conservation Authority. It is not for use by others.

W.F. Baird & Associates Coastal Engineers Ltd. and the client, Long Point Region Conservation Authority, are authorized users.

We trust that this report meets your present requirements. Should you have any questions regarding the information presented, please do not hesitate to contact our office.

Terraprobe Inc.

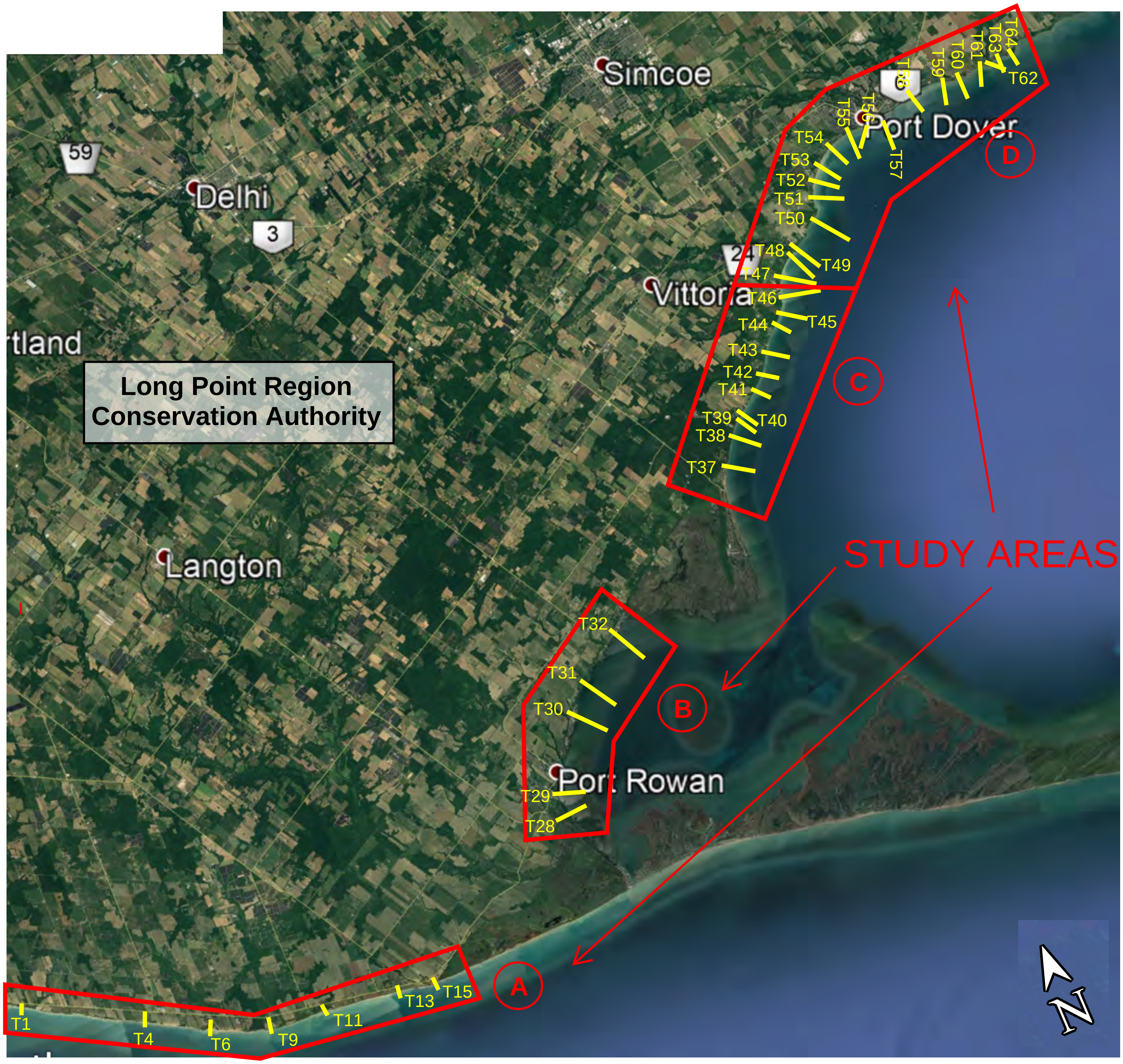
Jory Hunter, B.Sc.(Eng.), E.I.T.
Geotechnical Engineering Division

Jason Crowder, Ph.D., P.Eng.
Principal

LICENSED PROFESSIONAL ENGINEER
J. J. CROWDER
100077148
15/10/2019
PROVINCE OF ONTARIO

FIGURES

TERRAPROBE INC.



Scale

20 km

Terraprobe

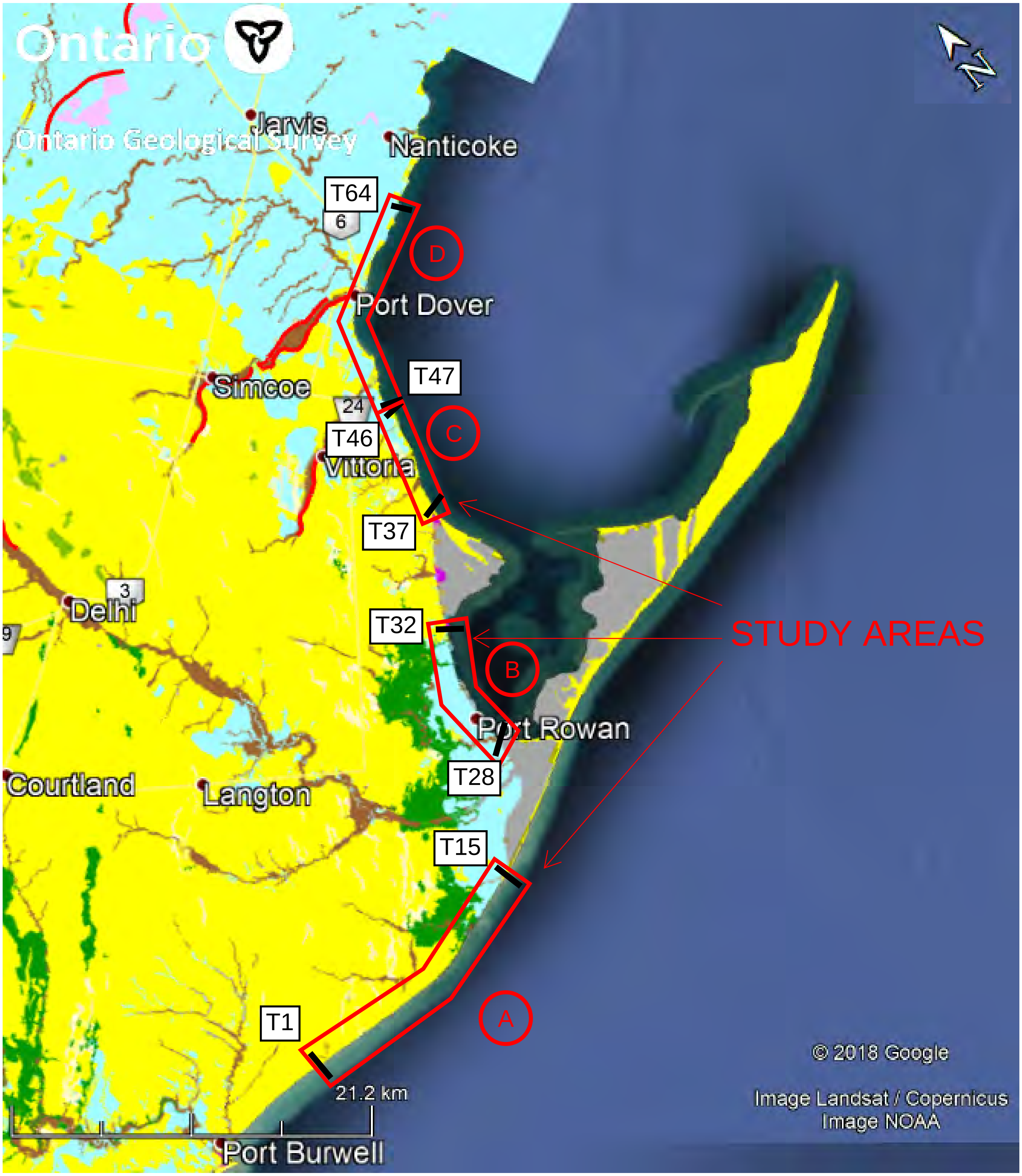
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

Site Location Plan

File. No.: 1-19-0230-01

FIGURE : 1



LEGEND

🟨 Coarse-textured glaciolacustrine deposits
sand, gravel, minor silt and clay

🟫 Older alluvial deposits
clay, silt, sand, gravel, may contain organic remains

🟩 Till
clay to silt textured till (derived from glaciolacustrine deposits or shale)

🟦 Fine-textured glaciolacustrine deposits
silt and clay, minor sand and gravel, massive to well laminated

⬜ Organic Deposits
peat, muck, marl

Terraprobe

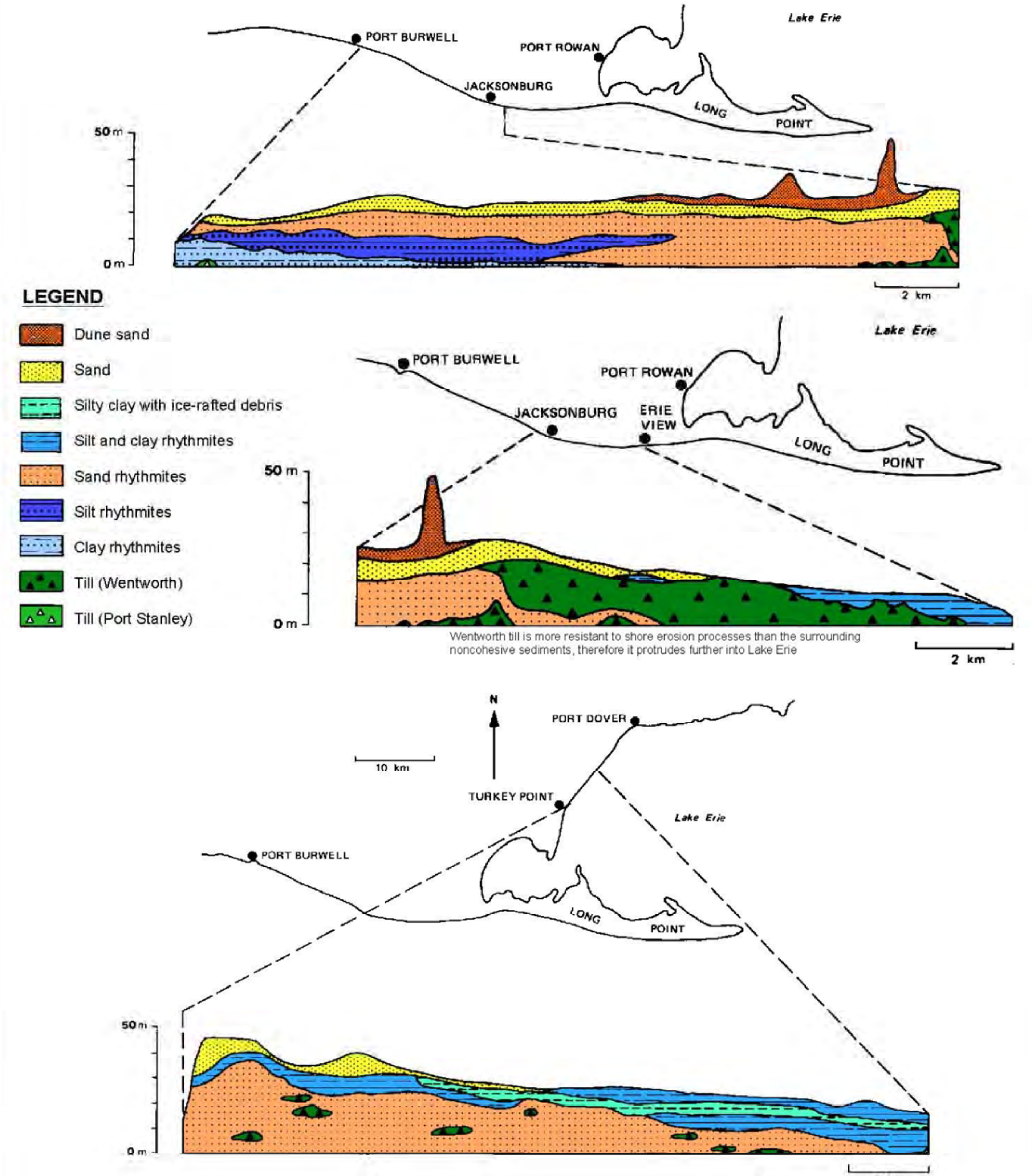
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

MNDM Surficial Geology

File. No.: 1-19-0230-01

FIGURE : 2



Wentworth till is more resistant to shore erosion processes than the surrounding noncohesive sediments, therefore it protrudes further into Lake Erie

REFERENCE
"Quaternary Geology Long Point-Port Burwell Area", Ontario Geological Survey Report 298, dated 1998

Terraprobe

11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:
OGS CROSS SECTIONS

File. No.: 1-19-0230-01

FIGURE : 3

APPENDIX

TERRAPROBE INC.

APPENDIX A

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Legend

1 Photo Locations

/ Section Locations

⊕ OGS Geotechnical Boreholes (MNDM)

⊕ Ontario Well Records

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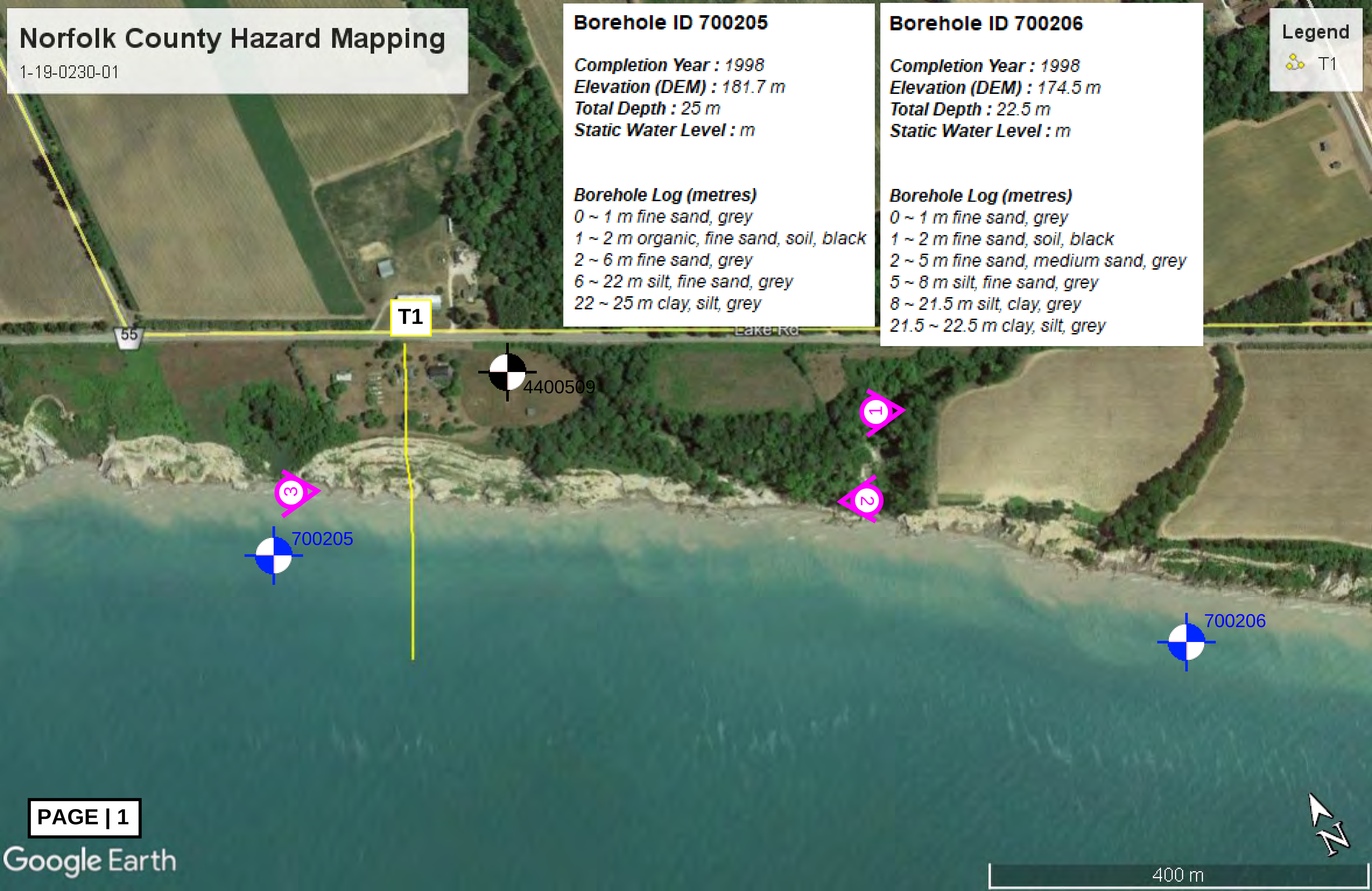
11 Indell Lane, Brampton, Ontario, L6T 3Y3
Tel: (905) 796-2650 Fax: (905) 796-2250

Title:

Legend

File. No.:

FIGURE :



Norfolk County Hazard Mapping

1-19-0230-01

Borehole ID 700205

Completion Year : *1998*
Elevation (DEM) : *181.7 m*
Total Depth : *25 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 1 m fine sand, grey
1 ~ 2 m organic, fine sand, soil, black
2 ~ 6 m fine sand, grey
6 ~ 22 m silt, fine sand, grey
22 ~ 25 m clay, silt, grey

Borehole ID 700206

Completion Year : *1998*
Elevation (DEM) : *174.5 m*
Total Depth : *22.5 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 1 m fine sand, grey
1 ~ 2 m fine sand, soil, black
2 ~ 5 m fine sand, medium sand, grey
5 ~ 8 m silt, fine sand, grey
8 ~ 21.5 m silt, clay, grey
21.5 ~ 22.5 m clay, silt, grey

Norfolk County Hazard Mapping

1-19-0230-01

Norfolk County Hazard Mapping

1-19-0230-01

Norfolk County Hazard Mapping

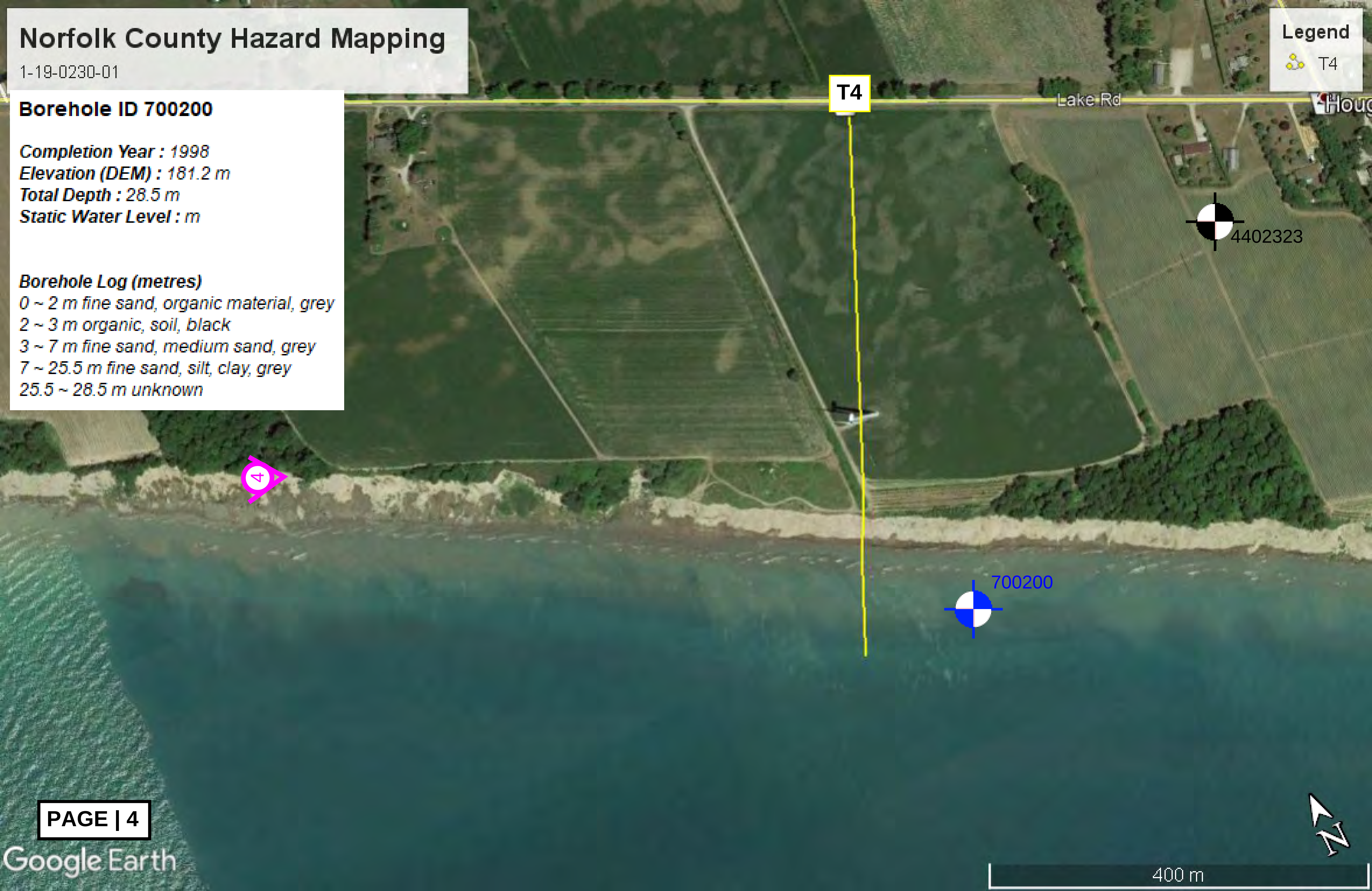
1-19-0230-01

Borehole ID 700200

Completion Year : *1998*
Elevation (DEM) : *181.2 m*
Total Depth : *28.5 m*
Static Water Level : *m*

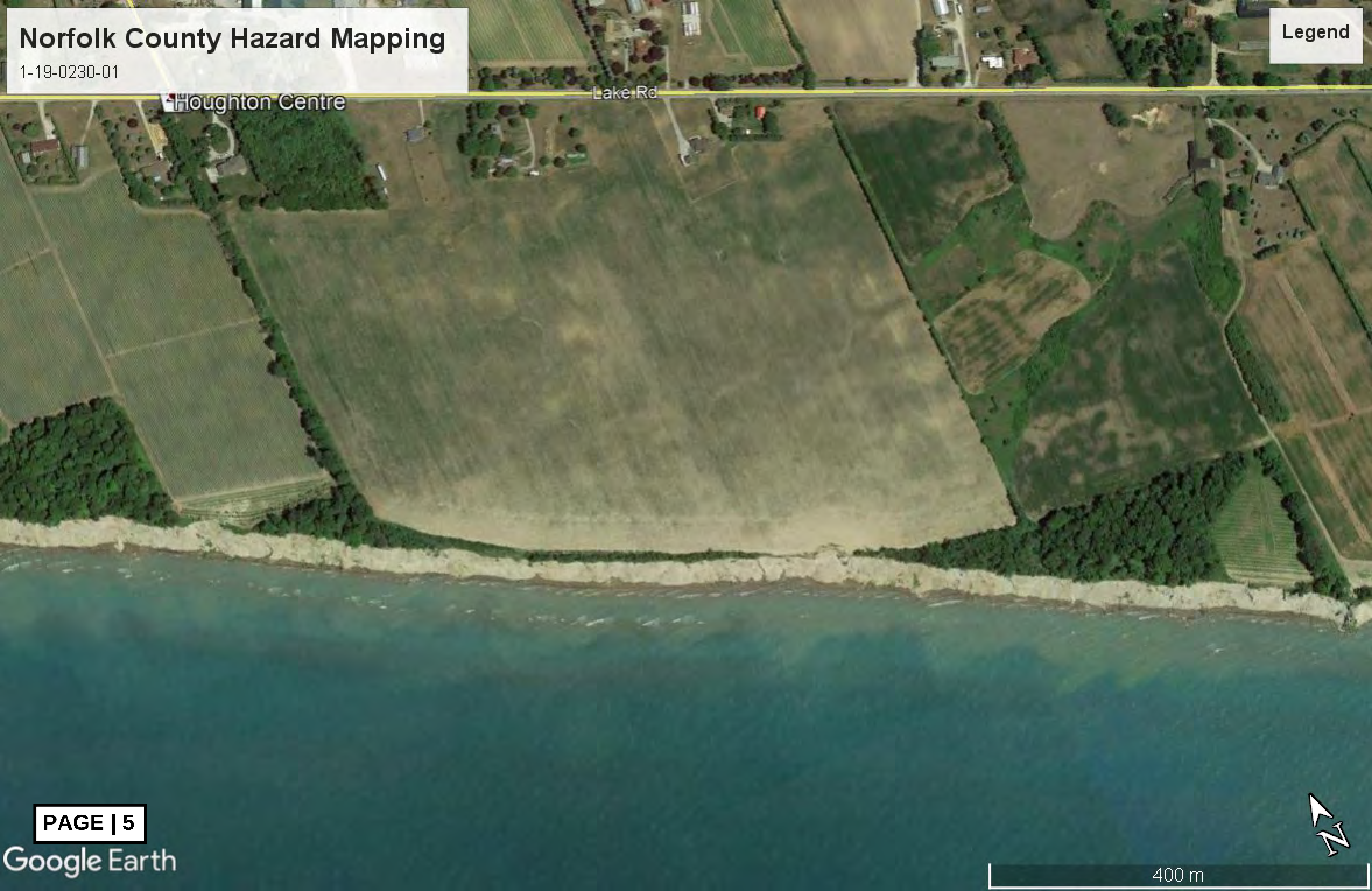
Borehole Log (metres)

0 ~ 2 m fine sand, organic material, grey
2 ~ 3 m organic, soil, black
3 ~ 7 m fine sand, medium sand, grey
7 ~ 25.5 m fine sand, silt, clay, grey
25.5 ~ 28.5 m unknown



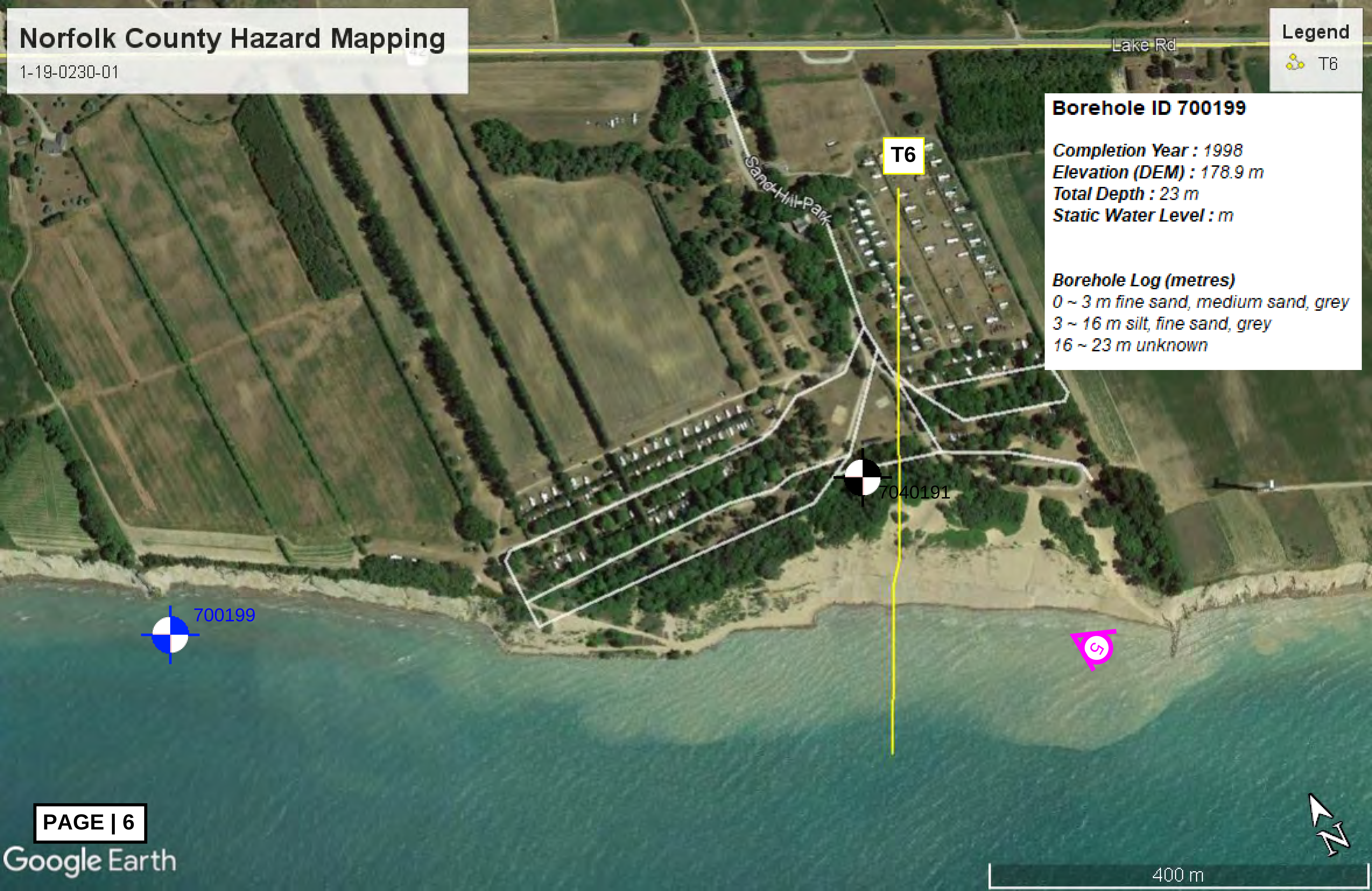
Norfolk County Hazard Mapping

1-19-0230-01



Norfolk County Hazard Mapping

1-19-0230-01



Borehole ID 700199

Completion Year : *1998*
Elevation (DEM) : *178.9 m*
Total Depth : *23 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 3 m fine sand, medium sand, grey
3 ~ 16 m silt, fine sand, grey
16 ~ 23 m unknown

Norfolk County Hazard Mapping

1-19-0230-01

Borehole ID 700213

Completion Year : *1998*
Elevation (DEM) : *172.3 m*
Total Depth : *30 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 2 m fine sand, organic material, grey
2 ~ 3 m organic, fine sand, black
3 ~ 15 m fine sand, medium sand, silt, clay, grey
15 ~ 23 m fine sand, silt, clay, grey
23 ~ 30 m silt, fine sand, grey
23 ~ 26.5 m till, grey

Norfolk County Hazard Mapping

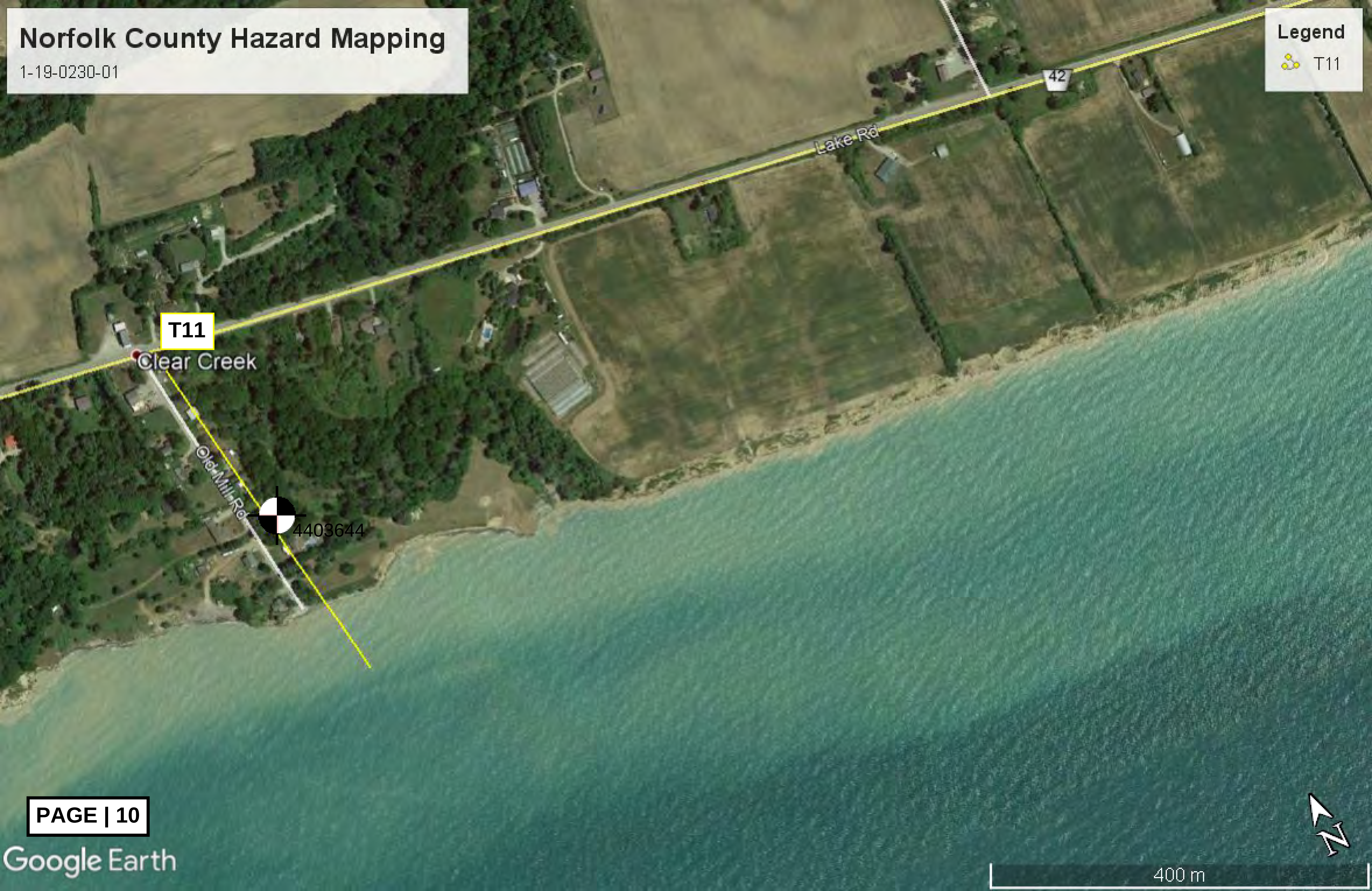
1-19-0230-01

Norfolk County Hazard Mapping

1-19-0230-01

Norfolk County Hazard Mapping

1-19-0230-01



Norfolk County Hazard Mapping

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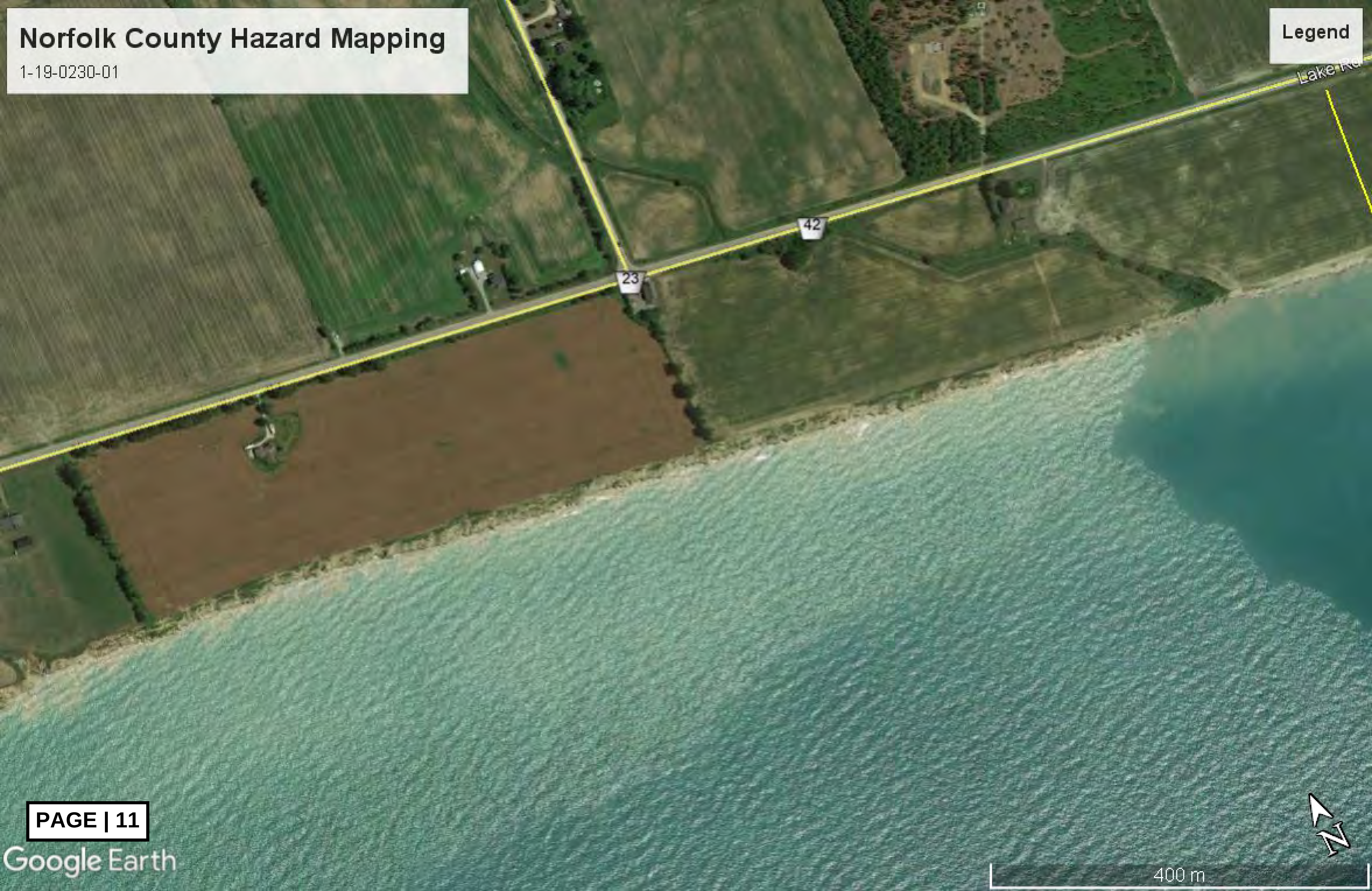

Norfolk County Hazard Mapping

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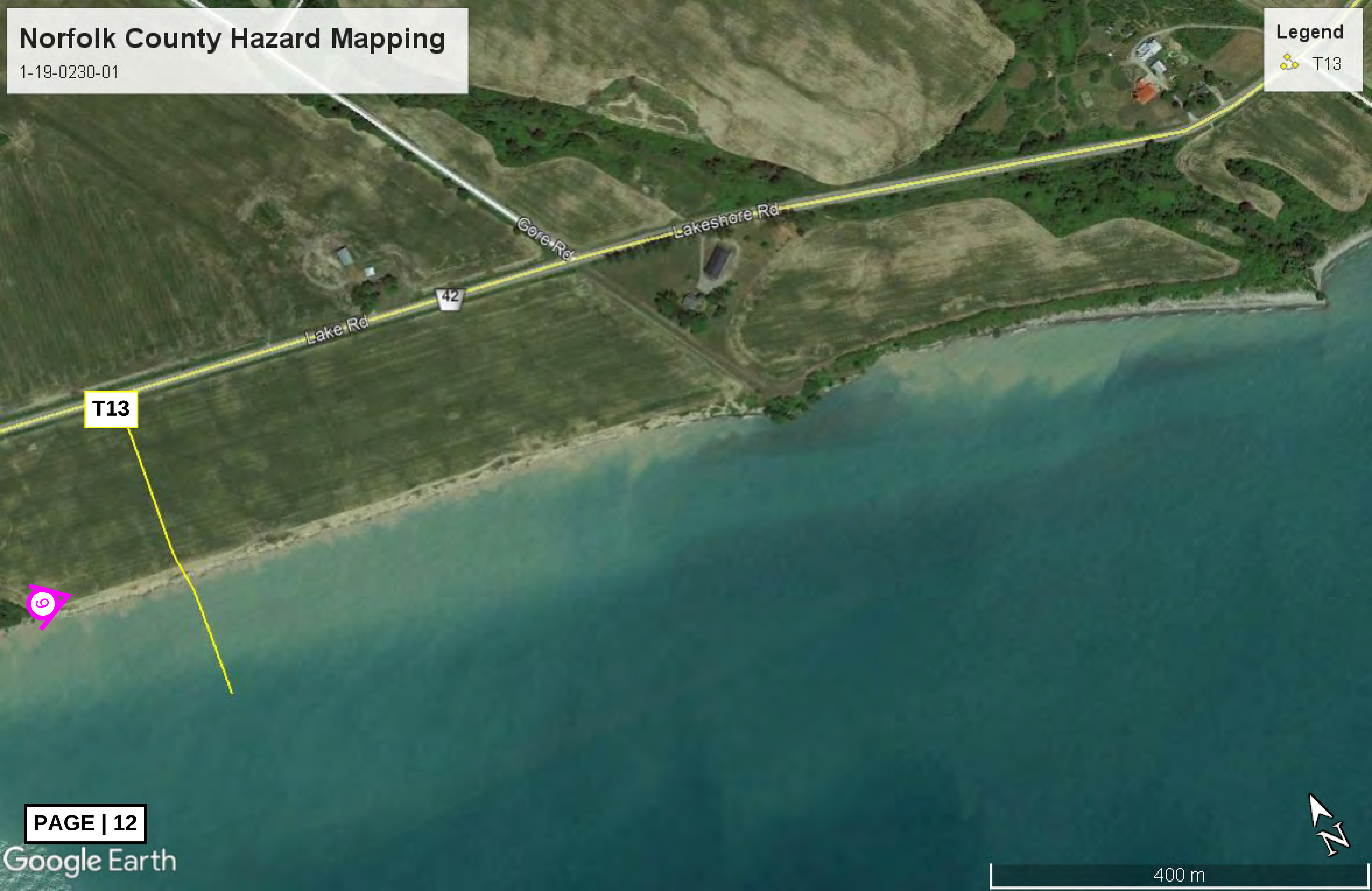

Norfolk County Hazard Mapping

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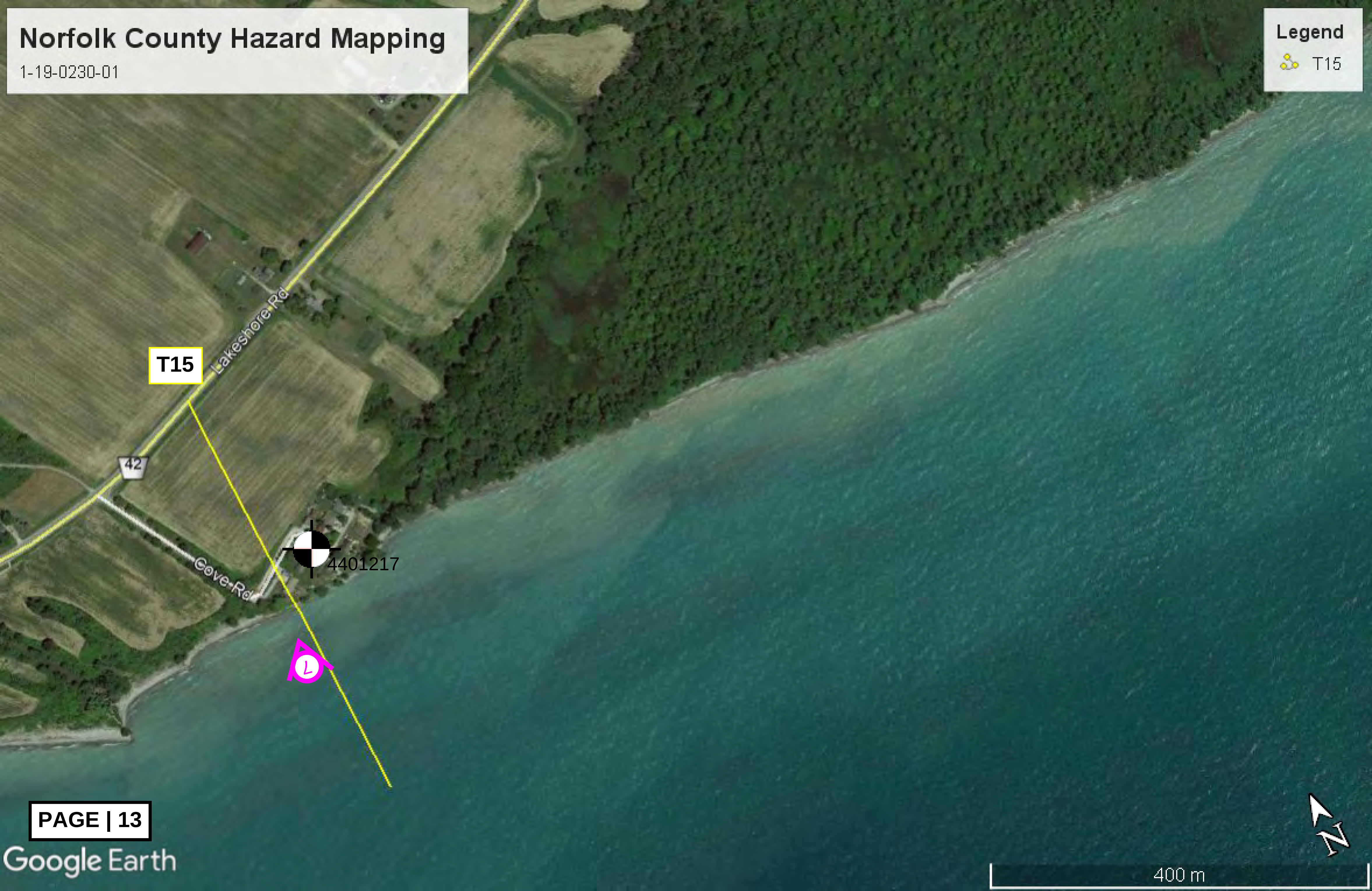

Norfolk County Hazard Mapping

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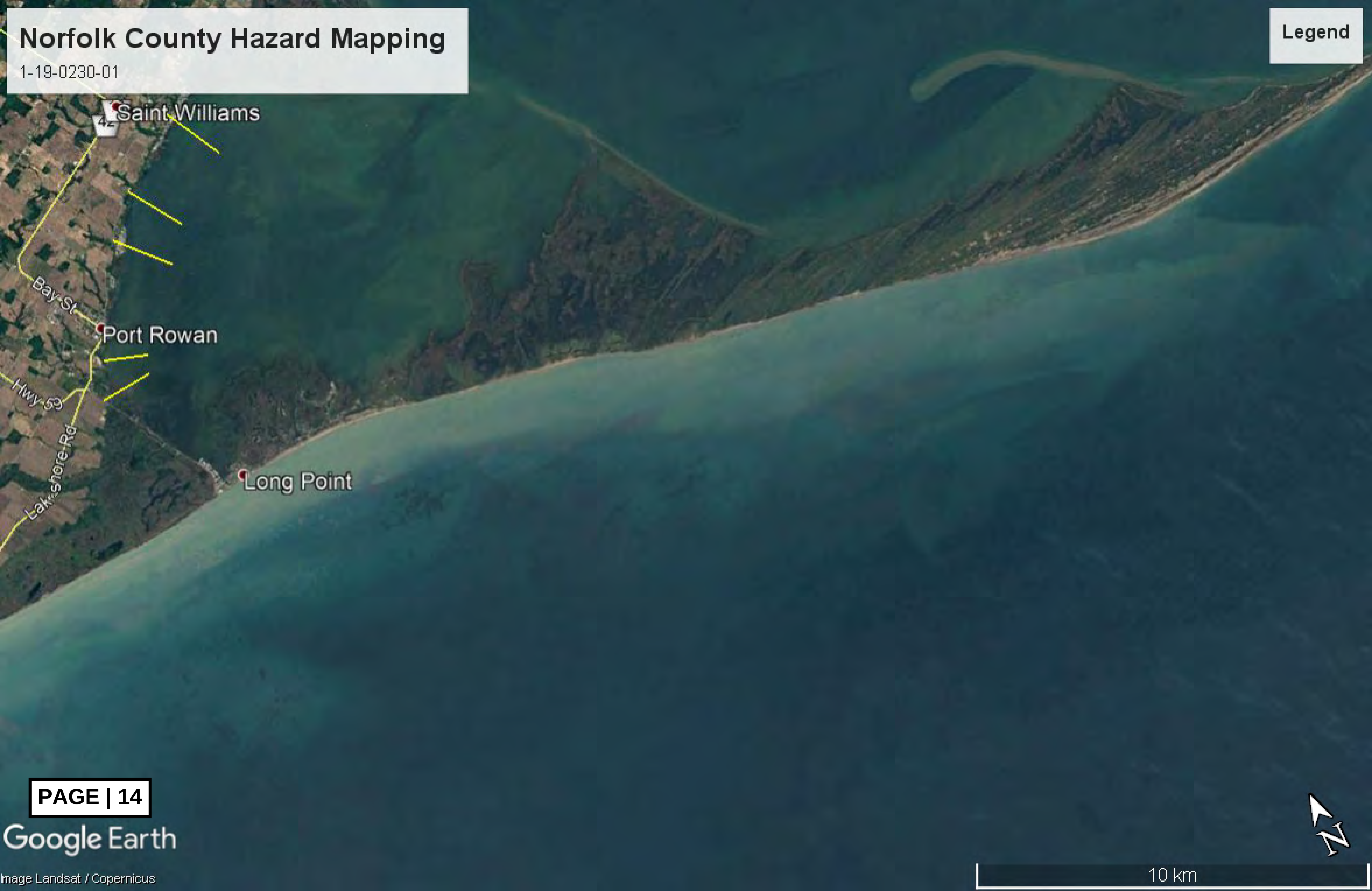

Norfolk County Hazard Mapping

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Norfolk County Hazard Mapping

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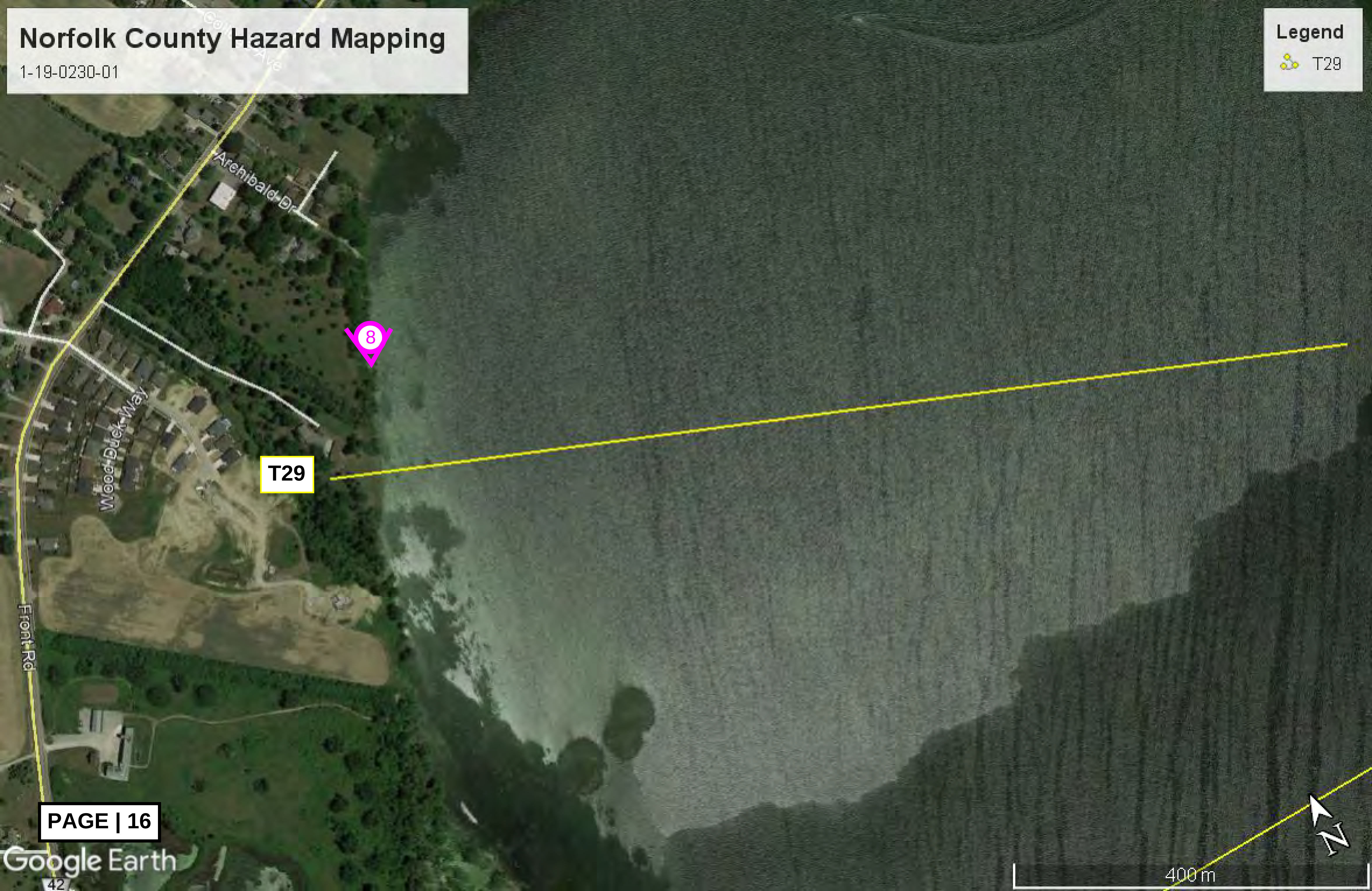

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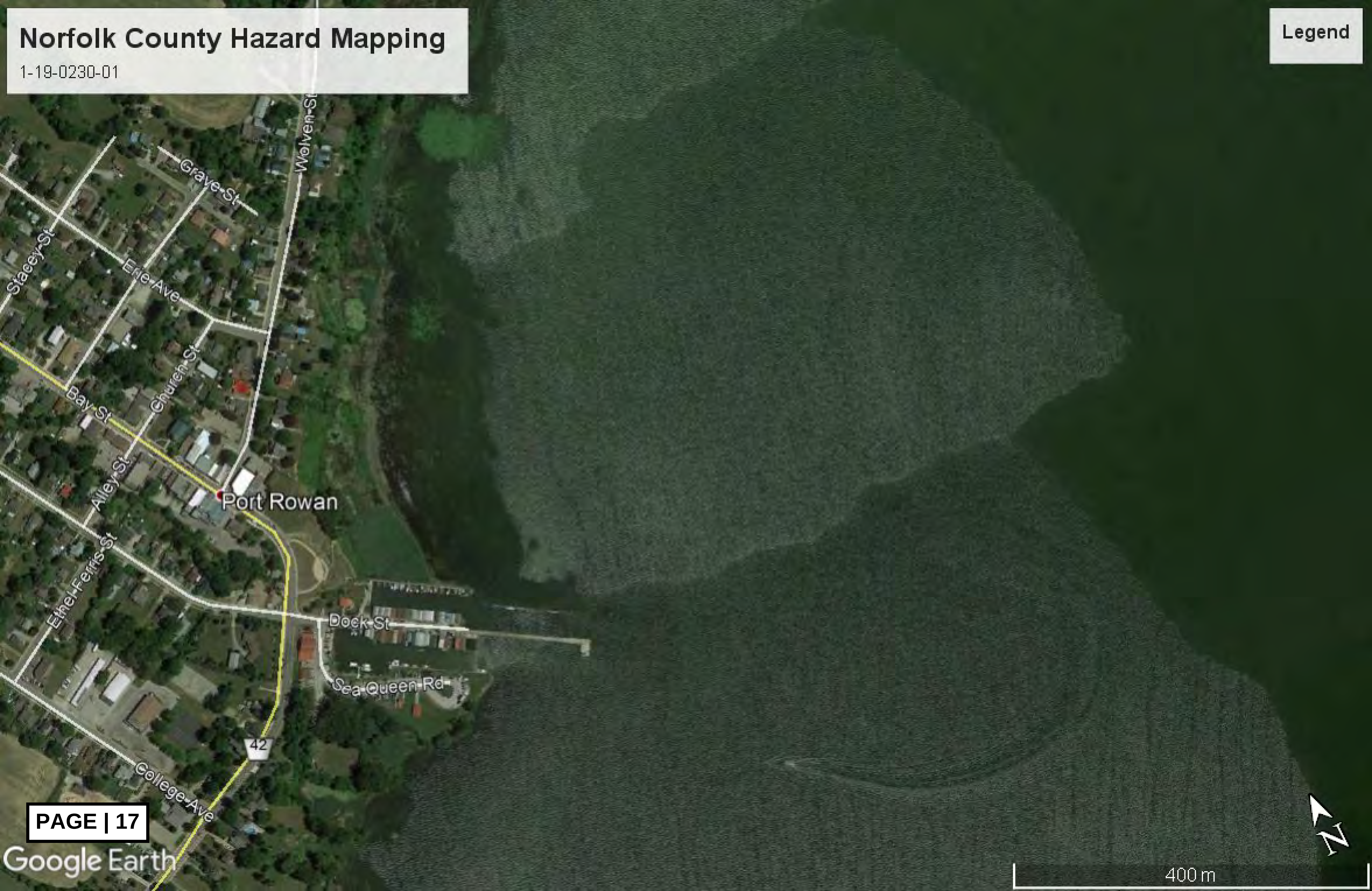

Norfolk County Hazard Mapping

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Norfolk County Hazard Mapping

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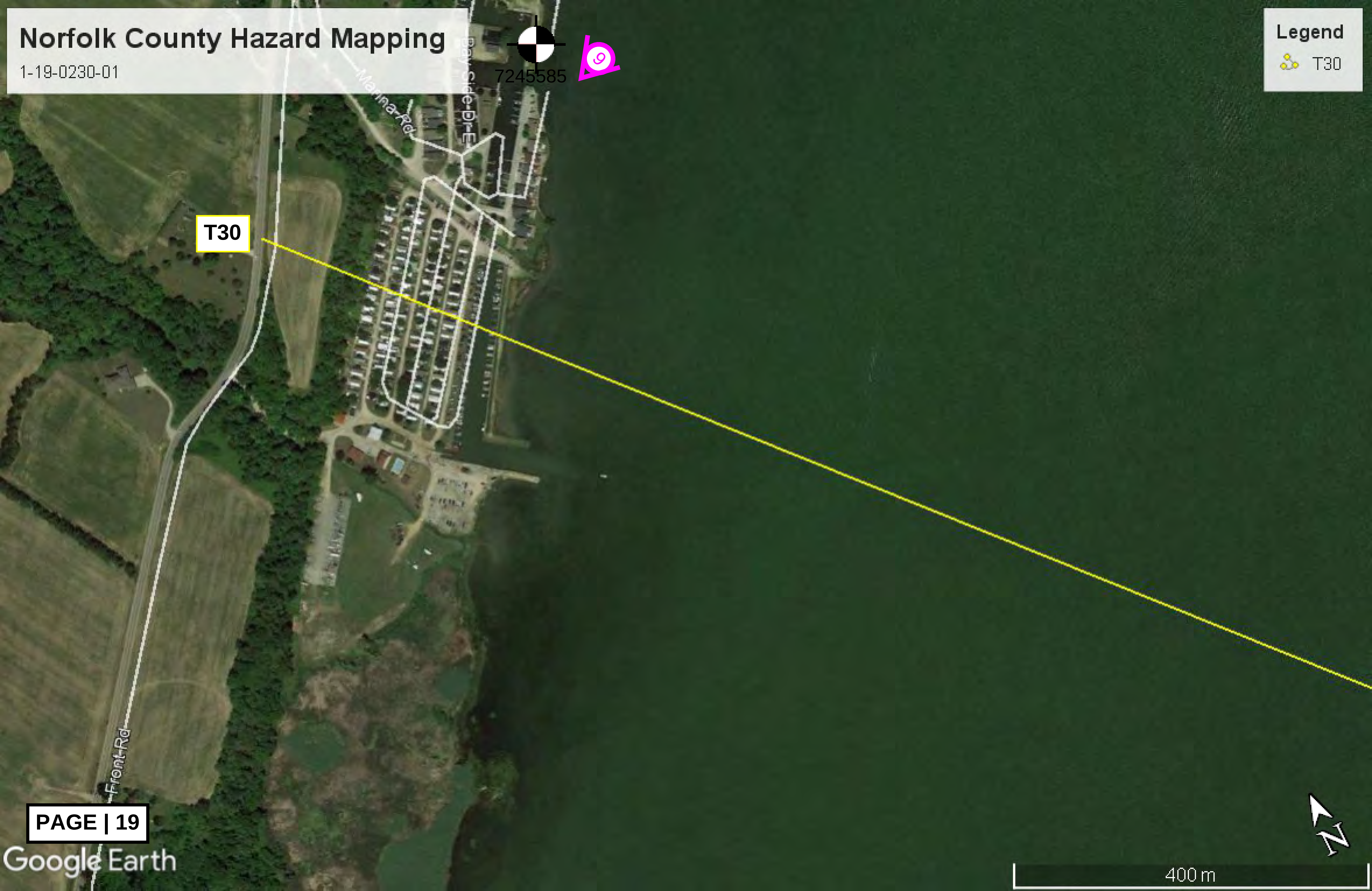

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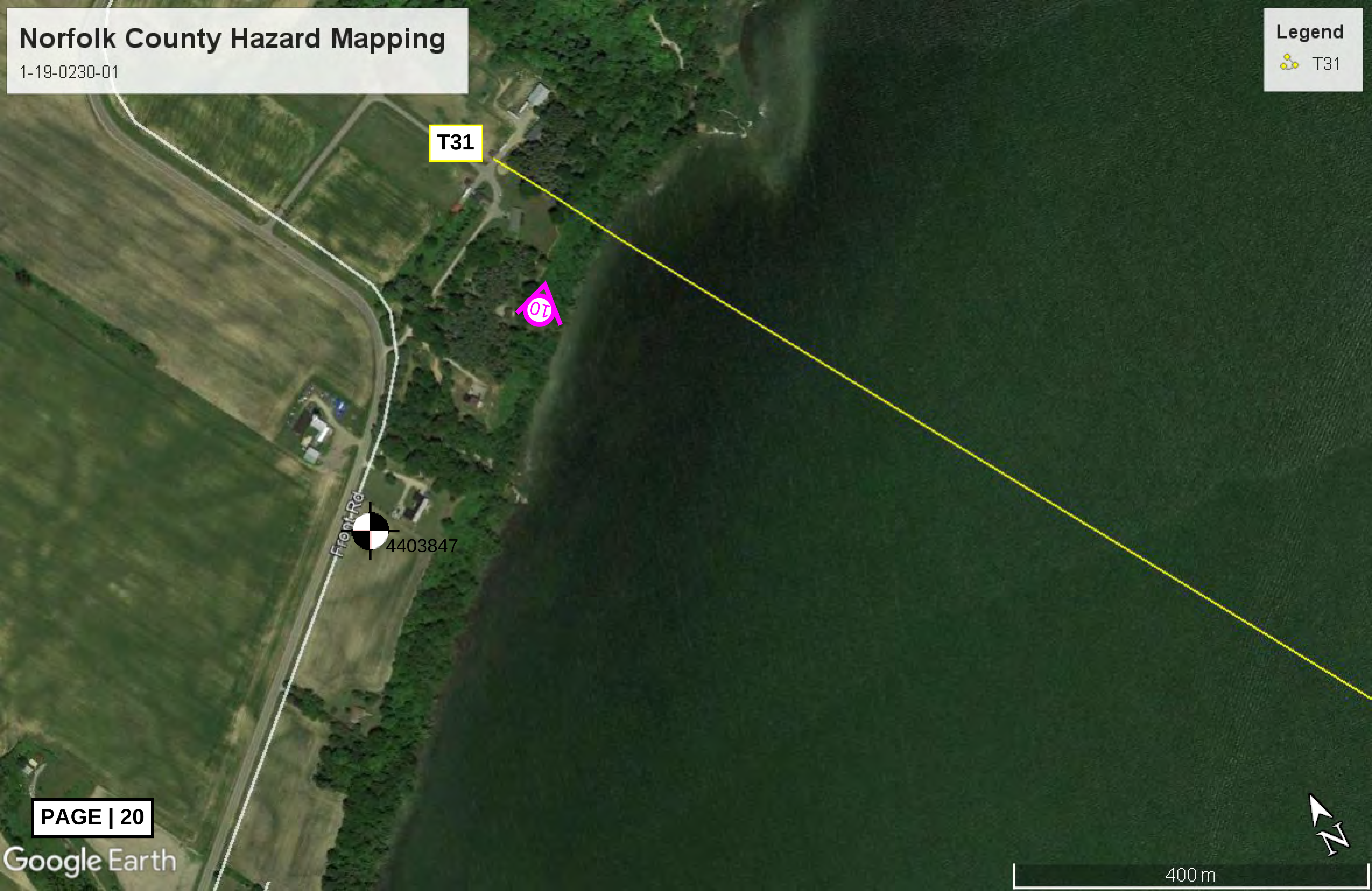

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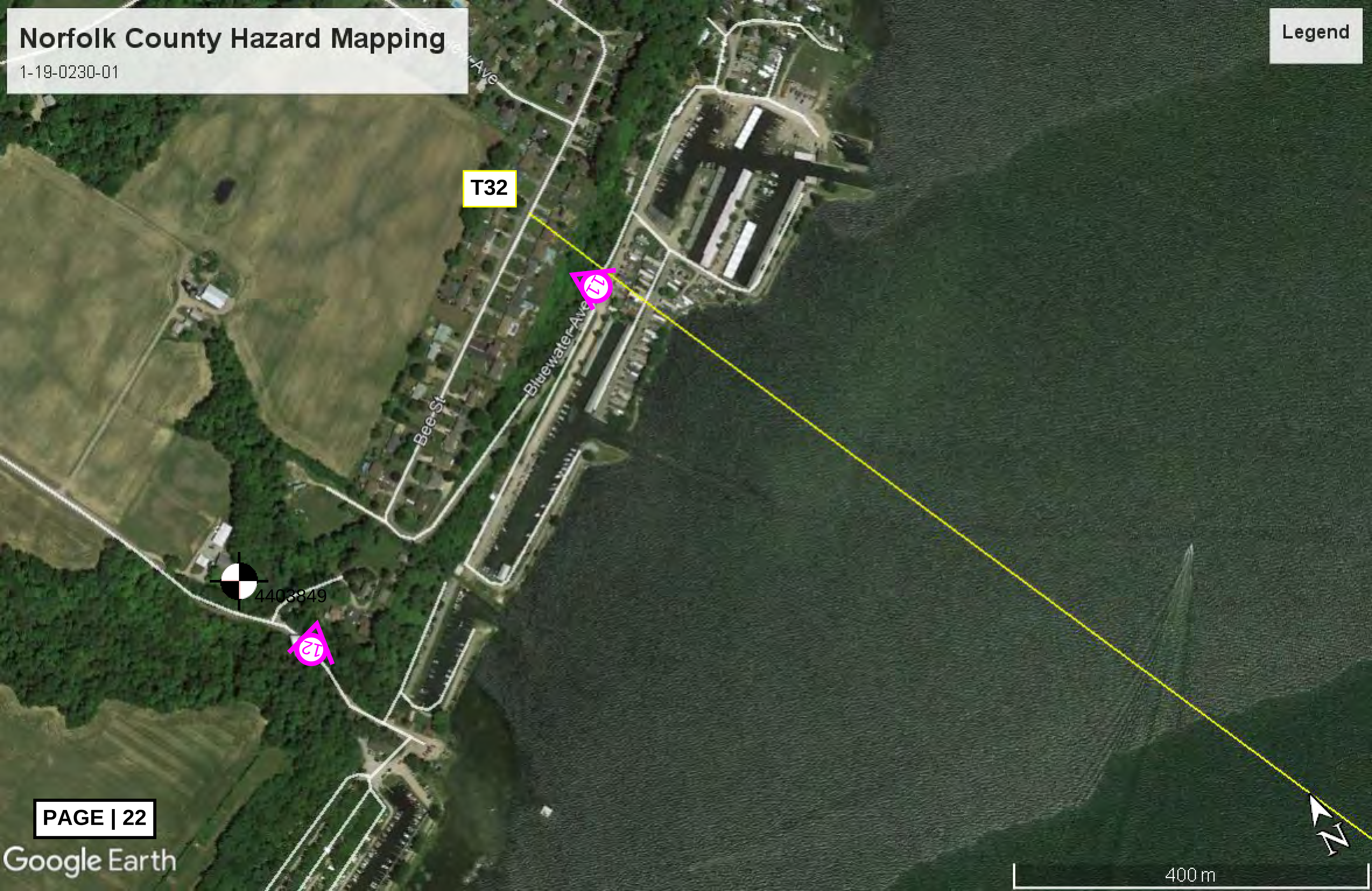

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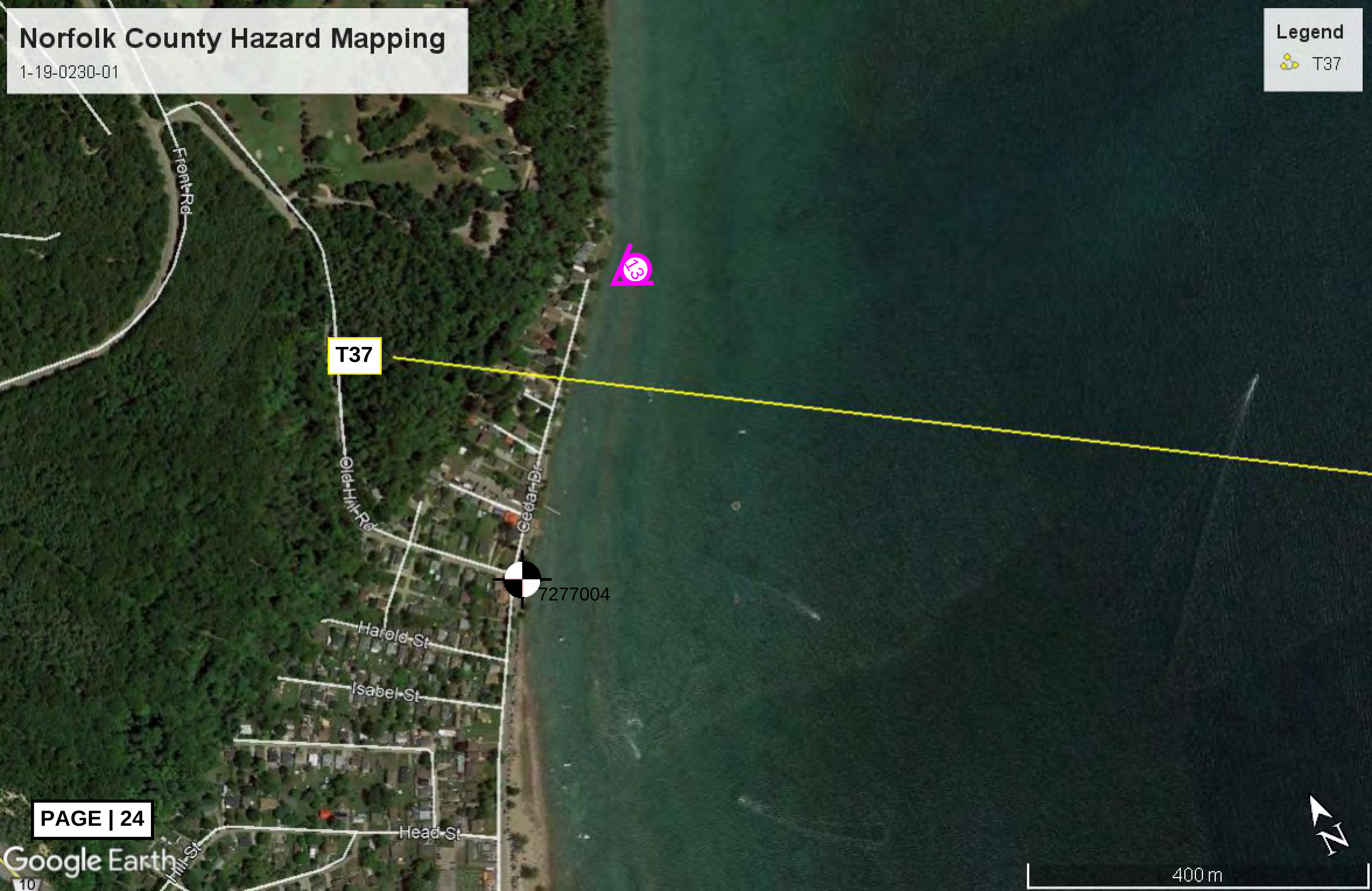

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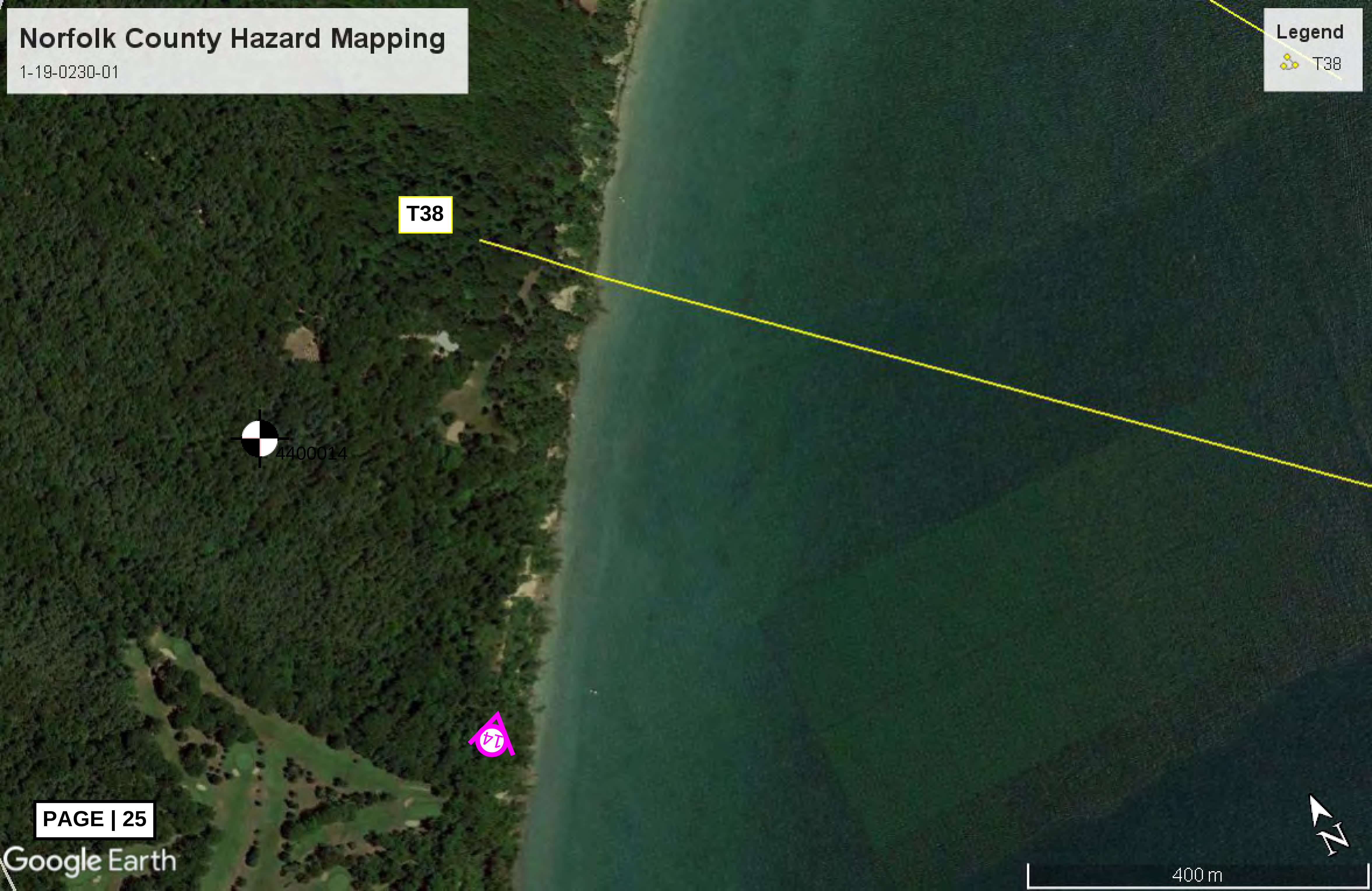

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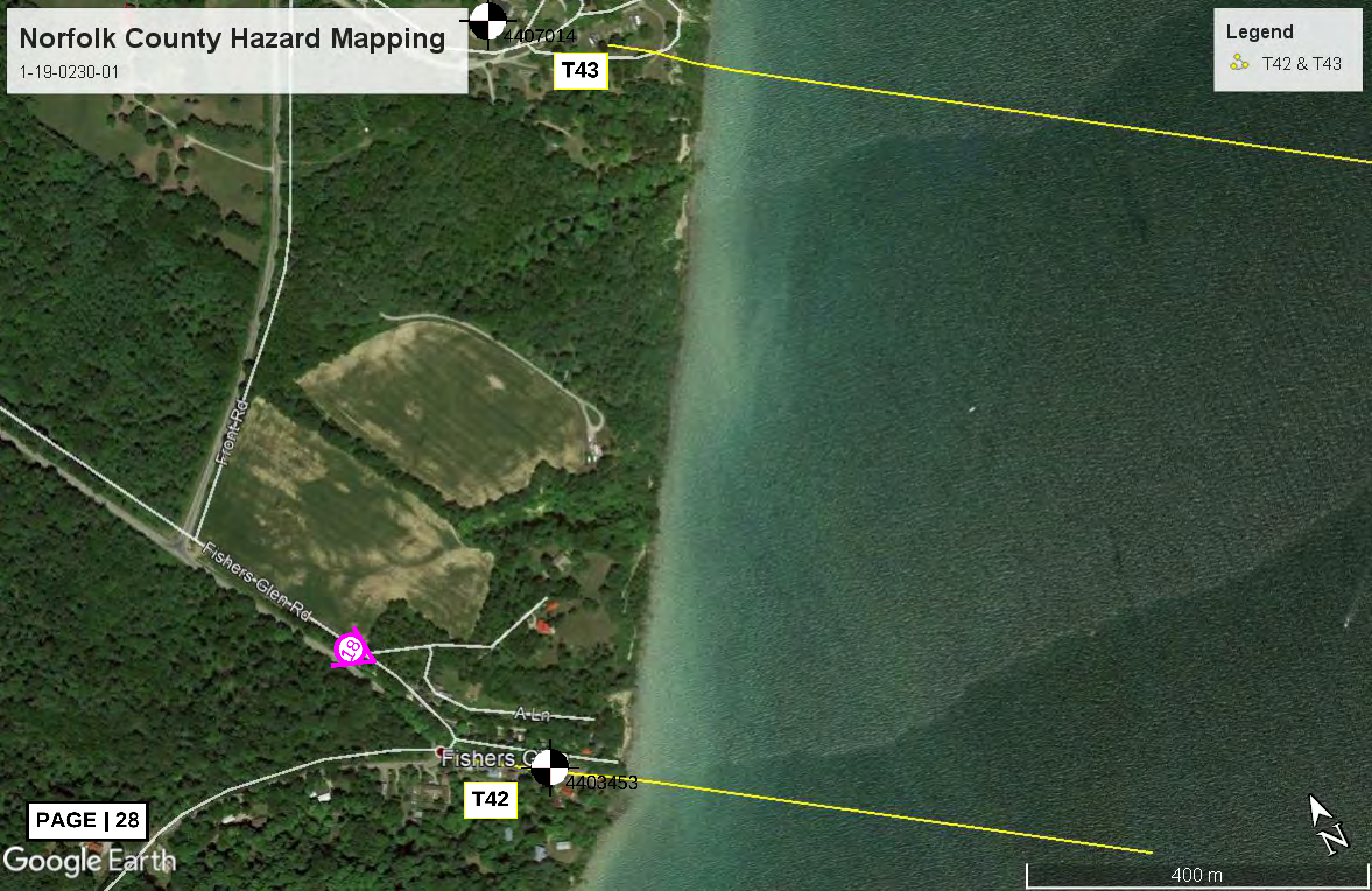

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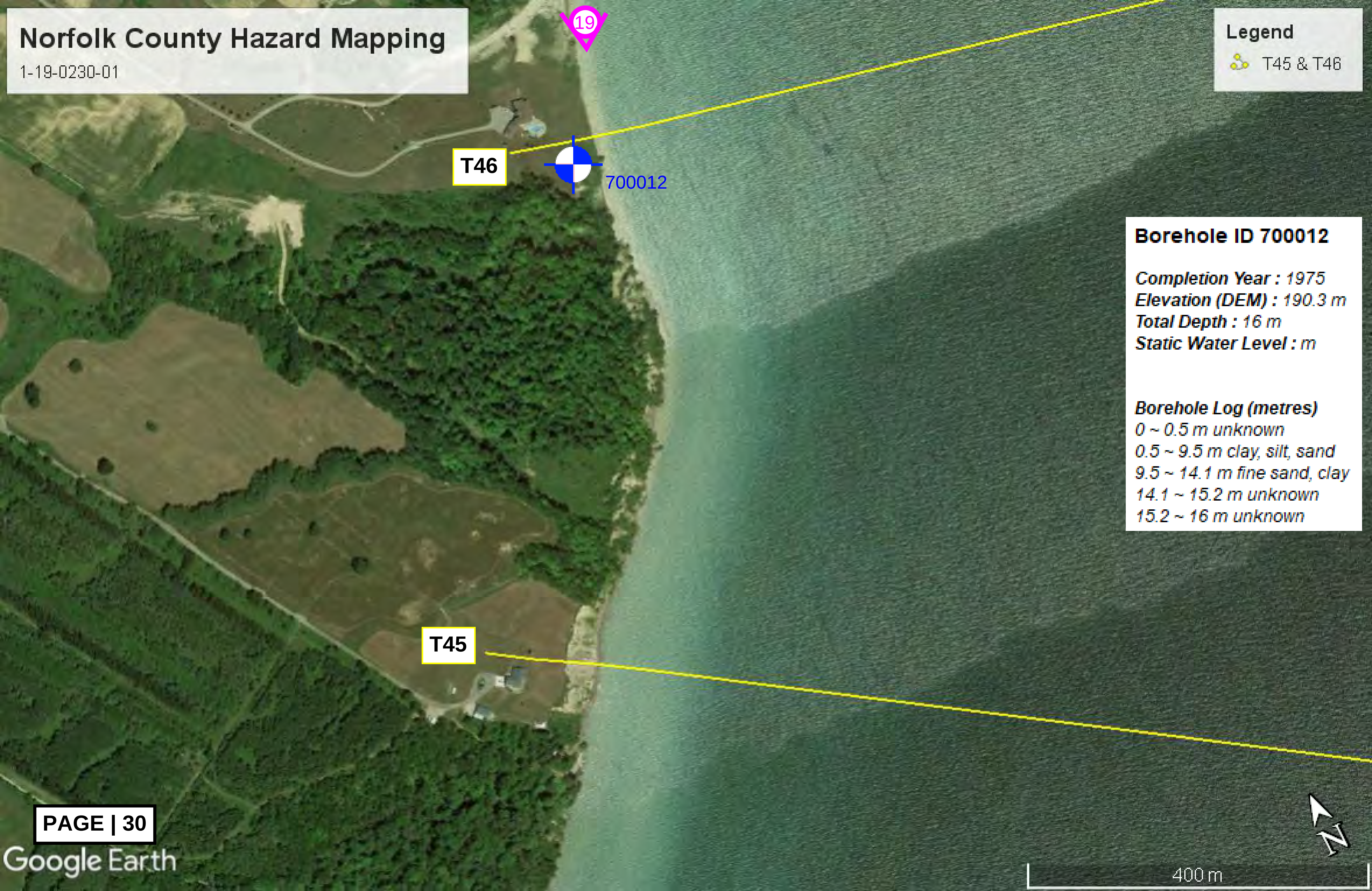


Legend

- T45 & T46

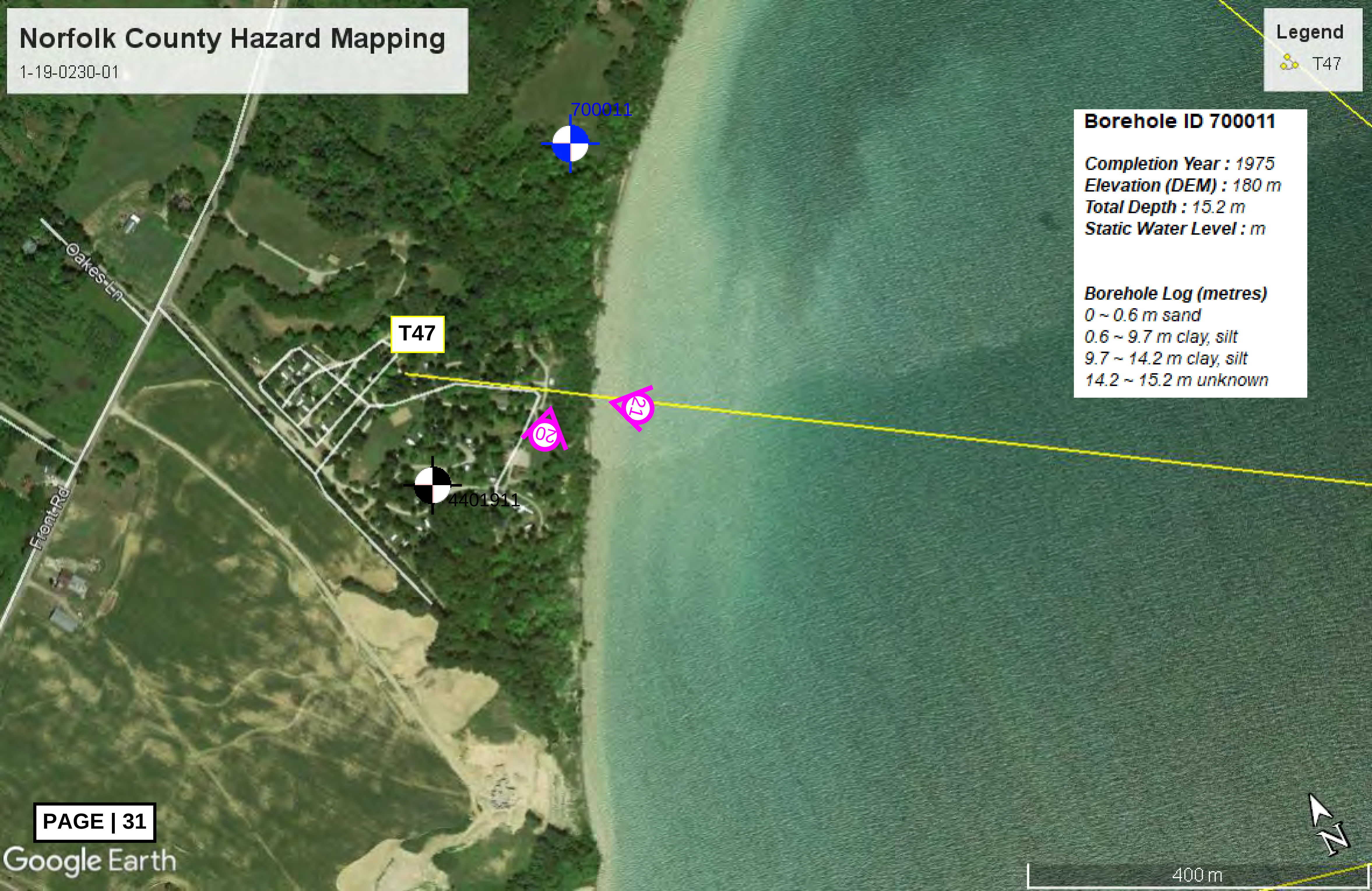
Borehole ID 700012

Completion Year : *1975*
Elevation (DEM) : *190.3 m*
Total Depth : *16 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.5 m unknown
0.5 ~ 9.5 m clay, silt, sand
9.5 ~ 14.1 m fine sand, clay
14.1 ~ 15.2 m unknown
15.2 ~ 16 m unknown

Norfolk County Hazard Mapping

1-19-0230-01



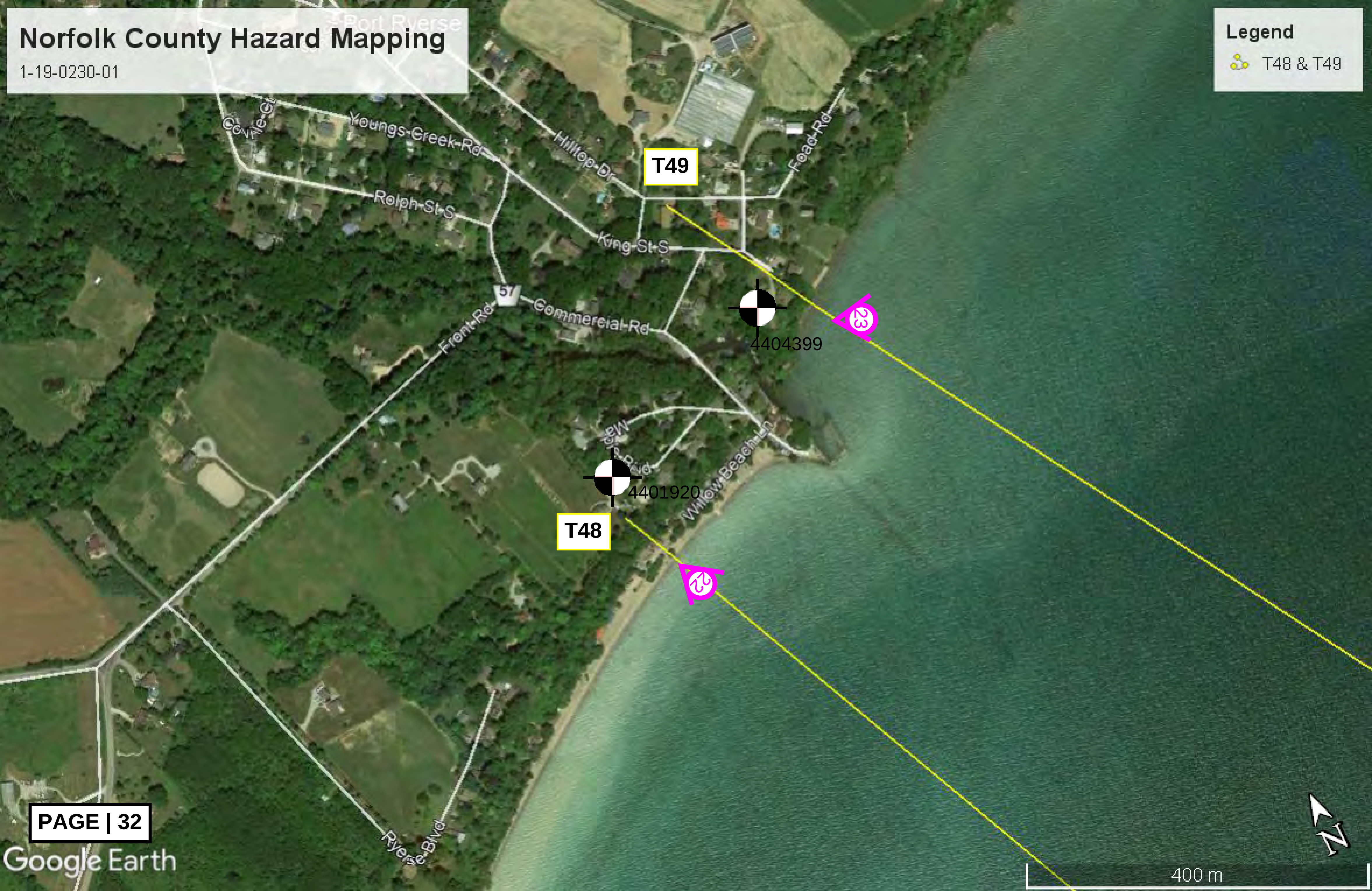
Borehole ID 700011

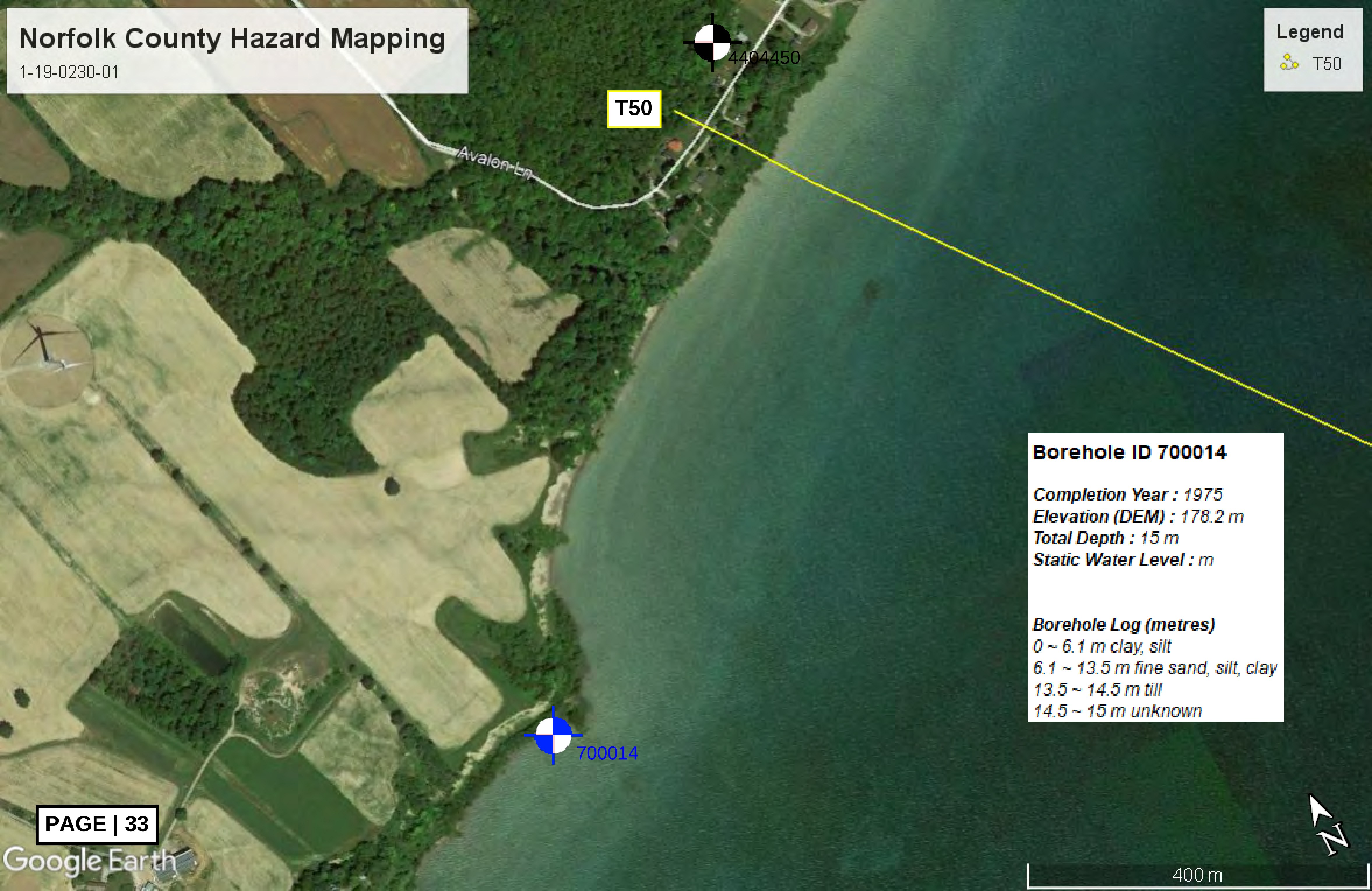
Completion Year : *1975*
Elevation (DEM) : *180 m*
Total Depth : *15.2 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.6 m sand
0.6 ~ 9.7 m clay, silt
9.7 ~ 14.2 m clay, silt
14.2 ~ 15.2 m unknown

Norfolk County Hazard Mapping

1-19-0230-01





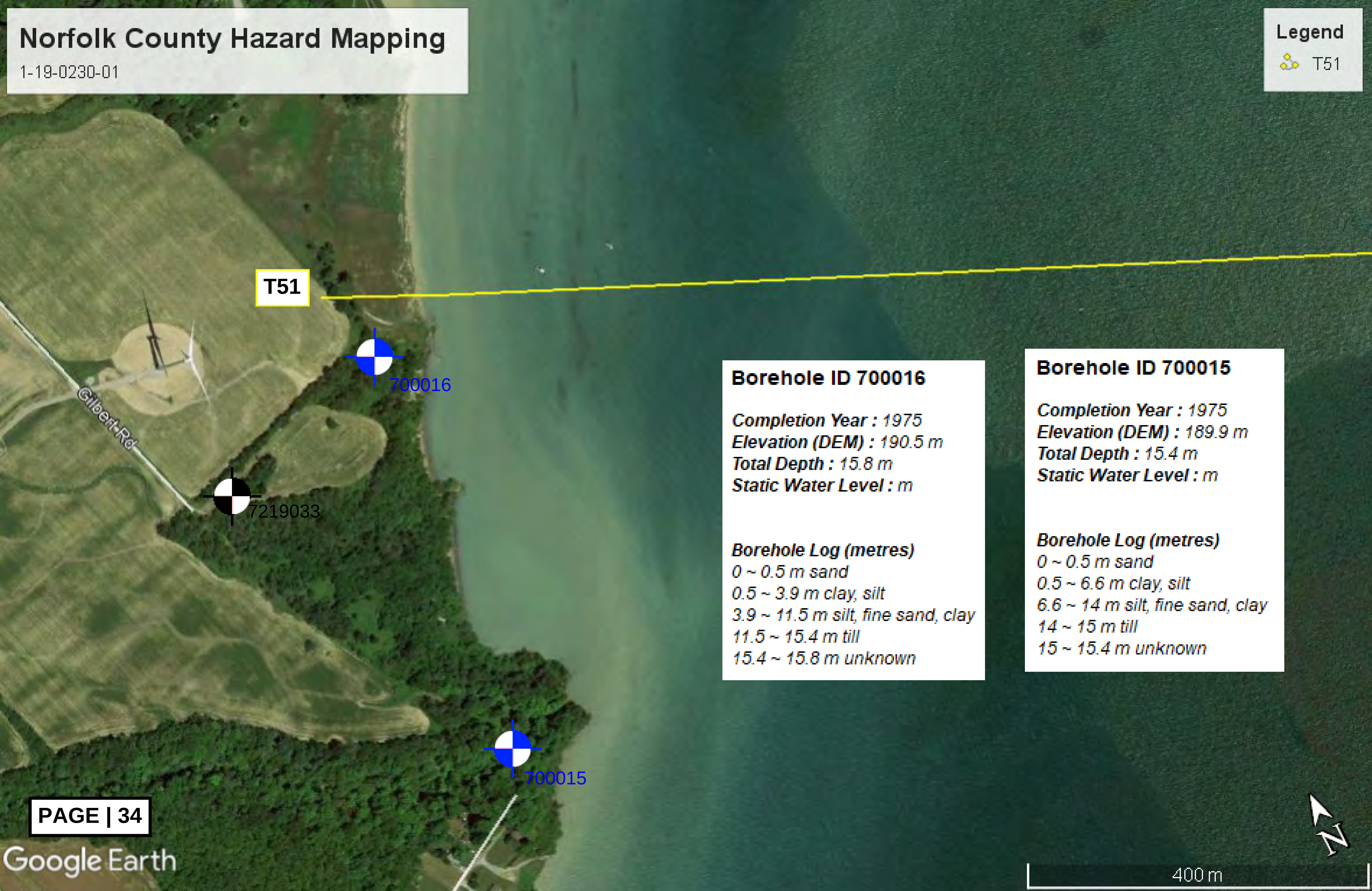
Borehole ID 700014

Completion Year : *1975*
Elevation (DEM) : *178.2 m*
Total Depth : *15 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 6.1 m clay, silt
6.1 ~ 13.5 m fine sand, silt, clay
13.5 ~ 14.5 m till
14.5 ~ 15 m unknown

Norfolk County Hazard Mapping

1-19-0230-01



Borehole ID 700016

Completion Year : *1975*
Elevation (DEM) : *190.5 m*
Total Depth : *15.8 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.5 m sand
0.5 ~ 3.9 m clay, silt
3.9 ~ 11.5 m silt, fine sand, clay
11.5 ~ 15.4 m till
15.4 ~ 15.8 m unknown

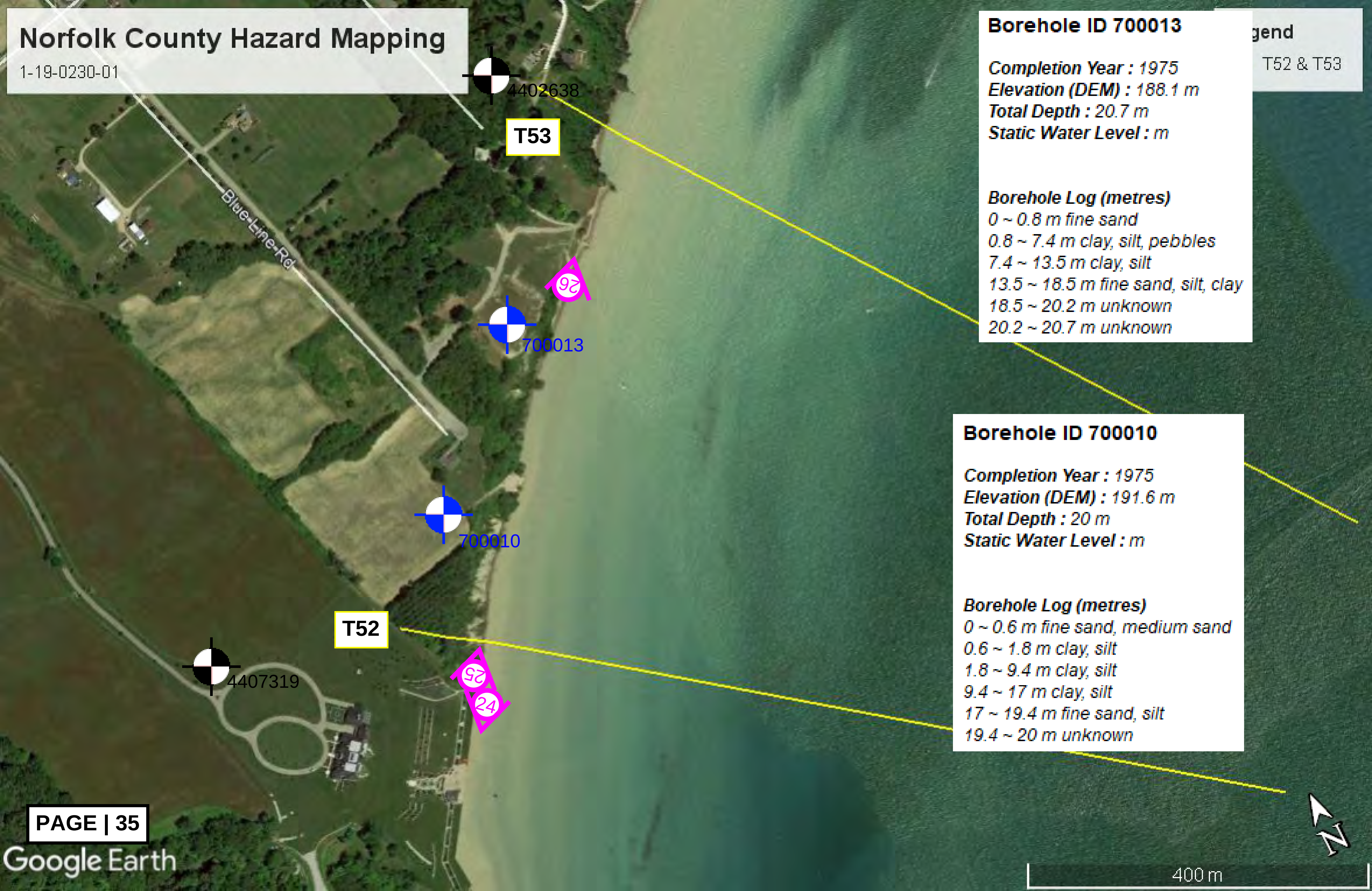
Borehole ID 700015

Completion Year : *1975*
Elevation (DEM) : *189.9 m*
Total Depth : *15.4 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.5 m sand
0.5 ~ 6.6 m clay, silt
6.6 ~ 14 m silt, fine sand, clay
14 ~ 15 m till
15 ~ 15.4 m unknown

Norfolk County Hazard Mapping

1-19-0230-01



Borehole ID 700013

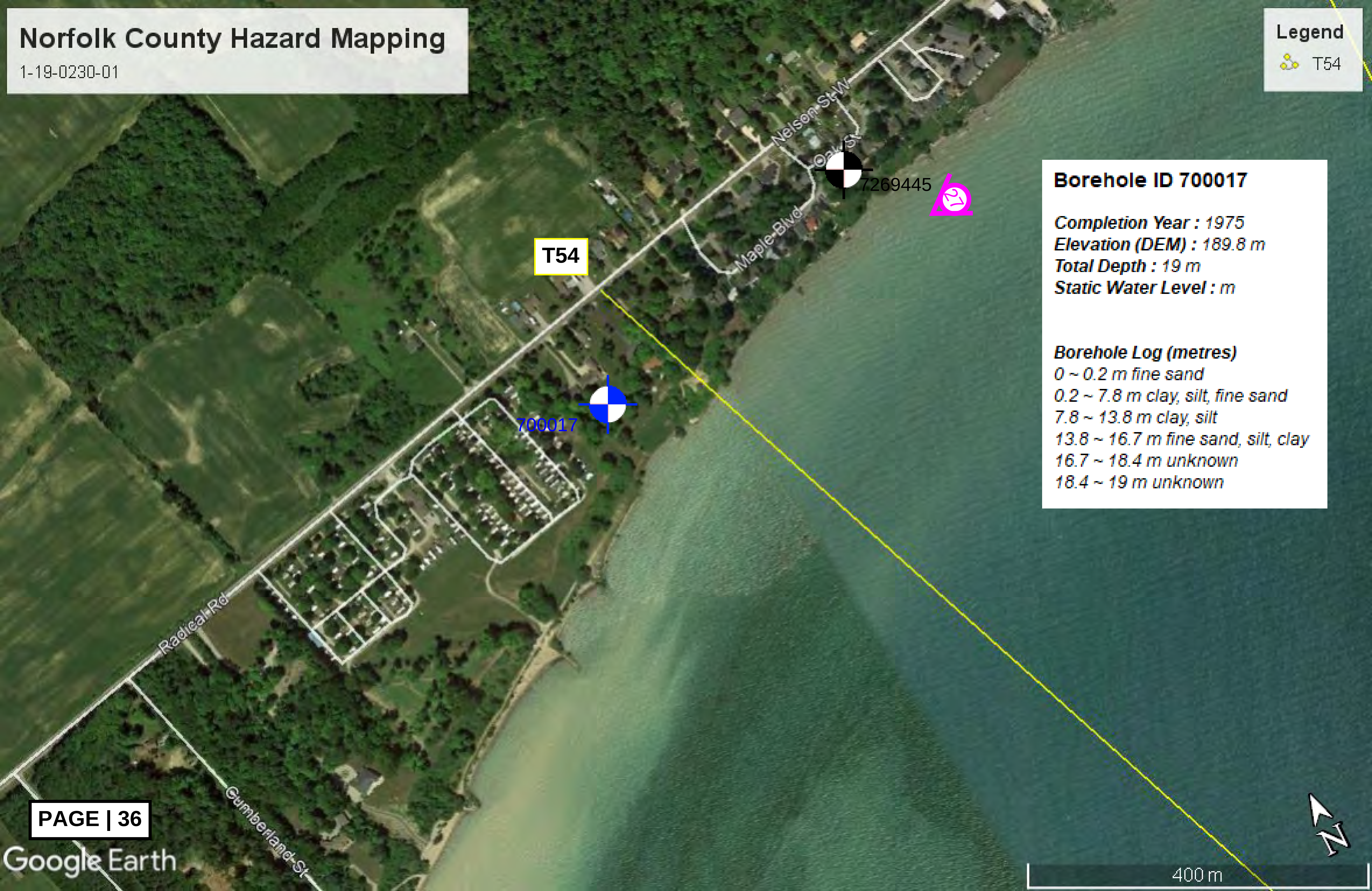
Completion Year : *1975*
Elevation (DEM) : *188.1 m*
Total Depth : *20.7 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.8 m fine sand
0.8 ~ 7.4 m clay, silt, pebbles
7.4 ~ 13.5 m clay, silt
13.5 ~ 18.5 m fine sand, silt, clay
18.5 ~ 20.2 m unknown
20.2 ~ 20.7 m unknown

Borehole ID 700010

Completion Year : *1975*
Elevation (DEM) : *191.6 m*
Total Depth : *20 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.6 m fine sand, medium sand
0.6 ~ 1.8 m clay, silt
1.8 ~ 9.4 m clay, silt
9.4 ~ 17 m clay, silt
17 ~ 19.4 m fine sand, silt
19.4 ~ 20 m unknown



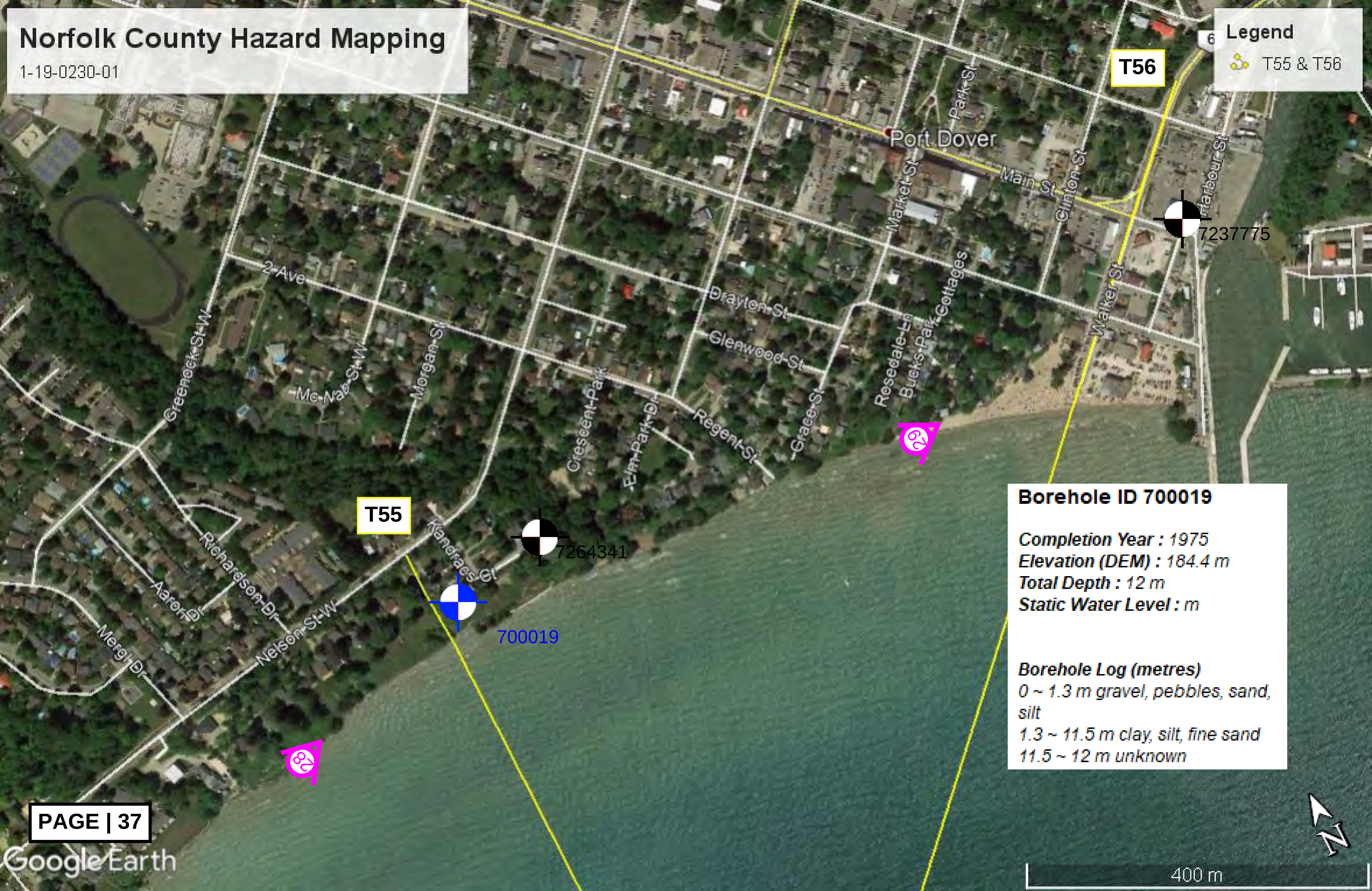
Borehole ID 700017

Completion Year : *1975*
Elevation (DEM) : *189.8 m*
Total Depth : *19 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.2 m fine sand
0.2 ~ 7.8 m clay, silt, fine sand
7.8 ~ 13.8 m clay, silt
13.8 ~ 16.7 m fine sand, silt, clay
16.7 ~ 18.4 m unknown
18.4 ~ 19 m unknown

Norfolk County Hazard Mapping

1-19-0230-01



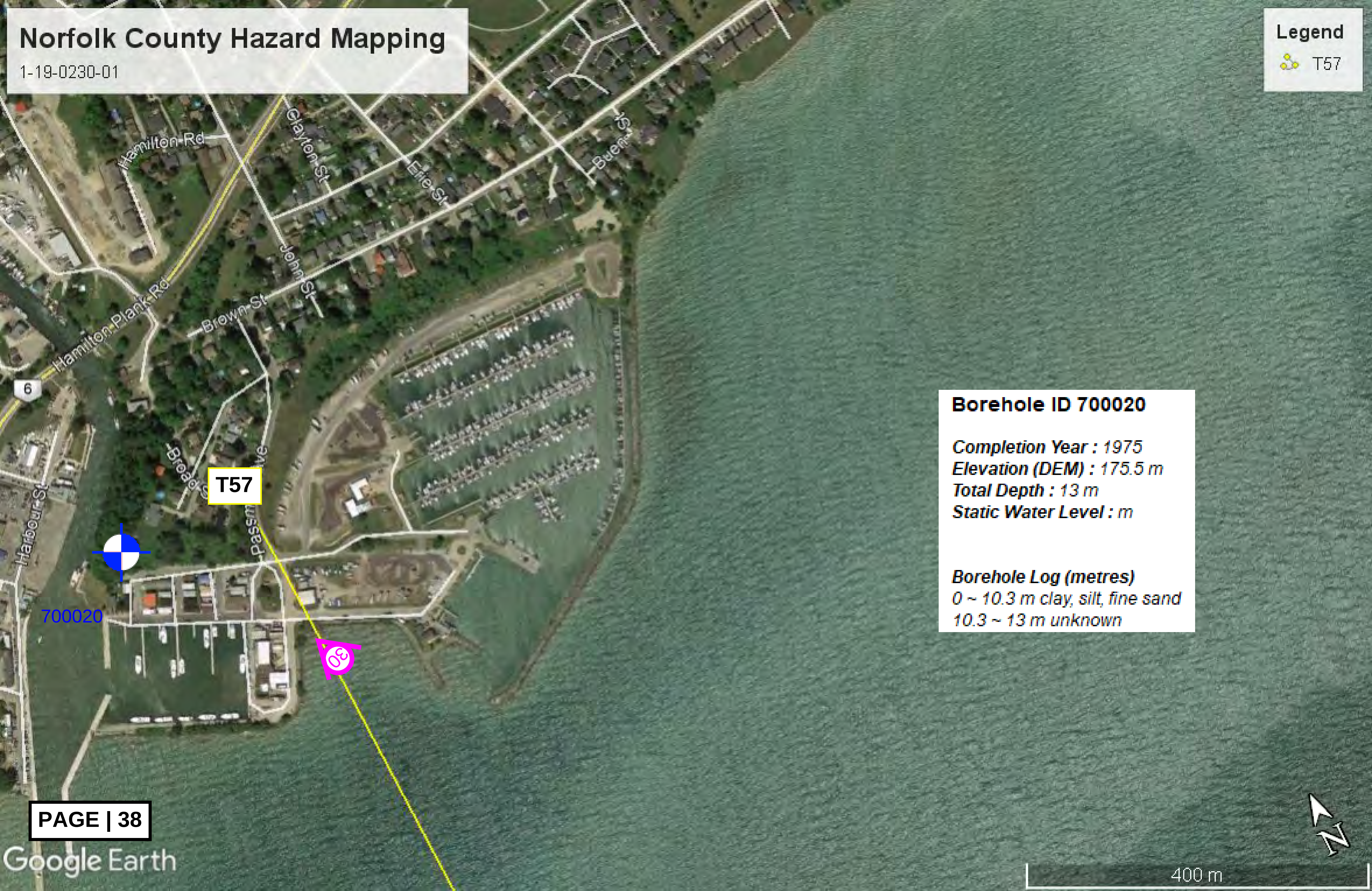
Borehole ID 700019

Completion Year : *1975*
Elevation (DEM) : *184.4 m*
Total Depth : *12 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 1.3 m gravel, pebbles, sand, silt
1.3 ~ 11.5 m clay, silt, fine sand
11.5 ~ 12 m unknown

Norfolk County Hazard Mapping

1-19-0230-01



Borehole ID 700020

Completion Year : *1975*
Elevation (DEM) : *175.5 m*
Total Depth : *13 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 10.3 m clay, silt, fine sand
10.3 ~ 13 m unknown

Norfolk County Hazard Mapping

1-19-0230-01

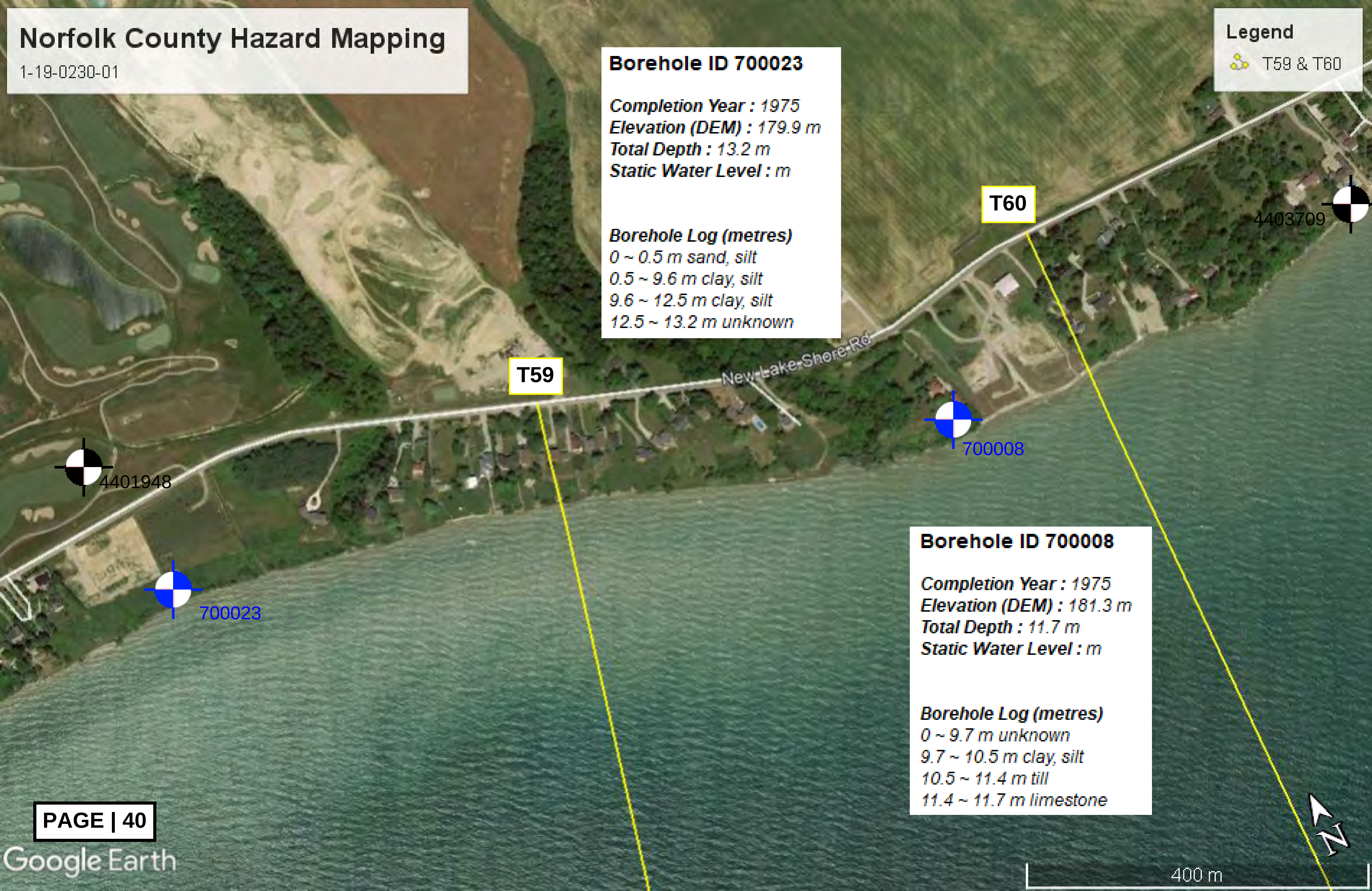
Borehole ID 700009

Completion Year : *1975*
Elevation (DEM) : *183.3 m*
Total Depth : *11.3 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 2.4 m clay, sand
2.4 ~ 4.8 m clay, silt
4.8 ~ 8.4 m clay, silt, stones
8.4 ~ 11 m clay, silt
11 ~ 11.3 m unknown

Norfolk County Hazard Mapping

1-19-0230-01



Borehole ID 700023

Completion Year : *1975*
Elevation (DEM) : *179.9 m*
Total Depth : *13.2 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 0.5 m sand, silt
0.5 ~ 9.6 m clay, silt
9.6 ~ 12.5 m clay, silt
12.5 ~ 13.2 m unknown

Borehole ID 700008

Completion Year : *1975*
Elevation (DEM) : *181.3 m*
Total Depth : *11.7 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 9.7 m unknown
9.7 ~ 10.5 m clay, silt
10.5 ~ 11.4 m till
11.4 ~ 11.7 m limestone

Norfolk County Hazard Mapping

1-19-0230-01

Borehole ID 700000

Completion Year : 1975
Elevation (DEM) : 177.3 m
Total Depth : 10.1 m
Static Water Level : m

Borehole Log (metres)
0 ~ 4.6 m clay, silt
4.6 ~ 7.6 m unknown
7.6 ~ 9.6 m clay, silt, pebbles
9.6 ~ 10.1 m unknown

Norfolk County Hazard Mapping

1-19-0230-01

Borehole ID 700001

Completion Year : *1975*
Elevation (DEM) : *177.1 m*
Total Depth : *9.8 m*
Static Water Level : *m*

Borehole Log (metres)
0 ~ 6.1 m unknown
6.1 ~ 8.8 m clay, silt, pebbles
8.8 ~ 9.2 m till
9.2 ~ 9.8 m limestone

APPENDIX B

TERRAPROBE INC.

W

UTM 17 Z ~~North~~ 523200 E

5 R 4718525 N

Elev. 5 R 06511

Basin 23

GROUND WATER BRANCH
JUN 14 1962 № 44
ONTARIO WATER RESOURCES COMMISSION

509

62-1

The Ontario Water Resources Commission Act

WATER WELL RECORD

401/10E

County or District Norfolk
Township, Village, Town or City Houghton
Con. N. L. R. LRN Lot 1
Date completed 13 (day) April (month) 1962 (year)
Owner [redacted] (print in block letters)
Address RR#3 Tillsonburg Ont.

Casing and Screen Record

[redacted]

Inside diameter of casing 1¼ in.
Total length of casing 15 ft.
Type of screen 2 in. Weaver Filter
Length of screen 5 ft.
Depth to top of screen 20 ft.
Diameter of finished hole 1¼ in.

Pumping Test

Static level 18 ft.
Test-pumping rate 500 gph ~~G.P.M.~~
Pumping level Hd.
Duration of test pumping 1 hr.
Water clear or cloudy at end of test clear.
Recommended pumping rate 500 gph. ~~G.P.M.~~
with pump setting of ~~5 ft.~~ Hd. feet below ground surface

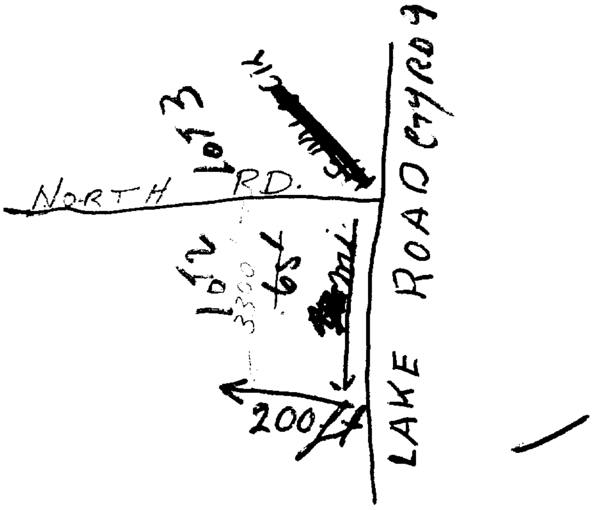
Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Top soil	0	1		
Yellow sand	1	5		
White sand	5	18	18	Fresh
Brown water sand	18	23		
Blue water sand	23	25		

For what purpose(s) is the water to be used? House & Tobacco Farm
Is well on upland, in valley, or on hillside? Level
Drilling or Boring Firm James A. Weaver & Son
Address 332 Tillson Ave.
Tillsonburg
Licence Number 664
Name of Driller or Borer James A. Weaver
Address Same
Date April 14, 1962
James A. Weaver
(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow. ← N



CSS.S8

Form 7 15M Sets 60-5930

OWRC COPY

TM 17 Z 527560 Con IX Lot 8 401/10E

4 R 4716300 CODED 4402323 7

3 9

Elev. 5 R 0660

asin 23

The Ontario Water Resources Commission Act

WATER WELL RECORD

DIVISION OF WATER RESOURCES
APR 29 1969
WATER
COMMISSION

County or District Norfolk Township, Village, Town or City Houghton

Con. 9 LR 5 Lot 8 Date completed 11 (day) April (month) 1969 (year)

[redacted] Simcoe Str. Tillsonburg

5b

Casing and Screen Record

Inside diameter of casing 2"

Total length of casing 35'

Type of screen Johnson Stainless #7

Length of screen 8'

Depth to top of screen 35

Diameter of finished hole 2"

Pumping Test

Static level 10'

Test-pumping rate 5 G.P.M.

Pumping level 2" inner jet - direct.

Duration of test pumping 5 hrs

Water clear or cloudy at end of test clear

Recommended pumping rate 4-5 G.P.M.

with pump setting of 35' feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
black soil	0	2		
yellow sand	2	22		
grey sand	22	33		
wet putty sand	33	35		
fine water sand	35	43	←	fresh
(gravel pack)				

For what purpose(s) is the water to be used? domestic - Farm

Is well on upland, in valley, or on hillside? hillside

Drilling or Boring Firm Warren Water Wells

Address 94 North Str. W
Tillsonburg Ont.

Licence Number 3354

Name of Driller or Borer Gus Holzheu

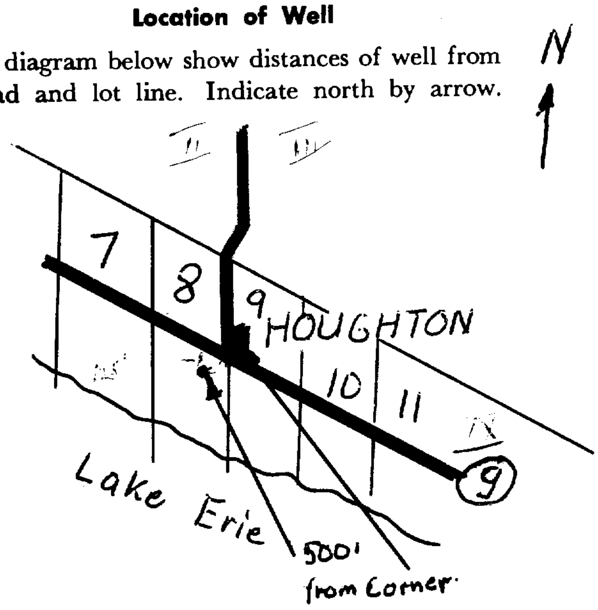
Address 94 North Str. W.

Date April 25/69

(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 7
OWRC COPY

CSS.S8

Ontario Ministry of the Environment

Well Tag Number (Place sticker and print number below)

A 038019

Well Record

Regulation 903 Ontario Water Resources Act

page 1 of 1

Instructions for Completing Form

- For use in the **Province of Ontario** only. This document is a permanent **legal** document. Please retain for future reference.
- All Sections **must** be completed in full to avoid delays in processing. Further instructions and explanations are available on the back of this form.
- Questions regarding completing this application can be directed to the Water Well Management Coordinator at 416-235-6203.
- **All metre measurements shall be reported to 1/10th of a metre.**
- Please print clearly in blue or black ink only.

Ministry Use Only

MUN | CON | LOT

Well Owner's Information and Location of Well Information

First Name: SANDHILL PARK
Last Name: c/o [redacted]
Mailing Address (Street Number/Name, RR Lot Concession): R.R. #2 PT. BURWELL ONT.
County/District/Municipality: NORFOLK
Township/City/Town/Village: HOUGHTON
Province: Ontario
Postal Code: NOJ-1TO
Telephone Number (include area code): (519) 875-1181
Address of Well Location (County/District/Municipality): NORFOLK.
Township: HOUGHTON
Lot: 11
Concession: LRS
RR#/Street Number/Name: R.R. #2 PT. BURWELL
City/Town/Village: PT. BURWELL
Site/Compartment/Block/Tract etc.:
GPS Reading: NAD 83 Zone 17 Easting 529330 Northing 4715325
Unit Make/Model: MAG.
Mode of Operation: ☑ Undifferentiated ☐ Averaged ☐ Differentiated, specify

Log of Overburden and Bedrock Materials (see instructions)

General Colour	Most common material	Other Materials	General Description	Depth Metres From	Depth Metres To
BROWN	SAND		DRY	0	40
BROWN/GREY	SAND		MIXED, FINE	40	69.
GREY	CLAY		LAYERED	69	70

Hole Diameter

Depth Metres From	Depth Metres To	Diameter Centimetres
0	69	12

Water Record

Water found at Metres: 41 m — Kind of Water: ☑ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:
m ☐ Fresh ☐ Sulphur ☐ Gas ☐ Salty ☐ Minerals ☐ Other:

After test of well yield, water was ☑ Clear and sediment free ☐ Other, specify

Chlorinated ☑ Yes ☐ No

Construction Record

Inside diam centimetres	Material	Wall thickness centimetres	Depth Metres From	Depth Metres To
Casing				
6"	☑ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	.188	+2	53
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
	☐ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized			
Screen STAINLESS				
Outside diam: 6"	☑ Steel ☐ Fibreglass ☐ Plastic ☐ Concrete ☐ Galvanized	Slot No.: 10	53	69
No Casing or Screen				
	☐ Open hole			

Test of Well Yield

Pumping test method: Pump
Pump intake set at - (metres): 67
Pumping rate - (litres/min): 10
Duration of pumping: 2 hrs + 0 min
Final water level end of pumping: 52 metres
Recommended pump type. ☐ Shallow ☑ Deep
Recommended pump depth. 67 metres
Recommended pump rate. 10 (litres/min)
If flowing give rate - ~~(litres/min)~~
If pumping discontinued, give reason. CLEAR

Draw Down Time min	Draw Down Water Level Metres	Recovery Time min	Recovery Water Level Metres
Static Level	41		52
1	41'9	1	45'11
2	42'7	2	43'2
3	43'1	3	41'10
4	44'0	4	41'4
5	44'6	5	41
10	46'9	10	41
15	51'2	15	41
20	52	20	41
25	52	25	41
30	52	30	41
40	52	40	41
50	52	50	41
60	52	60	41

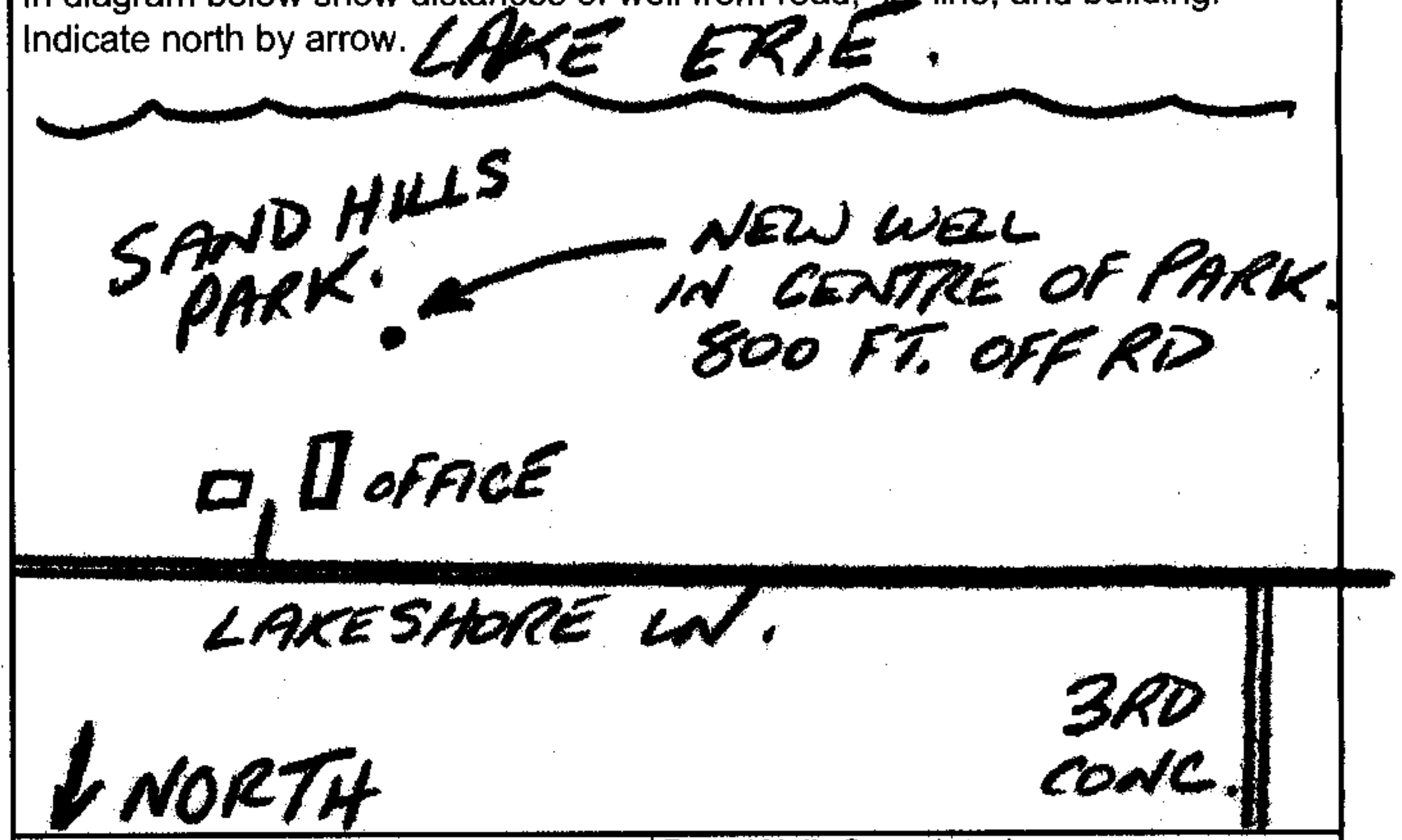
Plugging and Sealing Record

☑ Annular space ☐ Abandonment

Depth set at - Metres From	Depth set at - Metres To	Material and type (bentonite slurry, neat cement slurry) etc.	Volume Placed (cubic metres)
0	24	BENTONITE SLURRY	
24	69	SAND PACKED	

Location of Well

In diagram below show distances of well from road, lot line, and building. Indicate north by arrow.



Method of Construction

☐ Cable Tool ☐ Rotary (air) ☐ Diamond ☐ Digging
☑ Rotary (conventional) ☐ Air percussion ☐ Jetting ☐ Other
☐ Rotary (reverse) ☐ Boring ☐ Driving

Water Use

☐ Domestic ☐ Industrial ☑ Public Supply ☐ Other
☐ Stock ☐ Commercial ☐ Not used
☐ Irrigation ☐ Municipal ☐ Cooling & air conditioning

Final Status of Well

☑ Water Supply ☐ Recharge well ☐ Unfinished ☐ Abandoned, (Other)
☐ Observation well ☐ Abandoned, insufficient supply ☐ Dewatering
☐ Test Hole ☐ Abandoned, poor quality ☐ Replacement well

Audit No. Z 42388
Date Well Completed YYYY 06 MM 05 DD 16
Was the well owner's information package delivered? ☑ Yes ☐ No
Date Delivered YYYY 06 MM 05 DD 16

Well Contractor/Technician Information

Name of Well Contractor: HAYDEN WATER WELLS
Well Contractor's Licence No.: 7090
Business Address (street name, number, city etc.): LUCAN ONT
Name of Well Technician (last name, first name): J. HAYDEN
Well Technician's Licence No.: T1034
Signature of Technician/Contractor: X
Date Submitted YYYY MM DD

Ministry Use Only

Data Source
Contractor 7090
Date Received JAN 29 2007
Date of Inspection YYYY MM DD
Remarks
Well Record Number

0506E (09/03) Contractor's Copy ☐ Ministry's Copy ☐ Well Owner's Copy ☐ *Cette formule est disponible en français*

Ministry of the Environment
Ontario

NORFOLK

The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 4405425 MUNICIP 44002 CON. LRS

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT 25-27
HALDIMAND NORFOLK	HOUGHTON	COUNTY RD 42	15

[redacted] RR#1 CLEAR CREEK.

DATE COMPLETED 48-53 DAY 5 MO 5 YR 88

RC. ELEVATION RC BASIN CODE II III IV

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BROWN	TOP SOIL			0	1
BROWN	SAND			1	14
BROWN	SAND	WATER	FINE	14	16
BLUE	CLAY			16	35

31
32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
16	1 ☑ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS
	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERALS 6 ☐ GAS

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
30	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☑ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC	2	+6"	16
24	1 ☐ STEEL 2 ☑ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC	1/4	16	35
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE 5 ☐ PLASTIC			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)
DIAMETER INCHES
LENGTH FEET
MATERIAL AND TYPE
DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☑ PUMP 2 ☐ BAILER
PUMPING RATE: 5 INTM. GPM
DURATION OF PUMPING: ____ HOURS ____ MINS
STATIC LEVEL: 12 FEET
WATER LEVEL END OF PUMPING: FEET
WATER LEVELS DURING: 1 ☑ PUMPING 2 ☐ RECOVERY
15 MINUTES: 22 FEET
30 MINUTES: FEET
45 MINUTES: FEET
60 MINUTES: FEET
IF FLOWING, GIVE RATE: GPM
PUMP INTAKE SET AT: FEET
WATER AT END OF TEST: 1 ☑ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☑ DEEP
RECOMMENDED PUMP SETTING: 30 FEET
RECOMMENDED PUMPING RATE: 5 INTM. GPM

FINAL STATUS OF WELL

1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED INSUFFICIENT SUPPLY
6 ☐ ABANDONED POOR QUALITY
7 ☐ UNFINISHED
9 ☐ DEWATERING

WATER USE

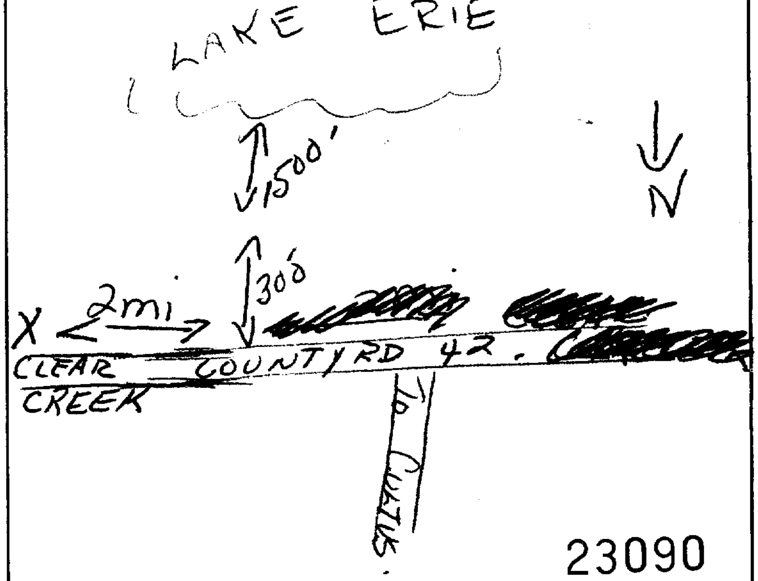
1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF CONSTRUCTION

1 ☐ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☑ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING
☐ DIGGING
☐ OTHER

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



23090

DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR: V. NORMAN BORING
WELL CONTRACTOR'S LICENCE NUMBER: 3910
ADDRESS: RR#4 AYLMER
NAME OF WELL TECHNICIAN: CHARLES B. NORMAN
WELL TECHNICIAN'S LICENCE NUMBER: T0506
SIGNATURE OF TECHNICIAN/CONTRACTOR: Vivian Norman
SUBMISSION DATE: DAY 5 MO. 5 YR. 88

OFFICE USE ONLY

DATA SOURCE
CONTRACTOR: 3910
DATE RECEIVED: MAY 29 1989
DATE OF INSPECTION
INSPECTOR
REMARKS

CSS.ES

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506 (11/86) FORM 9

#55

MINISTRY OF THE ENVIRONMENT
The Ontario Water Resources Act

WATER WELL RECORD

40-1/10a

Ontario

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 | 4403644. | MUNICIP. 44002 | CON. LR 5

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT 25-27
[redacted]	HOUGHTON	5 LAKE RD	018

[redacted] CLEAR CREEK

DATE COMPLETED 48-53: DAY 16 MO. 06 YR. 76

21 | [redacted] 14080 | 4 | ELEVATION 0608 | 4 | BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BROWN	TOP-SOIL			0	1
BROWN	SANDY	CLAY		1	15
BLUE	CLAY			15	23
		DRY HOLE ON COMPLETION			

31 | 0001602 | 0015560581 | 0023305

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
10-13 0015	1 ☑ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
15-18	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
20-23	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
25-28	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
30-33	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
10-11 36	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☑ CONCRETE 4 ☐ OPEN HOLE	3	0	13-16 0023 23
17-18	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			20-23
24-25	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			27-30

SCREEN

SIZE(S) OF OPENING (SLOT NO.) 31-33
DIAMETER 34-38 INCHES
LENGTH 39-40 FEET
MATERIAL AND TYPE
DEPTH TO TOP OF SCREEN 41-44 FEET

61 PLUGGING & SEALING RECORD

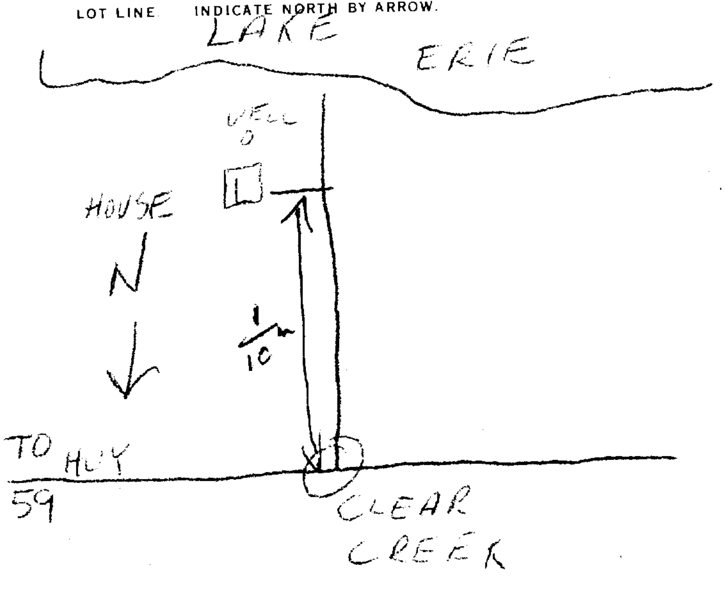
DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER, ETC.)
10-13	14-17	
18-21	22-25	
26-29	30-33	

71 PUMPING TEST

PUMPING TEST METHOD 10: 1 ☐ PUMP 2 ☐ BAILER
PUMPING RATE 11-14 GPM
DURATION OF PUMPING 15-16 HOURS 17-18 MINS
STATIC LEVEL 19-21: 015 FEET
WATER LEVEL END OF PUMPING 22-24 FEET
25 WATER LEVELS DURING 1 ☐ PUMPING 2 ☐ RECOVERY
15 MINUTES 26-28 FEET | 30 MINUTES 29-31 FEET | 45 MINUTES 32-34 FEET | 60 MINUTES 35-37 FEET
IF FLOWING, GIVE RATE 38-41 GPM
PUMP INTAKE SET AT FEET
WATER AT END OF TEST 42: 1 ☐ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☑ SHALLOW ☐ DEEP
RECOMMENDED PUMP SETTING 43-45: 020 FEET
RECOMMENDED PUMPING RATE 46-49: [illegible] GPM
50-53 GPM./FT. SPECIFIC CAPACITY

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

FINAL STATUS OF WELL 54: 1
1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 55-56: 01
1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 57: 6
1 ☐ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☑ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: Johnson + Pratt Well Boring
LICENCE NUMBER: 3030
ADDRESS: R.R. #1 Mt Pleasant
NAME OF DRILLER OR BORER: J. Pratt
LICENCE NUMBER:
SIGNATURE OF CONTRACTOR:
SUBMISSION DATE DAY MO. YR.

OFFICE USE ONLY

DATA SOURCE 58: 1
CONTRACTOR 59-62: 3030
DATE RECEIVED 63-68: 080776
DATE OF INSPECTION: July 27/77
INSPECTOR: [illegible]
REMARKS:
CSS.S8
P
WI

MINISTRY OF THE ENVIRONMENT COPY

FORM 7 MOE 07-091

UTM 17 Z 537860 E

19 R 4713425 N

CON B
Elev 9 R 0575
LOT 2

Basin 23

The Ontario Water Resources Commission Act

WATER WELL RECORD

~~GROUND WATER BRANCH~~
~~44 № 1217~~
~~OCT [illegible] 1963~~
~~ONTARIO WATER RESOURCES COMMISSION~~

County or District NORFOLK 40I/10E

Township, Village, Town or City SOUTH WALSINGHAM

Con. "B" Lot 2

Date completed ~~3~~ 21 (day) JULY (month) 63 (year)

[redacted]dress 185 MAITLAND. ST LONDON. ONT.

Casing and Screen Record

Inside diameter of casing 5"

Total length of casing 288'

Type of screen ✓

Length of screen

Depth to top of screen

Diameter of finished hole PULLED. PIPE.

Pumping Test

Static level NONE

Test-pumping rate G.P.M.

Pumping level

Duration of test pumping

Water clear or cloudy at end of test

Recommended pumping rate G.P.M.

with pump setting of feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
BROWN. CLAY.	0	10'		
BLUE CLAY.	10.	328.		
ABANDONED. HOLE.				

For what purpose(s) is the water to be used? ~~SUMMER COTTAGE~~. ABANDONED

Is well on upland, in valley, or on hillside? LAKE. BANK.

Drilling or Boring Firm CHAS. H. KENT.
WATER WELL DRILLING.

Address P.O. BOX 162
AYLMER ONT.

Licence Number 1167

Name of Driller or Borer CHAS. H. KENT.

Address P.O. BOX 162 AYLMER ONT.

Date

Charles H. Kent.

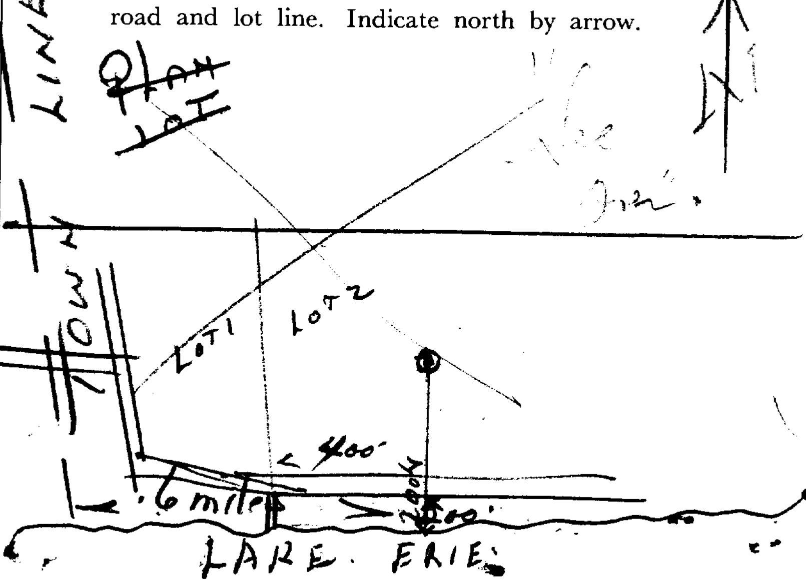
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M-60-4138 BACKEND OF OLD SKUSE FARM

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

3

6 - 671

GROUND WATER BRANCH
44 No 1219
22
ONTARIO WATER
RESOURCES COMMISSION

UTM 17 Z - 544400 E
5 R 4717100 N
Elev. 5 R 0575

The Ontario Water Resources Commission Act

WATER WELL RECORD

Basin 23
County or District Norfolk 4OT/9W
Township, Village, Town or City Longpoint.
Con. B. Lot 14
Date completed 4 (day) April (month) 1963 (year)
Owner [redacted] (print in block letters)
Address DELHI

Casing and Screen Record [redacted]

Inside diameter of casing 5"
Total length of casing 49'
Type of screen ✓
Length of screen ✓
Depth to top of screen ✓
Diameter of finished hole 3"

Pumping Test

Static level ✓
Test-pumping rate ✓ No water found. G.P.M.
Pumping level
Duration of test pumping Casing pulled out
Water clear or cloudy at end of test
Recommended pumping rate G.P.M.
with pump setting of feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
RED Clay ✓	0	49		

Water Record

For what purpose(s) is the water to be used?
Dry

Is well on upland, in valley, or on hillside? ✓

Drilling or Boring Firm R. HODGSON
Address R.R.1 VITTORIA

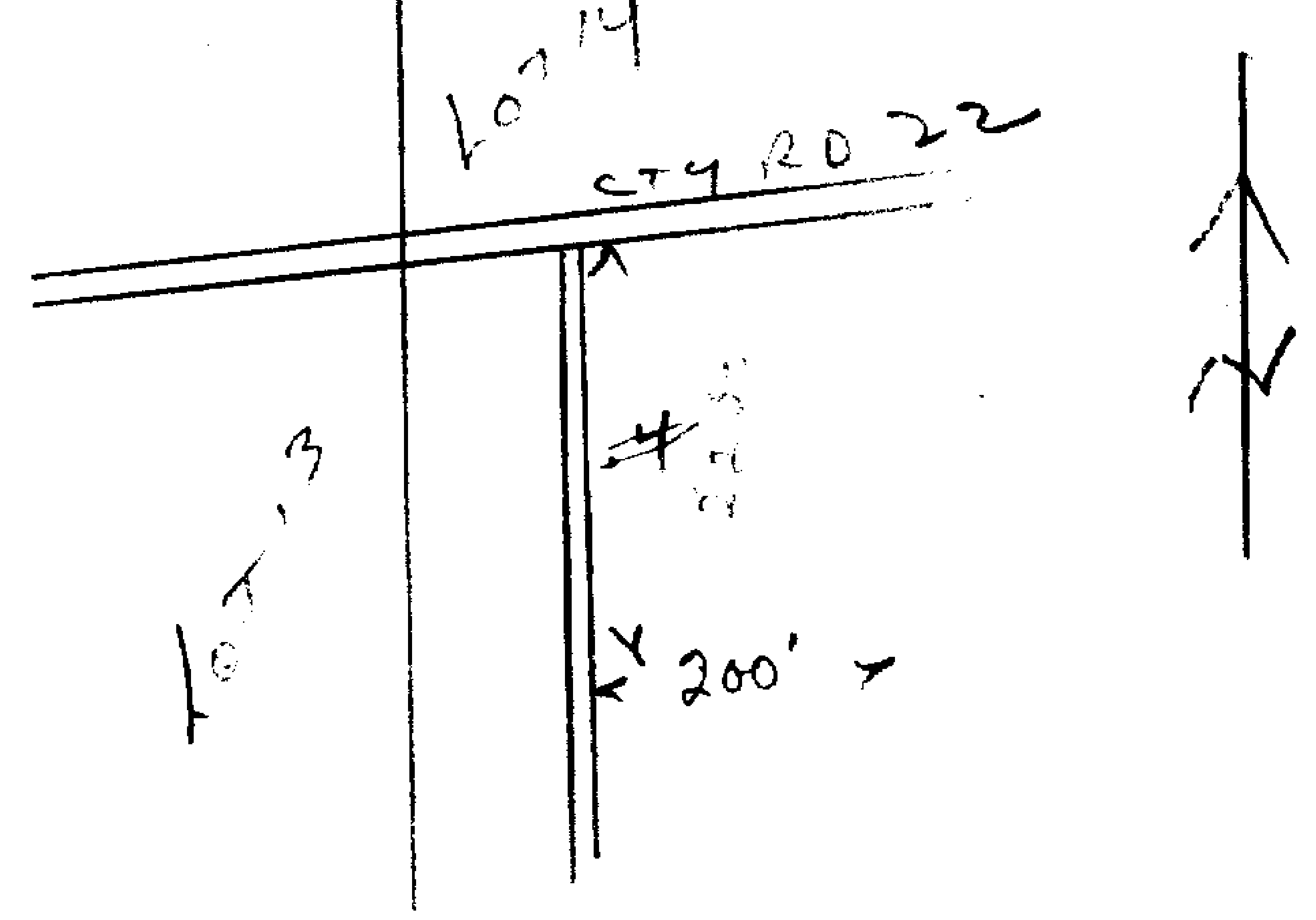
Licence Number 1071
Name of Driller or Borer SAME
Address Vittoria
Date MAY 6/63
Ray Hodgson
(Signature of Licensed Drilling or Boring Contractor)

Form 7 10M-62-1152

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

Peto

Ontario Ministry of the Environment

Measurements recorded in: ☐ Metric ☑ Imperial

Well Tag No. *(Place Sticker and/or Print Below)*

Tag #: A165782

Well Record

Regulation 903 Ontario Water Resources Act

Page 1 of 1

Well Owner's Information

First Name / Last Name / Organization: ROWAN BLUFFS HARBOUR INC. C/O LINWOOD PARKS INC.

E-mail Address:

☐ Well Constructed by Well Owner

Mailing Address (Street Number/Name): 143 WILLOWDALE AVE, STE200

Municipality: TORONTO

Province: ON

Postal Code: M2N4Y5

Telephone No. *(inc. area code)*: 4164815100

Well Location

Address of Well Location (Street Number/Name): 340 Front Road

Township:

Lot:

Concession:

County/District/Municipality: NORFOLK COUNTY

City/Town/Village: Port Rowan

Province: **Ontario**

Postal Code:

UTM Coordinates: NAD 83 Zone 17 Easting 546685 Northing 4721095

Municipal Plan and Sublot Number:

Other:

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth *(m/ft)* From	To
Brown	Clay	Silt	Stiff	0'	12'
Grey	Clay	—	Soft	12'	100'

"cluster of 2 monitoring wells"

Annular Space

Depth Set at *(m/ft)* From	To	Type of Sealant Used *(Material and Type)*	Volume Placed *(m³/ft³)*
100'	88'	#3 Silica Sand	200 LBS
88'	85'	3/8" Bentonite	50 LBS
85'	5'	Grout	100 LBS
5'	2'	3/8" Bentonite	50 LBS

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, *specify*

If pumping discontinued, give reason:

Pump intake set at *(m/ft)*

Pumping rate *(l/min / GPM)*

Duration of pumping
_____ hrs + _____ min

Final water level end of pumping *(m/ft)*

If flowing give rate *(l/min / GPM)*

Recommended pump depth *(m/ft)*

Recommended pump rate *(l/min / GPM)*

Well production *(l/min / GPM)*

Disinfected? ☐ Yes ☑ No

Draw Down Time *(min)*	Water Level *(m/ft)*	Recovery Time *(min)*	Water Level *(m/ft)*
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Method of Construction

☐ Cable Tool
☐ Rotary (Conventional)
☐ Rotary (Reverse)
☐ Boring
☐ Air percussion
☑ Other, *specify* Auger
☐ Diamond
☐ Jetting
☐ Driving
☐ Digging

Well Use

☐ Public
☐ Domestic
☐ Livestock
☐ Irrigation
☐ Industrial
☐ Other, *specify*
☐ Commercial
☐ Municipal
☐ Test Hole
☐ Cooling & Air Conditioning
☐ Not used
☐ Dewatering
☑ Monitoring

Construction Record - Casing

Inside Diameter *(cm/in)*	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness *(cm/in)*	Depth *(m/ft)* From	To
2"	PVC	1/16"	0'	90'

Construction Record - Screen

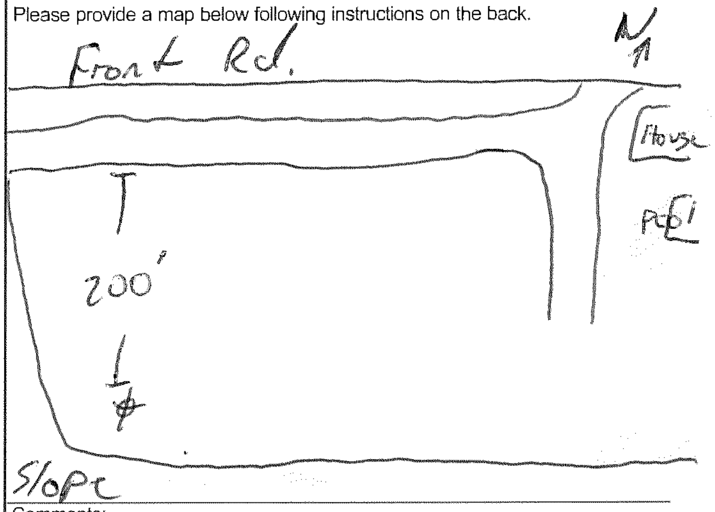
Outside Diameter *(cm/in)*	Material (Plastic, Galvanized, Steel)	Slot No.	Depth *(m/ft)* From	To
2 1/8"	PVC	40	90'	100'

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☑ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, *specify*
☐ Other, *specify*

Map of Well Location

Please provide a map below following instructions on the back.



Comments:

Water Details

Water found at Depth *(m/ft)* ☐ Gas | Kind of Water: ☐ Fresh ☐ Untested ☐ Other, *specify*

Water found at Depth *(m/ft)* ☐ Gas | Kind of Water: ☐ Fresh ☐ Untested ☐ Other, *specify*

Water found at Depth *(m/ft)* ☐ Gas | Kind of Water: ☐ Fresh ☐ Untested ☐ Other, *specify*

Hole Diameter

Depth *(m/ft)* From	To	Diameter *(cm/in)*
0'	100'	8"

Well Contractor and Well Technician Information

Business Name of Well Contractor: ELITE DRILLING SERVICES

Well Contractor's Licence No.: 7484

Business Address (Street Number/Name): BOX 20062

Municipality: ST. CATHARINES

Province: ON

Postal Code: L2M7W7

Business E-mail Address:

Bus. Telephone No. *(inc. area code)*: 9056878691

Name of Well Technician (Last Name, First Name): LIVINGSTON, CHRIS

Well Technician's Licence No.: 3579

Signature of Technician and/or Contractor:

Date Submitted: 20150707

Well owner's information package delivered ☐ Yes ☐ No

Date Package Delivered: Y Y Y Y M M D D

Date Work Completed: 20150529

Ministry Use Only

Audit No. Z189277

JUL 28 2015

Received

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40 I / 9E

The Ontario Water Resources Commission Act

WATER WELL RECORD

Water management in Ontario

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11   4403847   MUNICIP. 44006   CON. CON 01

COUNTY OR DISTRICT [redacted]	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE NORFOLK South Walsingham	CON., BLOCK, TRACT, SURVEY, ETC. I	LOT 021 20
			DATE COMPLETED DAY 10 MO. 06 YR. 72

[redacted] 21440   RC. 4   ELEVATION 0650   RC. 4   BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH – FEET FROM	DEPTH – FEET TO
BROWN	CLAY		LOOSE	0	5
BLUE	CLAY		HARD	5	83
BROWN	CLAY		SOFT	83	211
BLUE	CLAY		SOFT	211	246
GREY	CLAY		HARD	246	271
GREY	LIME		HARD	271	278

31   000560577   008330573   021160585   024630585   027120573   027821573

32

41 WATER RECORD

WATER FOUND AT – FEET	KIND OF WATER
0278	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH – FEET FROM	DEPTH – FEET TO
05"	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		0	0271
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☑ OPEN HOLE		271	0278 ~~278~~
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT – FEET FROM	DEPTH SET AT – FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
0000	0230	lead plugs.
0230	0276	cement.
0276 ~~230~~	0278	clay.

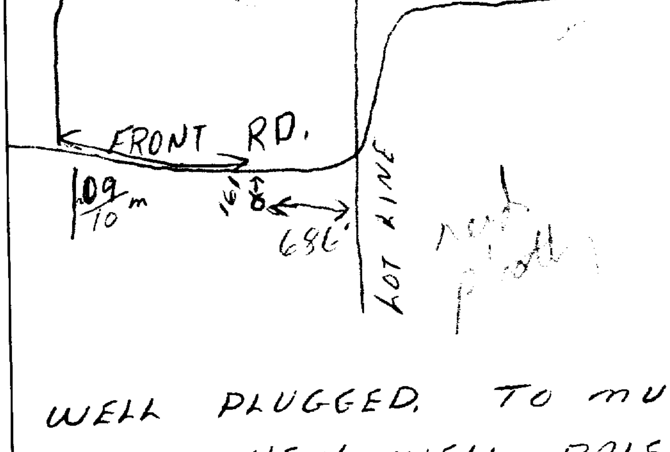
71 PUMPING TEST

PUMPING TEST METHOD 1 ☐ PUMP 2 ☐ BAILER	PUMPING RATE GPM.	DURATION OF PUMPING HOURS MINS.	
STATIC LEVEL FEET	WATER LEVEL END OF PUMPING FEET	WATER LEVELS DURING 1 ☐ PUMPING 2 ☐ RECOVERY: 15 MINUTES FEET, 30 MINUTES FEET, 45 MINUTES FEET, 60 MINUTES FEET	
IF FLOWING, GIVE RATE GPM.	PUMP INTAKE SET AT FEET	WATER AT END OF TEST 1 ☐ CLEAR 2 ☐ CLOUDY	
RECOMMENDED PUMP TYPE ☐ SHALLOW ☐ DEEP	RECOMMENDED PUMP SETTING FEET	RECOMMENDED PUMPING RATE GPM.	

____________ GPM./FT. SPECIFIC CAPACITY

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



WELL PLUGGED, TO MUCH GAS WHEN WELL BALED.

DRILLERS REMARKS:

FINAL STATUS OF WELL 6

1 ☐ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☒ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 09

1 ☐ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1

1 ☑ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR MURRAY ROSE	LICENCE NUMBER 4636
ADDRESS R.R#3 PT ROWAN	
NAME OF DRILLER OR BORER	LICENCE NUMBER
SIGNATURE OF CONTRACTOR Murray Rose	SUBMISSION DATE DAY ____ MO. ____ YR. ____

OFFICE USE ONLY

DATA SOURCE 1	CONTRACTOR 4636	DATE RECEIVED 160877
DATE OF INSPECTION Jun. 4/79	INSPECTOR	
REMARKS:		

OWRC COPY

The Ontario Water Resources Commission Act

WATER WELL RECORD

40 I /9e

Water management in Ontario

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 4403849 MUNICIP. 44001 CON. CON B

COUNTY OR DISTRICT: HALD - NORF

TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: ~~DELHI~~ Charlotteville

CON., BLOCK, TRACT, SURVEY, ETC.: B

LOT 25-27: 001

[redacted]

ADDRESS: ST WILLIAMS

DATE COMPLETED 48-53: DAY 07 MO. 07 YR. 77

NORTHING 722860 RC. 4 ELEVATION 0660 RC. 4 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH – FEET FROM	DEPTH – FEET TO
BROWN	CLAY		SOFT.	0	3
BROWN	CLAY		HARD	3	27
BLUE	CLAY		HARD	27	110
GREY	CLAY	STONE	HARD	110	247
BLUE	CLAY		SOFT	247	268
GREY	CLAY			268	284
LIME				284	292

31 0003605085 0027605073 0110305073 0247205 1273 0268305085 0284205 1

32 0292 15

41 WATER RECORD

WATER FOUND AT – FEET	KIND OF WATER
292	1 ☒ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH – FEET FROM	DEPTH – FEET TO
05"	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		0	0284
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE		284	0292 ~~292~~
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.) 31-33:
DIAMETER 34-38: INCHES
LENGTH 39-40: FEET
MATERIAL AND TYPE:
DEPTH TO TOP OF SCREEN 41-44: FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT – FEET FROM	DEPTH SET AT – FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☐ PUMP 2 ☒ BAILER

PUMPING RATE: 0045 GPM.

DURATION OF PUMPING: 04 HOURS 30 MINS.

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
062 FEET	186 FEET	121 FEET	142 FEET	168 FEET	186 FEET

WATER LEVELS DURING: 1 ☒ PUMPING 2 ☐ RECOVERY

IF FLOWING, GIVE RATE: GPM.

PUMP INTAKE SET AT: FEET

WATER AT END OF TEST: 1 ☒ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☐ DEEP

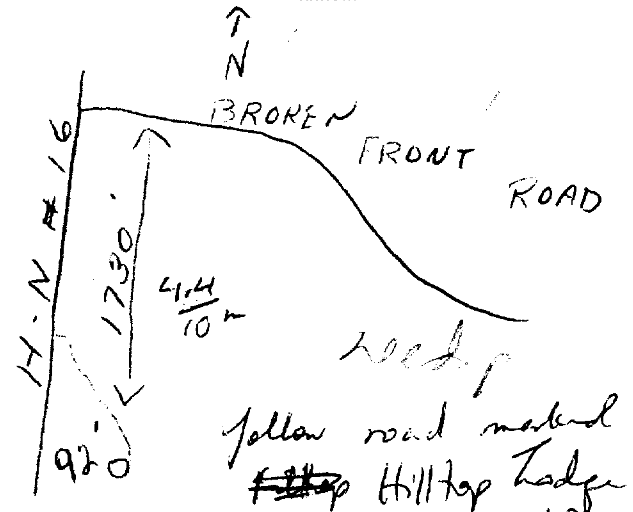
RECOMMENDED PUMP SETTING: FEET

RECOMMENDED PUMPING RATE: GPM.

____________ GPM./FT. SPECIFIC CAPACITY

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



follow road marked ~~Hilltop~~ Hilltop Lodge new house up there

DRILLERS REMARKS:

FINAL STATUS OF WELL 1

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1

1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: MURRAY ROSE
LICENCE NUMBER: 4636
ADDRESS: R.R. # 3 PT ROWAN
NAME OF DRILLER OR BORER:
LICENCE NUMBER:
SIGNATURE OF CONTRACTOR: Murray Rose
SUBMISSION DATE: DAY____ MO.____ YR.____

OFFICE USE ONLY

DATA SOURCE: 1
CONTRACTOR: 4636
DATE RECEIVED: 160877
DATE OF INSPECTION: June 6/79
INSPECTOR: SJ
REMARKS:

CSS.S8

OWRC COPY

Ontario Ministry of the Environment

PETO

Measurements recorded in: ☐ Metric ☒ Imperial

Well Tag N... (Sticker and/or Print Below)
Tag#: A136334

Well Record

Regulation 903 Ontario Water Resources Act

Page 1 of 1

Well Owner's Information

First Name / Last Name / Organization: COUNTY OF NORFOLK, PUBLIC WORKS and ENVIRONMENTAL SERVICES
E-mail Address:
☐ Well Constructed by Well Owner
Mailing Address (Street Number/Name): 50 COLBORNE ST. S.
Municipality: SIMCOE
Province: ON
Postal Code: N3Y4H3
Telephone No. (inc. area code): 5195822100

Well Location

Address of Well Location (Street Number/Name): OLD HILL RD (BEACH) at CEDAR DRIVE
Township:
Lot:
Concession:
County/District/Municipality: RFOLK CTY 555264
City/Town/Village: TURKEY POINT
Province: **Ontario**
Postal Code:
UTM Coordinates Zone Easting Northing: NAD 8 3 17 555264 4727104
Municipal Plan and Sublot Number:
Other:

Overburden and Bedrock Materials/Abandonment Sealing Record *(see instructions on the back of this form)*

General Colour	Most Common Material	Other Materials	General Description	Depth (m/ft) From	Depth (m/ft) To
BROWN	SAND	- WET AT 3 FT		0	15

UTM Co-ord 555264, 4727104

"Cluster of 4 monitoring wells"

Annular Space

Depth Set at (m/ft) From	Depth Set at (m/ft) To	Type of Sealant Used (Material and Type)	Volume Placed (m³/ft³)
0	3	BENTONITE CHIPS	50 LBS
3	15	SAND	

Method of Construction

☐ Cable Tool
☐ Rotary (Conventional)
☐ Rotary (Reverse)
☐ Boring
☐ Air percussion
☒ Other, specify AUGERED
☐ Diamond
☐ Jetting
☐ Driving
☐ Digging

Well Use

☐ Public
☐ Domestic
☐ Livestock
☐ Irrigation
☐ Industrial
☐ Other, specify
☐ Commercial
☐ Municipal
☐ Test Hole
☐ Cooling & Air Conditioning
☐ Not used
☐ Dewatering
☒ Monitoring

Construction Record - Casing

Inside Diameter (cm/in)	Open Hole OR Material (Galvanized, Fibreglass, Concrete, Plastic, Steel)	Wall Thickness (cm/in)	Depth (m/ft) From	Depth (m/ft) To
2"	PVC	1/4"	0	10

Status of Well

☐ Water Supply
☐ Replacement Well
☐ Test Hole
☐ Recharge Well
☐ Dewatering Well
☒ Observation and/or Monitoring Hole
☐ Alteration (Construction)
☐ Abandoned, Insufficient Supply
☐ Abandoned, Poor Water Quality
☐ Abandoned, other, specify
☐ Other, specify

Construction Record - Screen

Outside Diameter (cm/in)	Material ([✓ Plastic], Galvanized, Steel)	Slot No.	Depth (m/ft) From	Depth (m/ft) To
2"	PVC	10	10'	15

Results of Well Yield Testing

After test of well yield, water was:
☐ Clear and sand free
☐ Other, specify
If pumping discontinued, give reason:
Pump intake set at (m/ft)
Pumping rate (l/min / GPM)
Duration of pumping ___ hrs + ___ min
Final water level end of pumping (m/ft)
If flowing give rate (l/min / GPM)
Recommended pump depth (m/ft)
Recommended pump rate (l/min / GPM)
Well production (l/min / GPM)
Disinfected? ☐ Yes ☒ No

Draw Down Time (min)	Draw Down Water Level (m/ft)	Recovery Time (min)	Recovery Water Level (m/ft)
Static Level			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
50		50	
60		60	

Map of Well Location

Please provide a map below following instructions on the back.

Comments:

Water Details

Water found at Depth 3 (m/ft) ☐ Gas | Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify
Water found at Depth (m/ft) ☐ Gas | Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify
Water found at Depth (m/ft) ☐ Gas | Kind of Water: ☐ Fresh ☐ Untested ☐ Other, specify

Hole Diameter

Depth (m/ft) From	Depth (m/ft) To	Diameter (cm/in)
0	15	8"

Well Contractor and Well Technician Information

Business Name of Well Contractor: ELITE DRILLING SERVICES
Well Contractor's Licence No.: 7484
Business Address (Street Number/Name): BOX 20062
Municipality: ST. CATHARINES
Province: ON
Postal Code: L2M7W7
Business E-mail Address:
Bus. Telephone No. (inc. area code): 9056878691
Name of Well Technician (Last Name, First Name): GOW, JOHN
Well Technician's Licence No.: 2617
Signature of Technician and/or Contractor:
Date Submitted: 2016/11/16

Well owner's information package delivered ☐ Yes ☐ No
Date Package Delivered:
Date Work Completed: 2016/10/14

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DEC 13 2016
Received

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UTM 17 Z 555600 E

5 R 4728000 N

Elev. 5 R 06855

Basin 23

1 - 15

57-1

44 № 014

GROUND WATER BRANCH
DEC 3 1957
ONTARIO WATER RESOURCES COMMISSION

ONTARIO

The Water-well Drillers Act, 1954

Department of Mines

Water-Well Record

40I/9 W

County or Territorial District Norfolk Township, Village, Town or City Charlotteville

Con A Lot 15 Street and Number (if in Village, Town or City)

Owner [redacted] Address Vittoria

Date completed 4 (day) Nov (month) 57 (year)

Pipe and Casing Record

Casing diameter(s) 7" O.D.

Length(s) 258'

Type of screen

Length of screen

Pumping Test

Static level 93'

Pumping rate 300 per hr

Pumping level 93'

Duration of test 2 hrs

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth (s) at which water (s) found	No. of feet water rises	Kind of water (fresh, salty, or sulphur)
yellow sand	0	5	264	171	fresh
Clay	5	8			
grey sand	8	56			
soupy sand	56	110			
Clay	110	115			
Clay & sand	115	185			
soupy sand & clay	198	205			
Clay	205	258			
grey lime	258	266			

For what purpose(s) is the water to be used?
Church Camp

Is water clear or cloudy? Clear

Is well on upland, in valley, or on hillside? upland

Drilling firm

Address

Name of Driller Ray Hodgson

Address Vittoria

Licence Number 247

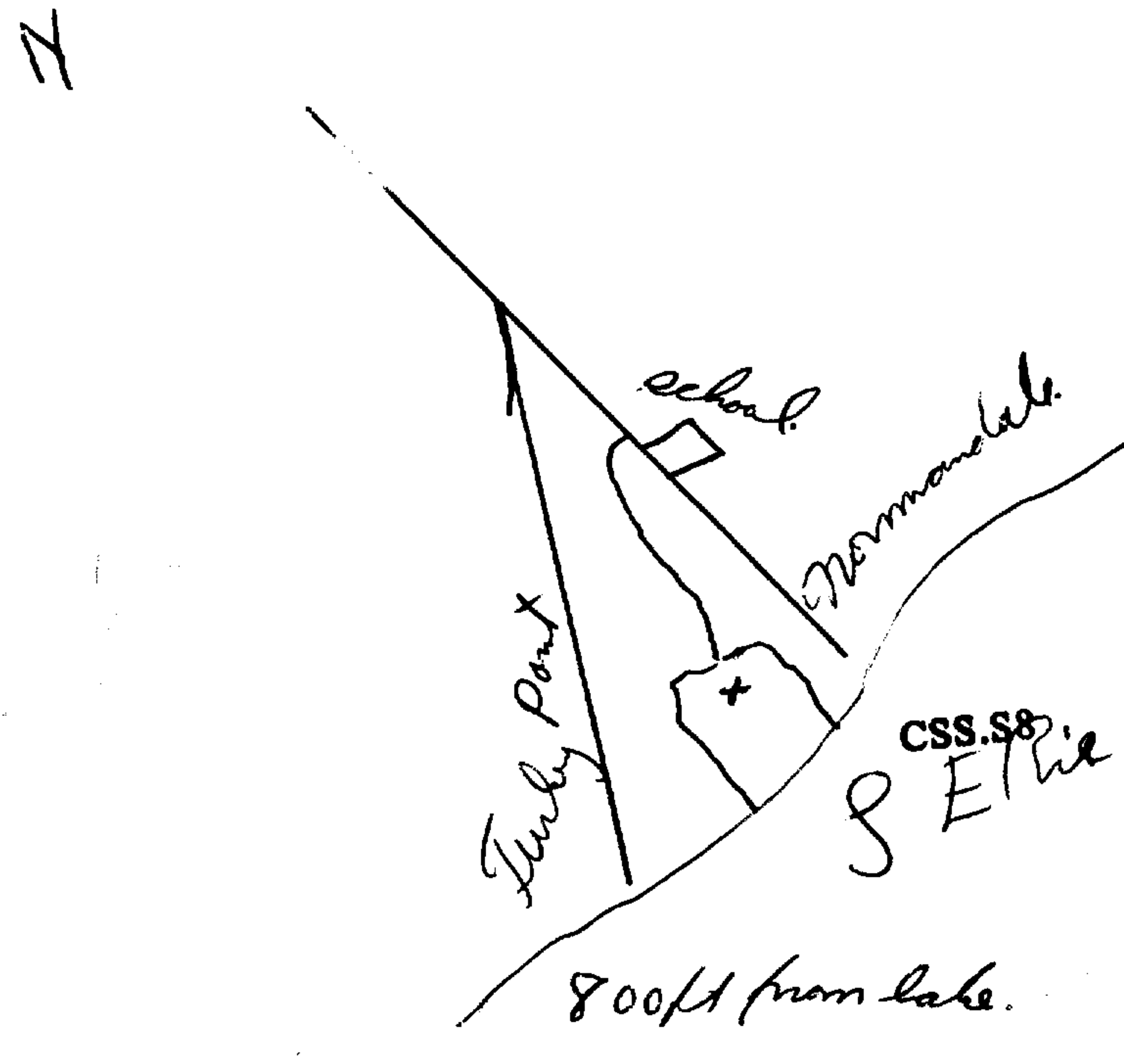
I certify that the foregoing statements of fact are true.

Date Nov 22 Ray Hodgson

Signature of Licensee

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

Form 5

UTM 17 Z 556375 E

Con 5 R A 4728560 N

Elev Lot 5 R 17 0610

Basin 23

The Ontario Water Resources Commission Act

WATER WELL RECORD

40I/9W

WATER RESOURCES DIVISION
44 No 0324-14
DEC 5 1964
ONTARIO WATER RESOURCES COMMISSION

County or District NORFOLK. Township, Village, Town or City ~~CHARLOTTEVILLE~~ NORMANDALE.

Con. ~~MARIN IN FRONT OF~~ ~~LOTS BF~~ CON A Lot ~~15-16~~ 17 Date completed 24 (day) 11 month 64 year)

[redacted] ress 1338 STRATHY AVE. PORT CREDIT.

Casing and Screen Record

Inside diameter of casing 2"
Total length of casing 22.
Type of screen JOHNSON
Length of screen 7'
Depth to top of screen 25
Diameter of finished hole 2"

Pumping Test

Static level 21
Test-pumping rate 4 G.P.M.
Pumping level CONNECT DIRECT
Duration of test pumping 1 HR.
Water clear or cloudy at end of test CLEAR.
Recommended pumping rate 3. G.P.M.
with pump setting of S/W feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.	Water Record: Depth(s) at which water(s) found	Water Record: Kind of water (fresh, salty, sulphur)
~~DUG~~ DUG OUT	0	3'		
BROWN SAND.	3'	9'		
GRAY SAND.	9	14.	14.	
CLAY GRAY.	14	17		
VERY FINE GRAY SAND.	17	21.		
FIN GRAY SAND	21	32.	21	FRESH

For what purpose(s) is the water to be used? COTTAGE.

Is well on upland, in valley, or on hillside?

Drilling or Boring Firm ROBT McKENZIE

Address VITTORIA

Licence Number 1269.

Name of Driller or Borer SAME

Address

Date NOV 28/64

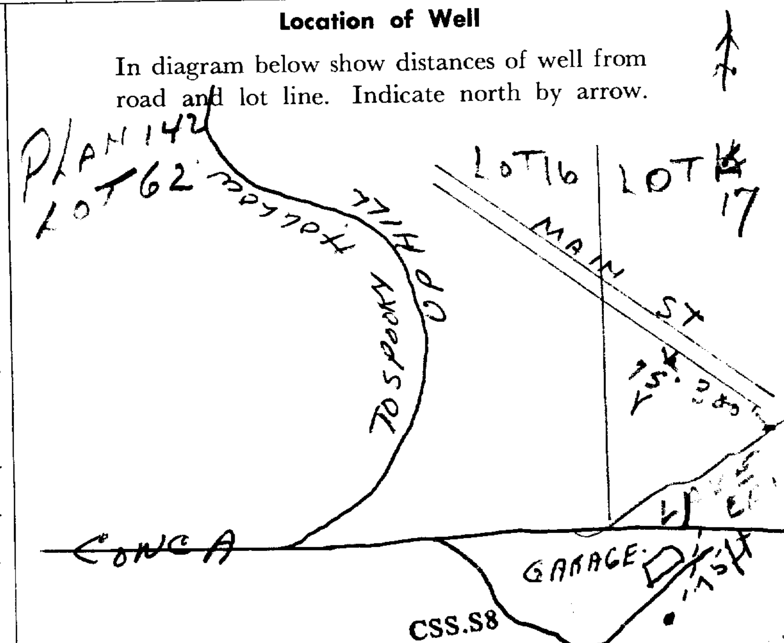
Robert McKenzie
(Signature of Licensed Drilling or Boring Contractor)

Form 7 15M-60-4138

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Ph. 426 - 4269
L.P.M.

Delhi

22-W Rig

40 119 f

Ontario

MINISTRY OF THE ENVIRONMENT
The Ontario Water Resources Act

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 | 4403786 | MUNICIP. 44001 | CON. CON 01

COUNTY OR DISTRICT: ✓ [redacted]

TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: CHARLOTTEVILLE

CON., BLOCK, TRACT, SURVEY, ETC.: A OR B

LOT: 017

SIMCOE Box 28

DATE COMPLETED: DAY 28 MO 01 YR 77

728680 4 | ELEVATION 0580 | 4 | BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
BROWN			CLAY	0	25
BROWN			WATER SAND	25	31

31 | 0025605 | 0031628911

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0025 to 31	1 ☑ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
6½ 02	1 ☑ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	231 pulled 6½	0 pipe	~~31~~ 0025 out
~~2~~	1 ☑ STEEL 2 ☑ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		~~0~~	~~25~~
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.): 006 6 - 12
DIAMETER: 02.000 INCHES
LENGTH: 06 FEET
MATERIAL AND TYPE: Johnson
DEPTH TO TOP OF SCREENS: 0025 FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER, ETC.)

71 PUMPING TEST

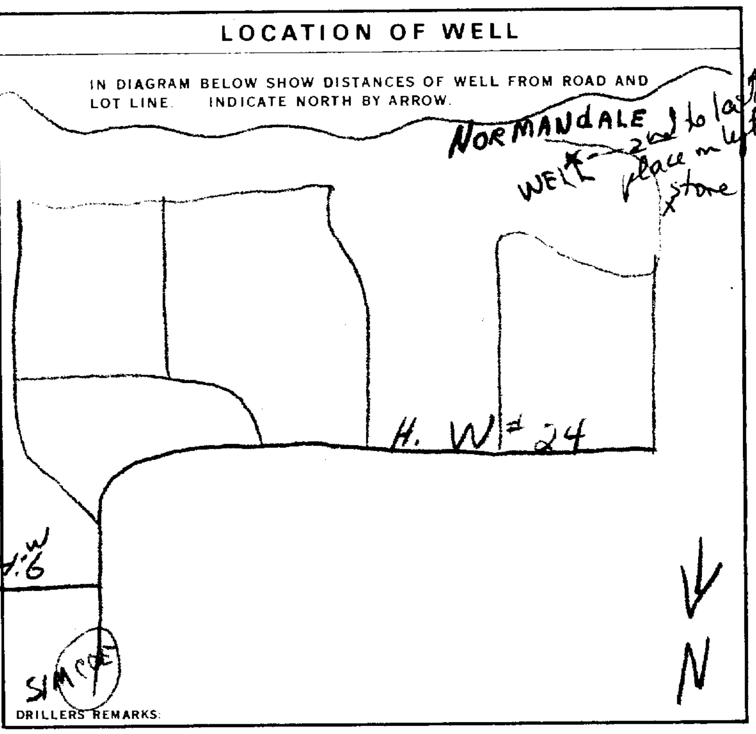
PUMPING TEST METHOD: 1 ☑ PUMP 2 ☐ BAILER
PUMPING RATE: ~~2½~~ 0003 GPM
DURATION OF PUMPING: 07 HOURS 00 MINS
WATER LEVELS DURING: 1 ☒ PUMPING 2 ☐ RECOVERY

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
019 FEET	026 FEET	026 FEET	026 FEET	026 FEET	026 FEET

IF FLOWING, GIVE RATE: GPM
PUMP INTAKE SET AT: 2 FEET
WATER AT END OF TEST: 1 ☑ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☑ SHALLOW ☐ DEEP
RECOMMENDED PUMP SETTING: 029 FEET
RECOMMENDED PUMPING RATE: 0003 2½ GPM
GPM./FT. SPECIFIC CAPACITY

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

FINAL STATUS OF WELL 1
1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01
1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1
1 ☑ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: ELGIN MITCHELL
LICENCE NUMBER: 3604
ADDRESS: JARVIS ONT
NAME OF DRILLER OR BORER: ELGIN MITCHELL
LICENCE NUMBER: 3604
SIGNATURE OF CONTRACTOR: Elgin Mitchell
SUBMISSION DATE: DAY 31 MO. 1 YR. 77

OFFICE USE ONLY

DATA SOURCE: 1
CONTRACTOR: 3604
DATE RECEIVED: 030377
DATE OF INSPECTION: July 22/77
INSPECTOR: [illegible]
REMARKS:
CSS.S8
P
WI

FORM 7 MOE 07-091

MINISTRY OF THE ENVIRONMENT COPY

Ontario ✓

MINISTRY OF THE ENVIRONMENT

The Ontario Water Resources Act

WATER WELL RECORD

40-I 19f

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11

14403453-1

MUNICIP. 44001

CON. B CØN lot 20 01

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT 25-27
Haldimand/Norfolk	FISHERS GLENN (CHARLOTTEVILLE)	PLAN. of FISHERS GLENN	C

[redacted] 61 EAST 17 ST. HAMILTON ONT.

DATE COMPLETED DAY 06 MO. 06 YR. 75

	NORTHING	RC.	ELEVATION	RC.	BASIN CODE	II	III	IV
4403453 17 557869	4729806	4	620	8	23	JUN 15, 1977		278

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BROWN	SAND	CLAY, GRAVEL.		0	45
GREY	CLAY	MUDDY SAND.		45	134
GREY	SHALE	LIMESTONE.		134	140

31 0045628051 1 01342052 8 0140217 1 S

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0138 (10-13)	1 ☑ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL (14)
(15-18)	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL (19)
(20-23)	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL (24)
(25-28)	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL (29)
(30-33)	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL (34, 80)

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
04 (10-11)	1 ☑ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE (12)	219	0	0134 (13-16)
(17-18)	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☑ OPEN HOLE (19)		134	0140 (20-23)
(24-25)	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE (26)			(27-30)

SCREEN

SIZE(S) OF OPENING (SLOT NO.) 31-33	DIAMETER 34-38 INCHES	LENGTH 39-40 FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN 41-44 FEET	80

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
10-13	14-17	
18-21	22-25	
26-29	30-33	80

71 PUMPING TEST

PUMPING TEST METHOD (10): 1 ☐ PUMP 2 ☑ BAILER

PUMPING RATE (11-14): 0006 GPM.

DURATION OF PUMPING: 03 (15-16) HOURS 30 (17-18) MINS.

WATER LEVELS DURING (25): 1 ☒ PUMPING 2 ☐ RECOVERY

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
-66 FEET (19-21)	138 FEET (22-24)	120 FEET (26-28)	138 FEET (29-31)	138 FEET (32-34)	138 FEET (35-37)

IF FLOWING, GIVE RATE (38-41): 0001 ~~72~~ GPM.

PUMP INTAKE SET AT: 135 FEET

WATER AT END OF TEST (42): 1 ☒ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☑ DEEP

RECOMMENDED PUMP SETTING (43-45): 135 FEET

RECOMMENDED PUMPING RATE (46-49): 0002 GPM.

50-53 ____ . ____ GPM./FT. SPECIFIC CAPACITY

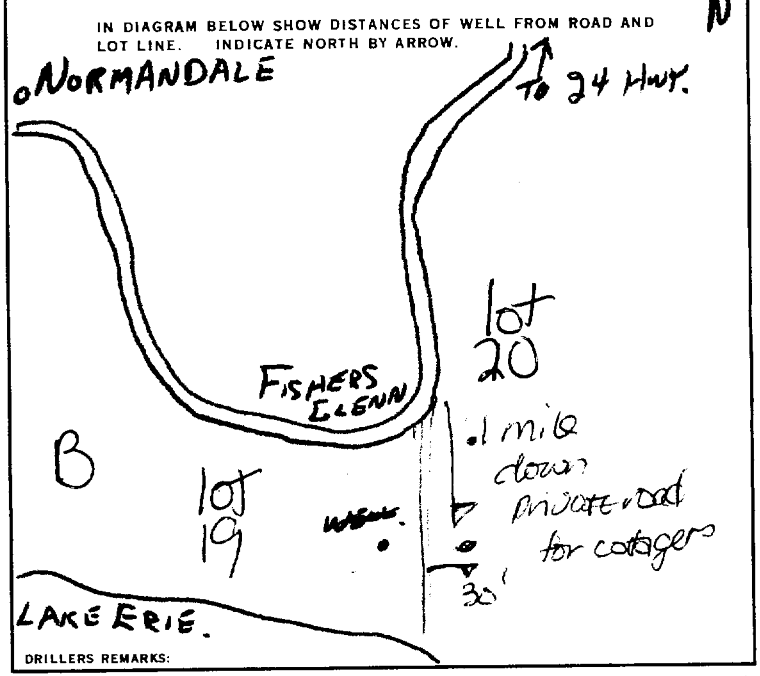
FINAL STATUS OF WELL 1 (54)
- 1 ☑ WATER SUPPLY
- 2 ☐ OBSERVATION WELL
- 3 ☐ TEST HOLE
- 4 ☐ RECHARGE WELL
- 5 ☐ ABANDONED, INSUFFICIENT SUPPLY
- 6 ☐ ABANDONED, POOR QUALITY
- 7 ☐ UNFINISHED

WATER USE 01 (55-56)
- 1 ☑ DOMESTIC
- 2 ☐ STOCK
- 3 ☐ IRRIGATION
- 4 ☐ INDUSTRIAL
- ☐ OTHER
- 5 ☐ COMMERCIAL
- 6 ☐ MUNICIPAL
- 7 ☐ PUBLIC SUPPLY
- 8 ☐ COOLING OR AIR CONDITIONING
- 9 ☐ NOT USED

METHOD OF DRILLING 1 (57)
- 1 ☑ CABLE TOOL
- 2 ☐ ROTARY (CONVENTIONAL)
- 3 ☐ ROTARY (REVERSE)
- 4 ☐ ROTARY (AIR)
- 5 ☐ AIR PERCUSSION
- 6 ☐ BORING
- 7 ☐ DIAMOND
- 8 ☐ JETTING
- 9 ☐ DRIVING

LOCATION OF WELL 5729

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

CONTRACTOR

NAME OF WELL CONTRACTOR: DAVID L MITCHELL — LICENCE NUMBER: 3653.

ADDRESS: BOX 26 JARVIS ONT.

NAME OF DRILLER OR BORER: DAVID MITCHELL — LICENCE NUMBER: 3653

SIGNATURE OF CONTRACTOR: David Mitchell

SUBMISSION DATE DAY 25 MO. 6 YR. 75

OFFICE USE ONLY

DATA SOURCE (58): 1

CONTRACTOR (59-62): 3653

DATE RECEIVED (63-68): 28 06 75

80

DATE OF INSPECTION:

INSPECTOR:

REMARKS: CSS.S8

P KP

WI

FORM 7 MOE 07-091

MINISTRY OF THE ENVIRONMENT COPY

Ministry of Environment and Energy
Ontario

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

NORFOLK

11

4407014

Municipality 44001 Con. CON 01

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
HALD-NORFOLK	DELHI (CHARLOTTEVILLE)	A B	20

Owner's surname / First name	Address	Date completed
ROSS HOMES (CONTRACTOR)	36 OAK ST. SIMCOE	8 day 7 month 98 year

21 Zone Easting Northing RC Elevation RC Basin Code

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth – feet From	Depth – feet To
BROWN	CLAY			0	15
BLUE	CLAY	GRAVEL		15	65
GREY	SILT	BLUE CLAY		65	83
GREY	SILT			83	160
BLUE	CLAY	GRAVEL		160	177
GREY	LIMESTONE			177	201

31

32

41 WATER RECORD

Water found at – feet	Kind of water
200	☐ Fresh ☐ Salty ☑ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

51 CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth – feet From	Depth – feet To
5	☑ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	244	0	177
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)	Diameter inches	Length feet

Material and type
Depth at top of screen feet

61 PLUGGING & SEALING RECORD

☑ Annular space ☐ Abandonment

Depth set at – feet From	Depth set at – feet To	Material and type (Cement grout, bentonite, etc.)
0	10	3/8 HOLE PLUG

71 PUMPING TEST

Pumping test method: ☐ Pump ☑ Bailer	Pumping rate 15 GPM	Duration of pumping 1 Hours 00 Mins	
Static level 71 feet	Water level end of pumping 85 feet	Water levels during ☑ Pumping ☐ Recovery	
15 minutes 85 feet	30 minutes 85 feet	45 minutes 85 feet	60 minutes 85 feet
If flowing give rate GPM	Pump intake set at 150 feet	Water at end of test ☐ Clear ☑ Cloudy	
Recommended pump type ☐ Shallow ☑ Deep	Recommended pump setting 150 feet	Recommended pump rate 15 GPM	

FINAL STATUS OF WELL

- ☑ Water supply
- ☐ Observation well
- ☐ Test hole
- ☐ Recharge well
- ☐ Abandoned, insufficient supply
- ☐ Abandoned, poor quality
- ☐ Abandoned (Other)
- ☐ Dewatering
- ☐ Unfinished
- ☐ Replacement well

WATER USE

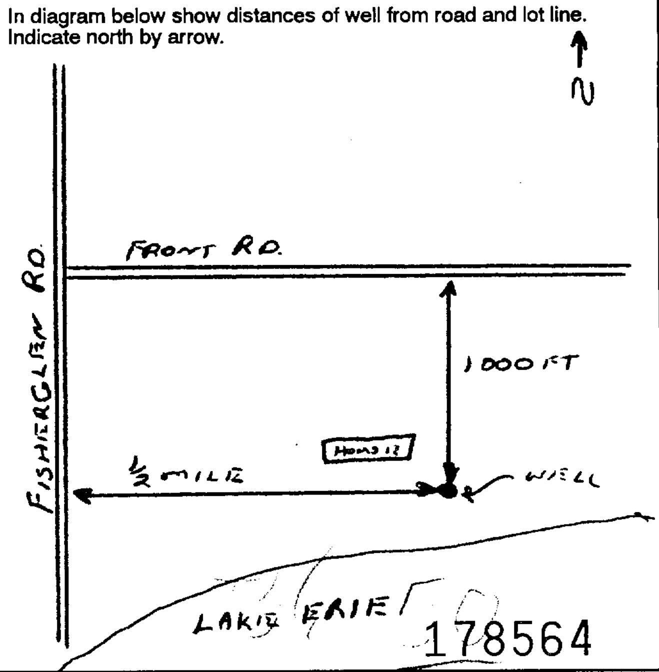
- ☑ Domestic
- ☐ Stock
- ☐ Irrigation
- ☐ Industrial
- ☐ Commercial
- ☐ Municipal
- ☐ Public supply
- ☐ Cooling & air conditioning
- ☐ Not used
- ☐ Other

METHOD OF CONSTRUCTION

- ☑ Cable tool
- ☐ Rotary (conventional)
- ☐ Rotary (reverse)
- ☐ Rotary (air)
- ☐ Air percussion
- ☐ Boring
- ☐ Diamond
- ☐ Jetting
- ☐ Driving
- ☐ Digging
- ☐ Other

LOCATION OF WELL

In diagram below show distances of well from road and lot line.
Indicate north by arrow.



178564

Name of Well Contractor	Well Contractor's Licence No.
TED VAN KESSEL WATERWELLS	5201
Address: 179 SHERMAN ST. SIMCOE	
Name of Well Technician: MARK VAN KESSEL	Well Technician's Licence No.: T-0528
Signature of Technician/Contractor	Submission date day mo yr

MINISTRY USE ONLY

Data source	Contractor 5201	Date received JUL 22 1998
Date of inspection	Inspector	
Remarks		CSS. S9

0506 (07/94) Front Form 9

2 - MINISTRY OF ENVIRONMENT & ENERGY COPY

401|16W

UTM 17 Z 559800 E

5 R 4732840 N

Elev. 5 R 0640

Basin 23

GROUND WATER BRANCH
MAY 28 1962 № 1911
ONTARIO WATER RESOURCES COMMISSION

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District Norfolk

Township, Village, Town or City Woodhouse

Con. B. F. Lot 1

Date completed 10 (day) May (month) 1962 (year)

Owner Norfolk County Park (print in block letters)

Address

Casing and Screen Record

Inside diameter of casing 5"

Total length of casing 134'

Type of screen ✓

Length of screen ✓

Depth to top of screen ✓

Diameter of finished hole 5"

Pumping Test

Static level 50'

Test-pumping rate 8 G.P.M.

Pumping level 100'

Duration of test pumping 3 hrs

Water clear or cloudy at end of test clear

Recommended pumping rate 5 G.P.M.

with pump setting of 100. feet below ground surface

Well Log

Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
Blue Clay	0	35	130'	fresh
soupy " clay	35	130		
" " sand	130	—		

For what purpose(s) is the water to be used? Park

Is well on upland, in valley, or on hillside? upland

Drilling or Boring Firm Ray Hodgson

Address Vittoria

Licence Number 663

Name of Driller or Borer

~~Address~~ May 15/62

Date

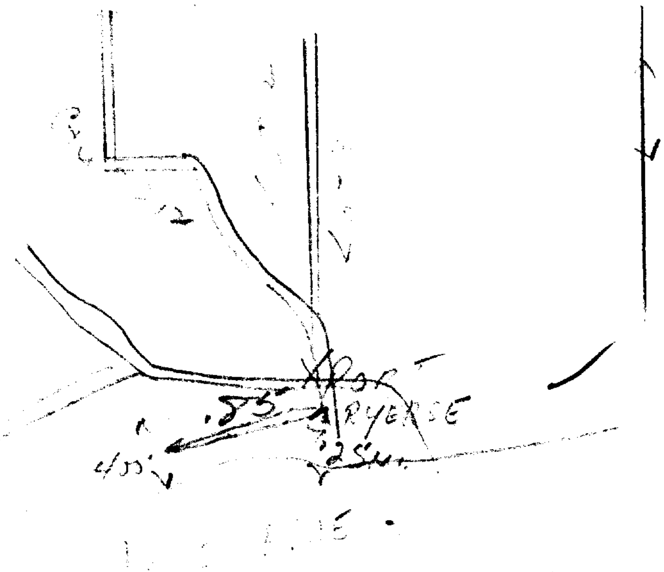
Ray Hodgson
(Signature of Licensed Drilling or Boring Contractor)

Form 7 5M-61-3852

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

401/16W

GROUND WATER BRANCH
AUG 27 1962
44 No. 1920
ONTARIO WATER
RESOURCES COMMISSION

62-5

UTM 17 Z 560600 E
5 R 4733500 N

Elev. 5 R 0600

Basin 23

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District Norfolk Township, Village, Town or City [illegible]

Con. B. F. Lot 2 Date completed 8 (day) June month 1962 year)

[redacted] ress Simcoe

Casing and Screen Record

Inside diameter of casing 5"

Total length of casing 63'

Type of screen ✓

Length of screen ✓

Depth to top of screen ✓

Diameter of finished hole 5"

Pumping Test

Static level flows 6' FT ABOVE G.L.

Test-pumping rate ~~flows~~ 6 G.P.M.

Pumping level ✓

Duration of test pumping ✓ NO TEST.

Water clear or cloudy at end of test clear

Recommended pumping rate 6 G.P.M.

with pump setting of ✓ feet below ground surface

Well Log

Overburden and Bedrock Record	From ft.	To ft.
clay	0	4
Blue Clay	4	63
Lime Rock	63	72.

Water Record

Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
72'	sulphur

For what purpose(s) is the water to be used? domestic

Is well on upland, in valley, or on hillside? valley

Drilling or Boring Firm Ray Hodgson

Address Vittoria

Licence Number 663

Name of Driller or Borer

Address

Date July

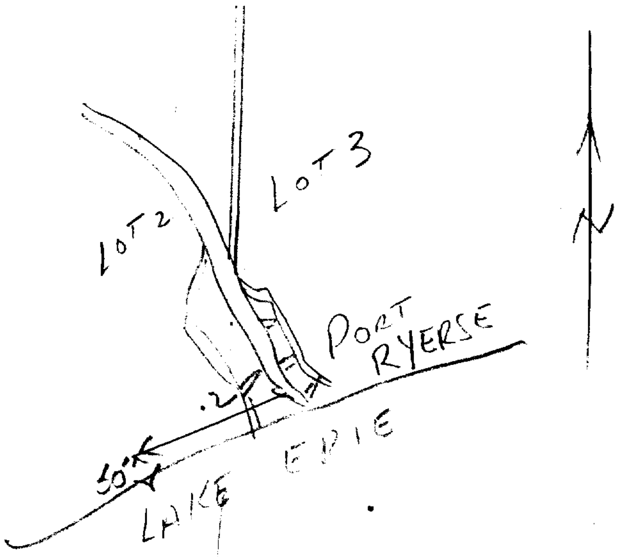
Ray Hodgson
(Signature of Licensed Drilling or Boring Contractor)

Form 7 5M-61-3852

OWRC COPY

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



CSS.S8

Ministry of the Environment
Ontario

The Ontario Water Resources Act 40I-16C

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 4404399 WOODHOUSE?

MUNICIP. 44008 CON BF

COUNTY OR DISTRICT: ~~HAL~~ NORFOLK

[redacted]

TOWNSHIP, BOROUGH, CITY, TOWN: NANTICOKE

CON., BLOCK, TRACT, SURVEY, ETC: B.F OR GORE

LOT: 002

PORT RYERSE

DATE COMPLETED: DAY 30 MO 10 YR 20

NORTHING 733660 RC. 4 ELEVATION 0600 RC 4 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BROWN			TOP SOIL	0	2
GREY			COARSE SAND + STONES	2	12
=			FINE SAND + CLAY	12	30
=			CLAY + STONES	30	62
BROWN			FINE WATER SAND	62	65
GREY			LIME STONE	65	66

31 0002602 0012210012 0030208095 0062205012 0065698 0066215

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0062	1 ☑ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
05	1 ☑ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		0	0062
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.): 016

DIAMETER: 03000 INCHES

LENGTH: 03 FEET

MATERIAL AND TYPE: Johnson

DEPTH TO TOP OF SCREEN: 0062 FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☐ PUMP 2 ☑ BAILER

PUMPING RATE: 0003 GPM

DURATION OF PUMPING: 02 HOURS 10 MINS

WATER LEVELS DURING: 1 ☒ PUMPING 2 ☐ RECOVERY

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
000 FEET	063 FEET	063 FEET	063 FEET	063 FEET	063 FEET

IF FLOWING GIVE RATE: GPM

PUMP INTAKE SET AT: 4 1/2 FEET

WATER AT END OF TEST: 1 ☑ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☑ DEEP

RECOMMENDED PUMP SETTING: 064 FEET

RECOMMENDED PUMPING RATE: 0003 ~~2 1/2~~ GPM

FINAL STATUS OF WELL 1

1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

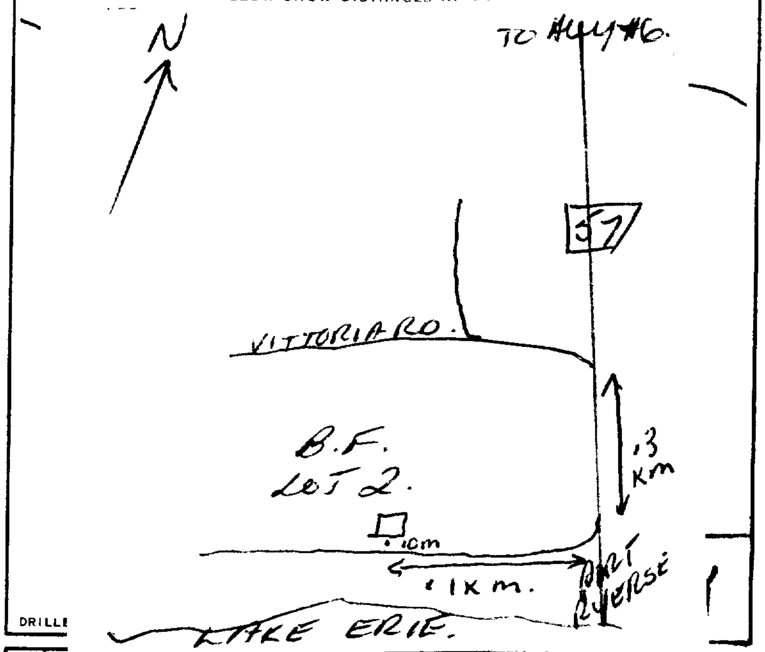
1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1

1 ☑ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD



DRILLER

CONTRACTOR

NAME OF WELL CONTRACTOR: ELGIN MITCHELL + SONS

LICENCE NUMBER: 3604

ADDRESS: RR5 SIMCOE N3Y 4K4

NAME OF DRILLER OR BORER: BRIAN SMELSER

LICENCE NUMBER:

SIGNATURE OF CONTRACTOR: Mitchell

SUBMISSION DATE: DAY 5 MO. 12 YR. 80

OFFICE USE ONLY

DATA SOURCE: 1

CONTRACTOR: 3604

DATE RECEIVED: 190281

DATE OF INSPECTION:

INSPECTOR:

REMARKS:

CSS.S8

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506—4—77 FORM 7

Ministry of the Environment
Ontario

The Ontario Water Resources Act 40I-16b.

WATER WELL RECORD

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 4404450 MUNICIP 44008 CON BF

COUNTY OR DISTRICT [redacted]
TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE ODHOUSE-NANTICOKE
CON, BLOCK, TRACT, SURVEY, ETC. B. F.
LOT 005
R.R.3 SIMCOE
DATE COMPLETED DAY 03 MO 03 YR 81
17 561880 NORTHING 734480 RC 4 ELEVATION 0640 RC 4 BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
Black		Top soil		0	3
yellow		Sand		3	20
Bleu		Clay		20	110
gray		Rock		110	145

31 0003802 0020528 0110805 0145212
32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0130	1 ☐ FRESH 3 ☑ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
04"	1 ☑ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE		0	0145
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.) —
DIAMETER — INCHES
LENGTH — FEET
MATERIAL AND TYPE —
DEPTH TO TOP OF SCREEN — FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD 1 ☑ PUMP 2 ☐ BAILER
PUMPING RATE ~~[illegible]~~ 0003 GPM
DURATION OF PUMPING 02 HOURS 30 MINS
STATIC LEVEL 030 ~~030~~ FEET
WATER LEVEL END OF PUMPING 140 FEET
WATER LEVELS DURING 1 ☐ PUMPING 2 ☐ RECOVERY
15 MINUTES — FEET 30 MINUTES — FEET 45 MINUTES — FEET 60 MINUTES — FEET
IF FLOWING, GIVE RATE — GPM
PUMP INTAKE SET AT 140 FEET
WATER AT END OF TEST 1 ☑ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE ☐ SHALLOW ☑ DEEP
RECOMMENDED PUMP SETTING 005 FEET
RECOMMENDED PUMPING RATE 0005 GPM

FINAL STATUS OF WELL 1

1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

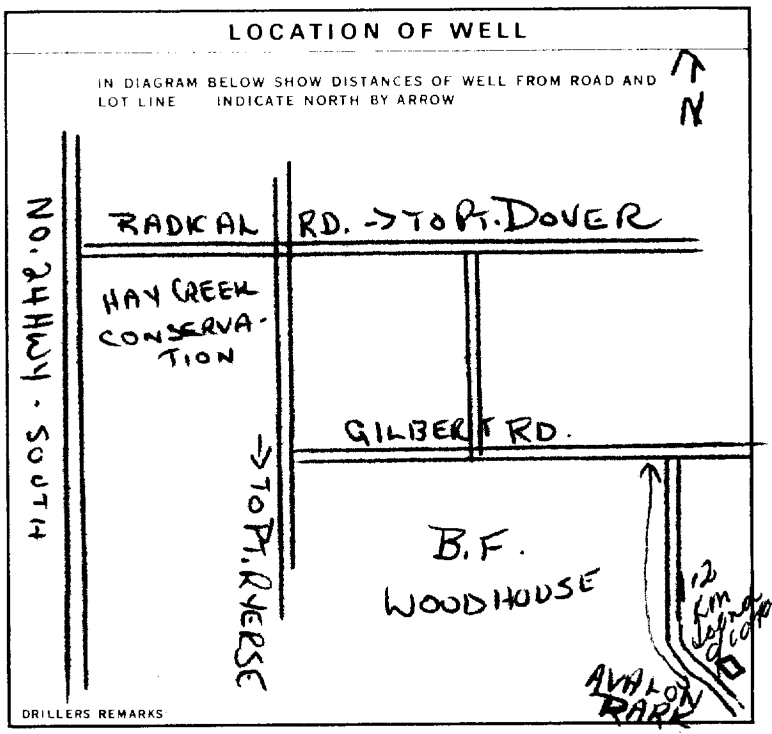
1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1

1 ☑ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW



DRILLERS REMARKS

CONTRACTOR

NAME OF WELL CONTRACTOR TED VAN KESSEL LICENCE NUMBER 5201
ADDRESS 179 SHERMAN ST. SIMCOE
NAME OF DRILLER OR BORER M. VAN KESSEL + J. LOTUS LICENCE NUMBER
SIGNATURE OF CONTRACTOR
SUBMISSION DATE DAY 3 MO. 3 YR. 81

OFFICE USE ONLY

DATA SOURCE 1 CONTRACTOR 5201 DATE RECEIVED 190381
DATE OF INSPECTION
INSPECTOR June 8/82
REMARKS
CSS.S8

MINISTRY OF THE ENVIRONMENT COPY

FORM NO. 0506—4—77 FORM 7

Well ID Number: 7219033

Well Audit Number: *Z185295*

Well Tag Number: *A134451*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	184 GILBERT ST
Township	WOODHOUSE TOWNSHIP
Lot	005
Concession	BF
County/District/Municipality	NORFOLK
City/Town/Village	
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 561985.00 Northing: 4735249.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	LOAM			0 ft	14 ft
BRWN	SAND	SILT		14 ft	14 ft
GREY	SILT	TILL		14 ft	18 ft
GREY	SILT	SAND		18 ft	92 ft

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 ft	44 ft	3/8 BENTONITE	

44 ft	55 ft	WELL SAND

Method of Construction & Well Use

Method of Construction	Well Use
Boring	

Status of Well

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
2 inch	PLASTIC	0 ft	45 ft

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
2.375 inch	PLASTIC	45 ft	55 ft

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 7383

Results of Well Yield Testing

After test of well yield, water was
If pumping discontinued, give reason
Pump intake set at
Pumping Rate
Duration of Pumping

Final water level	
If flowing give rate	
Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind
31 ft	

Hole Diameter

Depth From	Depth To	Diameter
0 ft	92 ft	8.5 inch

Audit Number: Z185295

Date Well Completed: October 02, 2012

Date Well Record Received by MOE: April 08, 2014

Updated: March 7, 2019

Recommended for you

How to use a Ministry of the Environment map

Technical documentation: Metadata record

Ontario Ministry of the Environment

The Ontario Water Resources Act
WATER WELL RECORD

Print only in spaces provided.
Mark correct box with a checkmark, where applicable.

11 4407319 Municipality 44008 Con BF

NORFOLK

County or District	Township/Borough/City/Town/Village	Con block tract survey, etc.	Lot
[redacted]	NANTICOKE (WOODHOUSE)	BF	6
	Address R.R.#3 Simcoe ON	Date completed	14 12 99 (day month year)

Northing RC Elevation RC Basin Code

LOG OF OVERBURDEN AND BEDROCK MATERIALS (see instructions)

General colour	Most common material	Other materials	General description	Depth - feet From	Depth - feet To
~~BLACK~~	~~TOPSOIL~~				
BROKEN	HOLE			0	44
BLUE	CLAY (GRAVEL			44	65
SILT				65	80
BLUE	CLAY (SILT)			80	95
BLUE	CLAY GRAVEL			95	113
GREY	LIMESTONE			113	117

WATER RECORD

Water found at - feet	Kind of water
116	☐ Fresh ☐ Salty ☑ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas
	☐ Fresh ☐ Salty ☐ Sulphur ☐ Minerals ☐ Gas

CASING & OPEN HOLE RECORD

Inside diam inches	Material	Wall thickness inches	Depth - feet From	Depth - feet To
5	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic	188	0	117
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			
	☐ Steel ☐ Galvanized ☐ Concrete ☐ Open hole ☐ Plastic			

SCREEN

Sizes of opening (Slot No.)	Diameter inches	Length feet

Material and type	Depth at top of screen feet

PLUGGING & SEALING RECORD

☑ Annular space ☐ Abandonment

Depth set at - feet From	To	Material and type (Cement grout, bentonite, etc.)
0	15	3/8 HOLE PLUG

PUMPING TEST

Pumping test method ☑ Pump ☐ Bailer		Pumping rate 10 GPM		Duration of pumping 25 Hours .... Mins	
Static level 55 feet	Water level end of pumping 65 feet	Water levels during ☑ Pumping ☐ Recovery 15 minutes 65 feet	30 minutes 65 feet	45 minutes 65 feet	60 minutes 65 feet
If flowing give rate GPM		Pump intake set at 110 feet		Water at end of test ☑ Clear ☐ Cloudy	
Recommended pump type ☐ Shallow ☑ Deep		Recommended pump setting 100 feet		Recommended pump rate 10 GPM	

FINAL STATUS OF WELL

- ☑ Water supply
- ☐ Observation well
- ☐ Test hole
- ☐ Recharge well
- ☐ Abandoned, insufficient supply
- ☐ Abandoned, poor quality
- ☐ Abandoned (Other)
- ☐ Dewatering
- ☐ Unfinished
- ☐ Replacement well

WATER USE

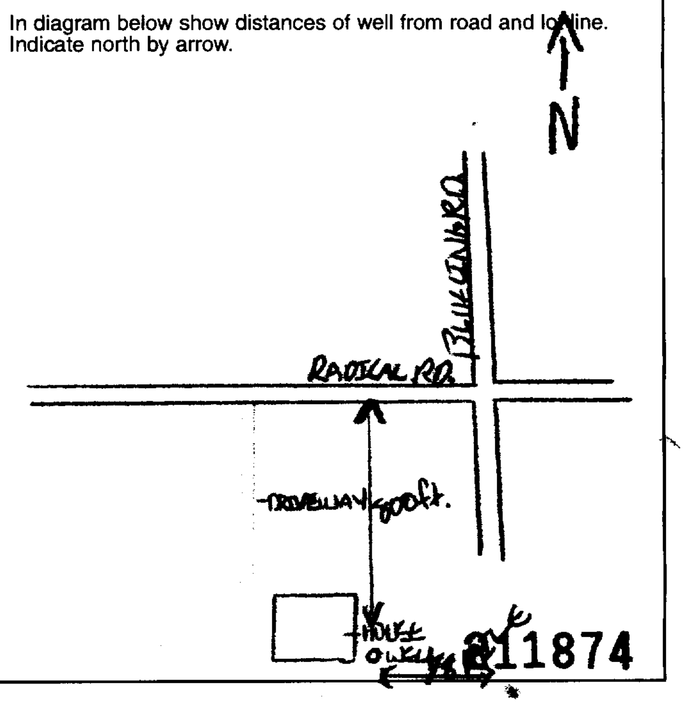
- ☑ Domestic
- ☐ Stock
- ☐ Irrigation
- ☐ Industrial
- ☐ Commercial
- ☐ Municipal
- ☐ Public supply
- ☐ Cooling & air conditioning
- ☐ Not use
- ☐ Other ....

METHOD OF CONSTRUCTION

- ☑ Cable tool
- ☐ Rotary (conventional)
- ☐ Rotary (reverse)
- ☐ Rotary (air)
- ☐ Air percussion
- ☐ Boring
- ☐ Diamond
- ☐ Jetting
- ☐ Driving
- ☐ Digging
- ☐ Other ....

LOCATION OF WELL

In diagram below show distances of well from road and lot line. Indicate north by arrow.



211874

Name of Well Contractor Ted Vankessel Waterwells	Well Contractor's Licence No. 5201
Address 179 Sherman St. Simcoe, ON	
Name of Well Technician MARK VANKESSEL	Well Technician's Licence No. T-0528
Signature of Technician/Contractor Mark Vankessel	Submission date day mo yr

MINISTRY USE ONLY

Data source	Contractor 5201	Date received JAN 0 7 2000
Date of inspection	Inspector	
Remarks		CSS.ES0

2 - MINISTRY OF THE ENVIRONMENT COPY

40 I 16 ~~E~~

40 I/16 b

The Ontario Water Resources Commission Act

WATER WELL RECORD

Water management in Ontario

1. PRINT ONLY IN SPACES PROVIDED
2. CHECK ☒ CORRECT BOX WHERE APPLICABLE

11 (1 2)

4402638 | MUNICIP. 44008 (10–14) | CON. BF (15; 22 23 24)

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE 3	CON., BLOCK, TRACT, SURVEY, ETC.	LOT 25-27
NORFOLK	WOODHOUSE	Con. 4 B.F.	007

[redacted] RADICAL RD. PORT DOVER

DATE COMPLETED 48-53: DAY 02 MO 09 YR. 70

ING 136980 (24) RC 4 (25) ELEVATION 06~~8~~40 (26) RC ~~5~~4 (30) BASIN CODE 23 (31) (47)

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH – FEET FROM	TO
	Top Soil			0	1
Yellow	sand			1	6
Brown	Clay			6	30
Gray	Clay			30	64
Gray	Sand Clay			64	77
Gray	Sand			77	78
Gray	Clay			78	92
Gray	Sand			92	93
Gray	Clay Sand			93	100
	Flint			100	101
	Lime Stone			101	123

31 | 0001 02 | 0006509 | 0030605 | 0064205 | 00772 9205 | 0078209 | 1

32 | 0092205 | 0093209 | 0100205109 | 0123 15 | | | (1 2 / 10 / 14 15 / 21 / 32 / 43 / 54 / 65 / 75 / 80)

41 WATER RECORD

WATER FOUND AT – FEET	KIND OF WATER
0077 (10-13)	1 ☒ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL (14)
0093 (15-18)	1 ☒ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL (19)
0117 (20-23)	1 ☒ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL (24)
(25-28)	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL (29)
(30-33)	1 ☐ FRESH 2 ☐ SALTY 3 ☐ SULPHUR 4 ☐ MINERAL (34) 80

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH – FEET FROM	TO
(10-11) ~~D~~ 04	1 ☒ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE (12)	208	0	(13-16) ~~100~~ 0100
(17-18)	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☒ OPEN HOLE (19)		100	(20-23) 0123 ~~123~~
(24-25)	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE (26)			(27-30)

SCREEN

SIZE(S) OF OPENING (SLOT NO.) 31-33	DIAMETER 34-38 INCHES	LENGTH 39-40 FEET
MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN 41-44 FEET	80

61 PLUGGING & SEALING RECORD

DEPTH SET AT – FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)
10-13	14-17	
18-21	22-25	
26-29	30-33	80

71 PUMPING TEST

PUMPING TEST METHOD (10): 1 ☒ PUMP 2 ☐ BAILER

PUMPING RATE (11-14): ~~½~~ 0002 GPM.

DURATION OF PUMPING: 01 HOURS (15-16) 00 MINS. (17-18)

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
(19-21) 055 FEET	(22-24) 122 FEET	(26-28) 122 FEET	(29-31) 122 FEET	(32-34) 122 FEET	(35-37) 122 FEET

25 WATER LEVELS DURING: 1 ☒ PUMPING 2 ☐ RECOVERY

IF FLOWING, GIVE RATE (38-41): GPM.

PUMP INTAKE SET AT: FEET

WATER AT END OF TEST (42): 1 ☒ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☐ DEEP

RECOMMENDED PUMP SETTING (43-45): 122 FEET

RECOMMENDED PUMPING RATE (46-49): ~~½~~ 0001 GPM.

50-53 __000.0 GPM./FT. SPECIFIC CAPACITY

FINAL STATUS OF WELL (54)

1 ☒ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01 (55-56)

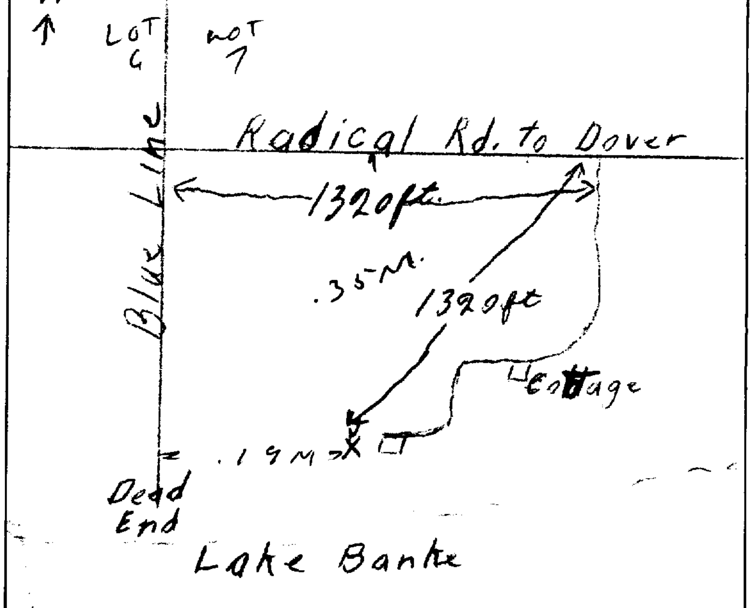
1 ☒ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☒ OTHER Cottage
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING (57)

1 ☒ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

CONTRACTOR

NAME OF WELL CONTRACTOR: THOMAS HILL — LICENCE NUMBER 2551

ADDRESS: RR1 VITTORIA

NAME OF DRILLER OR BORER: THOMAS HILL — LICENCE NUMBER 2551

SIGNATURE OF CONTRACTOR: Thomas Hill

SUBMISSION DATE: DAY 2 MO. 9 YR. 70

OFFICE USE ONLY

DATA SOURCE 58	CONTRACTOR 59-62	DATE RECEIVED 63-68	80
1	2551	250171	

DATE OF INSPECTION: 10, 9, 71

INSPECTOR: 7/P

REMARKS:

CSS.58 S.C.

OWRC COPY

Go Back to Map

Well ID

Well ID Number: 7269445
Well Audit Number: *Z228544*
Well Tag Number: *A177507*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	14 KIWANIS AVENUE
Township	PORT DOVER TOWN
Lot	
Concession	
County/District/Municipality	NORFOLK
City/Town/Village	PORT DOVER
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 563871.00 Northing: 4737036.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BLCK	LOAM	SILT	LOOS	0 ft	1 ft
BRWN	CLAY	SILT	DNSE	1 ft	10 ft

GREY	CLAY	SILT	DNSE	10 ft	40 ft
GREY	SILT	CLAY	DNSE	40 ft	86 ft

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 ft	43 ft	BENTONITE CHIPS	
43 ft	55 ft	SILICA SAND	
55 ft	86 ft	BENTONITE	

Method of Construction & Well Use

Method of Construction	Well Use
Rotary (Convent.)	
	Monitoring

Status of Well

Observation Wells

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
.75 inch	PLASTIC	0 ft	45 ft
.75 inch	PLASTIC	55 ft	86 ft

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
.75 inch	PLASTIC	45 ft	55 ft

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 7190

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	

Duration of Pumping	
Final water level	
If flowing give rate	
Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind
40 ft	

Hole Diameter

Depth From	Depth To	Diameter
0 ft	86 ft	4.25 inch

Audit Number: Z228544

Date Well Completed: June 21, 2016

Date Well Record Received by MOE: August 18, 2016

Updated: March 7, 2019
Share facebook twitter Print
Tags

- Environment and energy,
- Drinking water

Ministry of the Environment, Conservation and Parks

The Ministry of the Environment, Conservation and Parks works to protect and sustain the quality of Ontario's air, land, and water. We also coordinate Ontario's actions on climate change in the name of healthier communities, ecological protection and economic prosperity.

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Go Back to Map

Well ID

Well ID Number: 7264341
Well Audit Number: *Z232237*
Well Tag Number: *A204107*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	NELSON ST WEST
Township	PORT DOVER TOWN
Lot	
Concession	
County/District/Municipality	NORFOLK
City/Town/Village	PORT DOVER
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 564620.00 Northing: 4737185.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	CLAY	SILT	SOFT	0 m	3.1 m
GREY	CLAY	SILT	SOFT	3.1 m	6.08 m

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 m	.3 m	CONCRETE	
.3 m	2.7 m	BENTONITE 3/8 HOLEPLUG	
2.7 m	6.08 m	SILICA SAND #2	

Method of Construction & Well Use

Method of Construction	Well Use
Boring	
HSA	Test Hole

Status of Well

Test Hole

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
5.1 cm	PLASTIC	0 m	3.04 m

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
6.1 cm	PLASTIC	3.04 m	6.08 m

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 7320

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	
Duration of Pumping	
Final water level	

If flowing give rate	
Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind
	Untested

Hole Diameter

Depth From	Depth To	Diameter
0 m	6.08 m	21 cm

Audit Number: Z232237

Date Well Completed: May 05, 2016

Date Well Record Received by MOE: June 08, 2016

Updated: March 7, 2019
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Tags

- Environment and energy,
- Drinking water

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Topics

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Well ID

Well ID Number: 7237775
Well Audit Number: *Z204920*
Well Tag Number: *A176092*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	MAIN ST. 57
Township	PORT DOVER TOWN
Lot	
Concession	
County/District/Municipality	NORFOLK
City/Town/Village	PORT DOVER
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 565431.00 Northing: 4737164.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	CSND		PCKD	0 m	5.5 m
GREY	FILL	MSND	LOOS	5.5 m	6.4 m

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 m	2.5 m	BENTONITE	
2.5 m	5.5 m	SAND PACK	

Method of Construction & Well Use

Method of Construction	Well Use
Boring	
	Monitoring

Status of Well

Observation Wells

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
5.2 cm	PLASTIC	0 m	2.5 m

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
6.4 cm	PLASTIC	2.5 m	5.5 m

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 7472

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	
Duration of Pumping	
Final water level	
If flowing give rate	

Recommended pump depth
Recommended pump rate
Well Production
Disinfected?

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind

Hole Diameter

Depth From	Depth To	Diameter
0 m	5.5 m	21 cm

Audit Number: Z204920

Date Well Completed: November 21, 2014

Date Well Record Received by MOE: February 23, 2015

Updated: March 7, 2019
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Tags

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- Drinking water

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Topics

- Business and economy

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Well ID

Well ID Number: 7287720
Well Audit Number: *Z220756*
Well Tag Number: *A165777*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	146 CROWN ST
Township	WOODHOUSE TOWNSHIP
Lot	
Concession	
County/District/Municipality	NORFOLK
City/Town/Village	PORT DOVER
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 566999.00 Northing: 4737435.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	SILT	GRVL	FILL	0 ft	10 ft
GREY	CLAY	SLTY		10 ft	50 ft

GREY	CLAY	SLTY	GRVL	50 ft	61.5 ft

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 ft	55 ft	BENTONITE CHIPS 1000LBBS	
55 ft	61.5 ft	#3 WELL GRAVEL 150 LBS	

Method of Construction & Well Use

Method of Construction	Well Use
Other Method	
AUGER	Monitoring

Status of Well

Observation Wells

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
2 inch	PLASTIC	0 ft	56 ft

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
2.5 inch	PLASTIC	65 ft	61.5 ft

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 7484

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	
Duration of Pumping	

Final water level	
If flowing give rate	
Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind

Hole Diameter

Depth From	Depth To	Diameter
0 ft	61.5 ft	8 inch

Audit Number: Z220756

Date Well Completed: March 16, 2017

Date Well Record Received by MOE: June 05, 2017

Updated: March 7, 2019
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Tags

- Environment and energy,
- Drinking water

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401/16E

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C R 4737604 N

Elev 05 R 0630

Basin 23

WATER RESOURCES DIVISION
44 No. 1948
JUL 26 1965
ONTARIO WATER RESOURCES COMMISSION

The Ontario Water Resources Commission Act

WATER WELL RECORD

County or District NORFOLK Township, Village, Town or City WOOD HOUSE

Con. I Lot 15 Date completed 28 (day) MAY (month) 65 (year)

[redacted]ress PORT DOVER

Casing and Screen Record

Inside diameter of casing 6 1/4

Total length of casing 72

Type of screen

Length of screen

Depth to top of screen

Diameter of finished hole 5 5/8

Pumping Test

Static level 45

Test-pumping rate 10 G.P.M.

Pumping level 50

Duration of test pumping 2. HOURS

Water clear or cloudy at end of test cloudy

Recommended pumping rate 10 G.P.M.

with pump setting of 100 feet below ground surface

Well Log / Water Record

Overburden and Bedrock Record	From ft.	To ft.	Depth(s) at which water(s) found	Kind of water (fresh, salty, sulphur)
GREY CLAY	0	72		
BROWN LIME	72	92	88	sulphur
FLINT	92	125	124	sulphur and SALTY

For what purpose(s) is the water to be used? HOUSEHOLD

Is well on upland, in valley, or on hillside? LEVEL

Drilling or Boring Firm ELGIN A MITCHELL

Address ELIZABETH ST
JARVIS

Licence Number 1730

Name of Driller or Borer

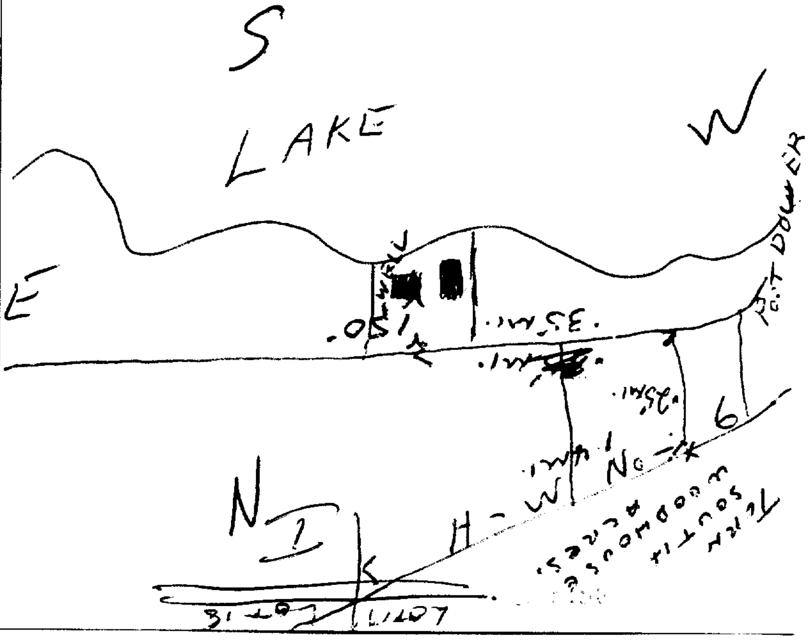
Address

Date JUNE 4 / 65

Elgin Mitchell
(Signature of Licensed Drilling or Boring Contractor)

Location of Well

In diagram below show distances of well from road and lot line. Indicate north by arrow.



Form 7 15M-60-4138

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The Ontario Water Resources Act

WATER WELL RECORD

Ontario

40 1/16 E

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11 | 4403709 | MUNICIP. 44008 | CON. CØN 01

COUNTY OR DISTRICT: HALD + NORFOLK
TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE: WOOD HOUSE
CON. BLOCK, TRACT, SURVEY, ETC.: 1
LOT: 018

[redacted]

ADDRESS: RR # 3 PORT DOVER
DATE COMPLETED: DAY 05 MO. 10 YR. 76

21 | UTM 17 | 569450 | NORTHING 4737200 | RC 5 | ELEVATION 0600 | RC 5 | BASIN CODE 23

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	DEPTH - FEET TO
BROWN			CLAY	0	35
=			FLINT	35	45
=			WATER SAND + GRAVEL	45	48

31 0035605 0045 40 0048 2891//
32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0045'	1 ☑ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	DEPTH - FEET TO
6 1/2 06 6 1/4	1 ☑ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☑ OPEN HOLE	244	0 35	0035 48
06	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☑ OPEN HOLE			0048
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.):
DIAMETER: INCHES
LENGTH: FEET
MATERIAL AND TYPE: NIL
DEPTH TO TOP OF SCREEN: FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	DEPTH SET AT - FEET TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

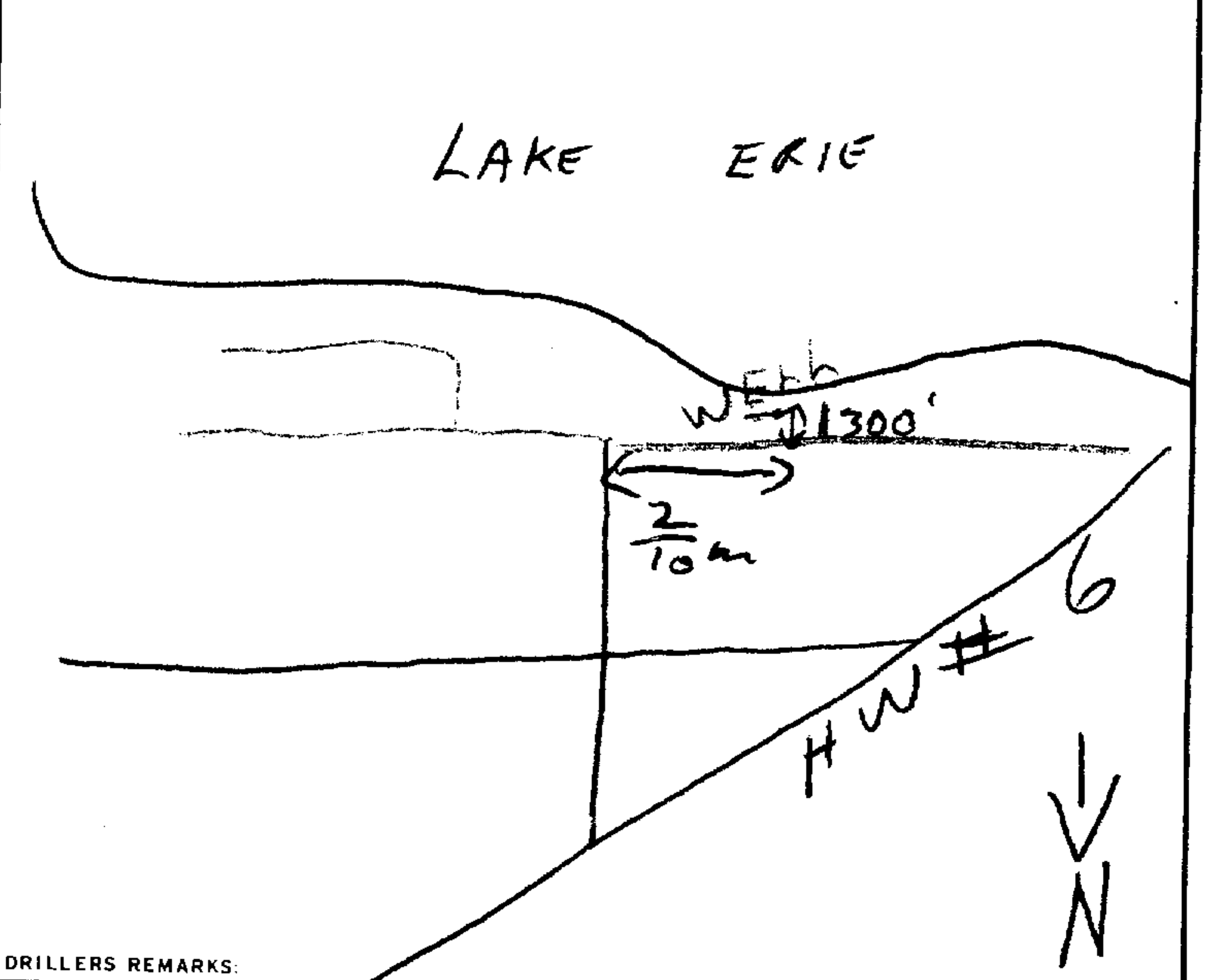
PUMPING TEST METHOD: 1 ☐ PUMP 2 ☑ BAILER
PUMPING RATE: 0006 GPM
DURATION OF PUMPING: 01 HOURS 20 MINS
WATER LEVELS DURING: 1 ☒ PUMPING 2 ☐ RECOVERY

STATIC LEVEL	WATER LEVEL END OF PUMPING	15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
020 FEET	040 FEET	040 FEET	040 FEET	040 FEET	040 FEET

IF FLOWING, GIVE RATE: GPM
PUMP INTAKE SET AT: FEET
WATER AT END OF TEST: 1 ☑ CLEAR 2 ☐ CLOUDY
RECOMMENDED PUMP TYPE: ☐ SHALLOW ☑ DEEP
RECOMMENDED PUMP SETTING: 041 FEET
RECOMMENDED PUMPING RATE: 0005 GPM
GPM./FT. SPECIFIC CAPACITY

LOCATION OF WELL

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

FINAL STATUS OF WELL 1

1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1

1 ☑ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

CONTRACTOR

NAME OF WELL CONTRACTOR: ELGIN MITCHELL
LICENCE NUMBER: 3604
ADDRESS: JARVIS ONT
NAME OF DRILLER OR BORER: ROGER MITCHELL
LICENCE NUMBER:
SIGNATURE OF CONTRACTOR: Elgin Mitchell
SUBMISSION DATE: DAY 15 MO. 11 YR. 76

OFFICE USE ONLY

DATA SOURCE: 1
CONTRACTOR: 3604
DATE RECEIVED: 251176
DATE OF INSPECTION: Aug 11/77
INSPECTOR: E4
REMARKS:
P
WI
CSS.58

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FORM 7 MOE 07-091

Ontario

MINISTRY OF THE ENVIRONMENT
The Ontario Water Resources Act

WATER WELL RECORD

40-1/16b

1. PRINT ONLY IN SPACES PROVIDED
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11 | 4403431 | MUNICIP 44008 | CON Con I | 01

COUNTY OR DISTRICT	TOWNSHIP, BOROUGH, CITY, TOWN, VILLAGE	CON., BLOCK, TRACT, SURVEY, ETC.	LOT
NORFOLK	WOODHOUSE	VAUGHN SURVEY	

[redacted]

ADDRESS: RR # 3 PORT DOVER

DATE COMPLETED: DAY 28 MO. 04 YR. 75

	ZONE	EASTING	NORTHING	RC	ELEVATION	RC	BASIN CODE			
4403431	17	570072	4737287	4	604	4	23	JUN 17, 1977		279

LOG OF OVERBURDEN AND BEDROCK MATERIALS (SEE INSTRUCTIONS)

GENERAL COLOUR	MOST COMMON MATERIAL	OTHER MATERIALS	GENERAL DESCRIPTION	DEPTH - FEET FROM	TO
GREY	CLAY			0	54
GREY	SHALE	GYP LIMESTONE		54	65

P.8

31 | 0054205 | 00652175

32

41 WATER RECORD

WATER FOUND AT - FEET	KIND OF WATER
0055	1 ☐ FRESH 3 ☒ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
0064	1 ☐ FRESH 3 ☒ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL
	1 ☐ FRESH 3 ☐ SULPHUR 2 ☐ SALTY 4 ☐ MINERAL

51 CASING & OPEN HOLE RECORD

INSIDE DIAM. INCHES	MATERIAL	WALL THICKNESS INCHES	DEPTH - FEET FROM	TO
5 05	1 ☑ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE	244	0	0054 54
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☑ OPEN HOLE		54	65 0065
	1 ☐ STEEL 2 ☐ GALVANIZED 3 ☐ CONCRETE 4 ☐ OPEN HOLE			

SCREEN

SIZE(S) OF OPENING (SLOT NO.)	DIAMETER INCHES	LENGTH FEET

MATERIAL AND TYPE	DEPTH TO TOP OF SCREEN FEET

61 PLUGGING & SEALING RECORD

DEPTH SET AT - FEET FROM	TO	MATERIAL AND TYPE (CEMENT GROUT, LEAD PACKER, ETC.)

71 PUMPING TEST

PUMPING TEST METHOD: 1 ☑ PUMP 2 ☐ BAILER

PUMPING RATE: 0012 GPM.

DURATION OF PUMPING: 02 HOURS 30 MINS.

STATIC LEVEL	WATER LEVEL END OF PUMPING	WATER LEVELS DURING 1 ☒ PUMPING 2 ☐ RECOVERY 15 MINUTES	30 MINUTES	45 MINUTES	60 MINUTES
035 FEET	040 FEET	040 FEET	040 FEET	040 FEET	040 FEET

IF FLOWING, GIVE RATE: GPM.

PUMP INTAKE SET AT: 60 FEET

WATER AT END OF TEST: 1 ☑ CLEAR 2 ☐ CLOUDY

RECOMMENDED PUMP TYPE: ☐ SHALLOW ☑ DEEP

RECOMMENDED PUMP SETTING: 055 FEET

RECOMMENDED PUMPING RATE: 0010 GPM.

____.__ GPM./FT. SPECIFIC CAPACITY

FINAL STATUS OF WELL 1

1 ☑ WATER SUPPLY
2 ☐ OBSERVATION WELL
3 ☐ TEST HOLE
4 ☐ RECHARGE WELL
5 ☐ ABANDONED, INSUFFICIENT SUPPLY
6 ☐ ABANDONED, POOR QUALITY
7 ☐ UNFINISHED

WATER USE 01

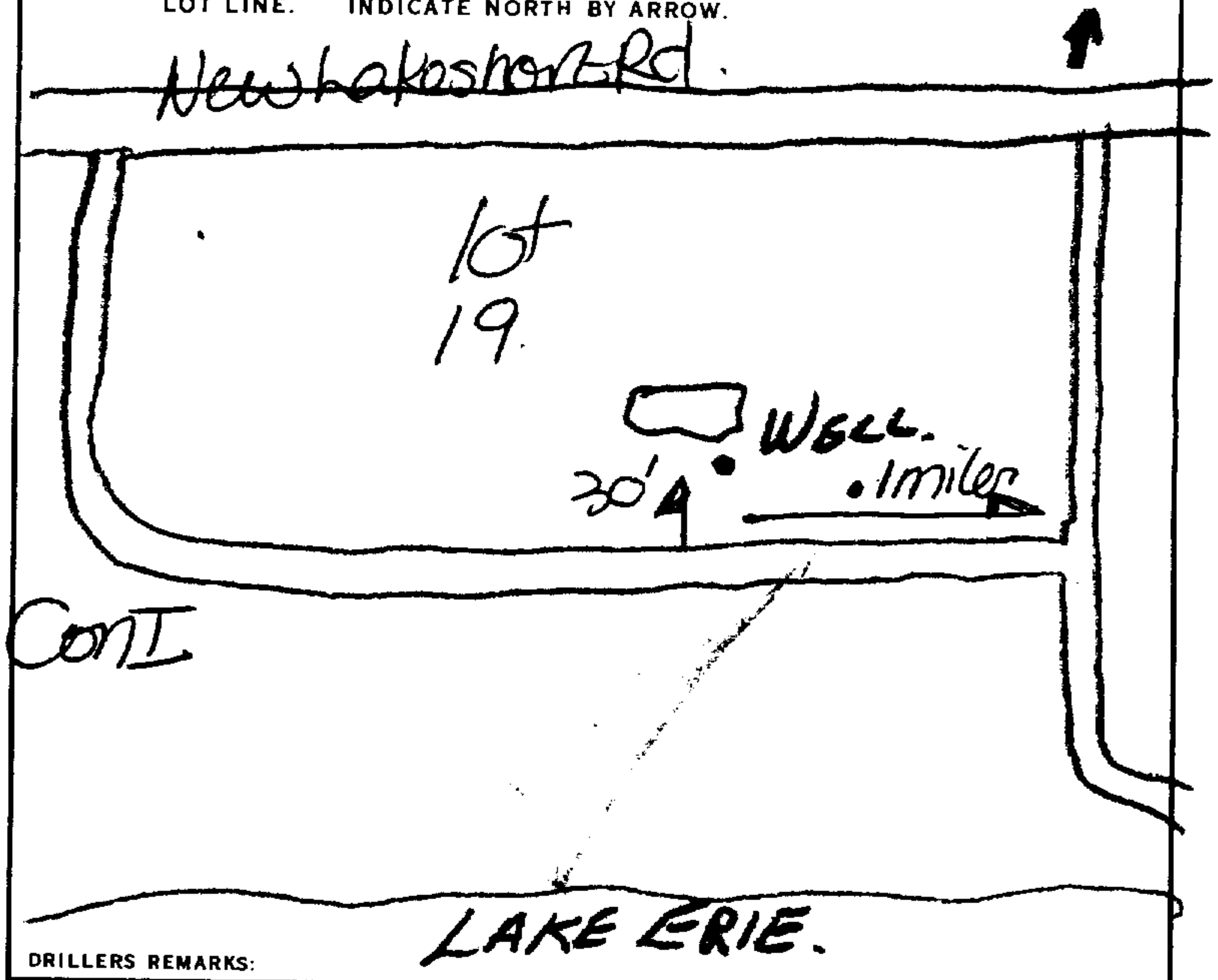
1 ☑ DOMESTIC
2 ☐ STOCK
3 ☐ IRRIGATION
4 ☐ INDUSTRIAL
☐ OTHER
5 ☐ COMMERCIAL
6 ☐ MUNICIPAL
7 ☐ PUBLIC SUPPLY
8 ☐ COOLING OR AIR CONDITIONING
9 ☐ NOT USED

METHOD OF DRILLING 1

1 ☑ CABLE TOOL
2 ☐ ROTARY (CONVENTIONAL)
3 ☐ ROTARY (REVERSE)
4 ☐ ROTARY (AIR)
5 ☐ AIR PERCUSSION
6 ☐ BORING
7 ☐ DIAMOND
8 ☐ JETTING
9 ☐ DRIVING

LOCATION OF WELL 7037

IN DIAGRAM BELOW SHOW DISTANCES OF WELL FROM ROAD AND LOT LINE. INDICATE NORTH BY ARROW.



DRILLERS REMARKS:

CONTRACTOR

NAME OF WELL CONTRACTOR: David G Mitchell | LICENCE NUMBER: 3653

ADDRESS: P.O. Box 26 Jarvis

NAME OF DRILLER OR BORER: David G Mitchell | LICENCE NUMBER: 3653.

SIGNATURE OF CONTRACTOR: David Mitchell

SUBMISSION DATE: DAY ___ MO. ___ YR. ___

OFFICE USE ONLY

DATA SOURCE	CONTRACTOR	DATE RECEIVED
1	3653	200575

DATE OF INSPECTION: | INSPECTOR:

REMARKS:

P KP

WI

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Well ID

Well ID Number: 7234652
Well Audit Number: *Z199857*
Well Tag Number: *A175509*

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	24 VAUGHAN DR
Township	WOODHOUSE TOWNSHIP
Lot	
Concession	
County/District/Municipality	NORFOLK
City/Town/Village	PORT DOVER
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 570754.00 Northing: 4737576.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
GREY	GRVL		FILL	0 m	1.5 m
GREY	CLAY	SILT	SOFT	1.5 m	12.2 m

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed
0 m	10 m	BENTONITE	
10 m	12.2 m	SAND	

Method of Construction & Well Use

Method of Construction	Well Use
Boring	
	Monitoring

Status of Well

Observation Wells

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
1.9 cm	PLASTIC	0 m	10.7 m

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To
2.7 cm	PLASTIC	10.7 m	12.2 m

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 6607

Results of Well Yield Testing

After test of well yield, water was	
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	
Duration of Pumping	
Final water level	
If flowing give rate	

Recommended pump depth	
Recommended pump rate	
Well Production	
Disinfected?	

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL			
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind

Hole Diameter

Depth From	Depth To	Diameter
0 m	12.2 m	15 cm

Audit Number: Z199857

Date Well Completed: November 11, 2014

Date Well Record Received by MOE: January 02, 2015

Updated: March 7, 2019
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Topics

- Business and economy

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Well ID

Well ID Number: 4402577
Well Audit Number:
Well Tag Number:

This table contains information from the original well record and any subsequent updates.

Well Location

Address of Well Location	
Township	WOODHOUSE TOWNSHIP
Lot	020
Concession	CON 01
County/District/Municipality	NORFOLK
City/Town/Village	
Province	ON
Postal Code	n/a
UTM Coordinates	NAD83 — Zone 17 Easting: 570954.20 Northing: 4737632.00
Municipal Plan and Sublot Number	
Other	

Overburden and Bedrock Materials Interval

General Colour	Most Common Material	Other Materials	General Description	Depth From	Depth To
BRWN	CLAY			0 ft	46 ft
GREY	GRVL			46 ft	47 ft

BRWN	LMSN	47 ft	51 ft

Annular Space/Abandonment Sealing Record

Depth From	Depth To	Type of Sealant Used (Material and Type)	Volume Placed

Method of Construction & Well Use

Method of Construction	Well Use
Cable Tool	
	Domestic

Status of Well

Water Supply

Construction Record - Casing

Inside Diameter	Open Hole or material	Depth From	Depth To
9 inch	STEEL		47 ft
	OPEN HOLE		51 ft

Construction Record - Screen

Outside Diameter	Material	Depth From	Depth To

Well Contractor and Well Technician Information

Well Contractor's Licence Number: 3604

Results of Well Yield Testing

After test of well yield, water was	CLOUDY
If pumping discontinued, give reason	
Pump intake set at	
Pumping Rate	3 GPM
Duration of Pumping	1 h:30 m
Final water level	50 ft

If flowing give rate	
Recommended pump depth	50 ft
Recommended pump rate	3 GPM
Well Production	BAILER
Disinfected?	

Draw Down & Recovery

Draw Down Time(min)	Draw Down Water level	Recovery Time(min)	Recovery Water level
SWL	19 ft		
1		1	
2		2	
3		3	
4		4	
5		5	
10		10	
15		15	
20		20	
25		25	
30		30	
40		40	
45		45	
50		50	
60		60	

Water Details

Water Found at Depth	Kind
46 ft	Fresh

Hole Diameter

Depth From	Depth To	Diameter

Audit Number:

Date Well Completed: September 10, 1970

Date Well Record Received by MOE: October 01, 1970

Updated: March 7, 2019
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APPENDIX C

TERRAPROBE INC.

Photograph 1

Location:	North of Section T1
Viewing:	East towards gully face
Description:	The soil stratigraphy around Section T1 is visible in a gully north of the Lake Erie shoreline. The stratigraphy consists of sand, over silt, over clayey silt.

Photograph 2

Location:	East of Section T1
Viewing:	West
Description:	The stratigraphy of the shoreline east of Section T1 is visible. Sand talus has accumulated at the toe of slope. There is no seepage visible through the slope face.

Photograph 3

Location:	Slope at Section T1
Viewing:	West
Description:	The slope at Section T1 is bare. There is talus accumulation at the toe of slope. Some seepage is visible through the lower slope face.

Photograph 4

Location:	Slope west of Section T4
Viewing:	East
Description:	The soil stratigraphy is visible in the bare slope face. There is some talus accumulation at the toe of slope. Seepage is visible at the toe of slope.

Photograph 5

Location:	Slope at Section T6
Viewing:	West
Description:	The slope at this section is bare. The stratigraphy of the slope is visible in the slope face. There is some seepage visible in the lower slope face.

Photograph 6

Location:	Slope at Section T13
Viewing:	East
Description:	The slope face is bare. The soil stratigraphy is visible in the slope face. The upper layer of sand is retrogressively failing.

Photograph 7

Location:	Slope at Section T15
Viewing:	East
Description:	The slope at this section is vegetated with shrubs. There is rubble fill down the slope face and at the toe of slope.

Photograph 8

Location:	Slope at Section T29
Viewing:	West
Description:	The slope at this section is landscaped with grass. There's a wall at the toe of slope. East of the section there is debris on the slope face and bare soil. Possibly retrogressive failure.

Photograph 9

Location:	Slope at Section T30
Viewing:	West
Description:	The slope at this section is vegetated with young trees. There is a marina at the toe of slope.

Photograph 10

Location:	Slope at Section T31
Viewing:	East
Description:	The slope is densely vegetated. There are some dwellings in close proximity to the slope crest.

Photograph 11

Location:	Slope at Section T32
Viewing:	North
Description:	The slope is densely vegetated. There is a marina at the toe of slope.

Photograph 12

Location:	Slope in north of Section T32
Viewing:	North
Description:	There are leaning trees on the slope face, with exposed bare soil on the roadway down to Section T32. The soil composition is a silt and clay.

Photograph 13

Location:	Slope at Section T37
Viewing:	East
Description:	The slope is densely vegetated. There are dwellings at the toe of slope.

Photograph 14

Location:	Slope at Section T38
Viewing:	East
Description:	The slope at this section is vegetated with some exposed bare soil.

Photograph 15

Location:	Slope west of Section T39
Viewing:	North
Description:	The slope west of T39 is bare and the soil stratigraphy is visible. There are dwellings in the tableland in close proximity to the slope crest.

Photograph 16

Location: Slope at Section T39

Viewing: West

Description: The slope at Section T39 is vegetated.

Photograph 17

Location: Slope at Section T40

Viewing: North

Description: There are dwellings at the toe of the slope and in the tableland. There is rubble fill at the toe of the slope.

Photograph 18

Location: Back from Section T42

Viewing: South

Description: The slope at Section T42 is a local low compared to the adjacent lands.

Photograph 19

Location:	Slope at Section T46
Viewing:	West
Description:	The slope is vegetated with grass, and at a shallower inclination than the adjacent slope face.

Photograph 20

Location:	Slope crest at Section T47
Viewing:	East towards Port Ryerse
Description:	The slope is well vegetated with no signs of erosion.

Photograph 21

Location:	Slope at Section 47
Viewing:	East
Description:	The slope face is vegetated. There are bare areas on the slope face where the vegetation has sloughed off the slope face.

Photograph 22

Location: Slope at Section T48

Viewing: North

Description: The slope is well vegetated with no signs of erosion. There are dwellings at the toe of slope. There is a sand beach and a toe wall at the toe of slope.

Photograph 23

Location: Slope at Section T49

Viewing: North

Description: The slope is well vegetated with no signs of erosion. There is concrete rubble at the toe of slope.

Photograph 24

Location: East of the slope at Section T51

Viewing: West

Description: The slope is vegetated with grasses at this section. There are wind turbines in the tableland.

Photograph 25

Location:	Slope at Section T52
Viewing:	East
Description:	The upper slope is vegetated and the lower slope is bare. No seepage observed through the slope face.

Photograph 26

Location:	West of the slope at Section T53
Viewing:	East
Description:	The slope at Section T53 is vegetated.

Photograph 27

Location:	East of the slope at Section T54
Viewing:	West
Description:	The slope at Section T52 appears sparsely vegetated on the upper slope face and well vegetated on the lower slope face.

Photograph 28

Location:	West of the slope at Section T55
Viewing:	East
Description:	The slope at Section T55 is vegetated with young trees. There is a wall at the toe of slope.

Photograph 29

Location:	Section T56
Viewing:	East
Description:	The shoreline at Section T56 appears to be a relatively flat lying sandy beach.

Photograph 30

Location:	Section T57
Viewing:	North
Description:	There is a marina at the shoreline at Section T57. The slope at this section is paved with asphalt. The slope west of this section is well vegetated.

Photograph 31

Location:	Section T58
Viewing:	West
Description:	The slope at this section has a sand beach at the toe. There are tires along the shoreline. The slope is vegetated with young to mature trees.

Photograph 32

Location:	Section T61
Viewing:	North
Description:	The slope at this section is vegetated with grass. There is a concrete wall at the toe of slope, with a sand beach at the shoreline.

Photograph 33

Location:	Section T62
Viewing:	East
Description:	The slope at this section is vegetated with young trees. Limestone is visible under the water.

Photograph 34

Location:	Slope at Section T63
Viewing:	North
Description:	There is a wooden wall at the toe of slope, with a sand beach at the shoreline. The slope is vegetated with grass.

Photograph 35

Location:	Section T64
Viewing:	North
Description:	The slope at this section is vegetated with grasses and trees. There is a concrete block wall at the toe 2.5 ±m in height. Limestone is visible at the shoreline.

APPENDIX D

TERRAPROBE INC.

Terraprobe
Consulting Geotechnical & Environmental Engineers
Construction Materials Inspection & Testing

SLOPE INSPECTION FORM

1. INSPECTION DATE (DD-MM-YYYY): May 13, 2019

FILE NO. 1-19-0230

WEATHER (circle): ○ sunny ☒ partly cloudy ○ cloudy ○ clear ○ fog ○ rain ○ snow

☒ calm ○ breeze ○ windy ○ cold ○ cool ○ warm ○ hot

estimated air temperature: 15 deg C

INSPECTED BY (name): J. Hunter

2. SITE LOCATION / DIRECTIONS (describe main roads, features)

Lake Erie shoreline from east of Port Burwell to east of Port Dover

SKETCH

3. WATERSHED

Lake Erie

4. PROPERTY OWNERSHIP (name, address, phone):

LEGAL DESCRIPTION

Lot

Concession

Township

County

CURRENT LAND USE (circle and describe)

- ○ **vacant** - field, bush, woods, forest, wilderness, tundra,
- ○ **passive** - recreational parks, golf courses, non-habitable structures, buried utilities, swimming pools,
- ○ **active** - habitable structures, residential, commercial, industrial, warehousing and storage,
- ○ **infra-structure or public use** - stadiums, hospitals, schools, bridges, high voltage power lines, waste management sites,

SLOPE INSPECTION FORM

5. SLOPE DATA

HEIGHT ○ 3 - 6 m ○ 6 - 10 m ○ 10 - 15 m ○ 15 - 20 m
☒ 20 - 25 m ○ 25 - 30 m ○ > 30 m

estimated height (m): up to 50 m in height

INCLINATION AND SHAPE

○ 4:1 or flatter 25 % 14°	○ up to 3:1 33 % 18½°	☒ up to 2:1 50 % 26½°
○ up to 1:1 100 % 45°	○ up to ½:1 200 % 63½°	☒ steeper than ½:1 > 63½°

6. SLOPE DRAINAGE (describe)

TOP
overland sheet flow

FACE
overland sheet flow

BOTTOM
overland sheet flow

7. SLOPE SOIL STRATIGRAPHY (describe, positions, thicknesses, types)

TOP generally cohesionless sand or cohesive silt and clay

FACE sand, silt and clay, or glacial till

BOTTOM
sand talus, sand beach, limestone bedrock, dwellings at toe or native soil

8. WATER COURSE FEATURES (circle and describe)

SWALE, CHANNEL

GULLY

STREAM, CREEK, RIVER

POND, BAY, [✓ LAKE] Lake Erie at the toe of slope

SPRINGS

MARSHY GROUND

9. VEGETATION COVER (grasses, weeds, shrubs, saplings, trees)

TOP

Generally vegetated

Forested, agricultural land, or landscaped

FACE

Vegetated with landscaped grass, forested, or bare

BOTTOM

Generally unvegetated

10. STRUCTURES (buildings, walls, fences, sewers, roads, stairs, decks, towers,)

TOP

Dwellings or wind turbines in tableland, some dwellings in close proximity to slope crest

FACE

Generally no structures on the face

Some properties have stairs down the face or retaining walls on the face

BOTTOM

Where properties are located there are toe walls or rip rap or sand beaches at the toe of slope

11. EROSION FEATURES (scour, undercutting, bare areas, piping, rills, gully)

TOP

None observed

FACE

Some natural piping and rills down bare slope faces

BOTTOM

Undercutting from Lake Erie

12. SLOPE SLIDE FEATURES (tension cracks, scarps, slumps, bulges, grabens, ridges, bent trees)

TOP

Tension cracks and slumping in some areas

FACE

Bare unvegetated slope faces

BOTTOM

Talus accumulation

13. PLAN SKETCH OF SLOPE

14. PROFILE SKETCH OF SLOPE

TABLE 8.1 - SLOPE STABILITY RATING CHART

Site Location: Area A, Lake Erie North Shoreline
File No. 1-19-0230
Property Owner:
Inspection Date: May 13, 2019
Inspected By: Jory Hunter
Weather: 15 deg C

				Rating Value
1.	**SLOPE INCLINATION**			
		degrees	**horiz. : vert.**	
	a)	18 or less	3 : 1 or flatter	0
	b)	18 - 26	2 : 1 to more than 3 : 1	6
	c)	more than 26	steeper than 2 : 1	[✓ 16]
2.	**SOIL STRATIGRAPHY**			
	a)	Shale, Limestone, Granite (Bedrock)		0
	b)	Sand, Gravel		[✓ 6]
	c)	Glacial Till		9
	d)	Clay, Silt		[✓ 12]
	e)	Fill		16
	f)	Leda Clay		24
3.	**SEEPAGE FROM SLOPE FACE**			
	a)	None or Near bottom only		[✓ 0]
	b)	Near mid-slope only		6
	c)	Near crest only or, From several levels		[✓ 12]
4.	**SLOPE HEIGHT**			
	a)	2 m or less		0
	b)	2.1 to 5 m		2
	c)	5.1 to 10 m		4
	d)	more than 10 m		[✓ 8]
5.	**VEGETATION COVER ON SLOPE FACE**			
	a)	Well vegetated; heavy shrubs or forested with mature trees		0
	b)	Light vegetation; Mostly grass, weeds, occasional trees, shrubs		[✓ 4]
	c)	No vegetation, bare		[✓ 8]
6.	**TABLE LAND DRAINAGE**			
	a)	Table land flat, no apparent drainage over slope		[✓ 0]
	b)	Minor drainage over slope, no active erosion		2
	c)	Drainage over slope, active erosion, gullies		4
7.	**PROXIMITY OF WATERCOURSE TO SLOPE TOE**			
	a)	15 metres or more from slope toe		0
	b)	Less than 15 metres from slope toe		[✓ 6]
8.	**PREVIOUS LANDSLIDE ACTIVITY**			
	a)	No		[✓ 0]
	b)	Yes		[✓ 6]

	SLOPE INSTABILITY RATING	**RATING VALUES TOTAL**	**INVESTIGATION REQUIREMENTS**
1.	Low potential	< 24	Site inspection only, confirmation, report letter.
2.	Slight potential	25-35	Site inspection and surveying, preliminary study, detailed report.
3.	Moderate potential	> 35	Boreholes, piezometers, lab tests, surveying, detailed report.

TOTAL
40-68

NOTES: a) Choose only one from each category; compare total rating value with above requirements.

b) If there is a water body (stream, creek, river, pond, bay, lake) at the slope toe; the potential for toe erosion and undercutting should be evaluated in detail and, protection provided if required.

TABLE 8.1 - SLOPE STABILITY RATING CHART

Site Location: Area B, Lake Erie North Shoreline
File No. 1-19-0230
Property Owner:
Inspection Date: May 13, 2019
Inspected By: Jory Hunter
Weather: 15 deg C

				Rating Value
1.	**SLOPE INCLINATION**			
		degrees	**horiz. : vert.**	
	a)	18 or less	3 : 1 or flatter	0
	b)	18 - 26	2 : 1 to more than 3 : 1	[✓ 6]
	c)	more than 26	steeper than 2 : 1	[✓ 16]
2.	**SOIL STRATIGRAPHY**			
	a)	Shale, Limestone, Granite (Bedrock)		0
	b)	Sand, Gravel		6
	c)	Glacial Till		[✓ 9]
	d)	Clay, Silt		[✓ 12]
	e)	Fill		16
	f)	Leda Clay		24
3.	**SEEPAGE FROM SLOPE FACE**			
	a)	None or Near bottom only		[✓ 0]
	b)	Near mid-slope only		6
	c)	Near crest only or, From several levels		12
4.	**SLOPE HEIGHT**			
	a)	2 m or less		0
	b)	2.1 to 5 m		2
	c)	5.1 to 10 m		4
	d)	more than 10 m		[✓ 8]
5.	**VEGETATION COVER ON SLOPE FACE**			
	a)	Well vegetated; heavy shrubs or forested with mature trees		[✓ 0]
	b)	Light vegetation; Mostly grass, weeds, occasional trees, shrubs		4
	c)	No vegetation, bare		8
6.	**TABLE LAND DRAINAGE**			
	a)	Table land flat, no apparent drainage over slope		[✓ 0]
	b)	Minor drainage over slope, no active erosion		2
	c)	Drainage over slope, active erosion, gullies		4
7.	**PROXIMITY OF WATERCOURSE TO SLOPE TOE**			
	a)	15 metres or more from slope toe		0
	b)	Less than 15 metres from slope toe		[✓ 6]
8.	**PREVIOUS LANDSLIDE ACTIVITY**			
	a)	No		[✓ 0]
	b)	Yes		6

	SLOPE INSTABILITY RATING	RATING VALUES TOTAL	INVESTIGATION REQUIREMENTS	TOTAL 29-42
1.	Low potential	< 24	Site inspection only, confirmation, report letter.	
2.	Slight potential	25-35	Site inspection and surveying, preliminary study, detailed report.	
3.	Moderate potential	> 35	Boreholes, piezometers, lab tests, surveying, detailed report.	

NOTES:
a) Choose only one from each category; compare total rating value with above requirements.
b) If there is a water body (stream, creek, river, pond, bay, lake) at the slope toe; the potential for toe erosion and undercutting should be evaluated in detail and, protection provided if required.

TABLE 8.1 - SLOPE STABILITY RATING CHART

Site Location: Area C, Lake Erie North Shoreline
File No. 1-19-0230
Property Owner:
Inspection Date: May 13, 2019
Inspected By: Jory Hunter
Weather: 15 deg C

				Rating Value
1.	**SLOPE INCLINATION**			
		degrees	**horiz. : vert.**	
	a)	18 or less	3 : 1 or flatter	0
	b)	18 - 26	2 : 1 to more than 3 : 1	6
	c)	more than 26	steeper than 2 : 1	[✓ 16]
2.	**SOIL STRATIGRAPHY**			
	a)	Shale, Limestone, Granite (Bedrock)		0
	b)	Sand, Gravel		[✓ 6]
	c)	Glacial Till		9
	d)	Clay, Silt		[✓ 12]
	e)	Fill		16
	f)	Leda Clay		24
3.	**SEEPAGE FROM SLOPE FACE**			
	a)	None or Near bottom only		[✓ 0]
	b)	Near mid-slope only		6
	c)	Near crest only or, From several levels		[✓ 12]
4.	**SLOPE HEIGHT**			
	a)	2 m or less		0
	b)	2.1 to 5 m		2
	c)	5.1 to 10 m		4
	d)	more than 10 m		[✓ 8]
5.	**VEGETATION COVER ON SLOPE FACE**			
	a)	Well vegetated; heavy shrubs or forested with mature trees		[✓ 0]
	b)	Light vegetation; Mostly grass, weeds, occasional trees, shrubs		4
	c)	No vegetation, bare		[✓ 8]
6.	**TABLE LAND DRAINAGE**			
	a)	Table land flat, no apparent drainage over slope		[✓ 0]
	b)	Minor drainage over slope, no active erosion		2
	c)	Drainage over slope, active erosion, gullies		4
7.	**PROXIMITY OF WATERCOURSE TO SLOPE TOE**			
	a)	15 metres or more from slope toe		0
	b)	Less than 15 metres from slope toe		[✓ 6]
8.	**PREVIOUS LANDSLIDE ACTIVITY**			
	a)	No		[✓ 0]
	b)	Yes		[✓ 6]

TOTAL
36-68

	SLOPE INSTABILITY RATING	**RATING VALUES TOTAL**	**INVESTIGATION REQUIREMENTS**
1.	Low potential	< 24	Site inspection only, confirmation, report letter.
2.	Slight potential	25-35	Site inspection and surveying, preliminary study, detailed report.
3.	Moderate potential	> 35	Boreholes, piezometers, lab tests, surveying, detailed report.

NOTES: a) Choose only one from each category; compare total rating value with above requirements.

b) If there is a water body (stream, creek, river, pond, bay, lake) at the slope toe; the potential for toe erosion and undercutting should be evaluated in detail and, protection provided if required.

TABLE 8.1 - SLOPE STABILITY RATING CHART

Site Location: Area C, Lake Erie North Shoreline
File No. 1-19-0230
Property Owner:
Inspection Date: May 13, 2019
Inspected By: Jory Hunter
Weather: 15 deg C

				Rating Value
1.	**SLOPE INCLINATION**			
		degrees	**horiz. : vert.**	
	a)	18 or less	3 : 1 or flatter	0
	b)	18 - 26	2 : 1 to more than 3 : 1	[✓ 6]
	c)	more than 26	steeper than 2 : 1	[✓ 16]
2.	**SOIL STRATIGRAPHY**			
	a)	Shale, Limestone, Granite (Bedrock)		0
	b)	Sand, Gravel		6
	c)	Glacial Till		9
	d)	Clay, Silt		[✓ 12]
	e)	Fill		16
	f)	Leda Clay		24
3.	**SEEPAGE FROM SLOPE FACE**			
	a)	None or Near bottom only		[✓ 0]
	b)	Near mid-slope only		[✓ 6]
	c)	Near crest only or, From several levels		12
4.	**SLOPE HEIGHT**			
	a)	2 m or less		0
	b)	2.1 to 5 m		2
	c)	5.1 to 10 m		4
	d)	more than 10 m		[✓ 8]
5.	**VEGETATION COVER ON SLOPE FACE**			
	a)	Well vegetated; heavy shrubs or forested with mature trees		[✓ 0]
	b)	Light vegetation; Mostly grass, weeds, occasional trees, shrubs		4
	c)	No vegetation, bare		[✓ 8]
6.	**TABLE LAND DRAINAGE**			
	a)	Table land flat, no apparent drainage over slope		[✓ 0]
	b)	Minor drainage over slope, no active erosion		[✓ 2]
	c)	Drainage over slope, active erosion, gullies		4
7.	**PROXIMITY OF WATERCOURSE TO SLOPE TOE**			
	a)	15 metres or more from slope toe		0
	b)	Less than 15 metres from slope toe		[✓ 6]
8.	**PREVIOUS LANDSLIDE ACTIVITY**			
	a)	No		[✓ 0]
	b)	Yes		[✓ 6]

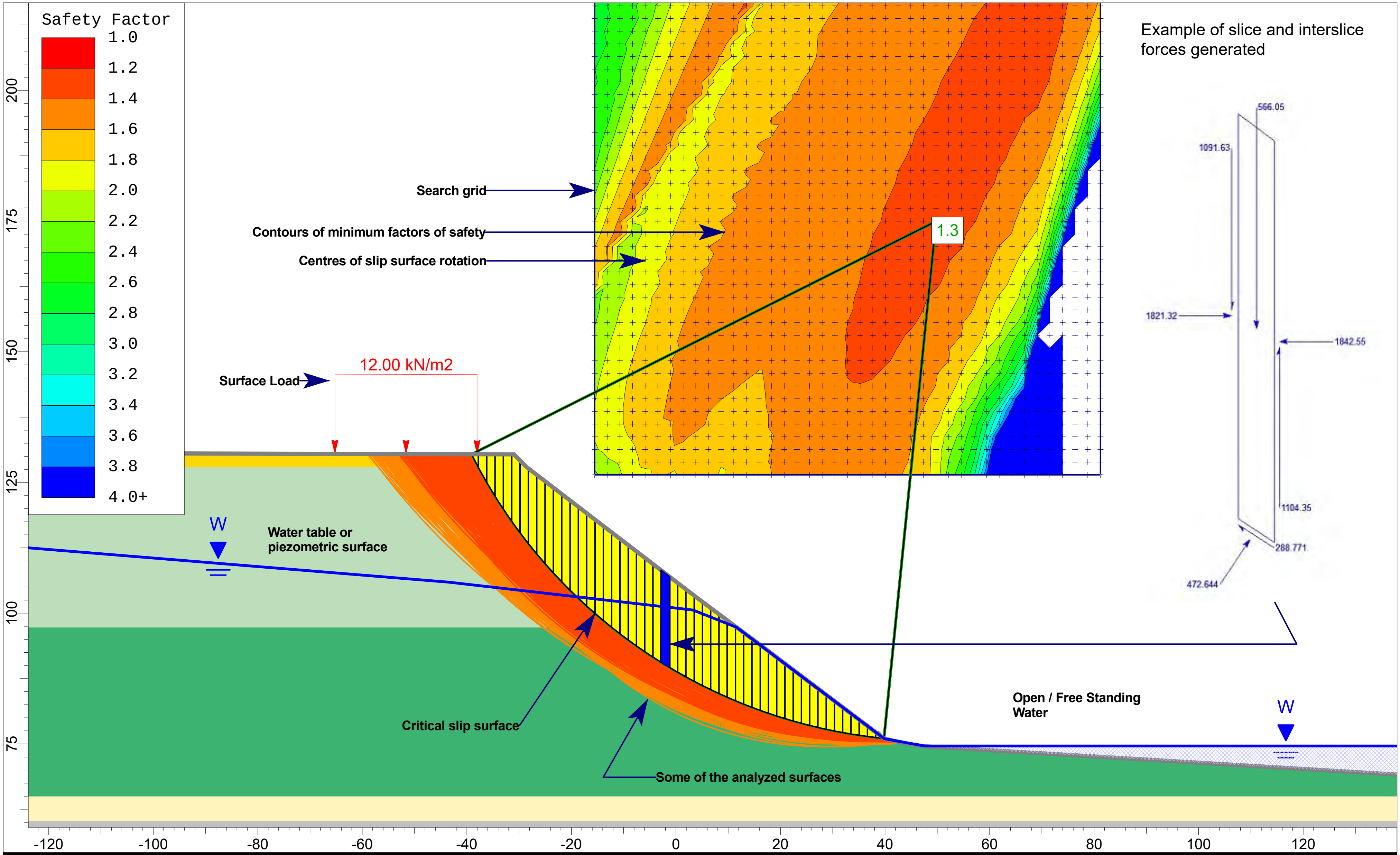
	SLOPE INSTABILITY RATING	RATING VALUES TOTAL	INVESTIGATION REQUIREMENTS	TOTAL 32-64
1.	Low potential	< 24	Site inspection only, confirmation, report letter.	
2.	Slight potential	25-35	Site inspection and surveying, preliminary study, detailed report.	
3.	Moderate potential	> 35	Boreholes, piezometers, lab tests, surveying, detailed report.	

NOTES: a) Choose only one from each category; compare total rating value with above requirements.

b) If there is a water body (stream, creek, river, pond, bay, lake) at the slope toe; the potential for toe erosion and undercutting should be evaluated in detail and, protection provided if required.

APPENDIX E

TERRAPROBE INC.



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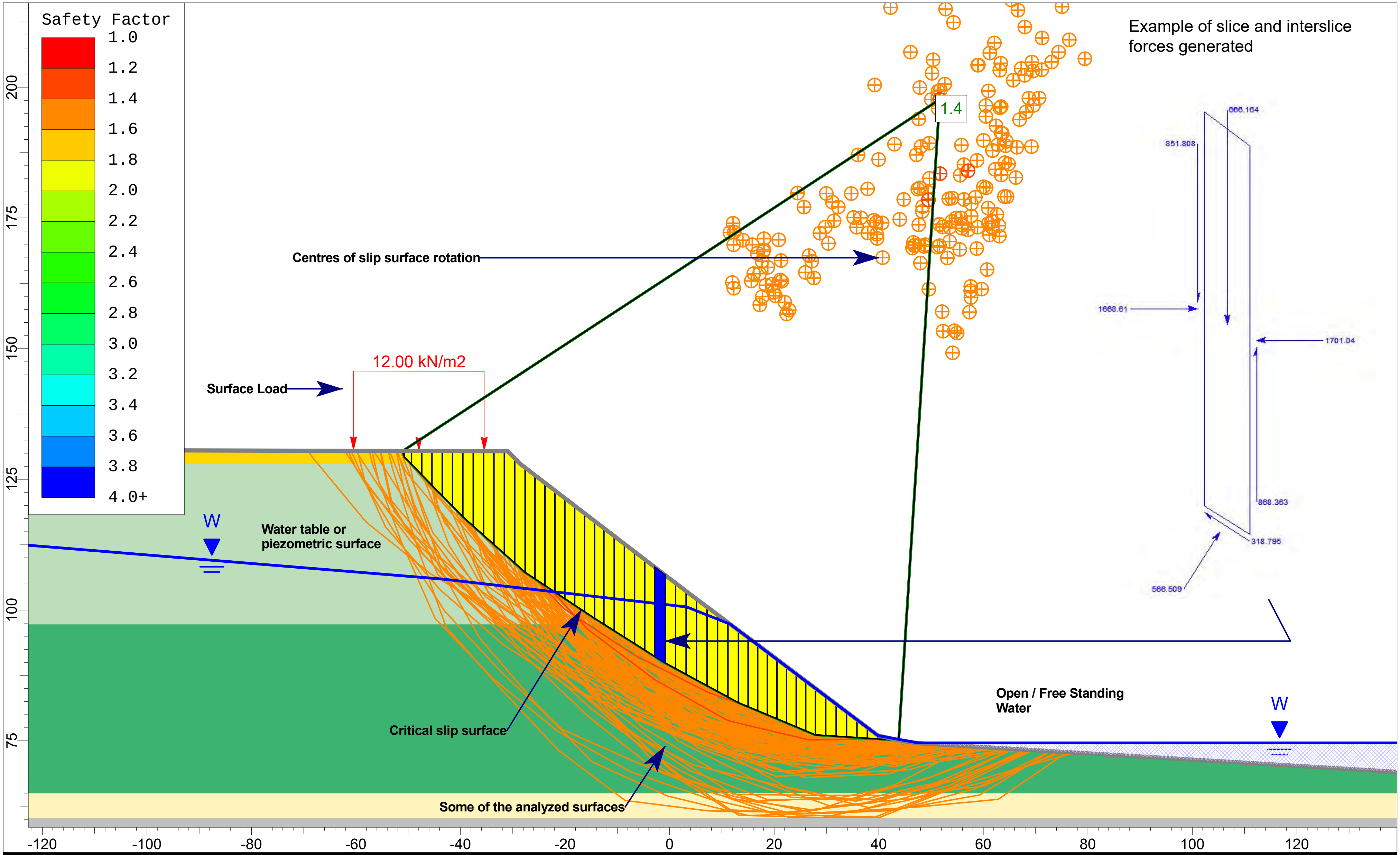
SLIDEINTERPRET 6.026

Project

Slope Stability Analysis - Explanation with Slices and Slice Forces

Analysis Description

Circular Analysis (example)



Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 6.026

Project

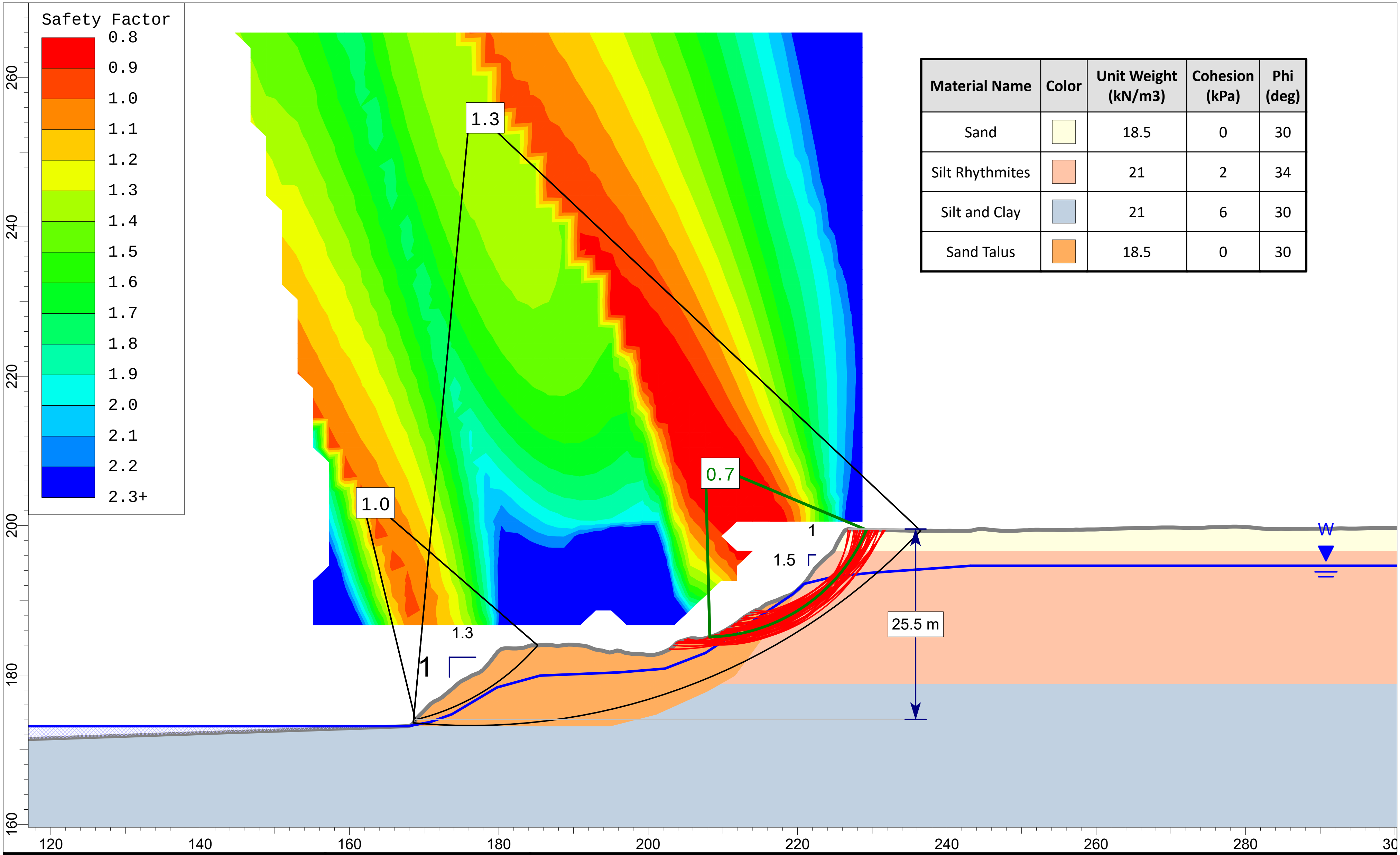
Slope Stability Analysis - Explanation with Slices and Slice Forces

Analysis Description

Non-Circular Analysis (example)

APPENDIX F

TERRAPROBE INC.



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt Rhythmites	🟥	21	2	34
Silt and Clay	🟦	21	6	30
Sand Talus	🟧	18.5	0	30

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SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T1 Existing Conditions, Master Scenario

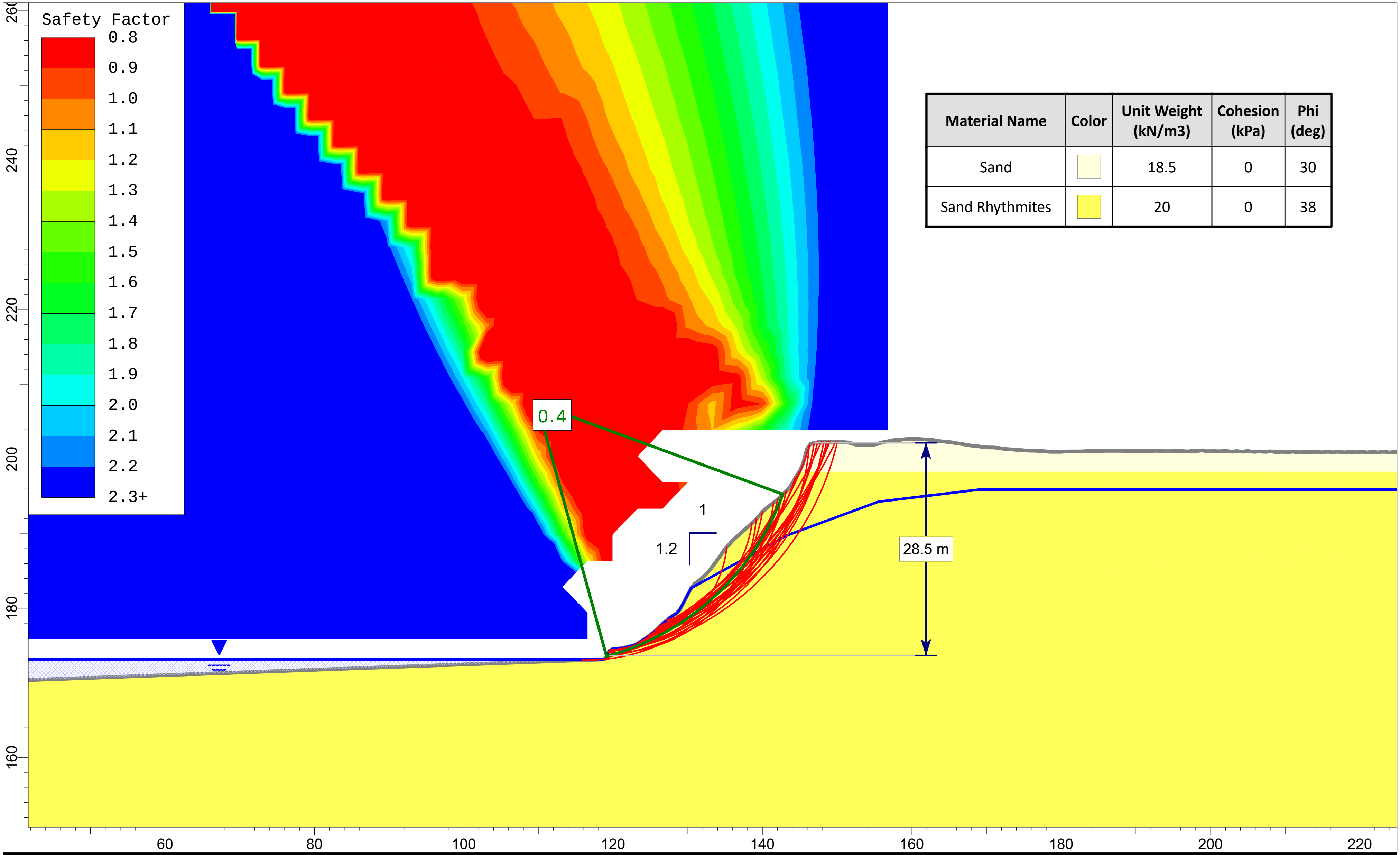
Date 7/31/2019

Scale 1:700

File T01 - T09.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

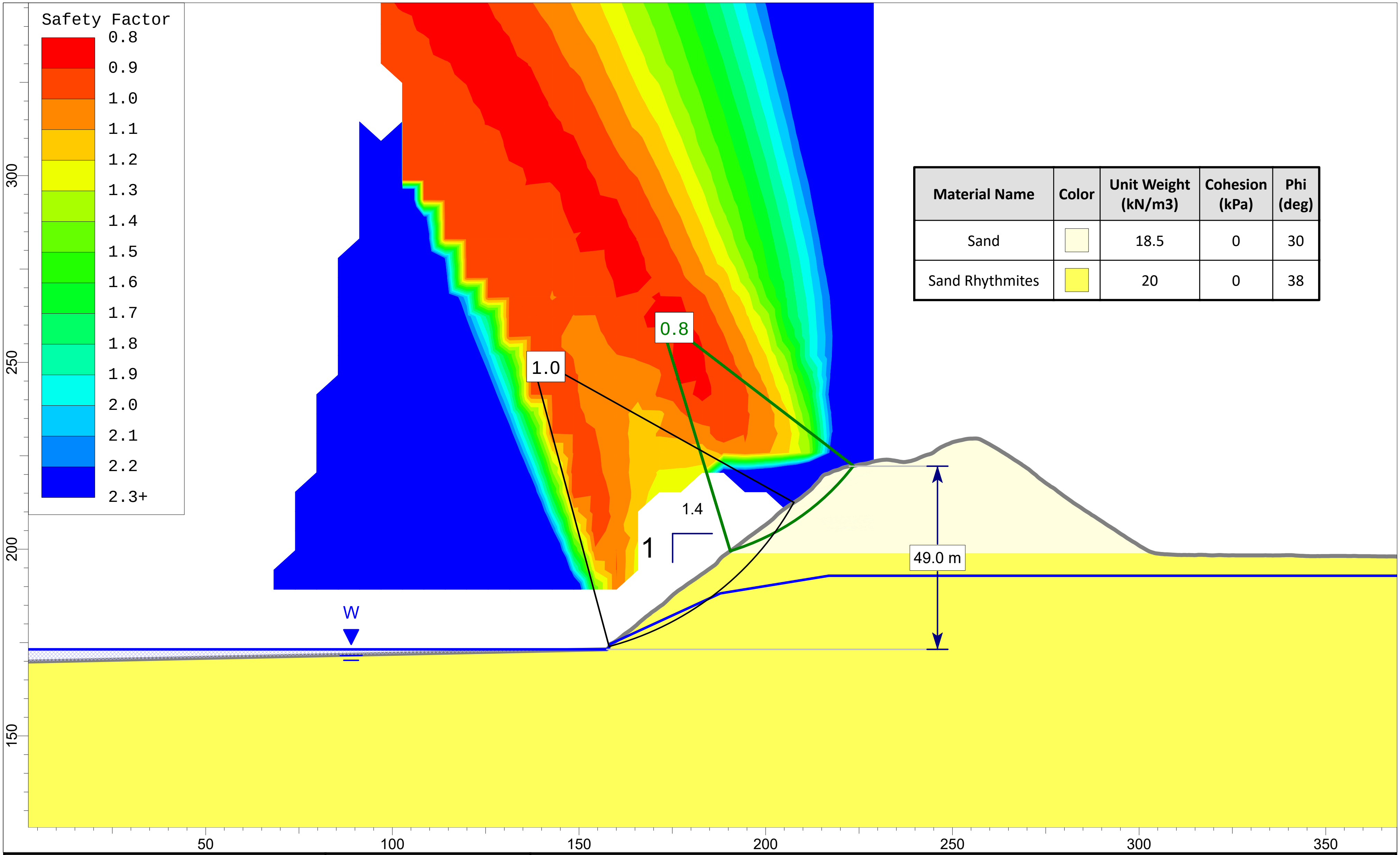
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T4 Existing Conditions, Master Scenario

Date	7/31/2019	Scale	1:700	File	T01 - T09.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Sand Rhythmites	🟨	20	0	38

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

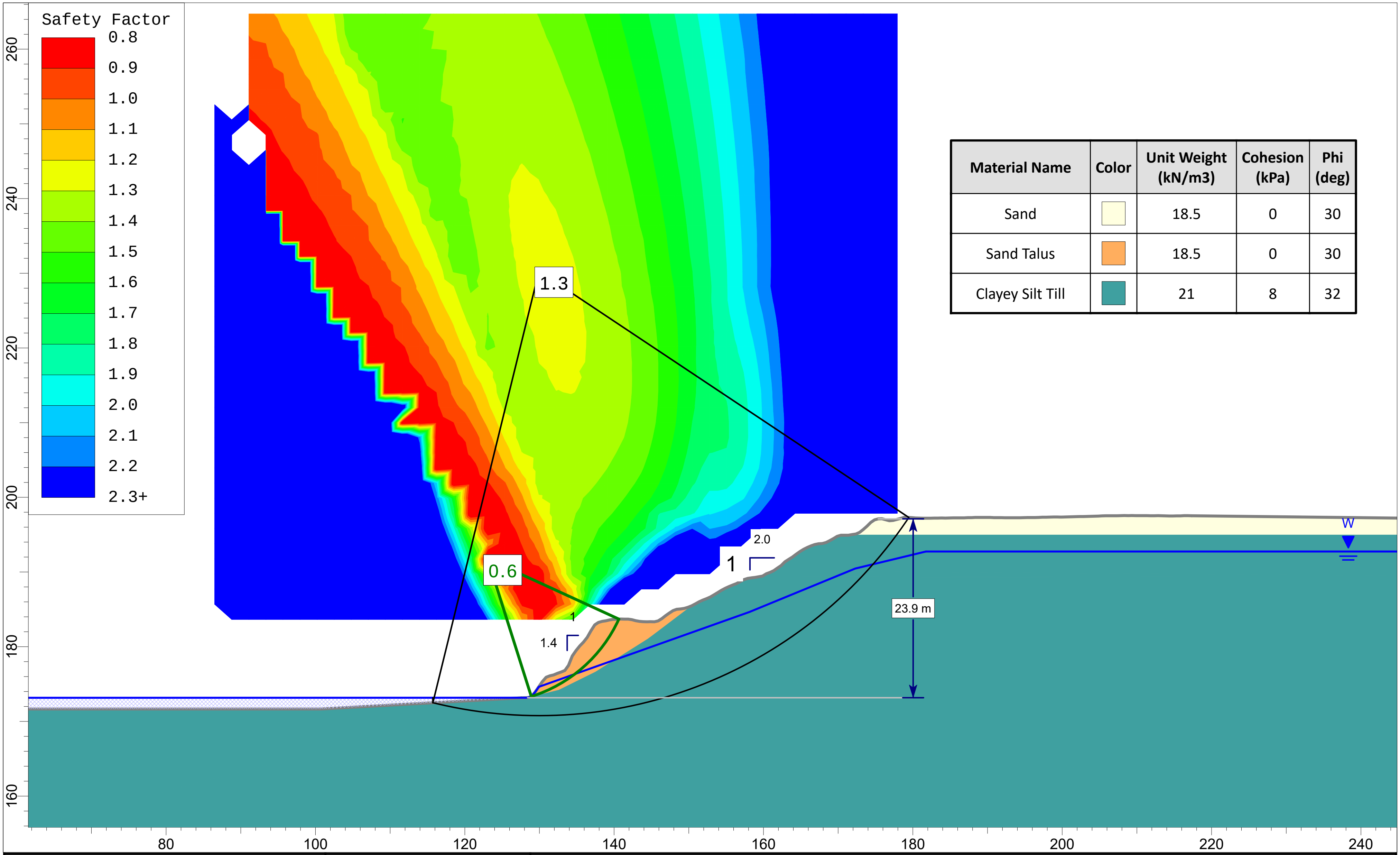
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T6 Existing Conditions, Master Scenario

Date 8/1/2019
Scale 1:1400
File T01 - T09.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Sand Talus	🟧	18.5	0	30
Clayey Silt Till	🟦	21	8	32

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

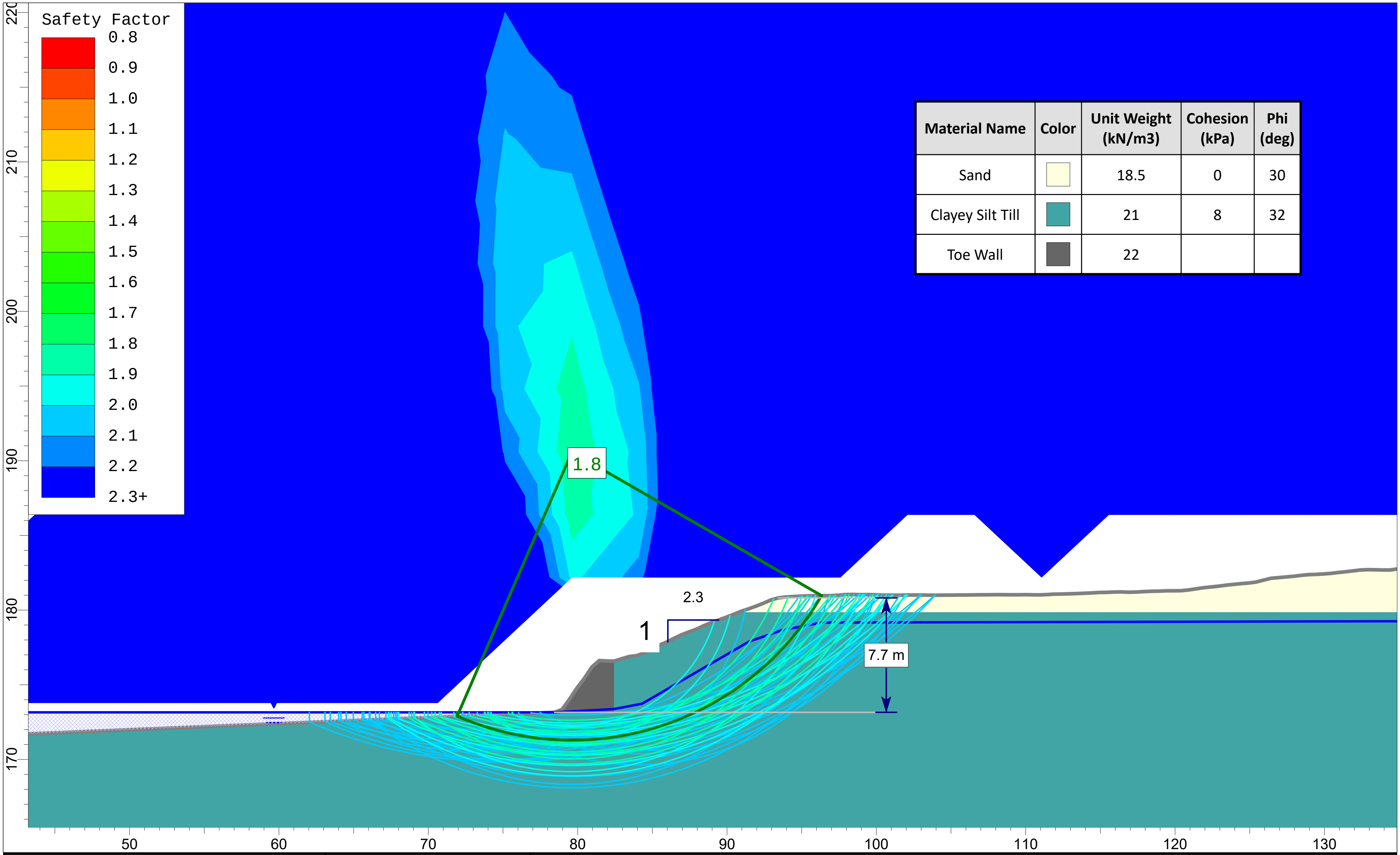
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T9 Existing Conditions, Master Scenario

Date 8/1/2019
Scale 1:700
File T01 - T09.slmd
By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Clayey Silt Till	🟦	21	8	32
Toe Wall	⬛	22		

Terraprobe
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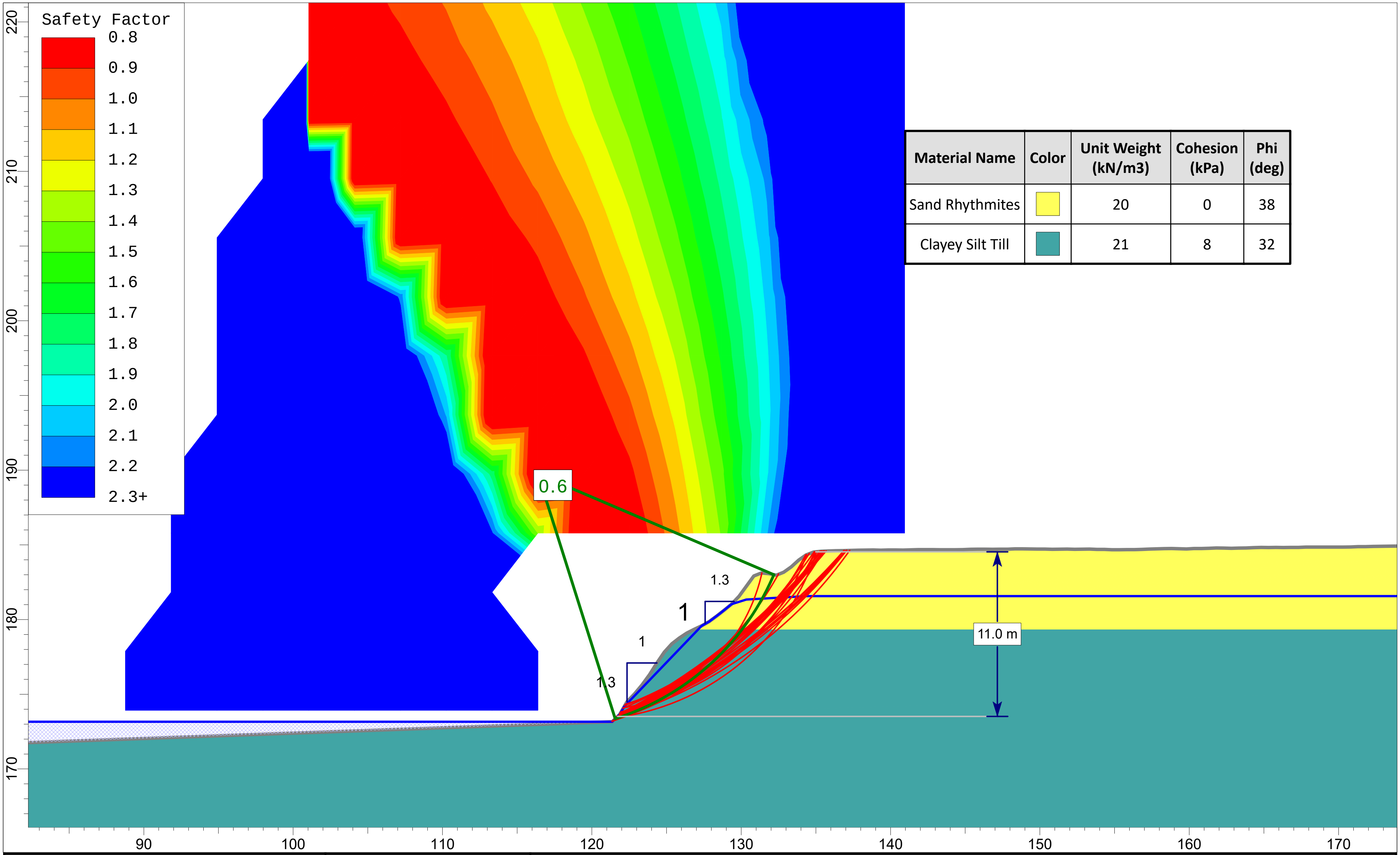
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T11 Existing Conditions, Master Scenario

Date	7/31/2019	Scale	1:350	File	T11 - T28.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand Rhythmites	🟨	20	0	38
Clayey Silt Till	🟦	21	8	32

Terraprobe
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Construction Materials Inspection & Testing

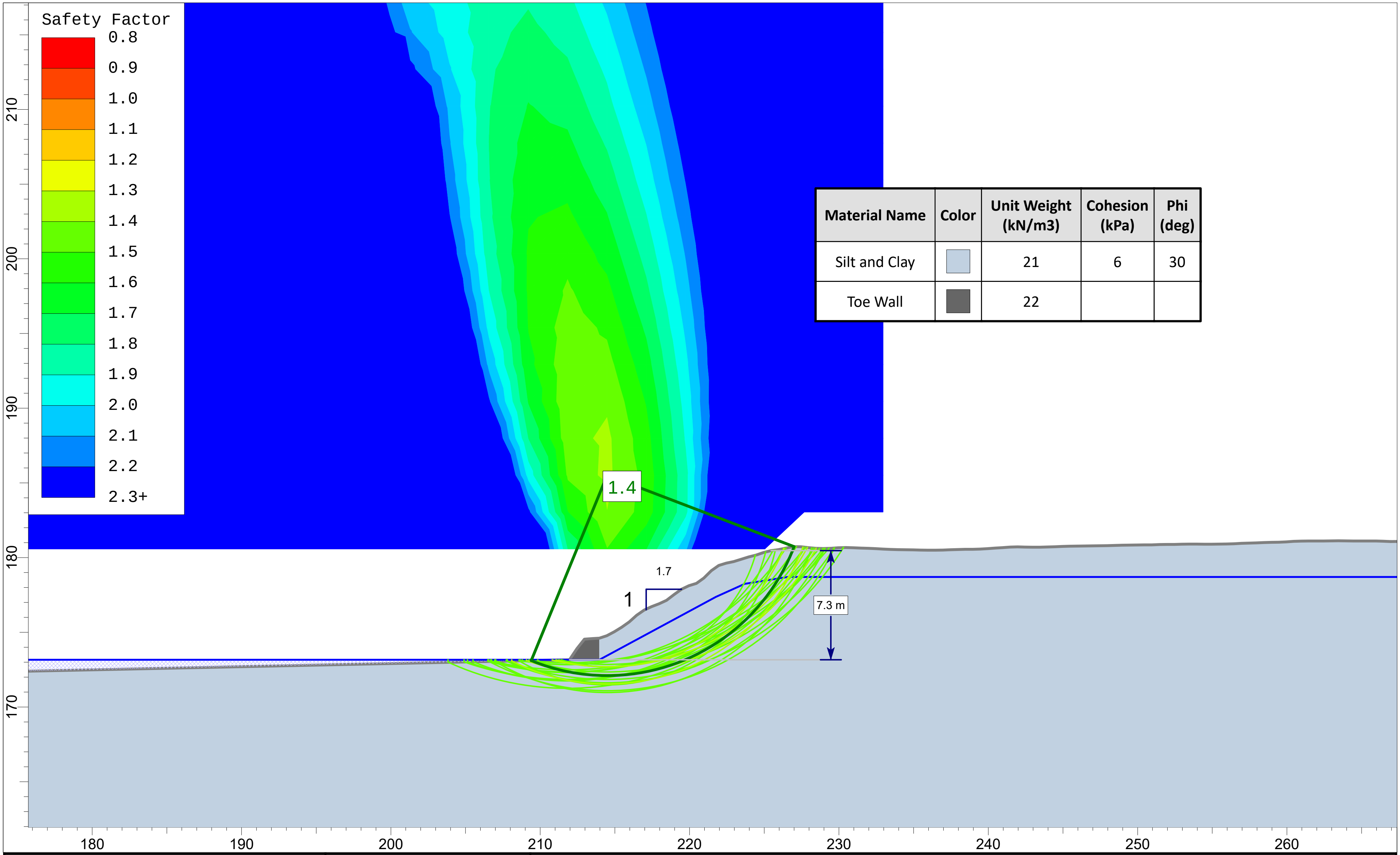
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T13 Existing Conditions, Master Scenario

Date	8/1/2019	Scale	1:350	File	T11 - T28.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30
Toe Wall	■	22		

Terraprobe
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Construction Materials Inspection & Testing

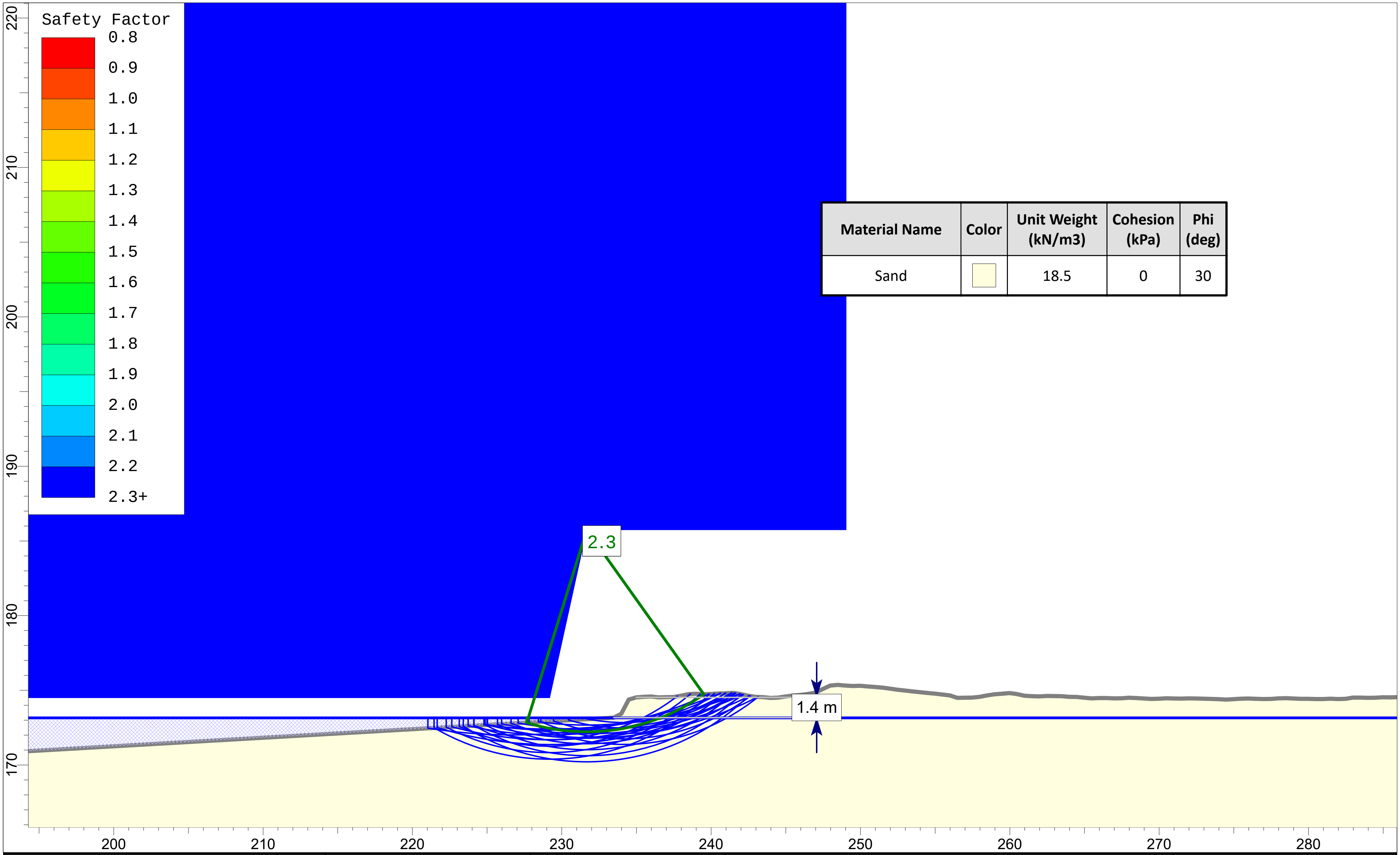
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T15 Existing Conditions, Master Scenario

Date	8/1/2019	Scale	1:350	File	T11 - T28.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	☐	18.5	0	30

Terraprobe

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Construction Materials Inspection & Testing

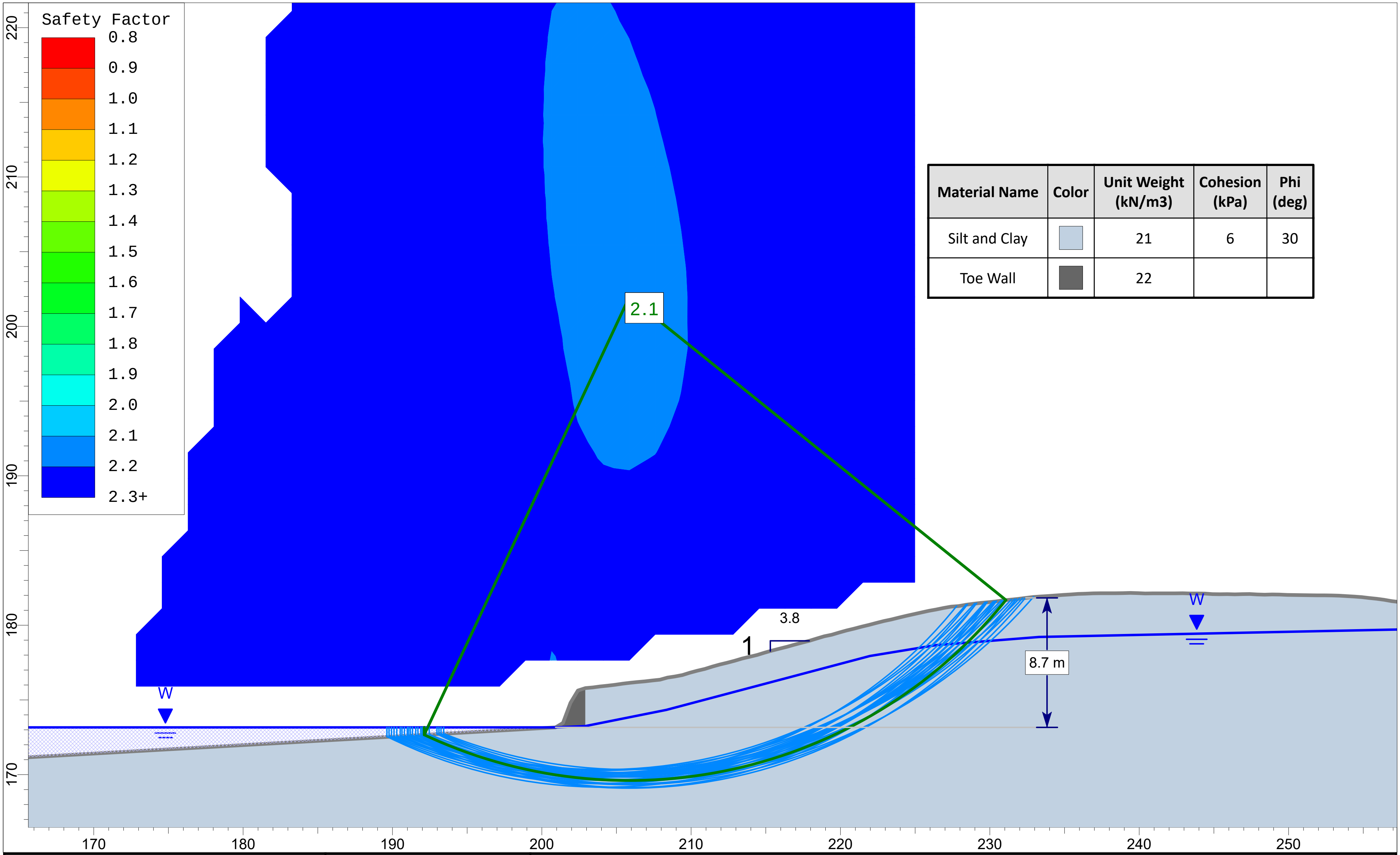
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T28 Existing Conditions, Master Scenario

Date	8/9/2019	Scale	1:350	File	T11 - T28.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30
Toe Wall	■	22		

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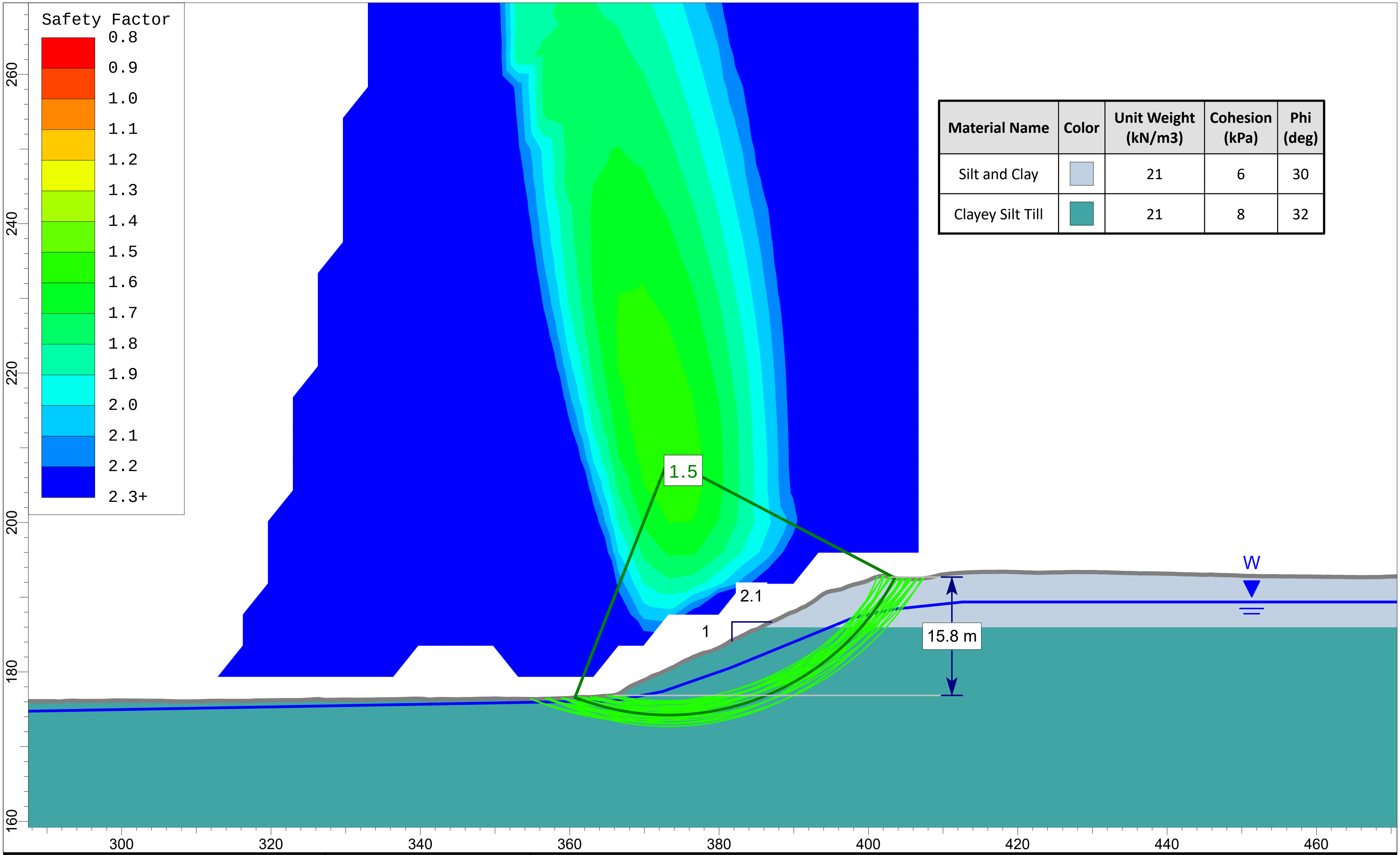
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T29 Existing Conditions, Master Scenario

Date	8/2/2019	Scale	1:350	File	T29 - T30.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Clayey Silt Till	🟦	21	8	32

Terraprobe

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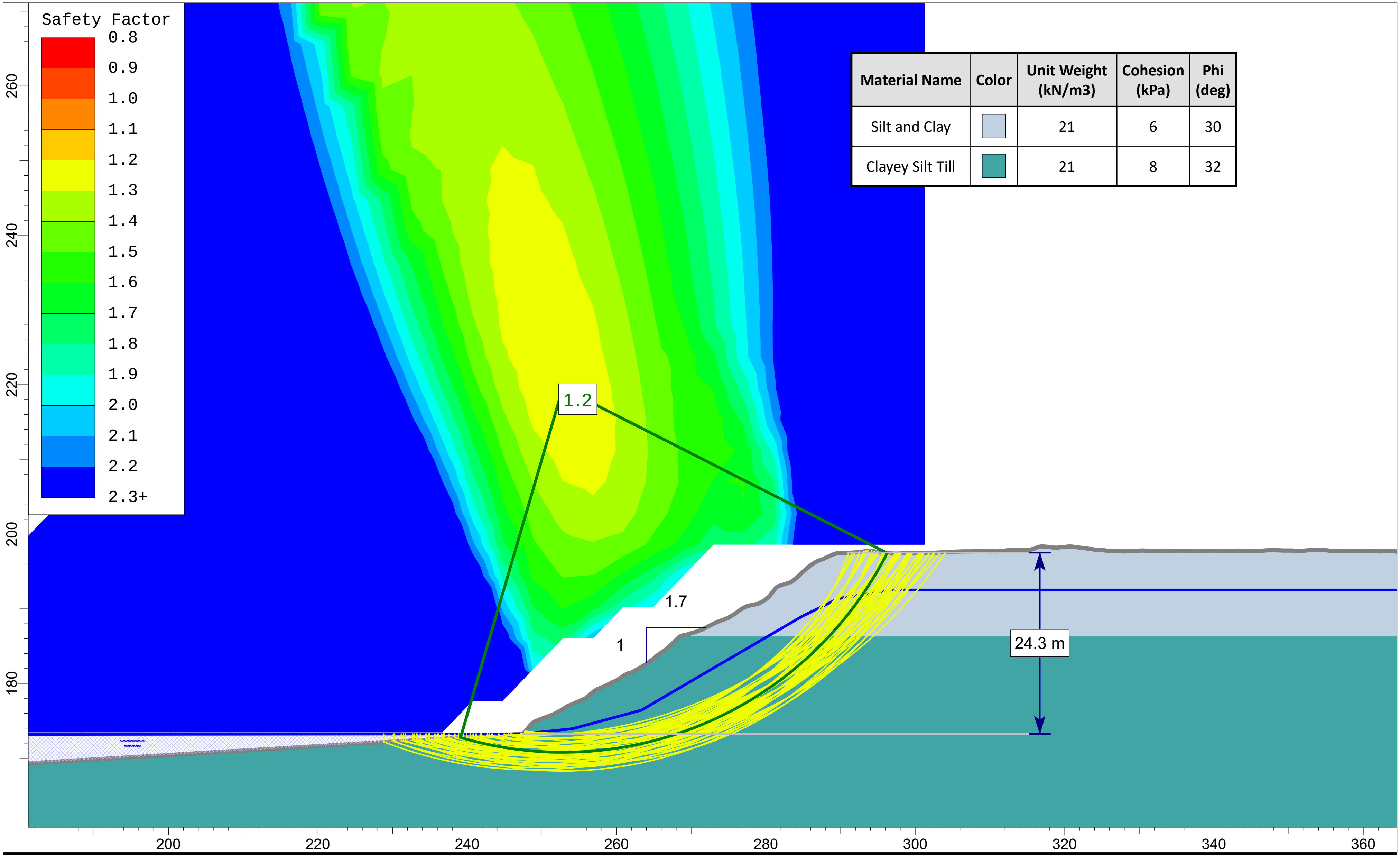
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T30 Existing Conditions, Master Scenario

Date	8/7/2019	Scale	1:700	File	T29 - T30.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Clayey Silt Till	🟦	21	8	32

Terraprobe

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Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T31 Existing Conditions, Master Scenario

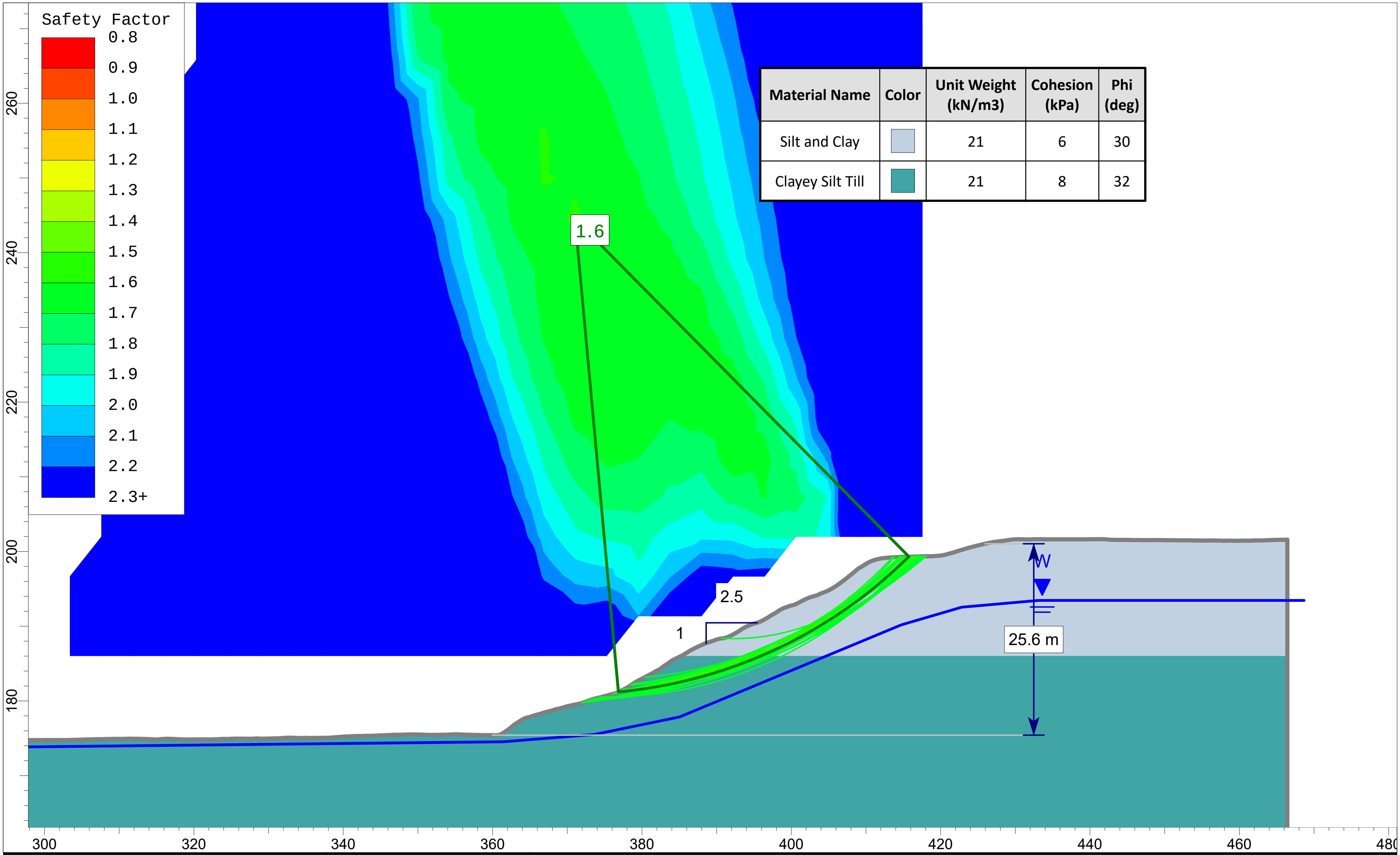
Date 8/1/2019

Scale 1:700

File T31 - T32.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Clayey Silt Till	🟦	21	8	32

Terraprobe
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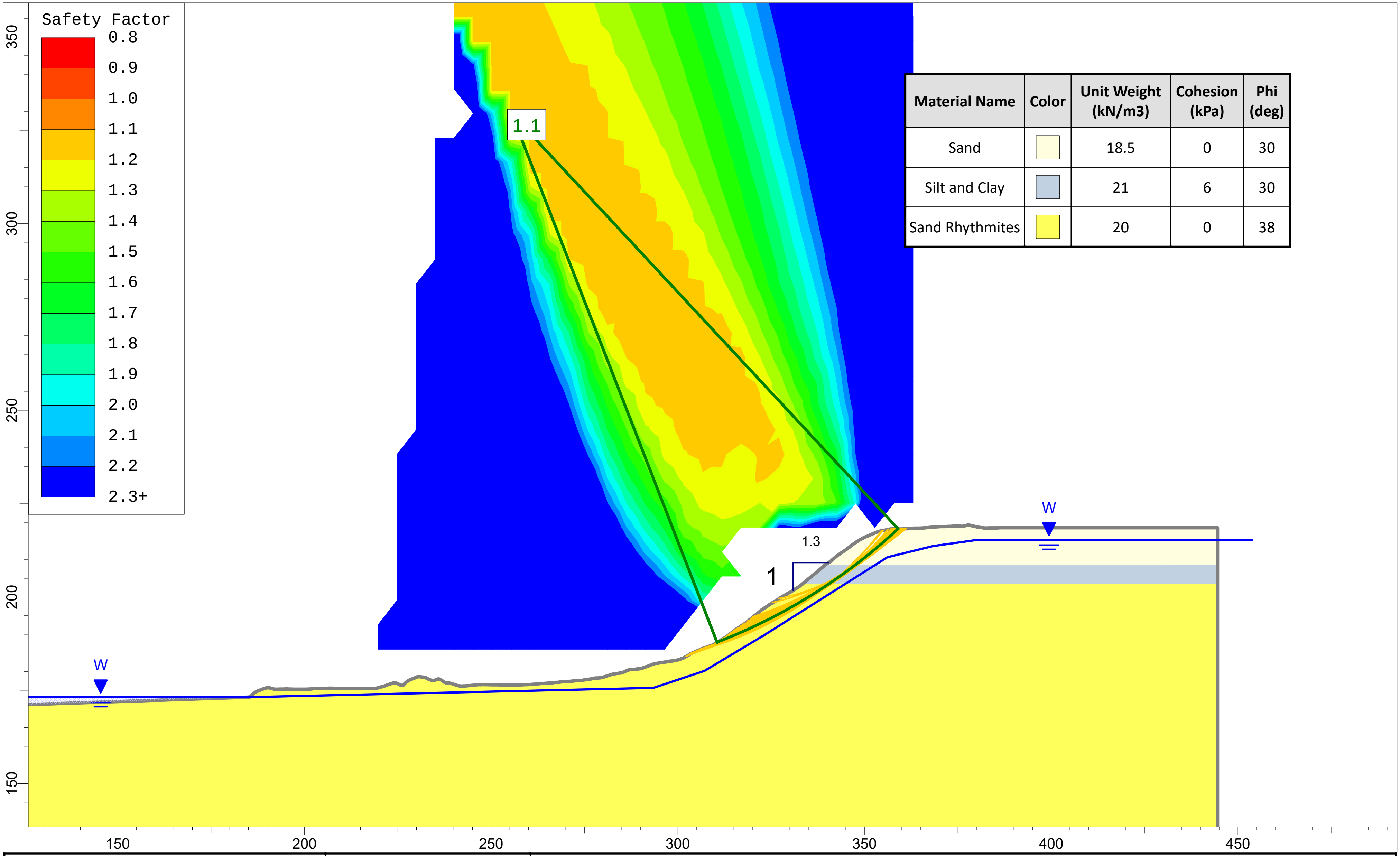
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T32 Existing Conditions, Master Scenario

Date	8/7/2019	Scale	1:700	File	T31 - T32.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	☐	18.5	0	30
Silt and Clay	▨	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

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Construction Materials Inspection & Testing

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Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

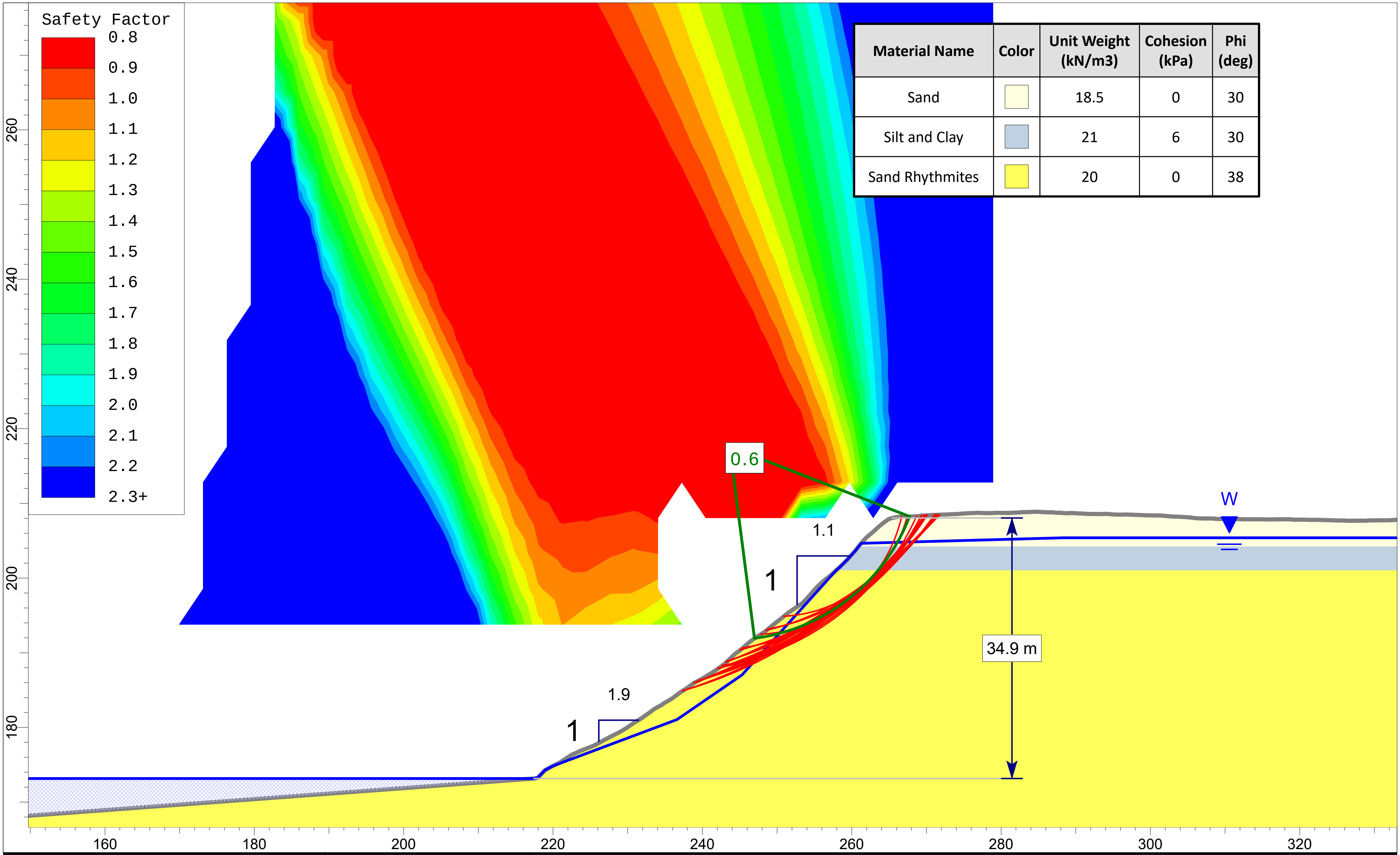
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T37 Existing Conditions, Master Scenario

Date	8/2/2019	Scale	1:1400	File	T37 - T38.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

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SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T38 Existing Conditions, Master Scenario

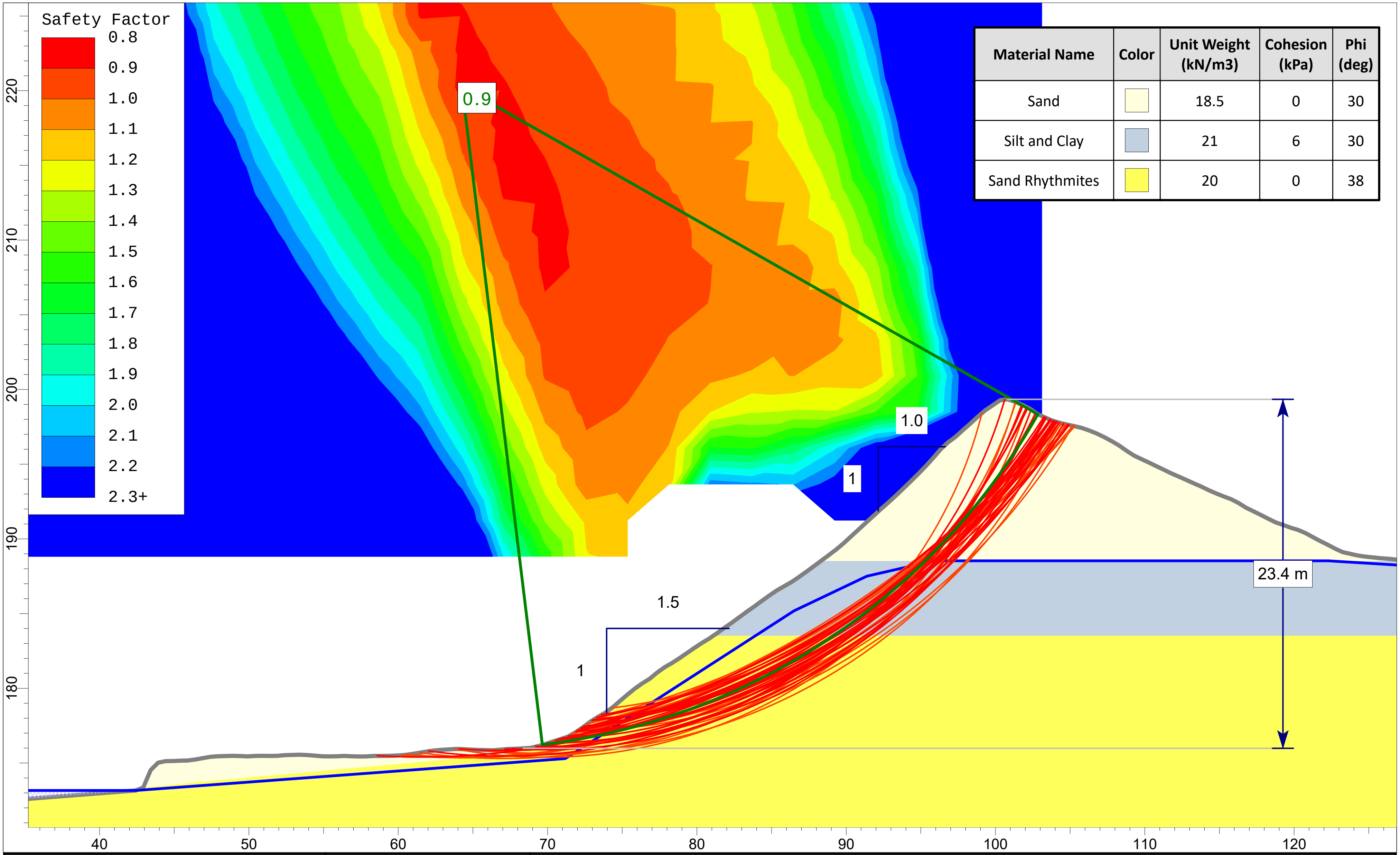
Date 8/2/2019

Scale 1:700

File T37 - T38.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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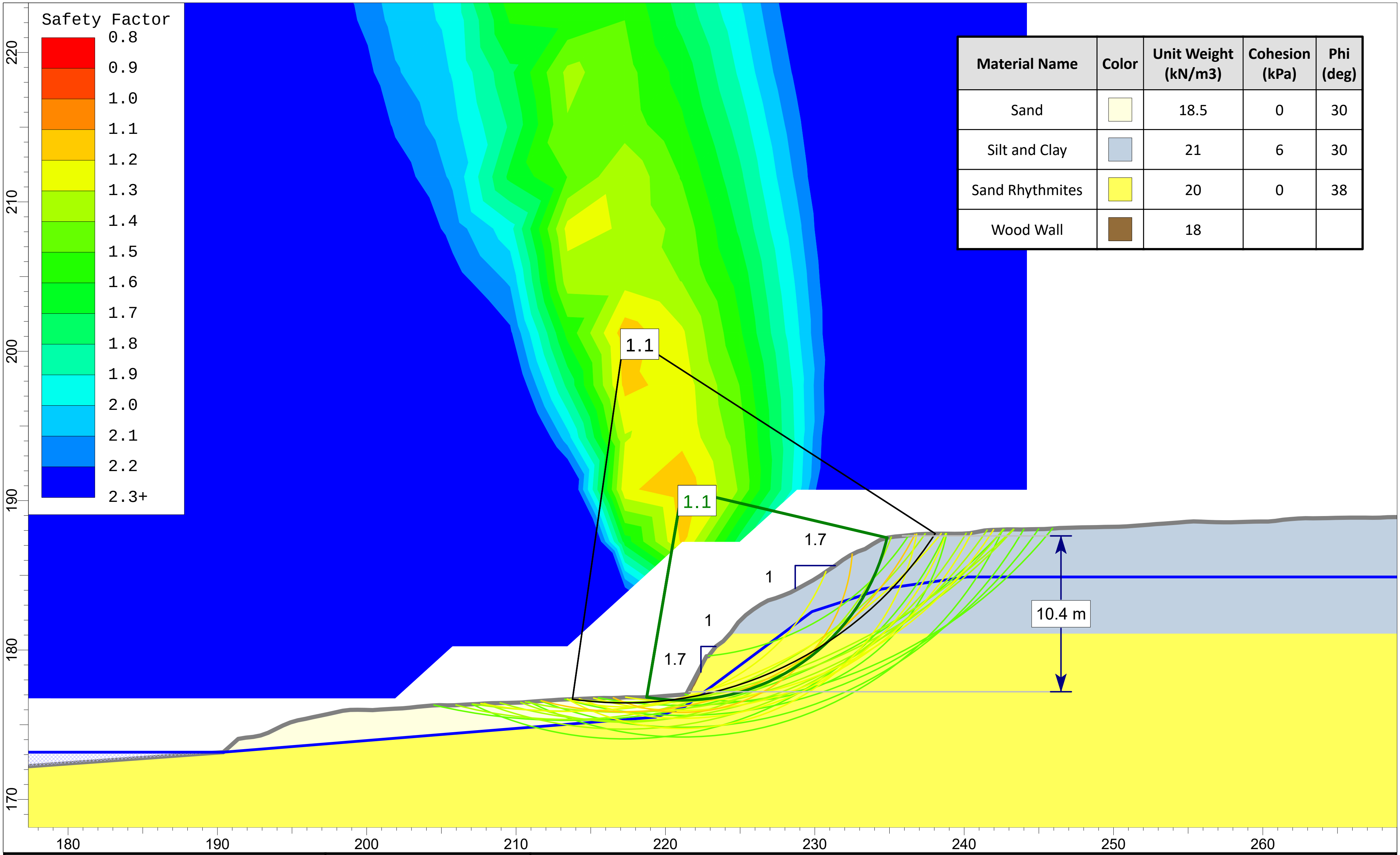
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T39 Existing Conditions, Master Scenario

Date	8/2/2019	Scale	1:350	File	T39 - T40.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38
Wood Wall	🟫	18		

Terraprobe

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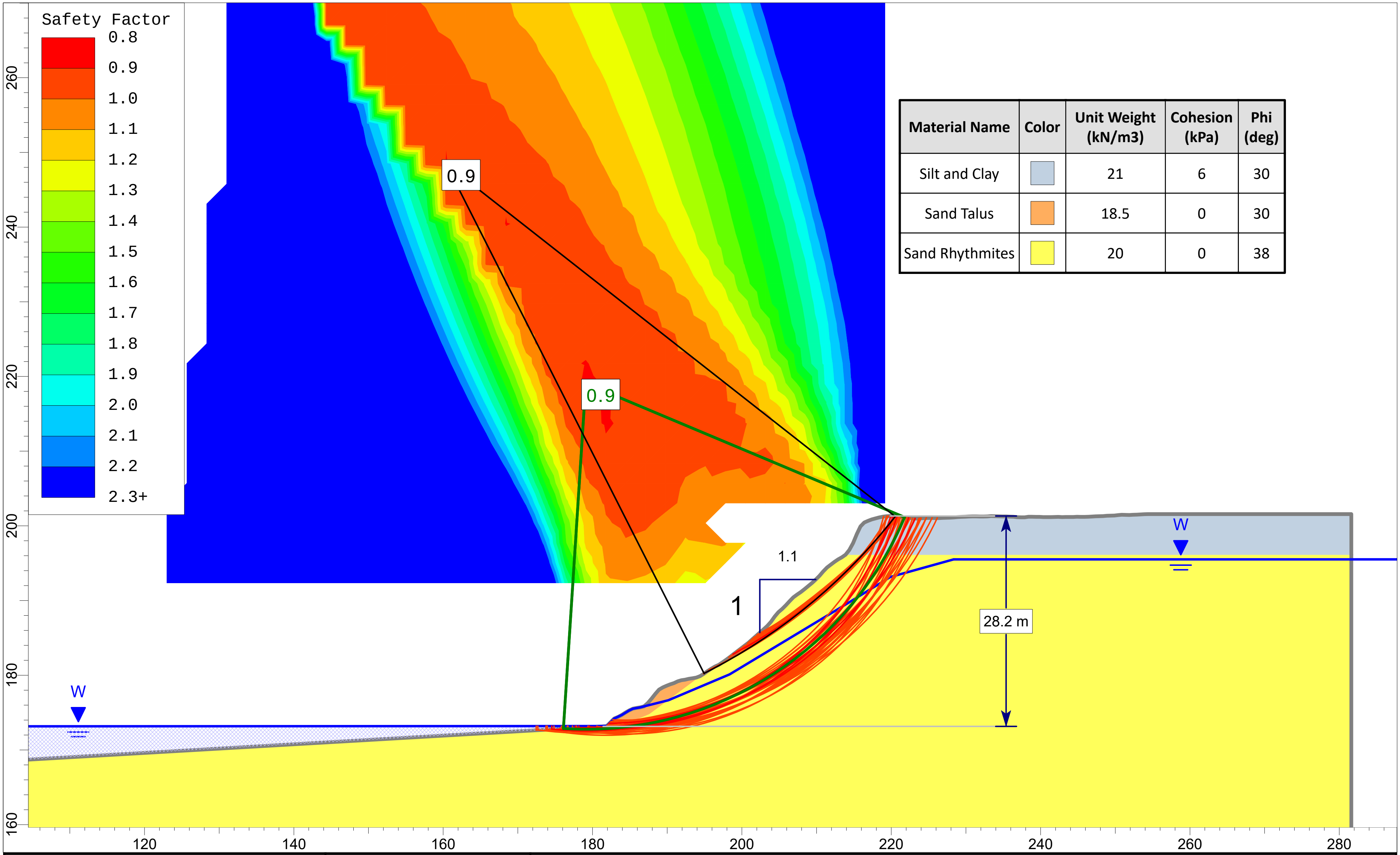
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T40 Existing Conditions, Master Scenario

Date	8/2/2019	Scale	1:350	File	T39 - T40.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Talus	🟧	18.5	0	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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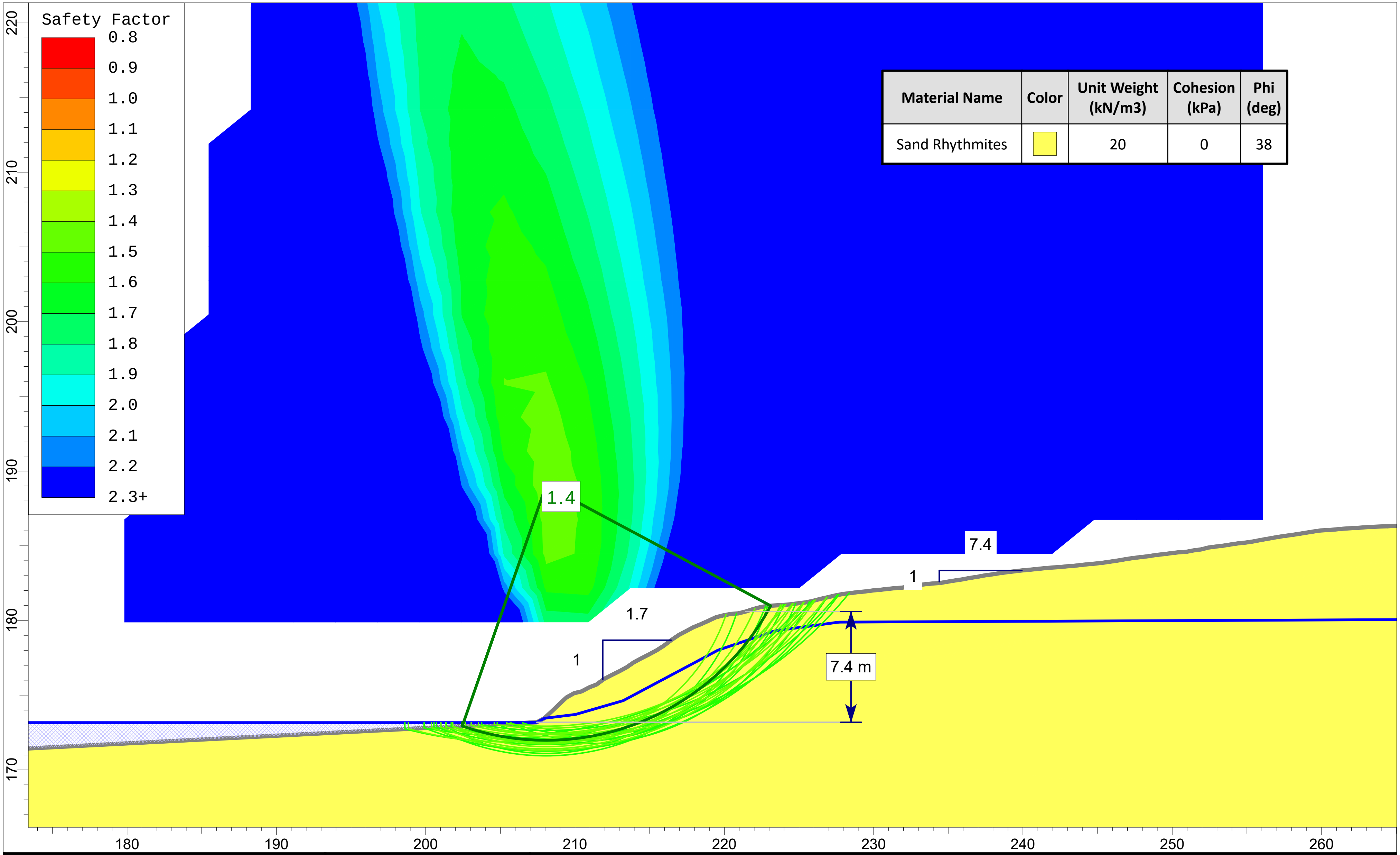
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T41 Existing Conditions, Master Scenario

Date	8/2/2019	Scale	1:700	File	T41 - T42.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand Rhythmites	🟨	20	0	38

Terraprobe

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Notes

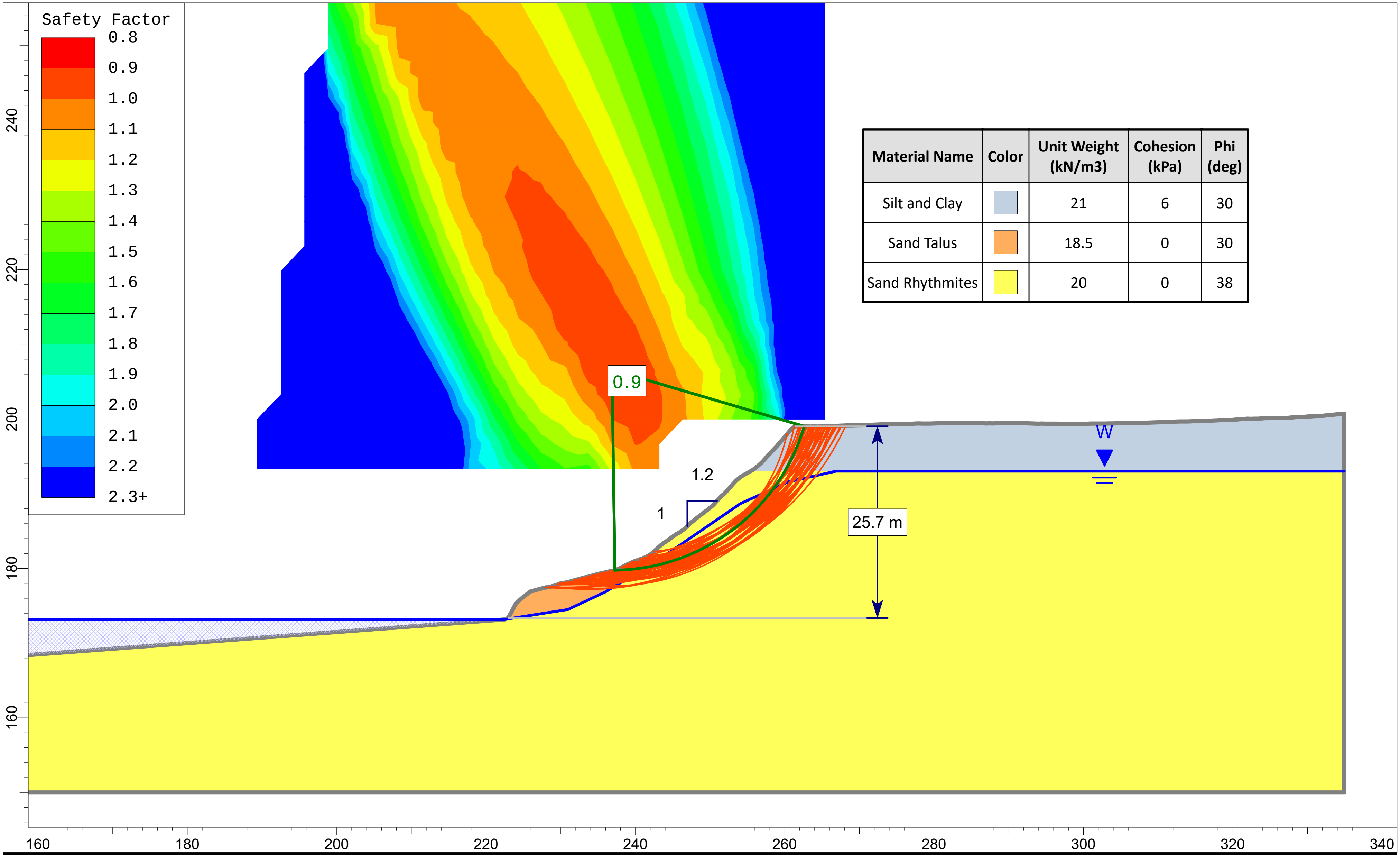
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T42 Existing Conditions, Master Scenario

Date 8/2/2019
Scale 1:350
File T41 - T42.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Talus	🟧	18.5	0	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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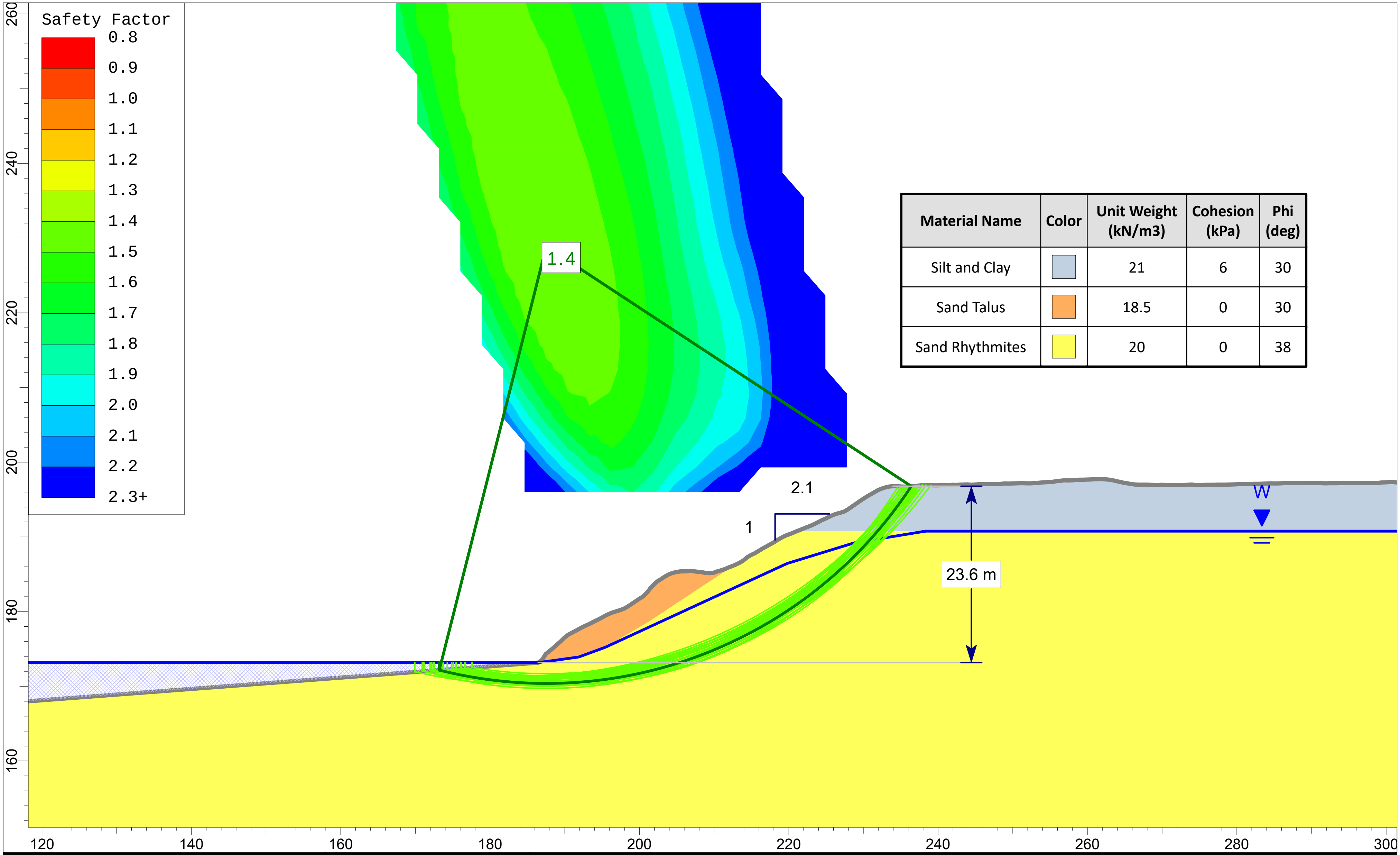
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**		
Analysis	Global Stability: T43 Existing Conditions, Master Scenario		
Date 8/6/2019	Scale 1:700	File	T43 - T44.slmd
By JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019	



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Talus	🟧	18.5	0	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

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Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

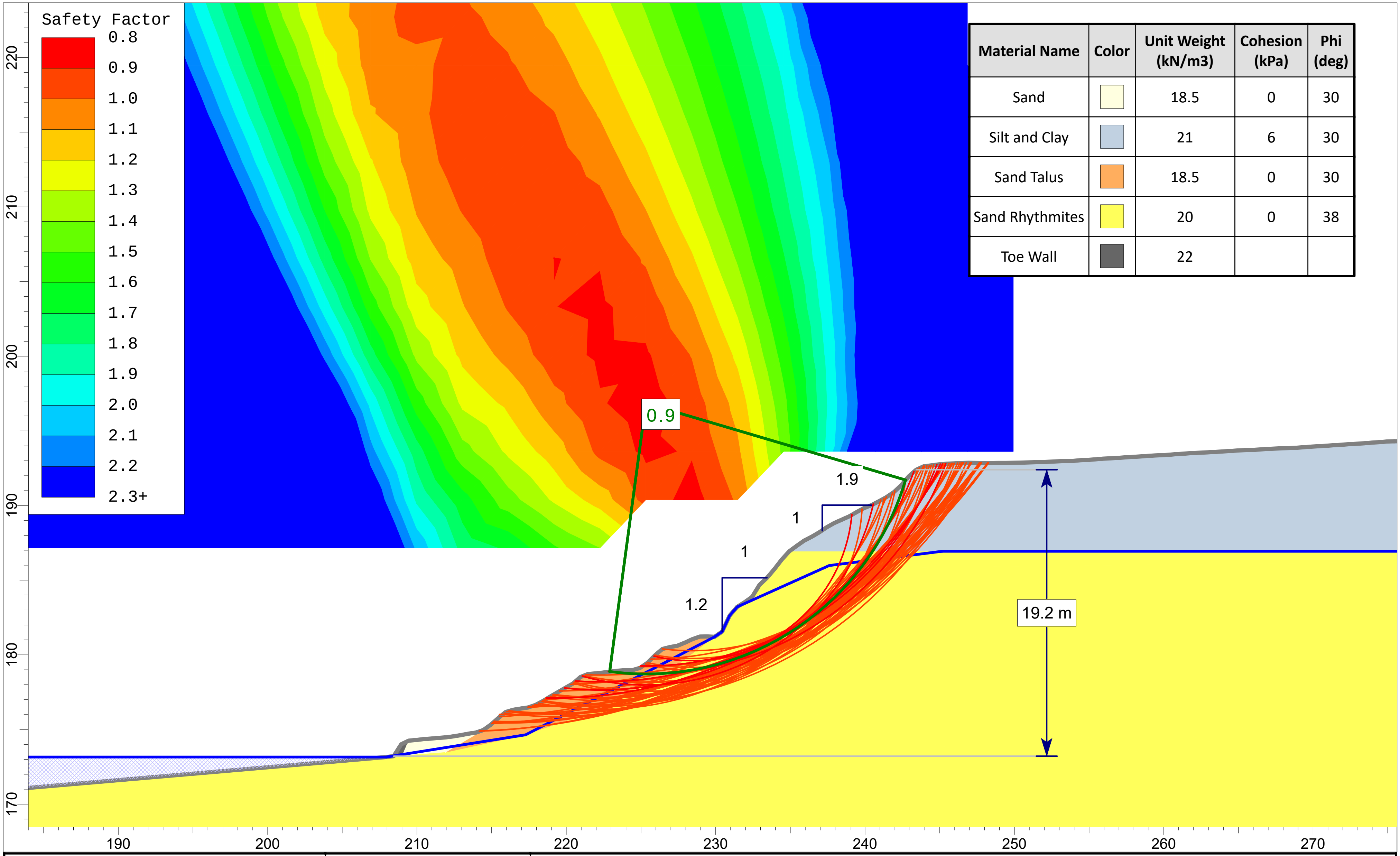
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T44 Existing Conditions, Master Scenario

Date	8/6/2019	Scale	1:700	File	T43 - T44.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Talus	🟧	18.5	0	30
Sand Rhythmites	🟨	20	0	38
Toe Wall	⬛	22		

Terraprobe
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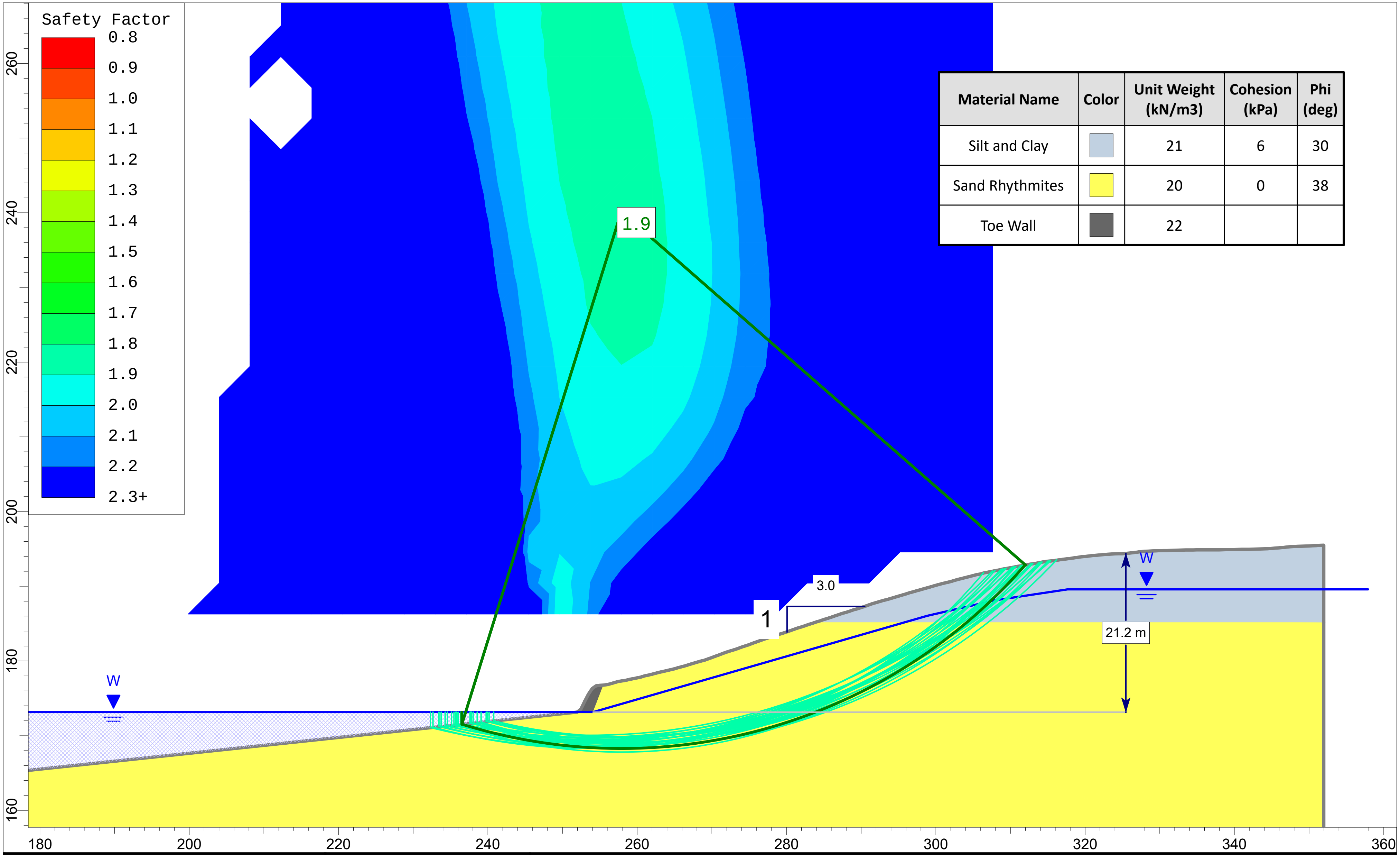
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T45 Existing Conditions, Master Scenario

Date 8/6/2019
Scale 1:350
File T45 - T46.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38
Toe Wall	⬛	22		

Terraprobe

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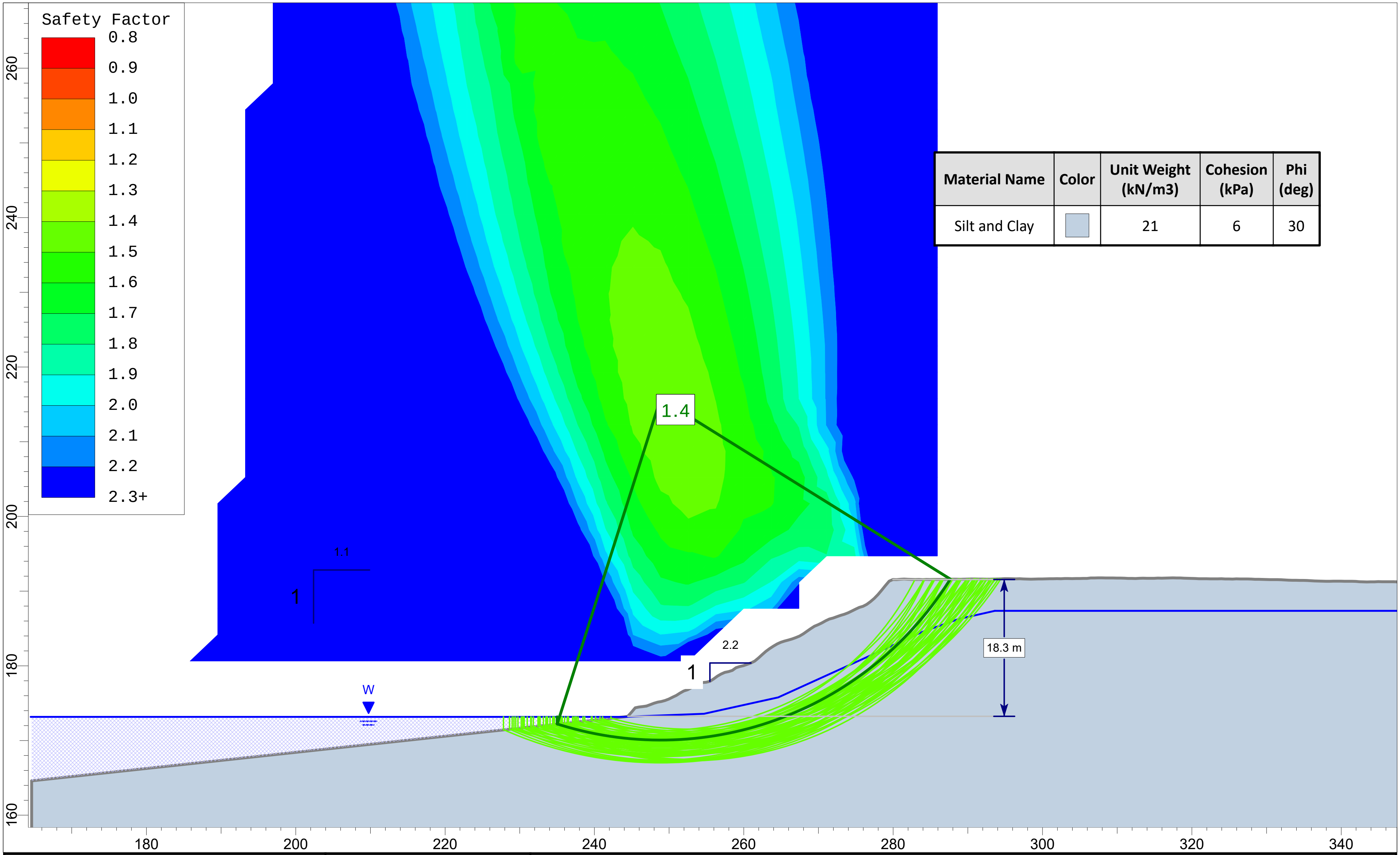
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**		
Analysis	Global Stability: T46 Existing Conditions, Master Scenario		
Date 8/6/2019	Scale 1:700	File T45 - T46.slmd	
By JH/JC	Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe
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Construction Materials Inspection & Testing

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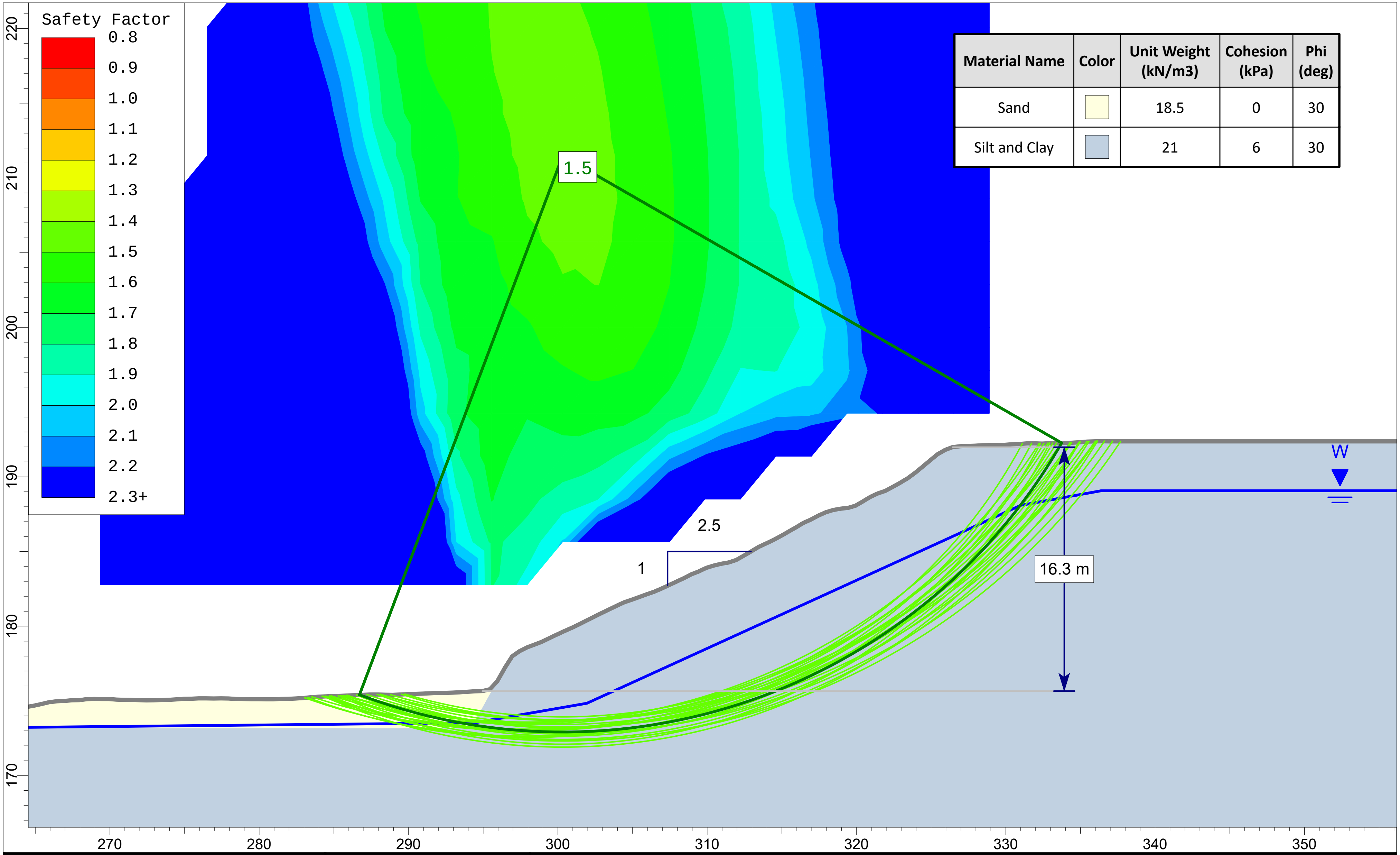
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T47 Existing Conditions, Master Scenario

Date	8/1/2019	Scale	1:700	File	T47 - T48.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt and Clay	🟦	21	6	30

Terraprobe

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Notes

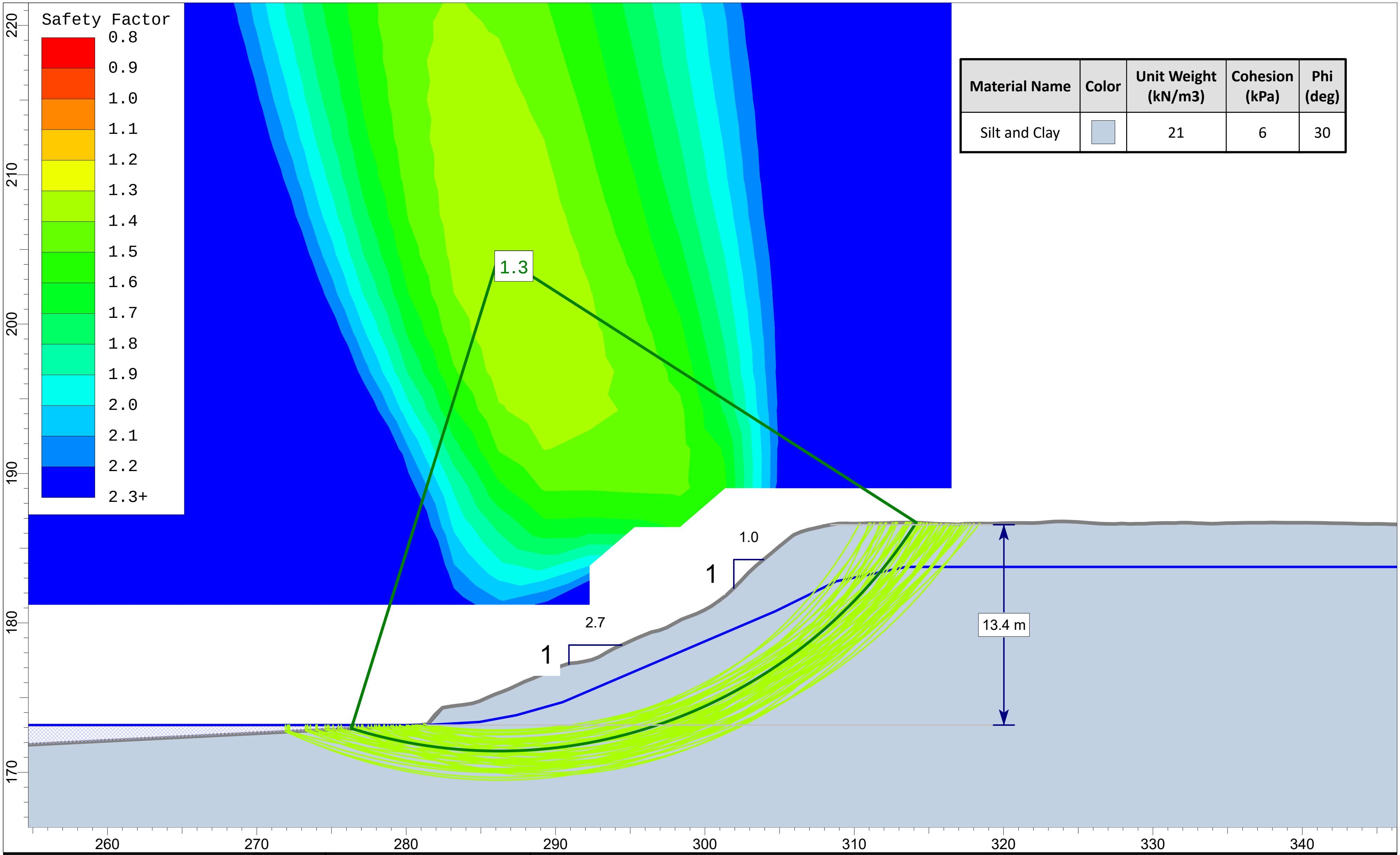
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T48 Existing Conditions, Master Scenario

Date 8/6/2019
Scale 1:350
File T47 - T48.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe

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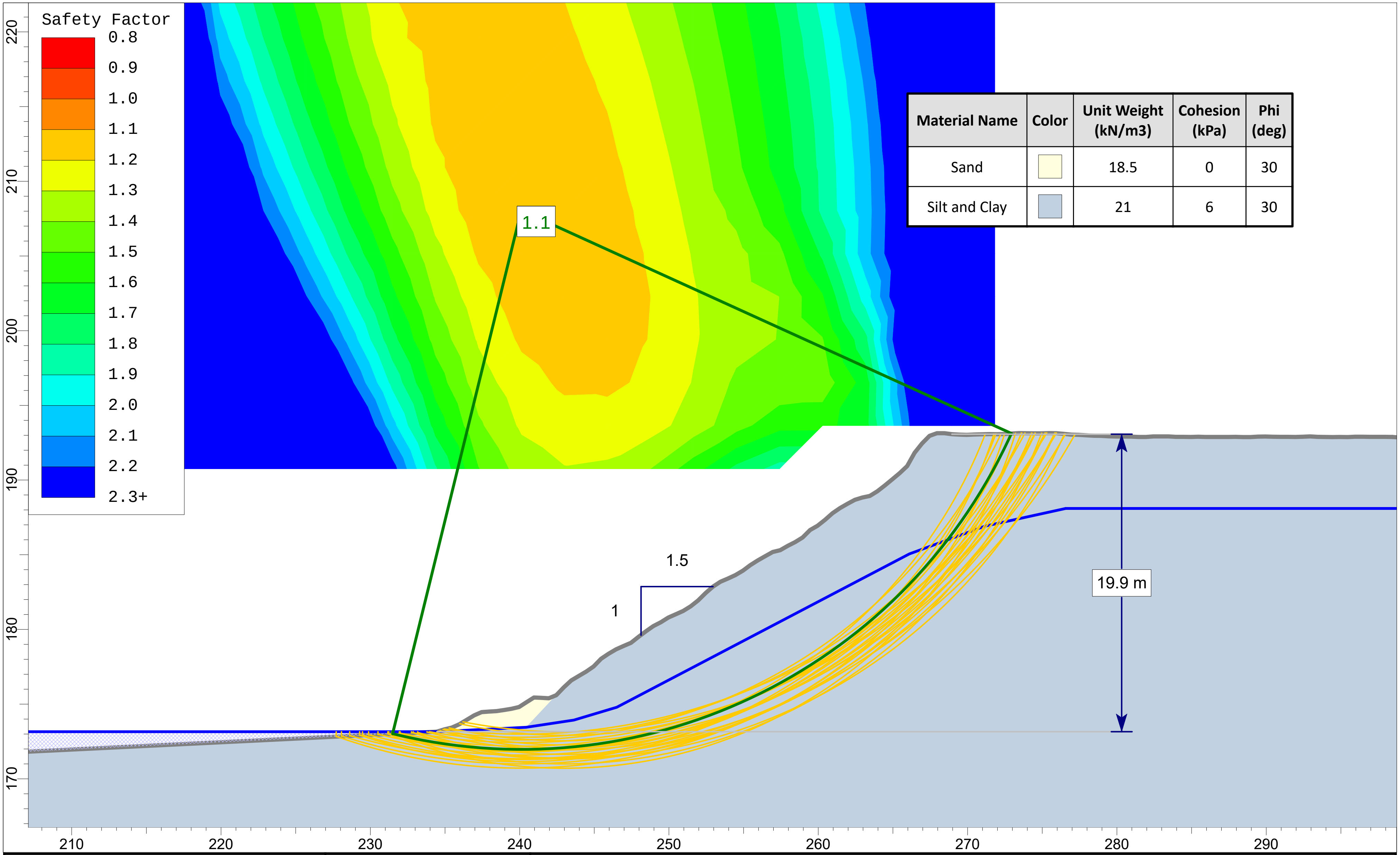
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T49 Existing Conditions, Master Scenario
Date	8/6/2019
Scale	1:350
File	T49 - T50.slmd
By	JH/JC
Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt and Clay	🟦	21	6	30

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

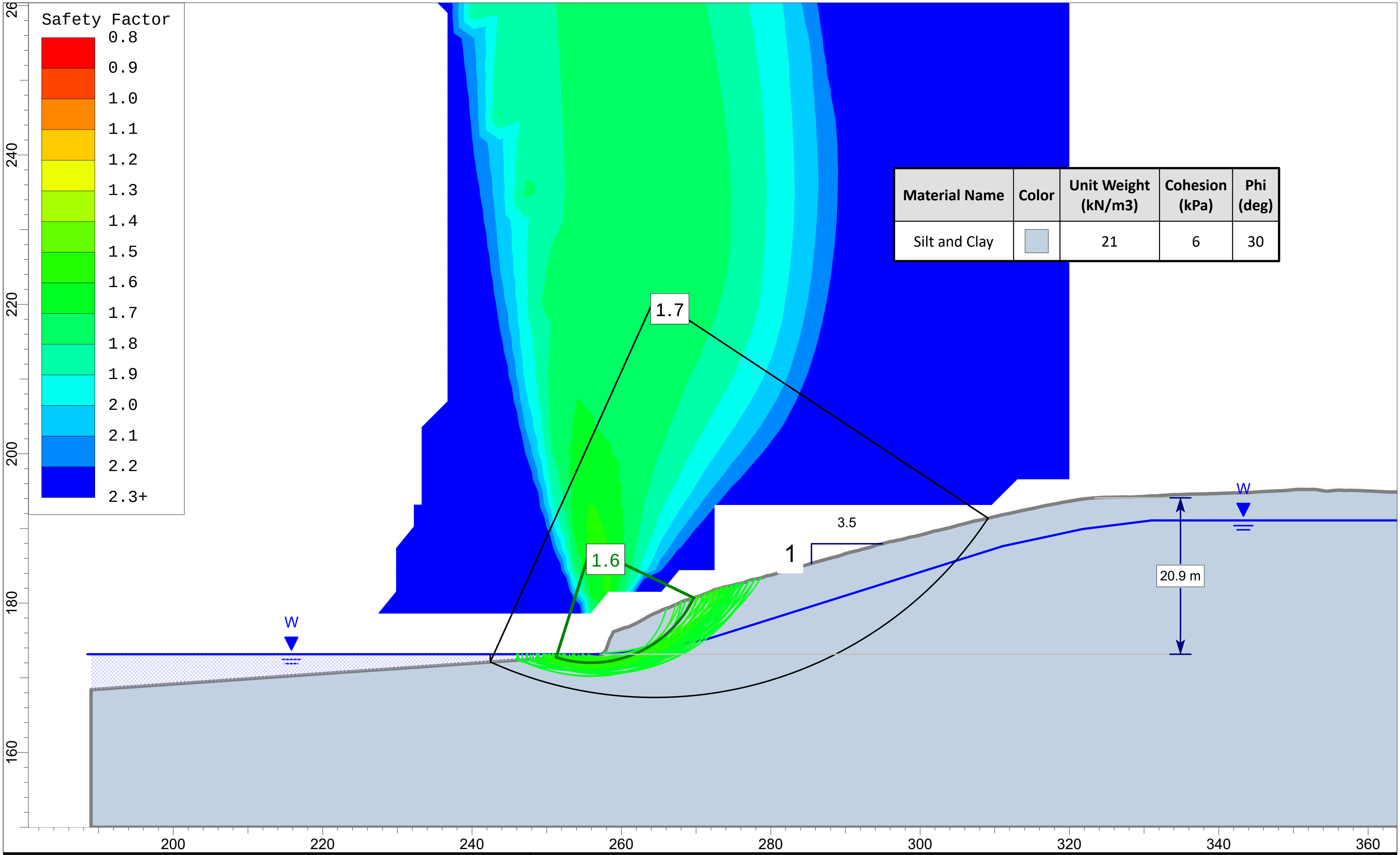
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T50 Existing Conditions, Master Scenario

Date	8/9/2019	Scale	1:350	File	T49 - T50.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30

Terraprobe

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Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

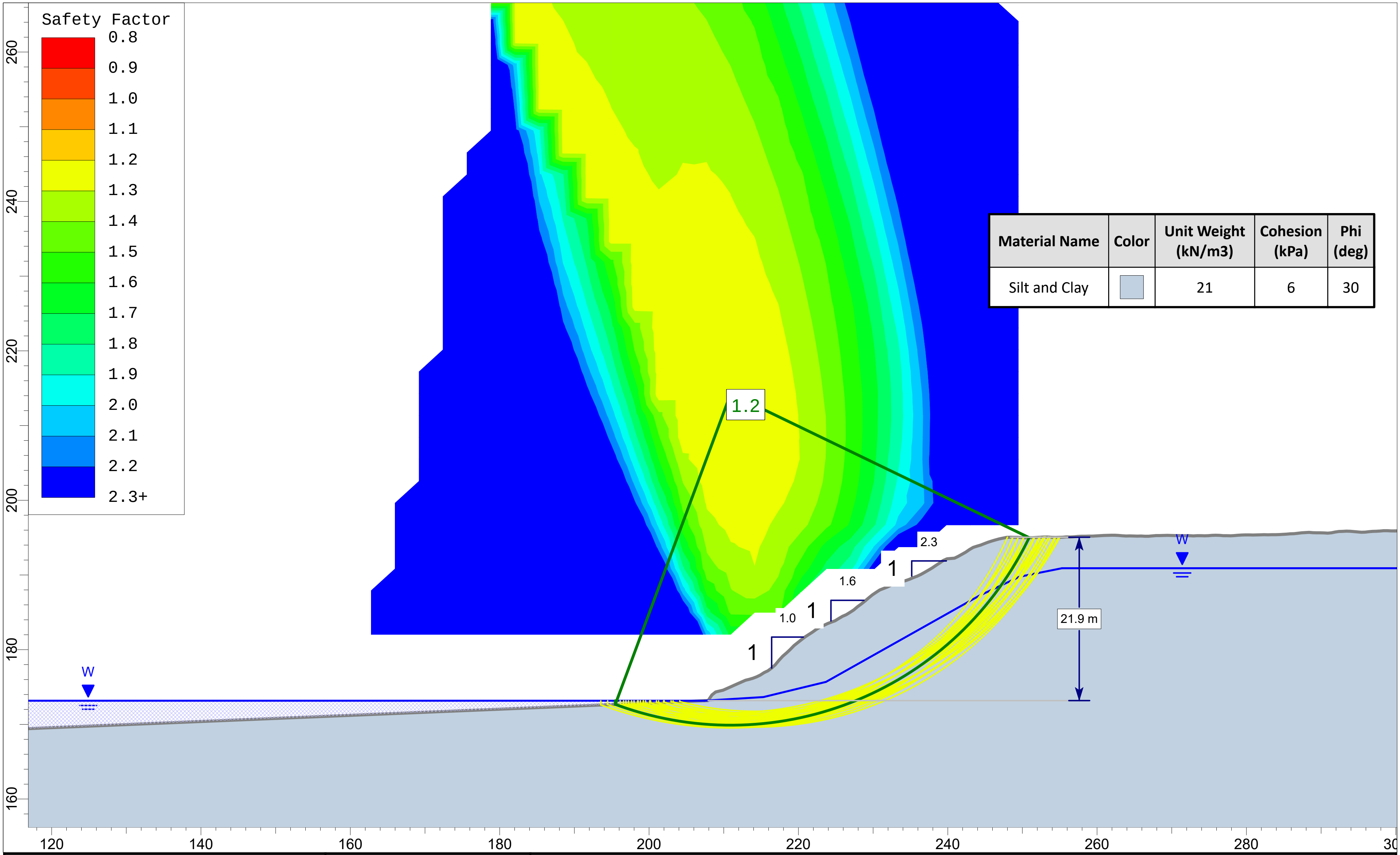
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T51 Existing Conditions, Master Scenario

Date	8/6/2019	Scale	1:700	File	T51 - T52.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

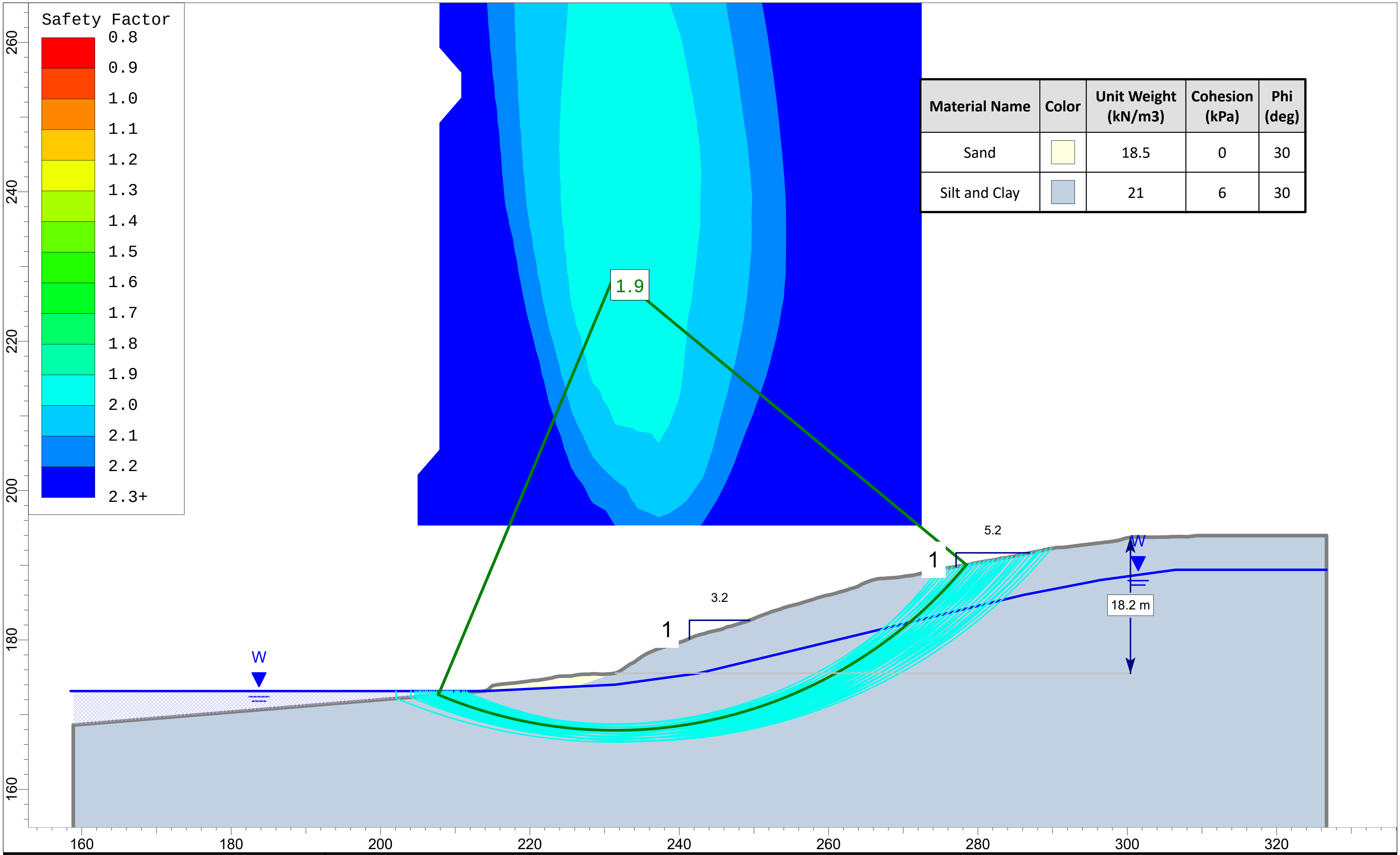
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T52 Existing Conditions, Master Scenario

Date	8/6/2019	Scale	1:700	File	T51 - T52.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt and Clay	🟦	21	6	30

Terraprobe

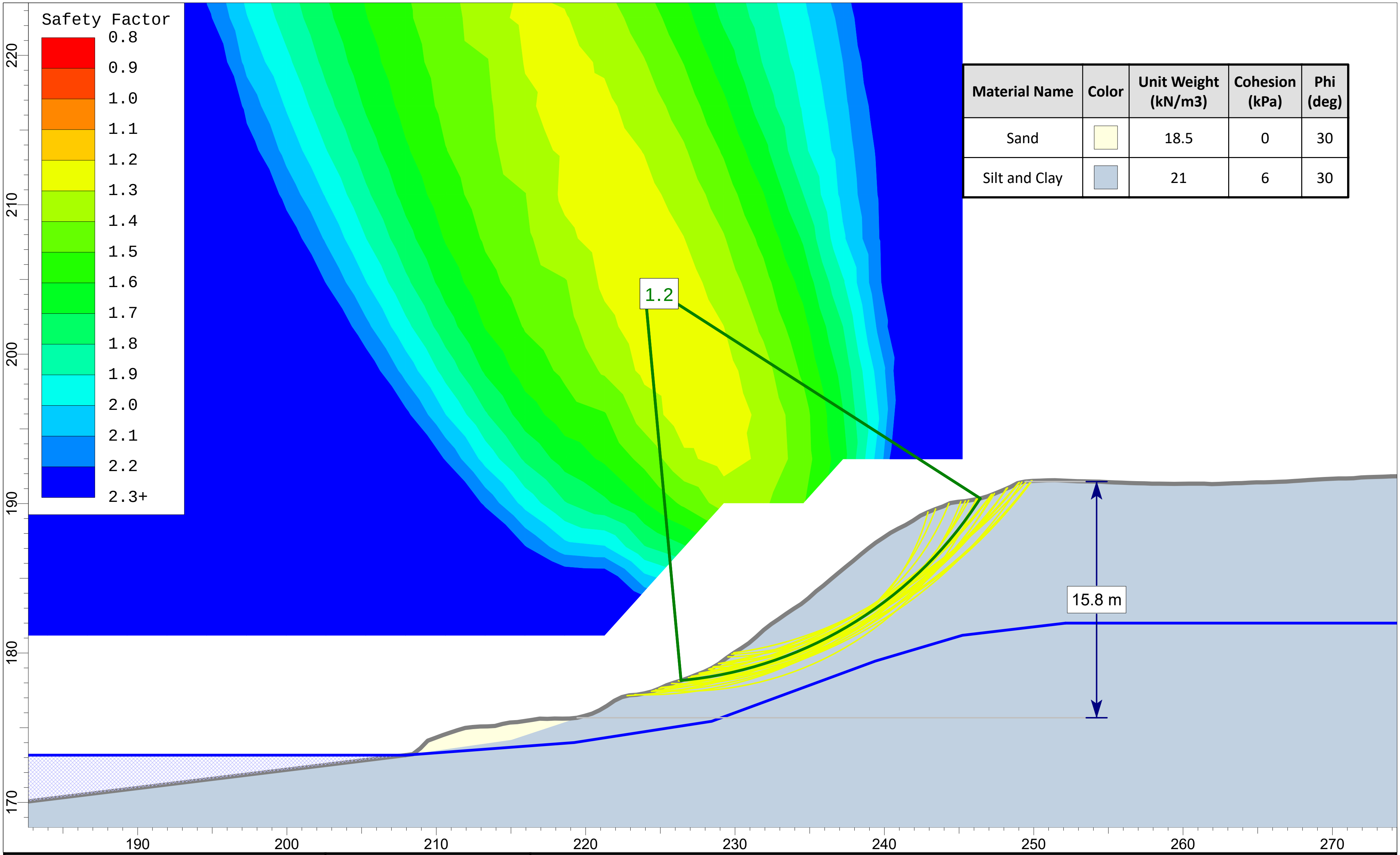
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**		
Analysis	Global Stability: T53 Existing Conditions, Master Scenario		
Date 8/6/2019	Scale 1:700	File	T53 - T54.slmd
By JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019	



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	⬜	21	6	30

Terraprobe

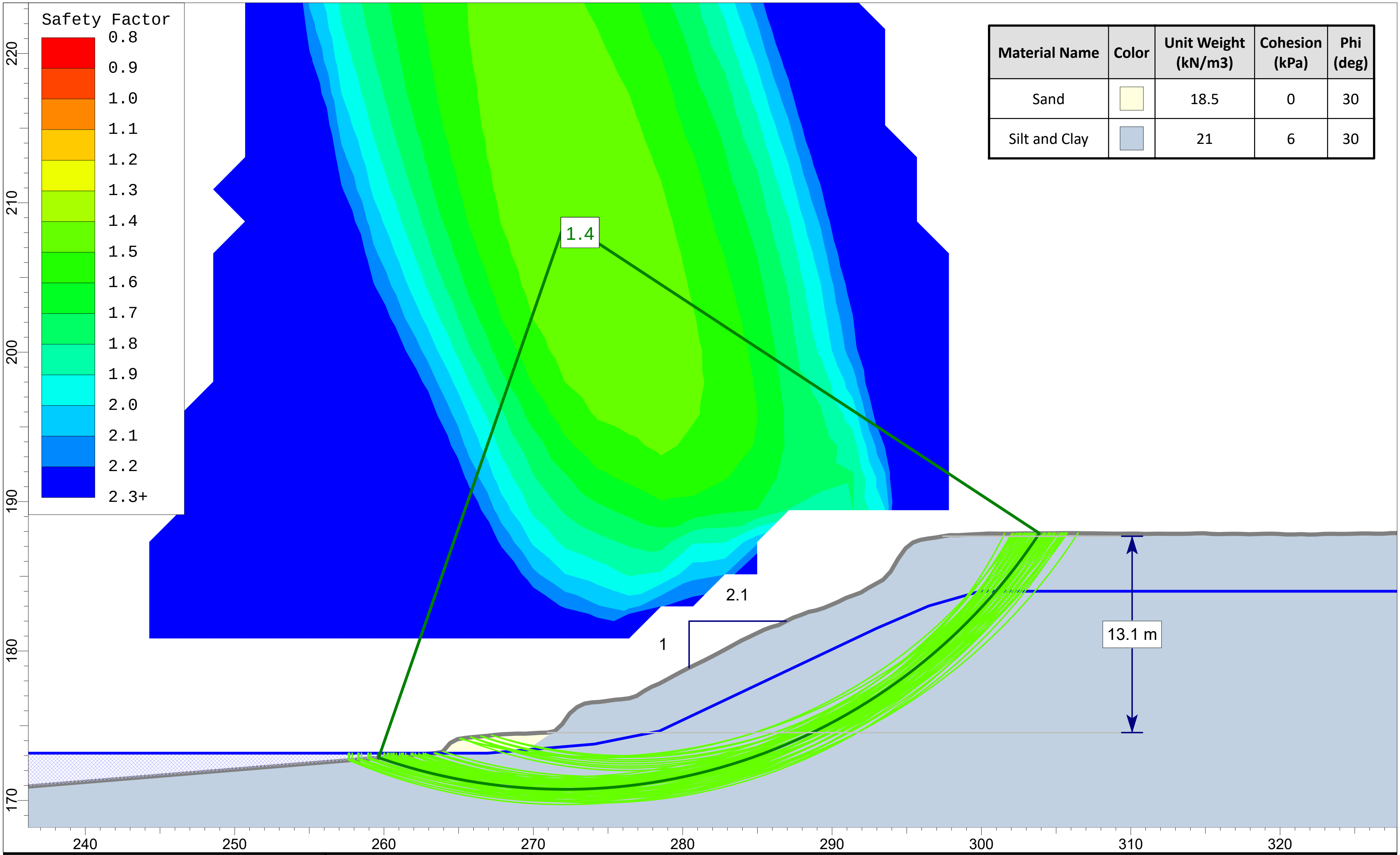
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T54 Existing Conditions, Master Scenario
Date	8/6/2019
Scale	1:350
File	T53 - T54.slmd
By	JH/JC
Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	▢	18.5	0	30
Silt and Clay	▨	21	6	30

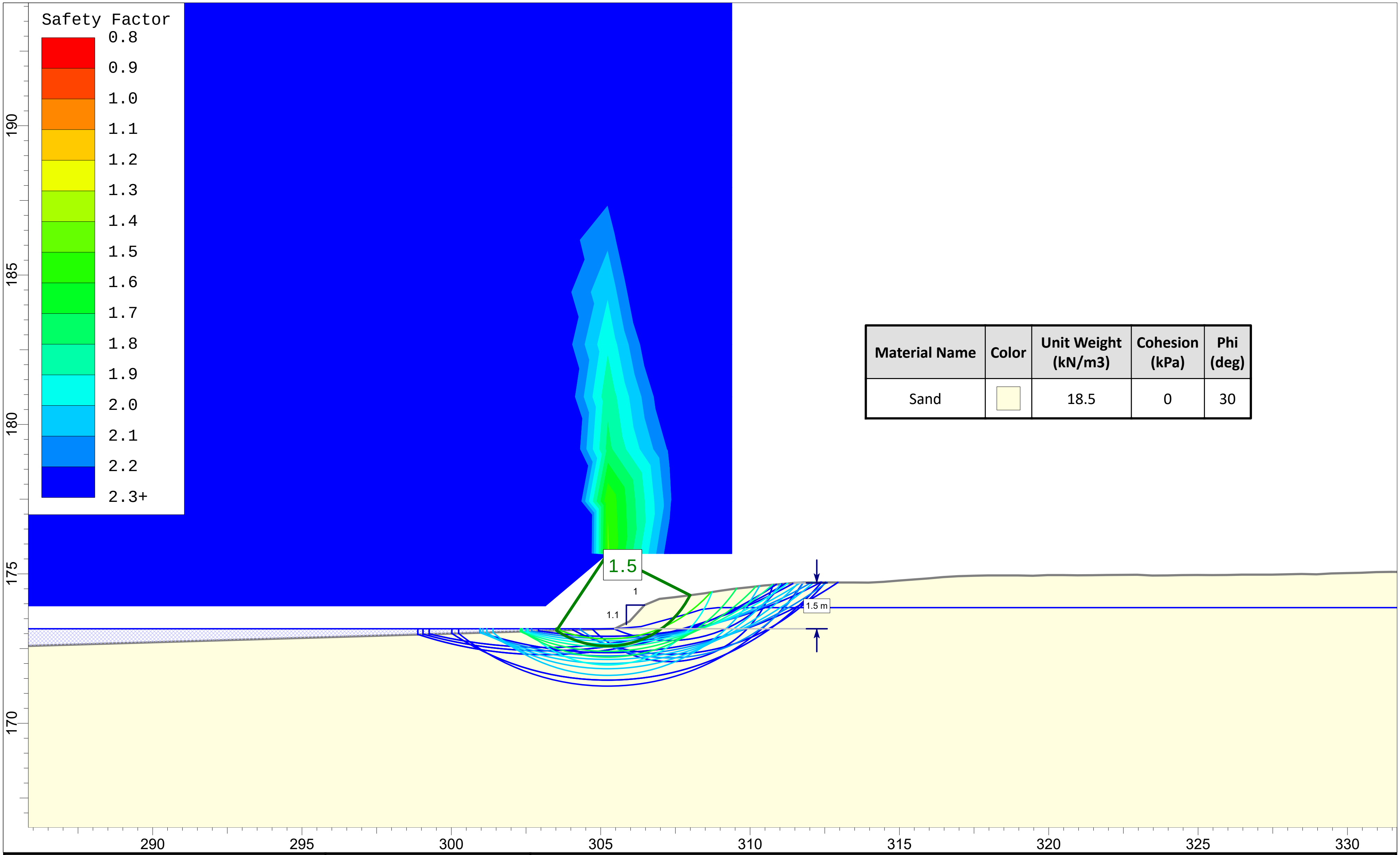
Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T55 Existing Conditions, Master Scenario

Date	8/6/2019	Scale	1:350	File	T55 - T56.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

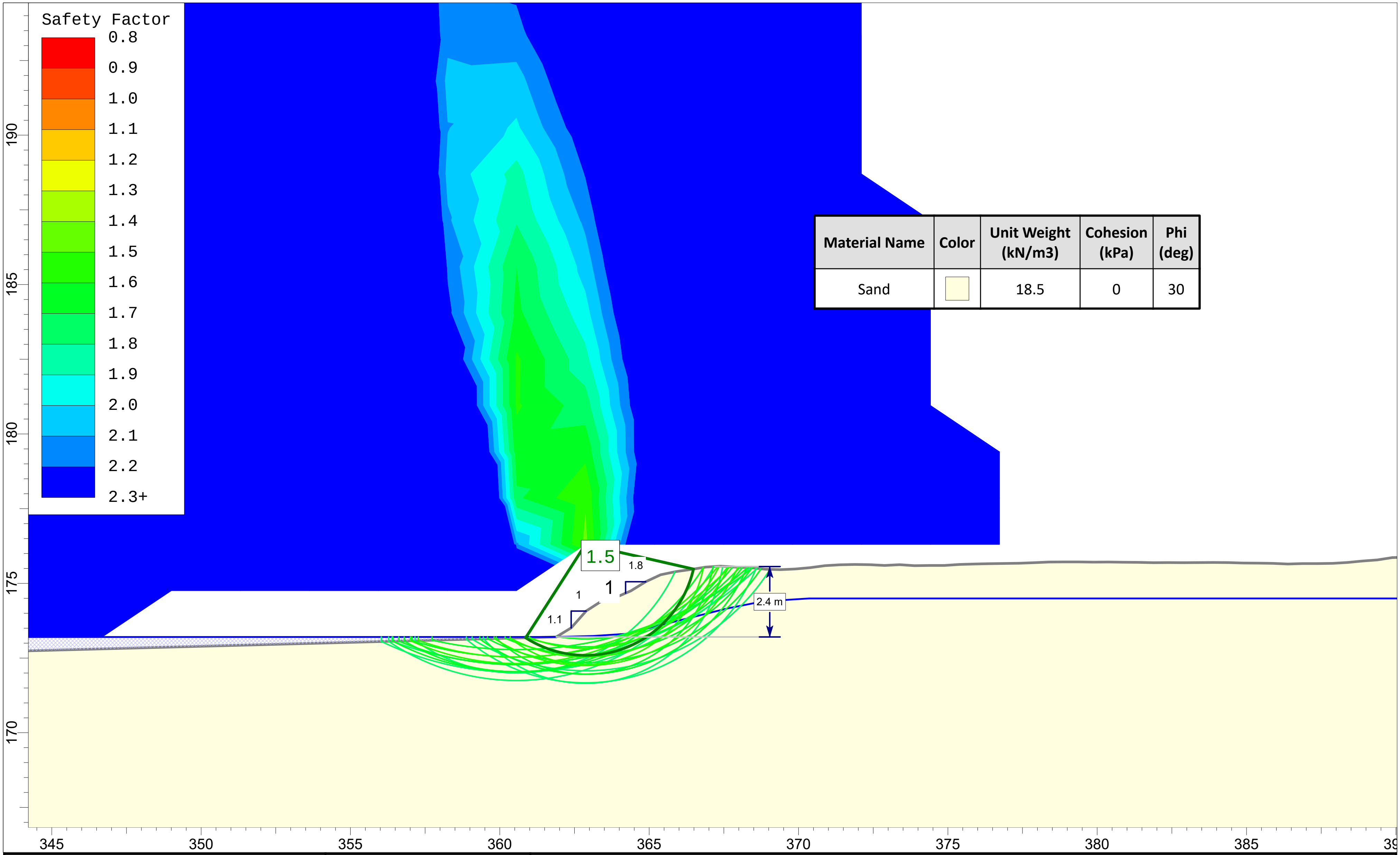
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T56 Existing Conditions, Master Scenario

Date	8/9/2019	Scale	1:175	File	T55 - T56.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	☐	18.5	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

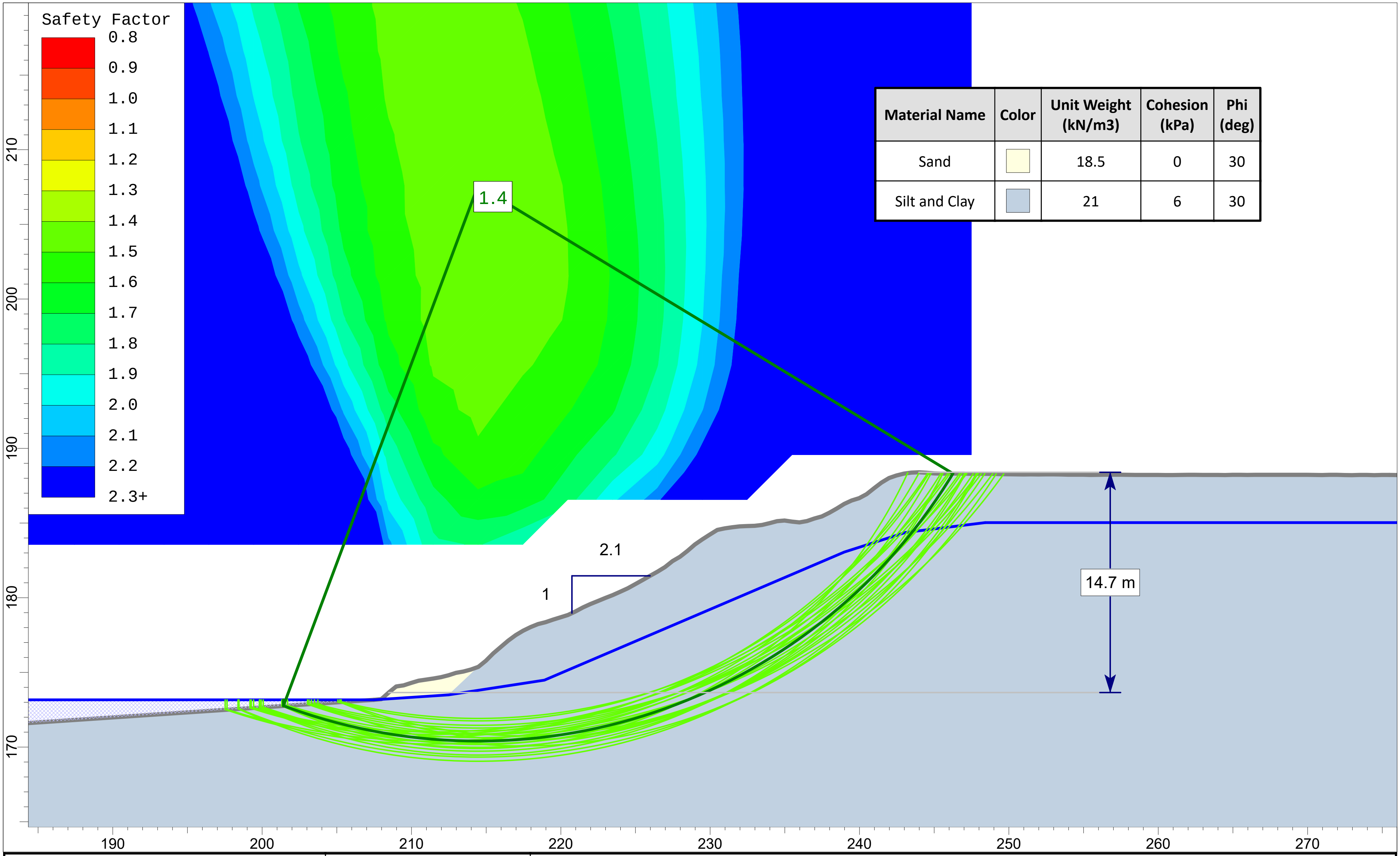
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project: **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis: Global Stability: T57 Existing Conditions, Master Scenario

Date: 8/9/2019
Scale: 1:175
File: T57 - T58.slmd
By: JH/JC
Ref.: LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



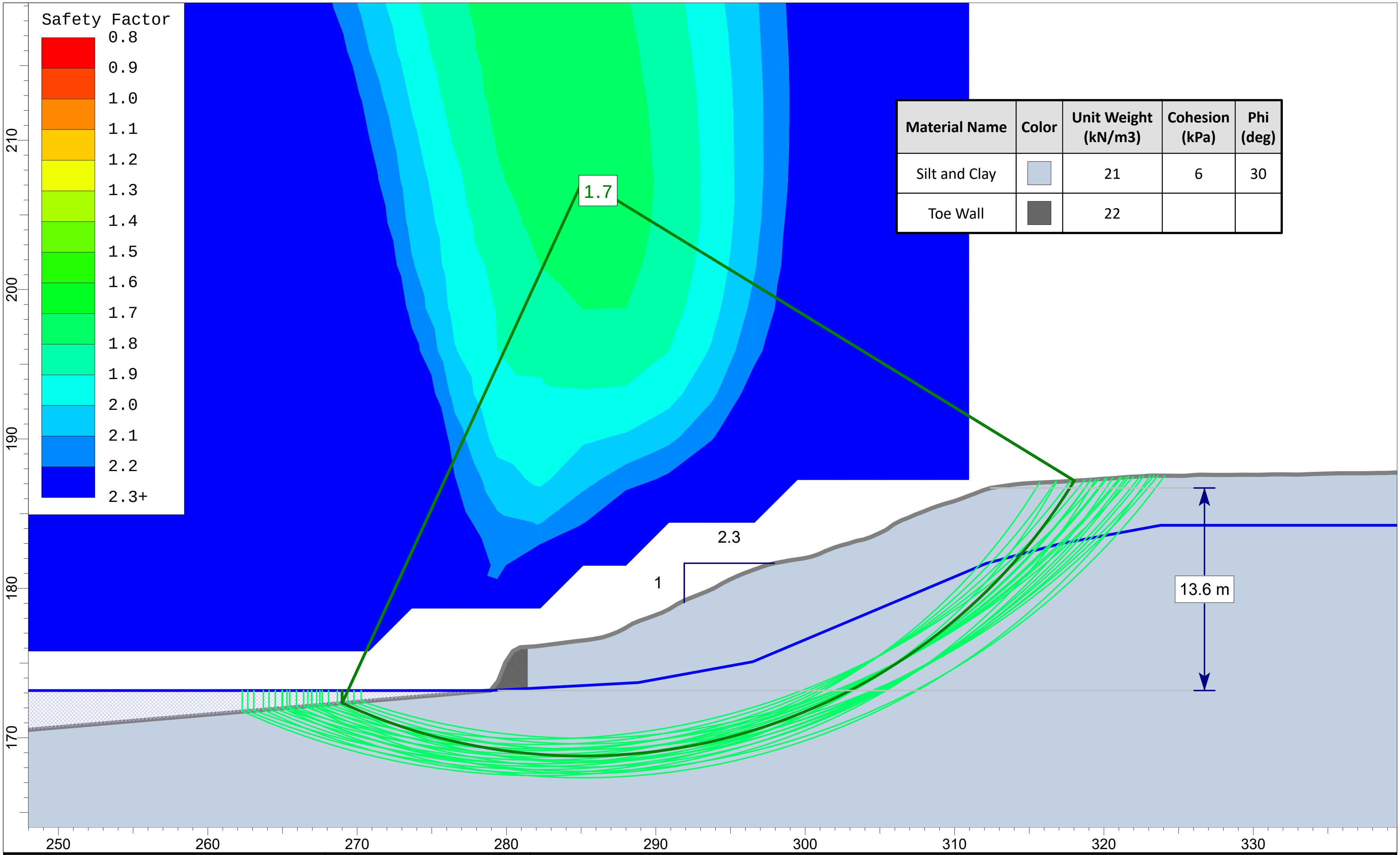
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt and Clay	🟦	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T58 Existing Conditions, Master Scenario
Date	8/9/2019
Scale	1:350
File	T57 - T58.slmd
By	JH/JC
Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Toe Wall	⬛	22		

Terraprobe
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Construction Materials Inspection & Testing

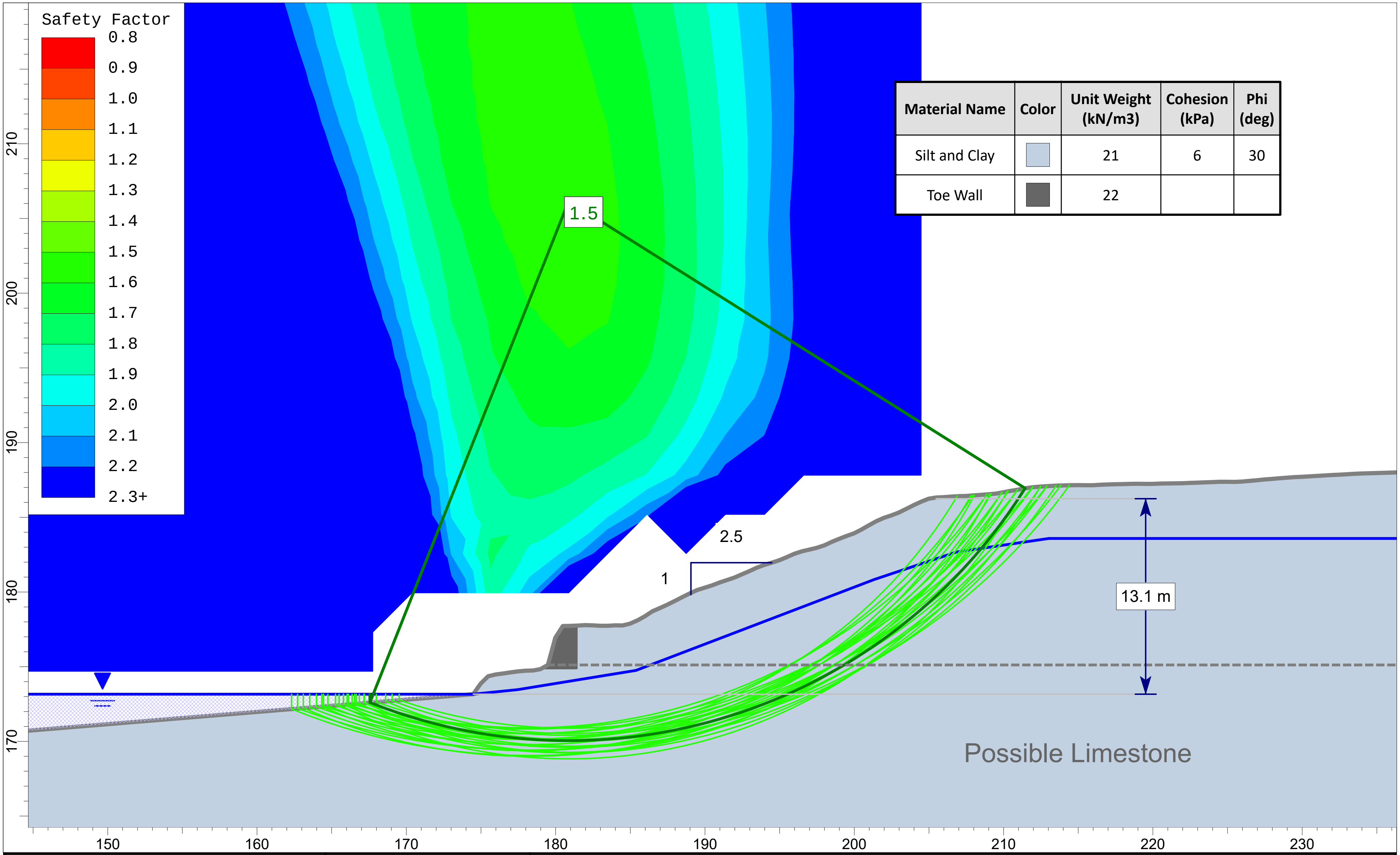
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T59 Existing Conditions, Master Scenario

Date 8/1/2019
Scale 1:350
File T59 - T60.slmd
By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Toe Wall	⬛	22		

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

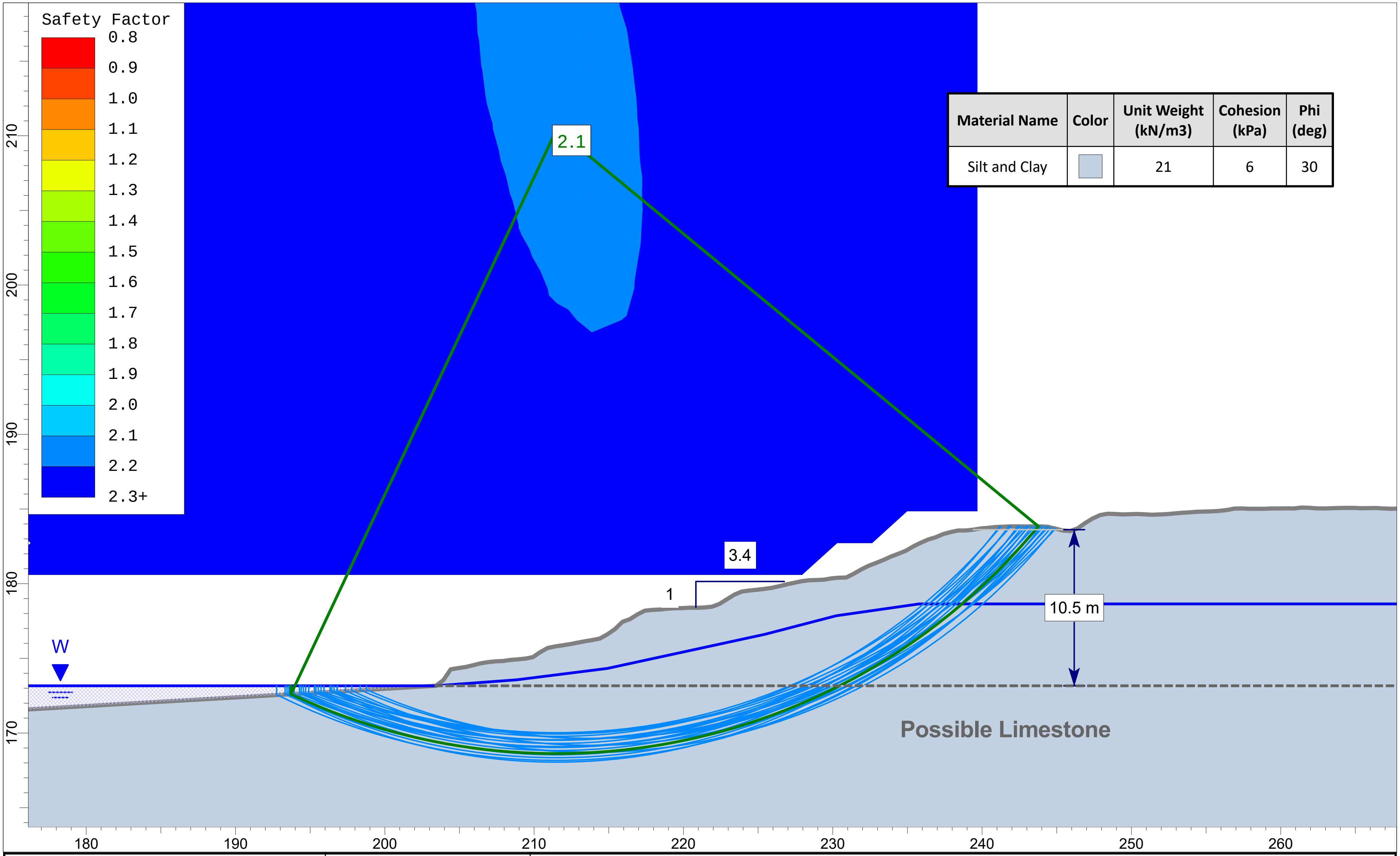
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T60 Existing Conditions, Master Scenario

Date	8/1/2019	Scale	1:350	File	T59 - T60.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

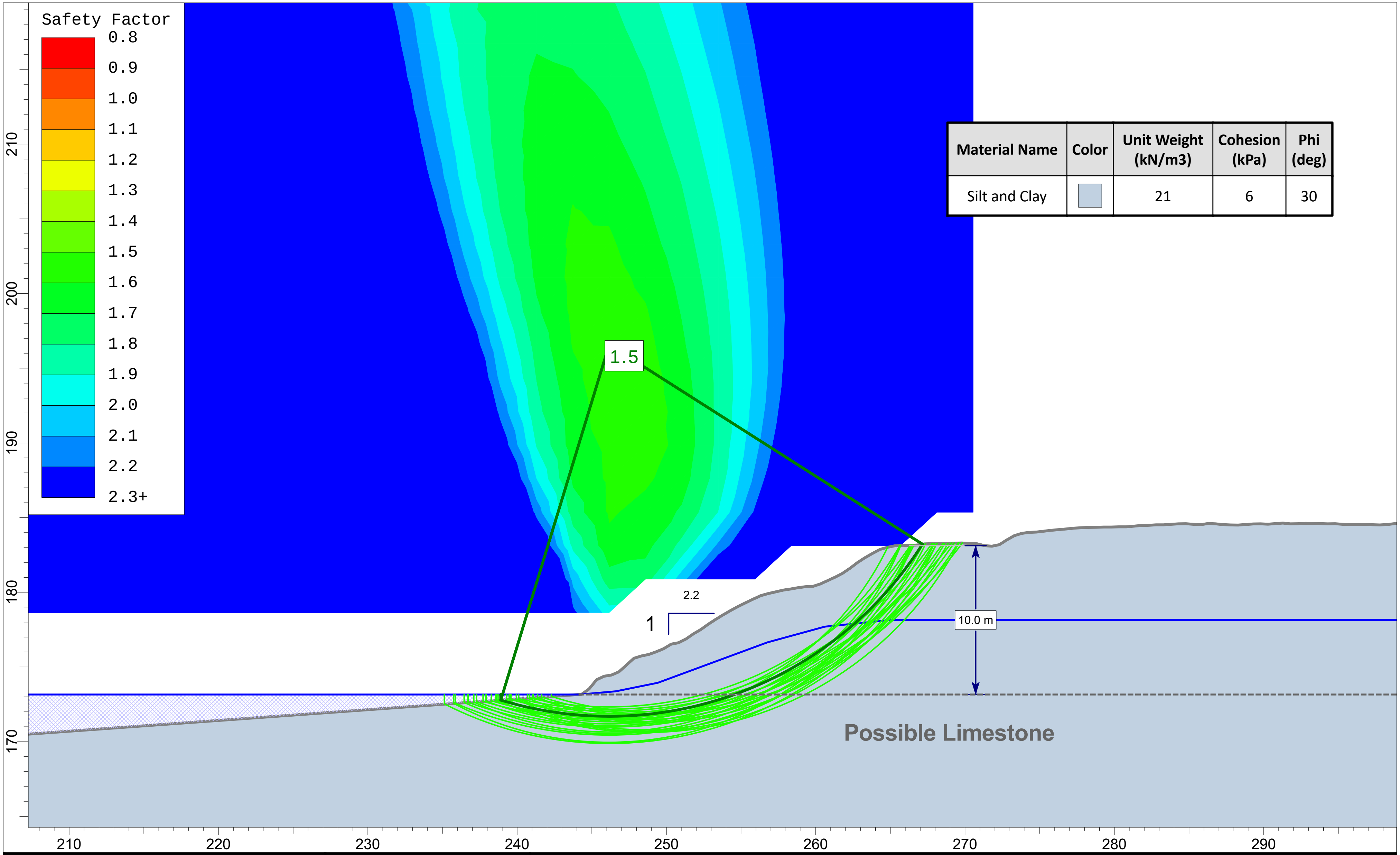
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T61 Existing Conditions, Master Scenario

Date 8/6/2019
Scale 1:350
File T61 - T62.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T62 Existing Conditions, Master Scenario

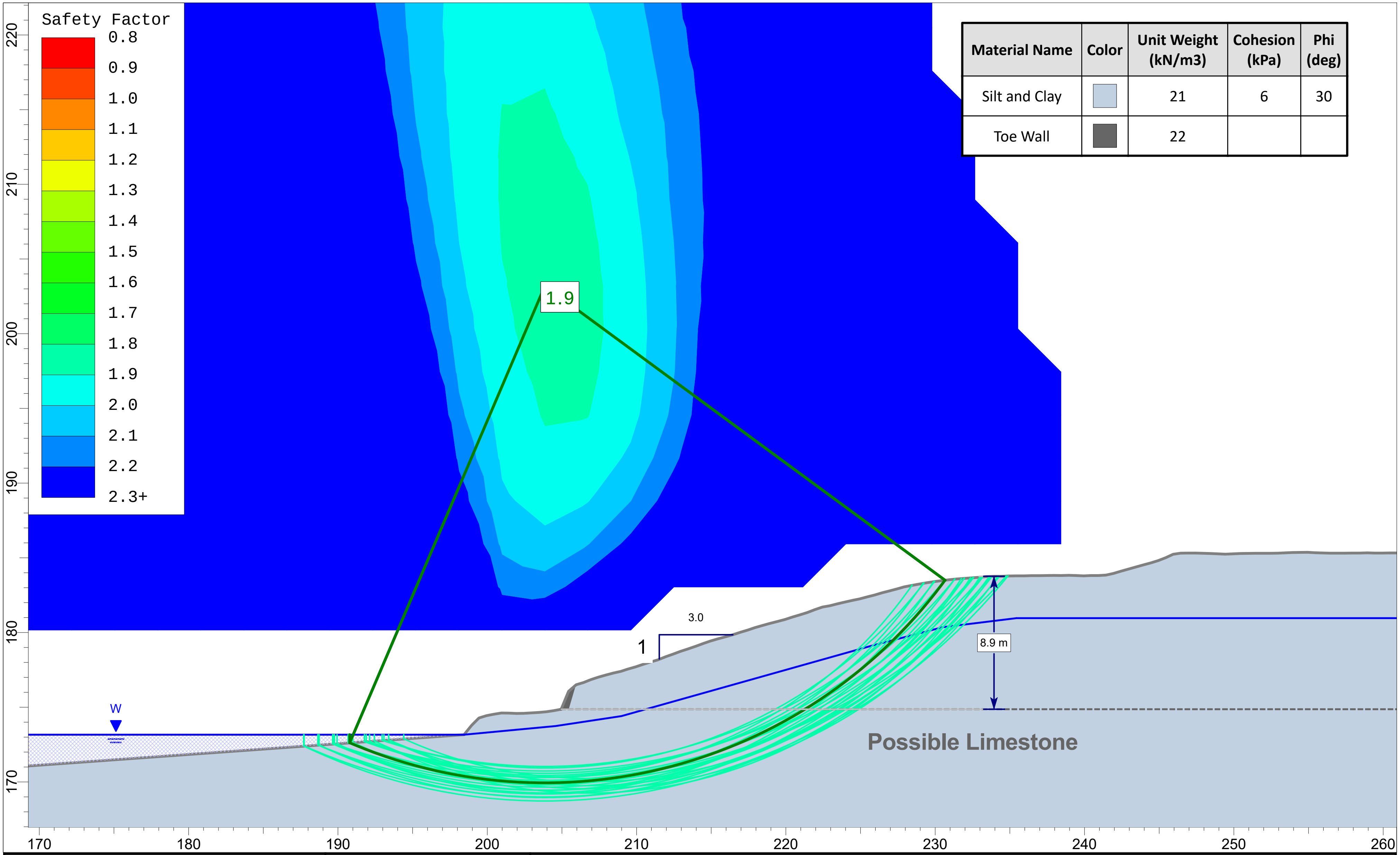
Date 8/6/2019

Scale 1:350

File T61 - T62.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Toe Wall	⬛	22		

Terraprobe

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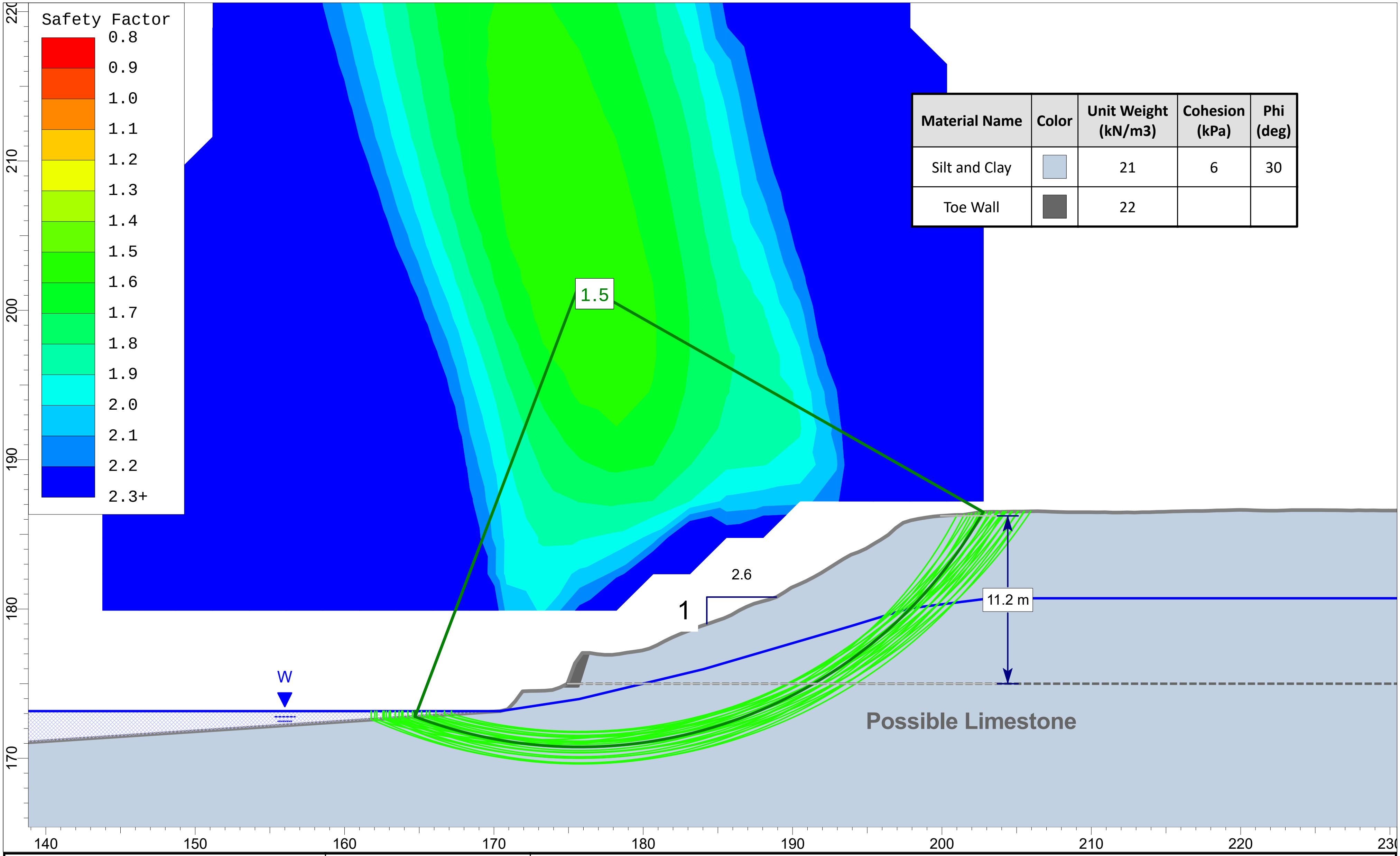
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**		
Analysis	Global Stability: T63 Existing Conditions, Master Scenario		
Date 8/6/2019	Scale 1:350	File	T63 - T64.slmd
By JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019	



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	□	21	6	30
Toe Wall	■	22		

Terraprobe
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Construction Materials Inspection & Testing

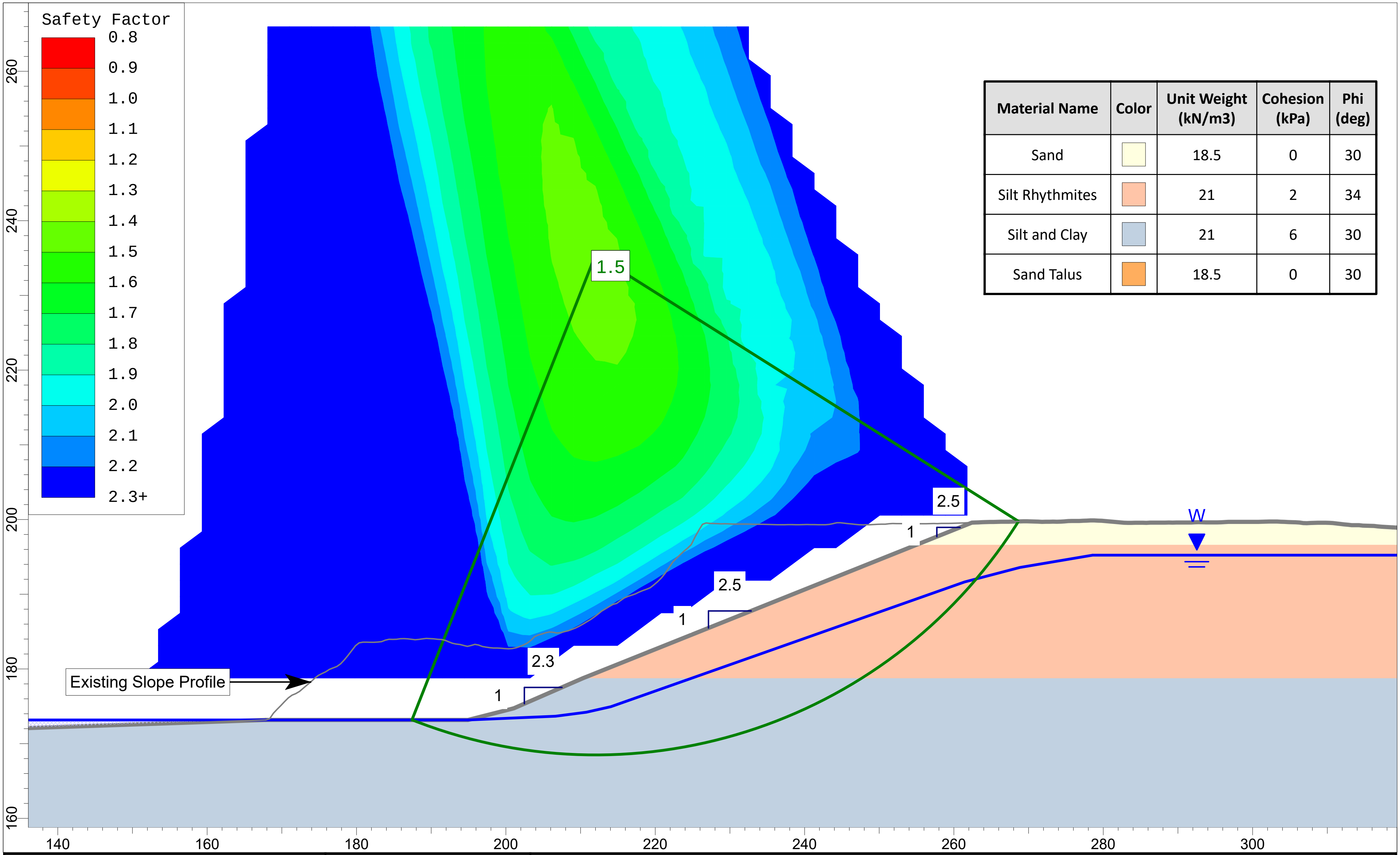
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**		
Analysis	Global Stability: T64 Existing Conditions, Master Scenario		
Date 8/6/2019	Scale 1:350	File	T63 - T64.slmd
By JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019	

APPENDIX G

TERRAPROBE INC.



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt Rhythmites	🟧	21	2	34
Silt and Clay	🟦	21	6	30
Sand Talus	🟧	18.5	0	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

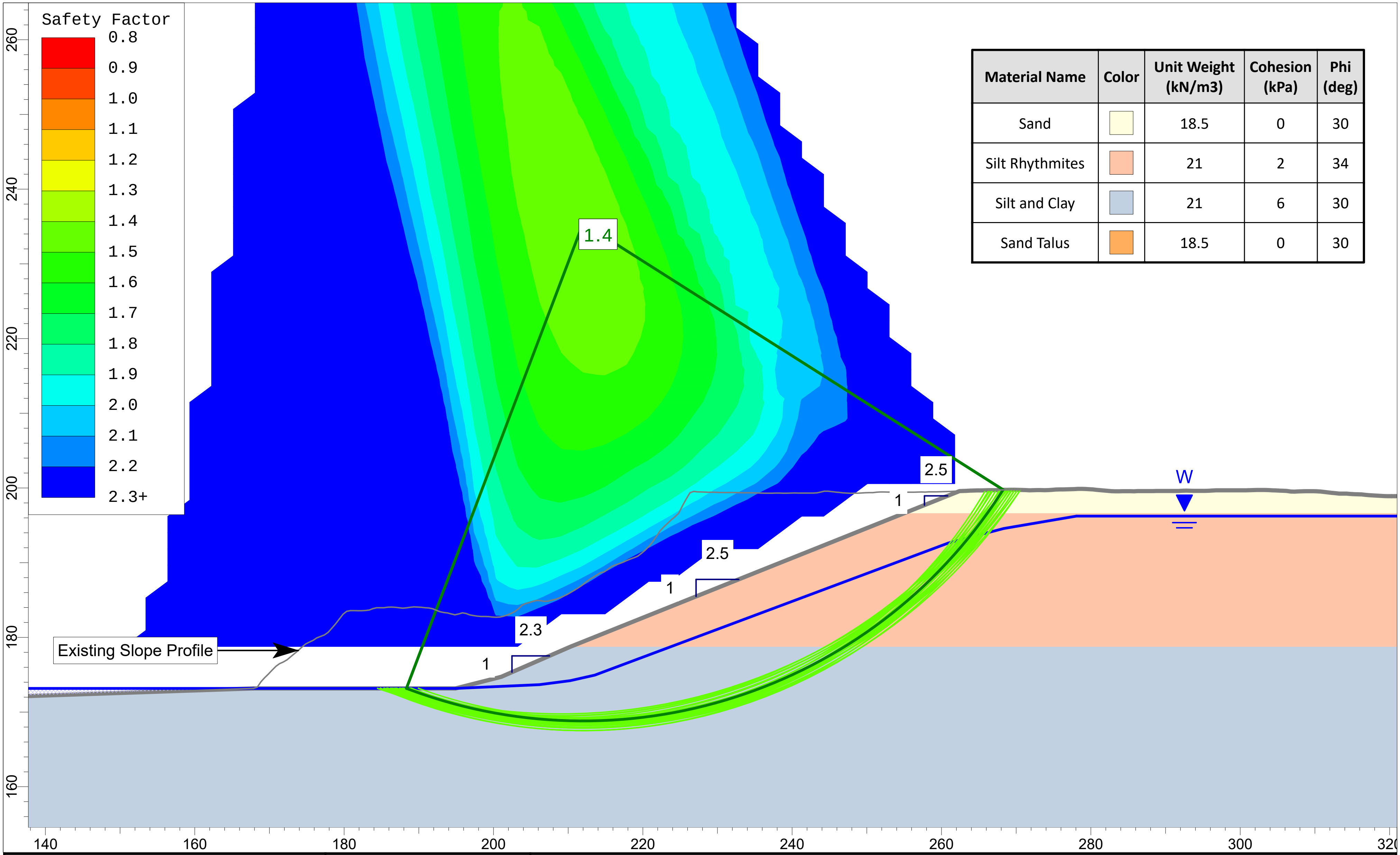
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T1 LTSSC, Master Scenario

Date 7/31/2019
Scale 1:700
File T01 - T09.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt Rhythmites	🟧	21	2	34
Silt and Clay	🟦	21	6	30
Sand Talus	🟧	18.5	0	30

Terraprobe
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Construction Materials Inspection & Testing

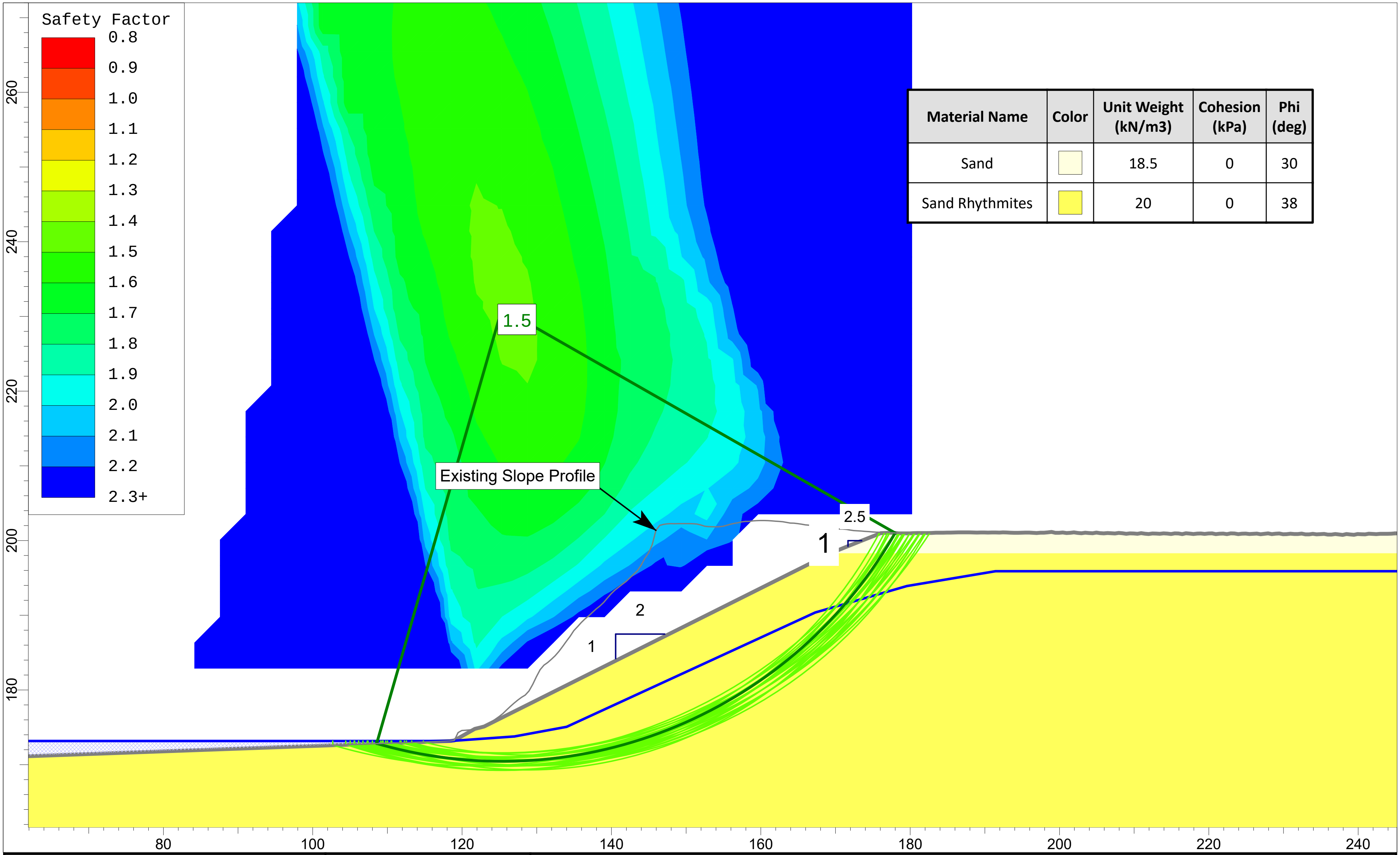
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T1 LTSSC, high GWT

Date 7/31/2019
Scale 1:700
File T01 - T09.slmd
By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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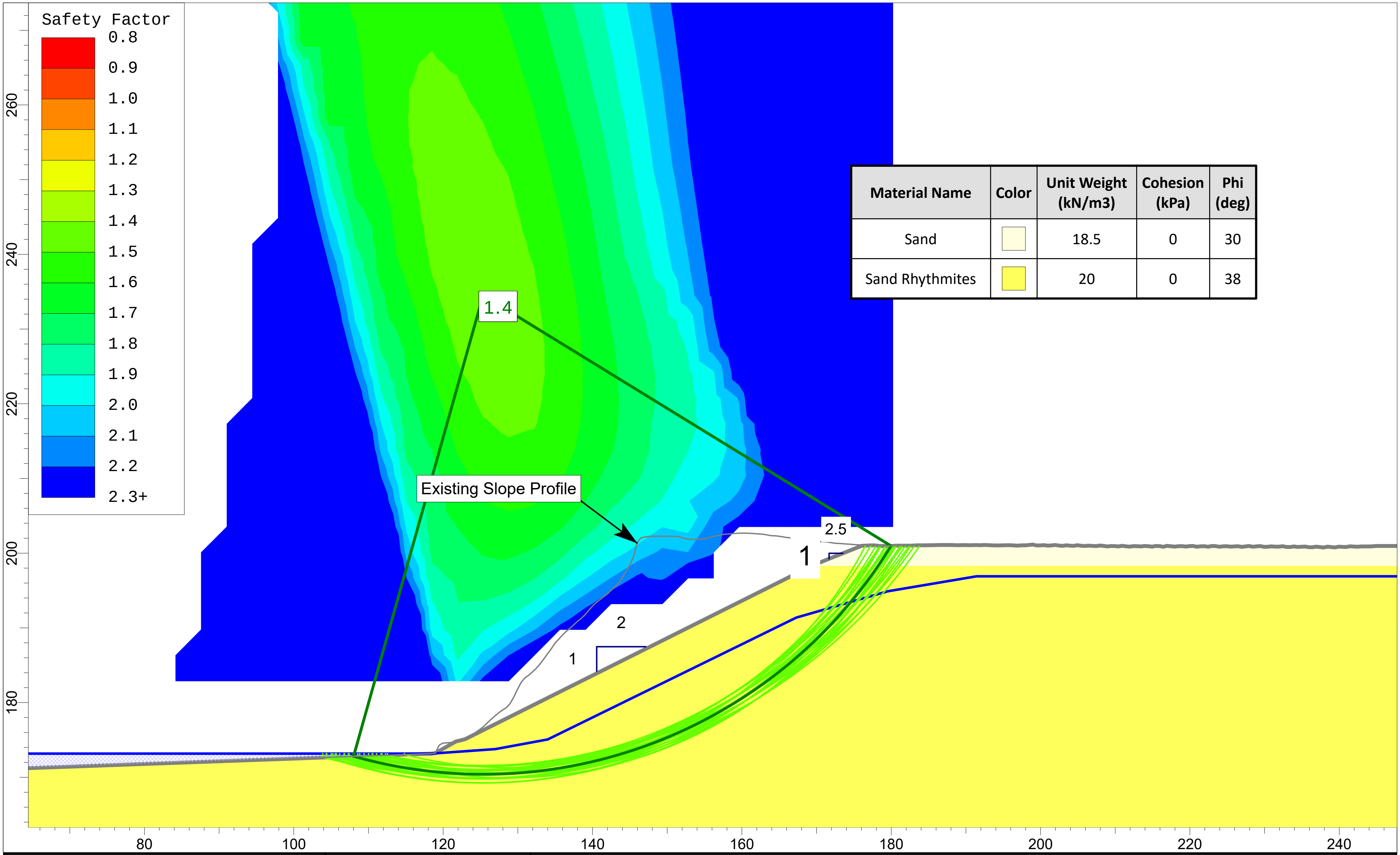
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T4 LTSSC, Master Scenario
Date	8/1/2019
Scale	1:700
File	T01 - T09.slmd
By	JH/JC
Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	▢	18.5	0	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

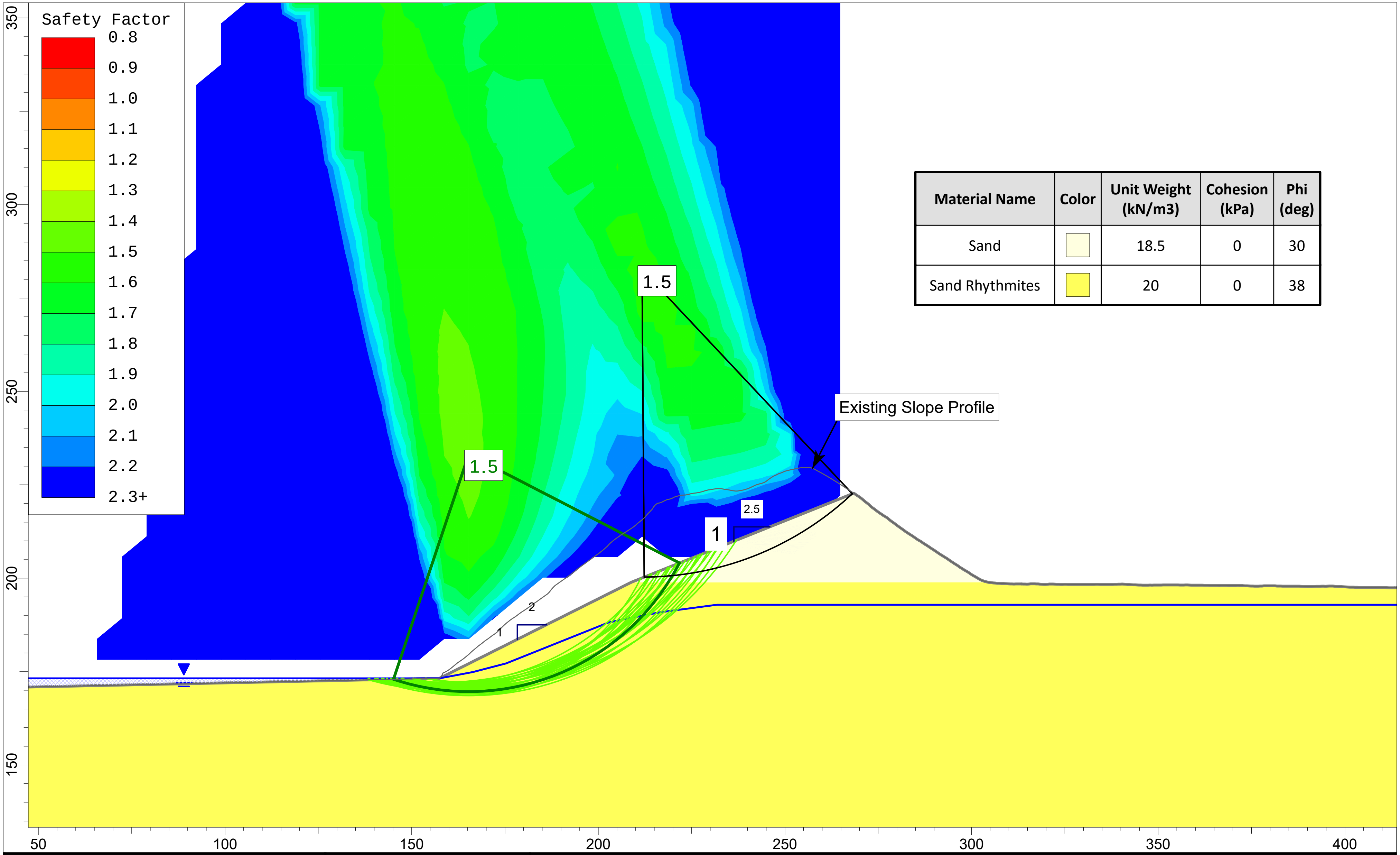
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T4 LTSSC, high GWT

Date	8/1/2019	Scale	1:700	File	T01 - T09.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	□	18.5	0	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

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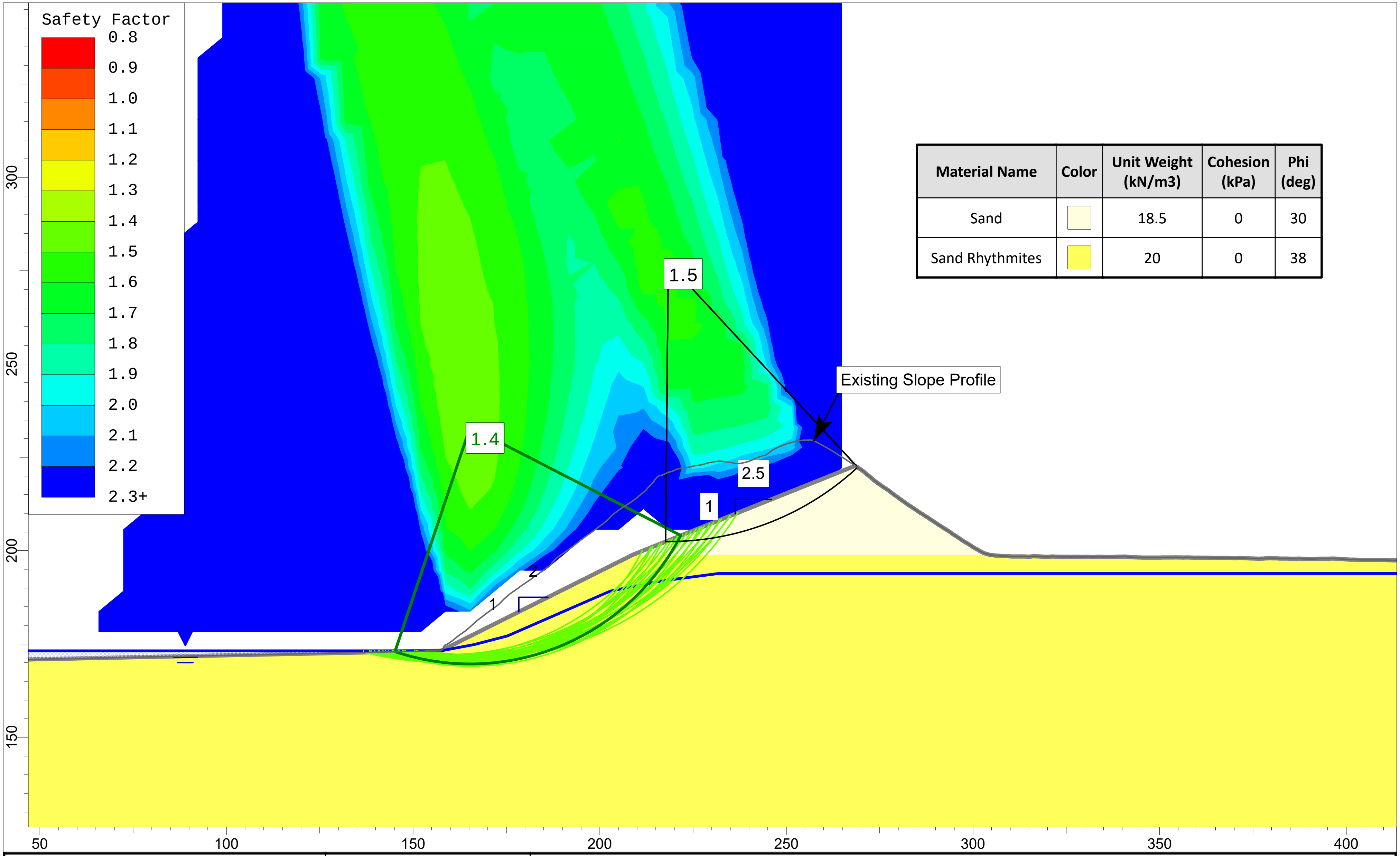
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T6 LTSSC, Master Scenario
Date	8/1/2019
Scale	1:1400
File	T01 - T09.slmd
By	JH/JC
Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

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Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

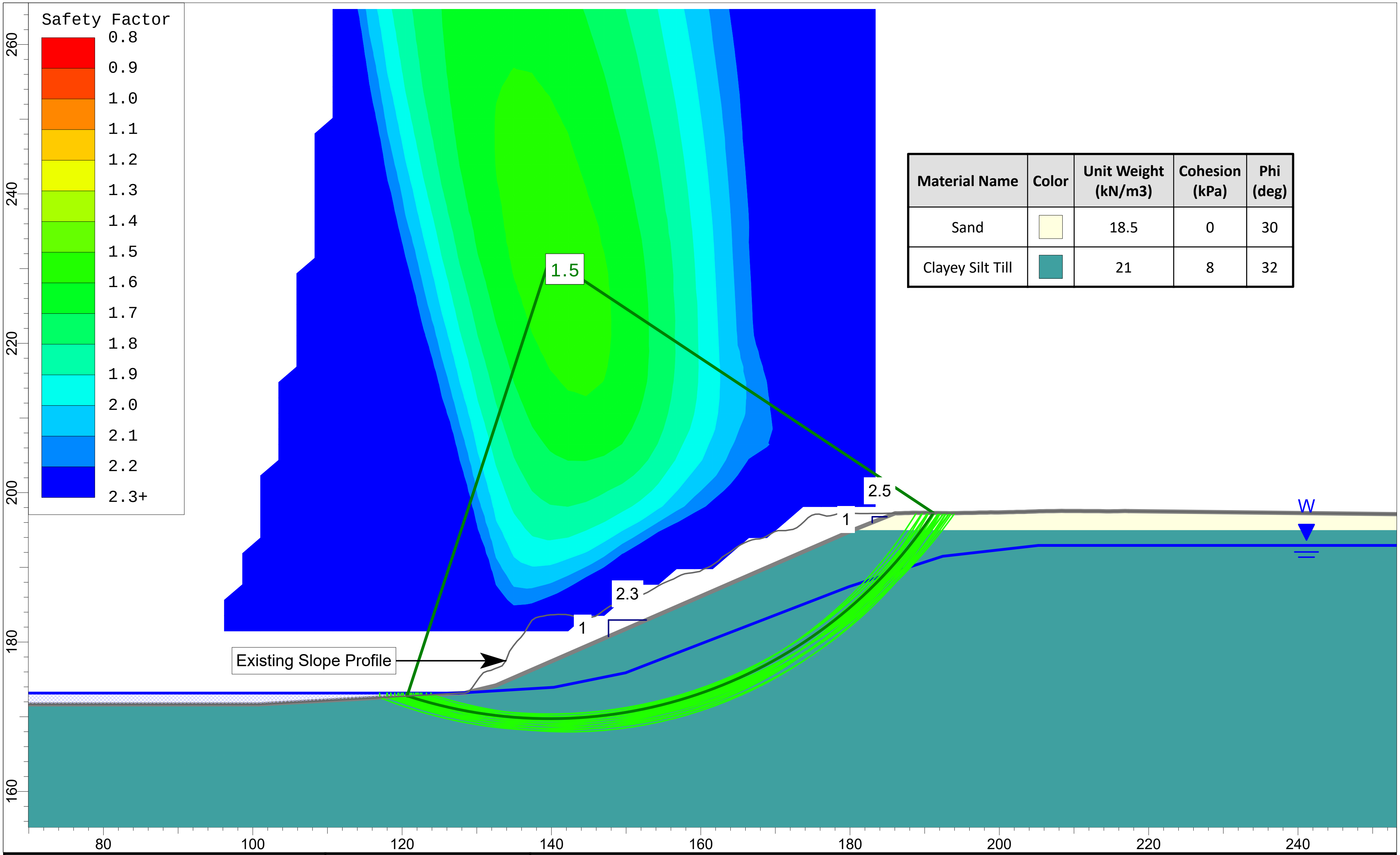
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T6 LTSSC, high GWT

Date	8/1/2019	Scale	1:1400	File	T01 - T09.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Clayey Silt Till	🟦	21	8	32

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

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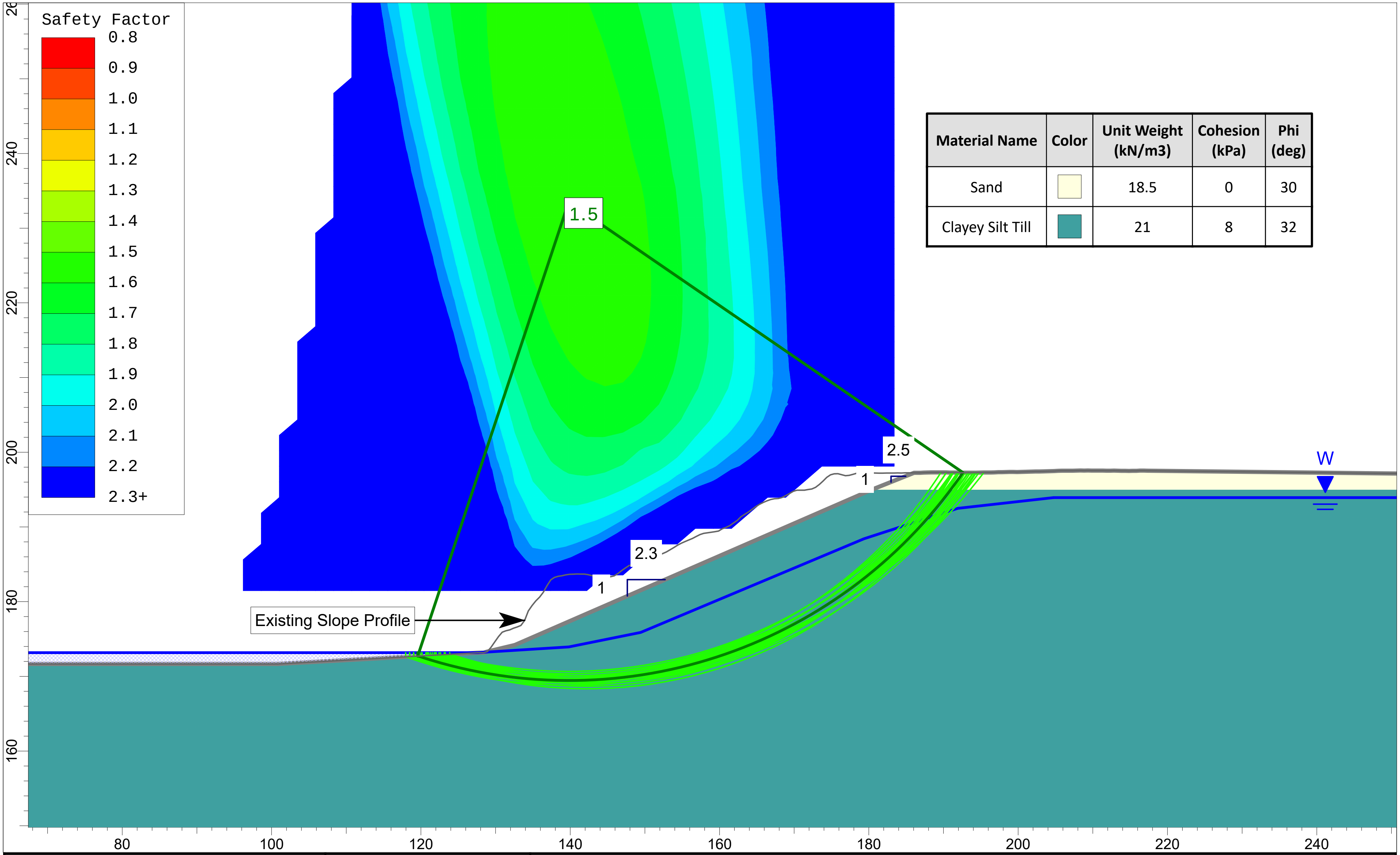
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T9 LTSSC, Master Scenario

Date	7/31/2019	Scale	1:700	File	T01 - T09.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Clayey Silt Till	🟦	21	8	32

Terraprobe

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Construction Materials Inspection & Testing

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T9 LTSSC, high GWT

Date	7/31/2019	Scale	1:700	File	T01 - T09.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		

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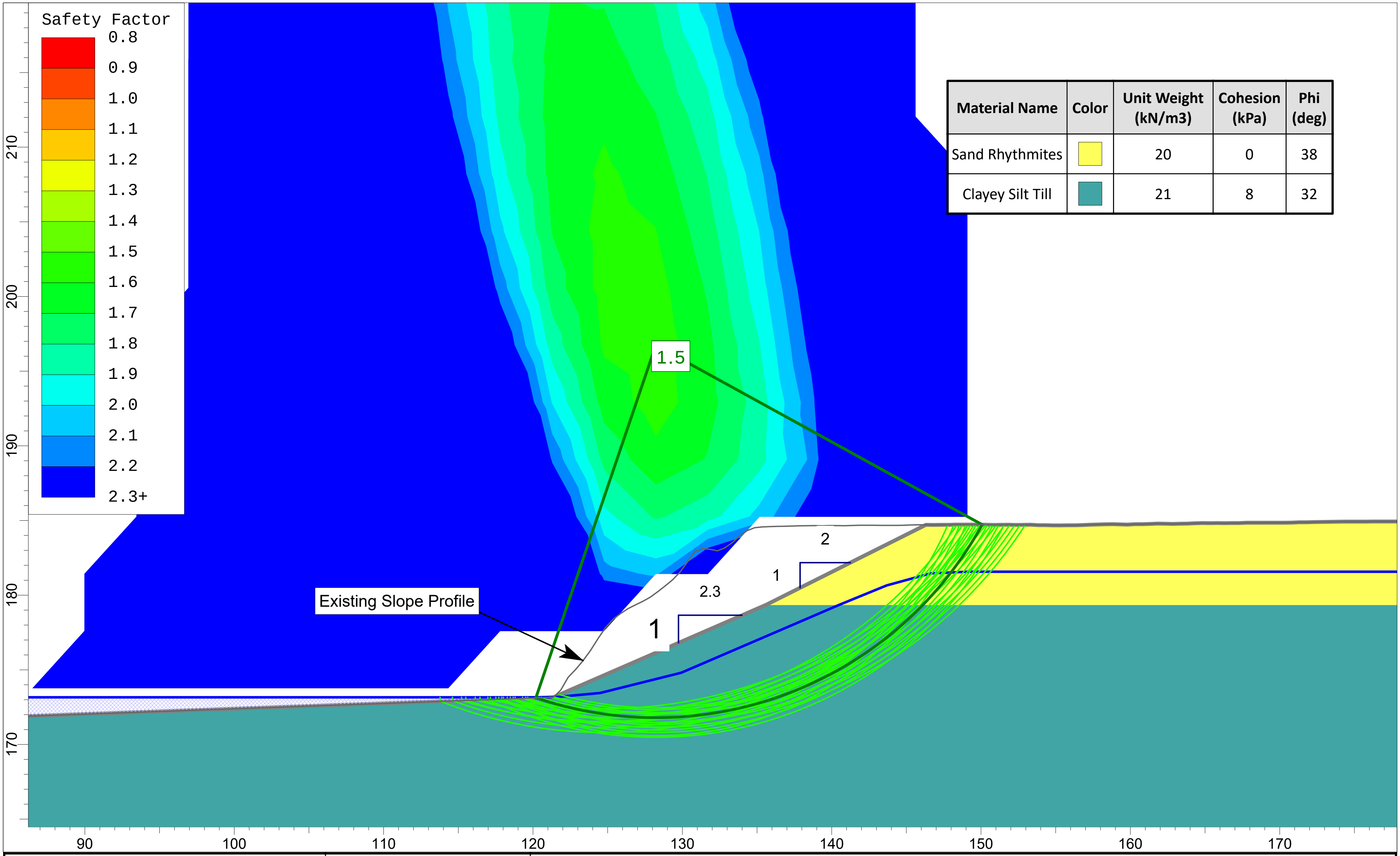


Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand Rhythmites	🟨	20	0	38
Clayey Silt Till	🟩	21	8	32

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

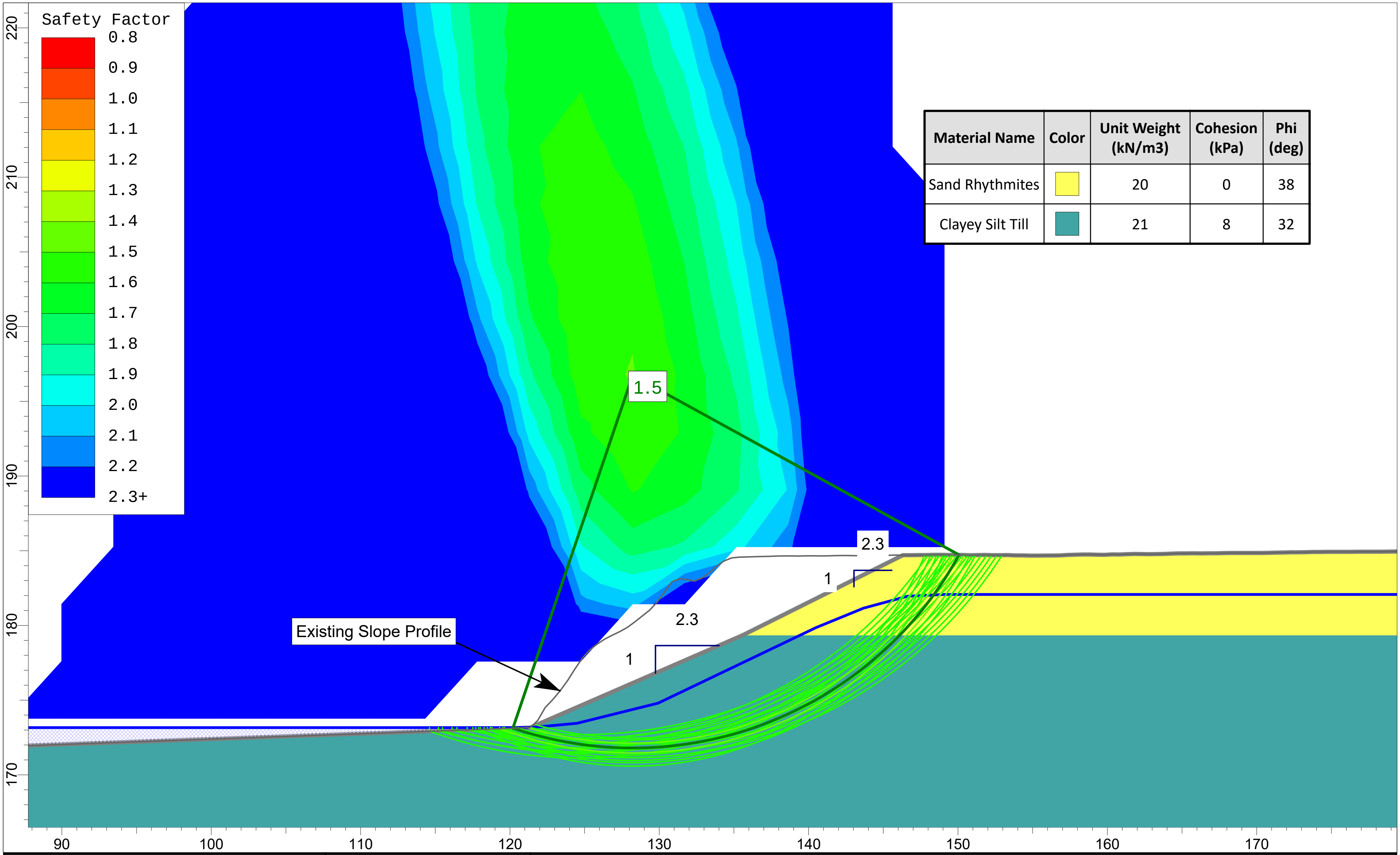
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T13 LTSSC, Master Scenario

Date	8/1/2019	Scale	1:350	File	T11 - T28.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand Rhythmites	🟨	20	0	38
Clayey Silt Till	🟦	21	8	32

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

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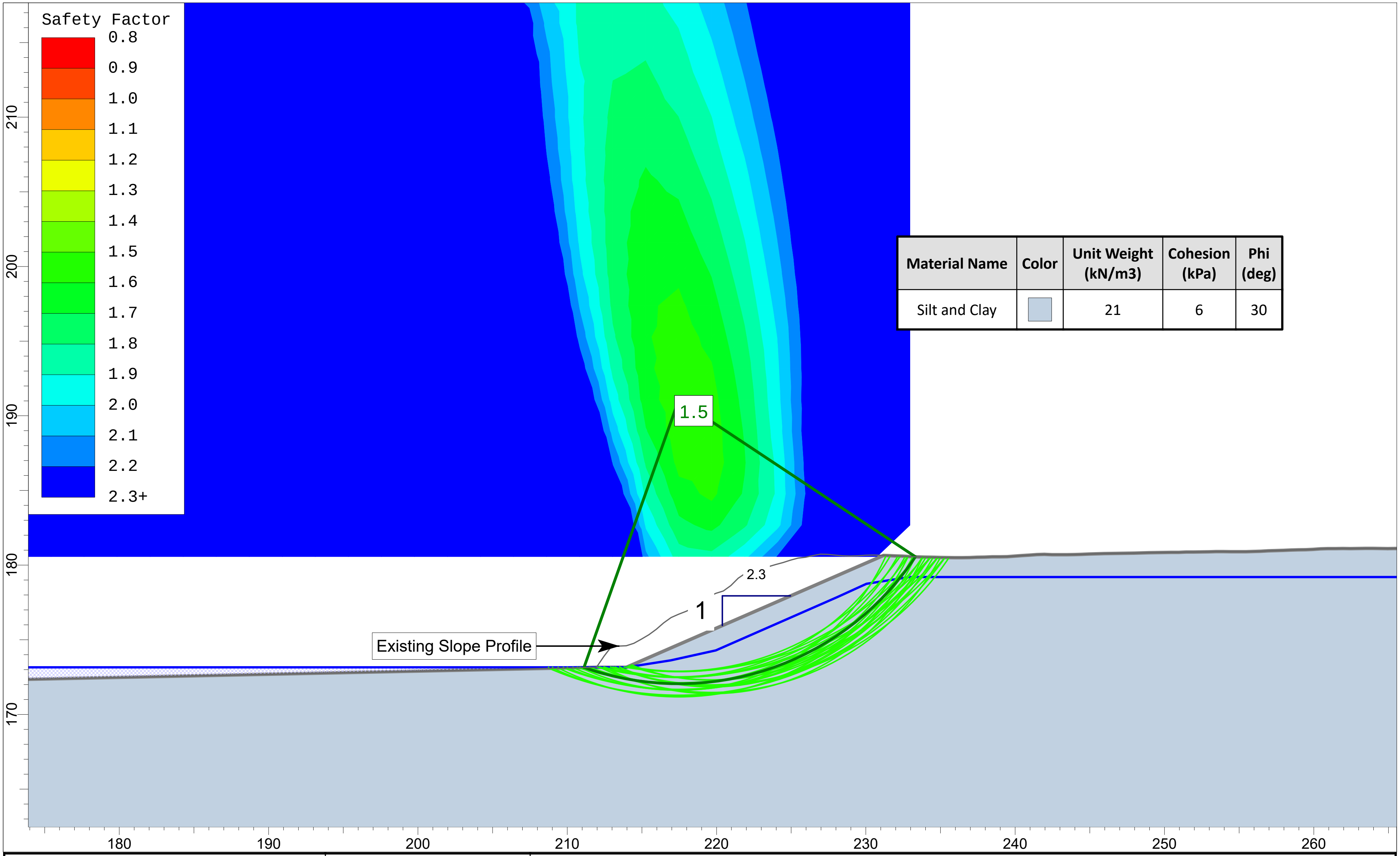
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T13 LTSSC, high gwt

Date 8/1/2019
Scale 1:350
File T11 - T28.slmd
By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

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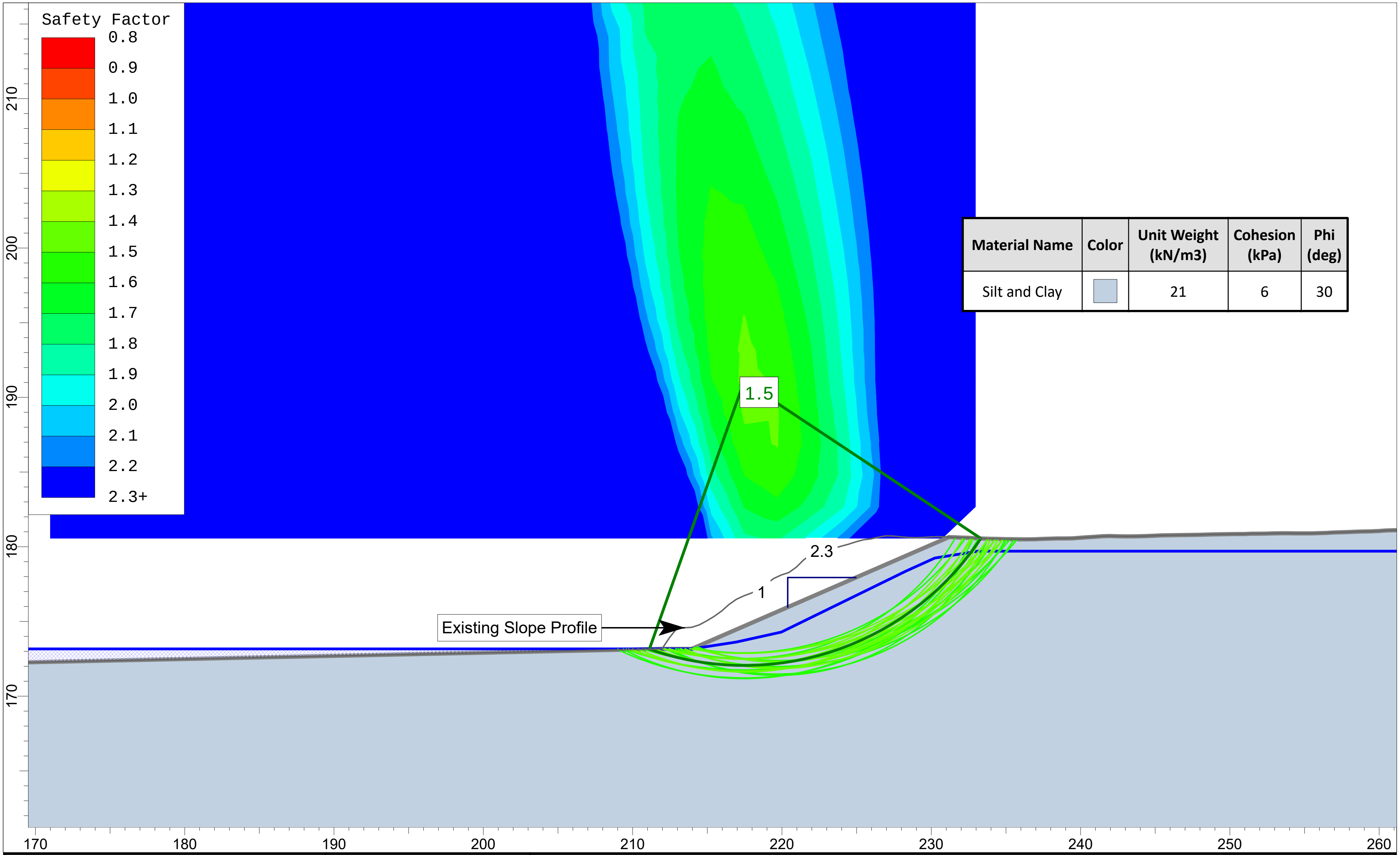
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T15 LTSSC, Master Scenario

Date	8/1/2019	Scale	1:350	File	T11 - T28.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

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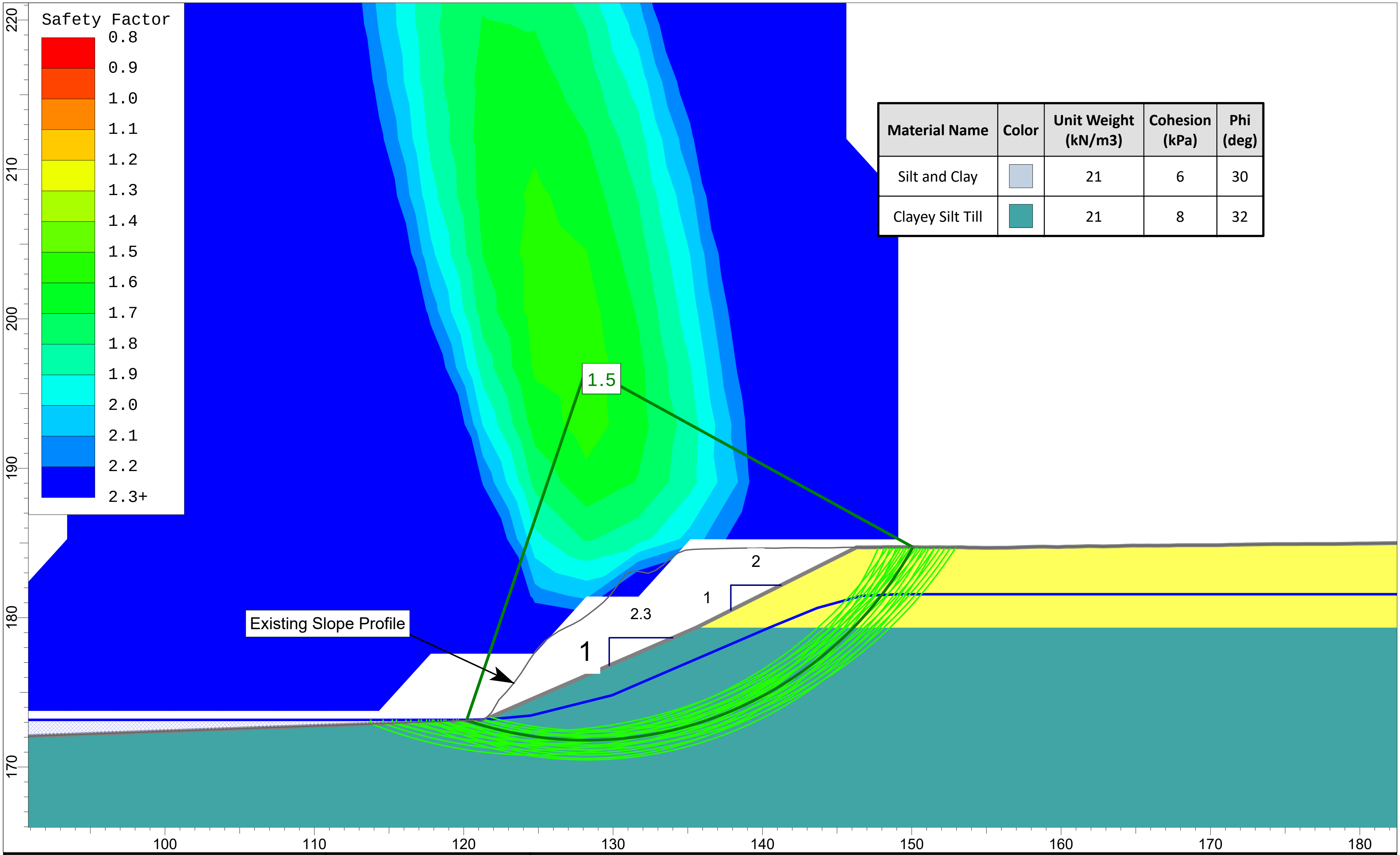
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T15 LTSSC, high gwt

Date 8/1/2019
Scale 1:350
File T11 - T28.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Clayey Silt Till	🟦	21	8	32

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

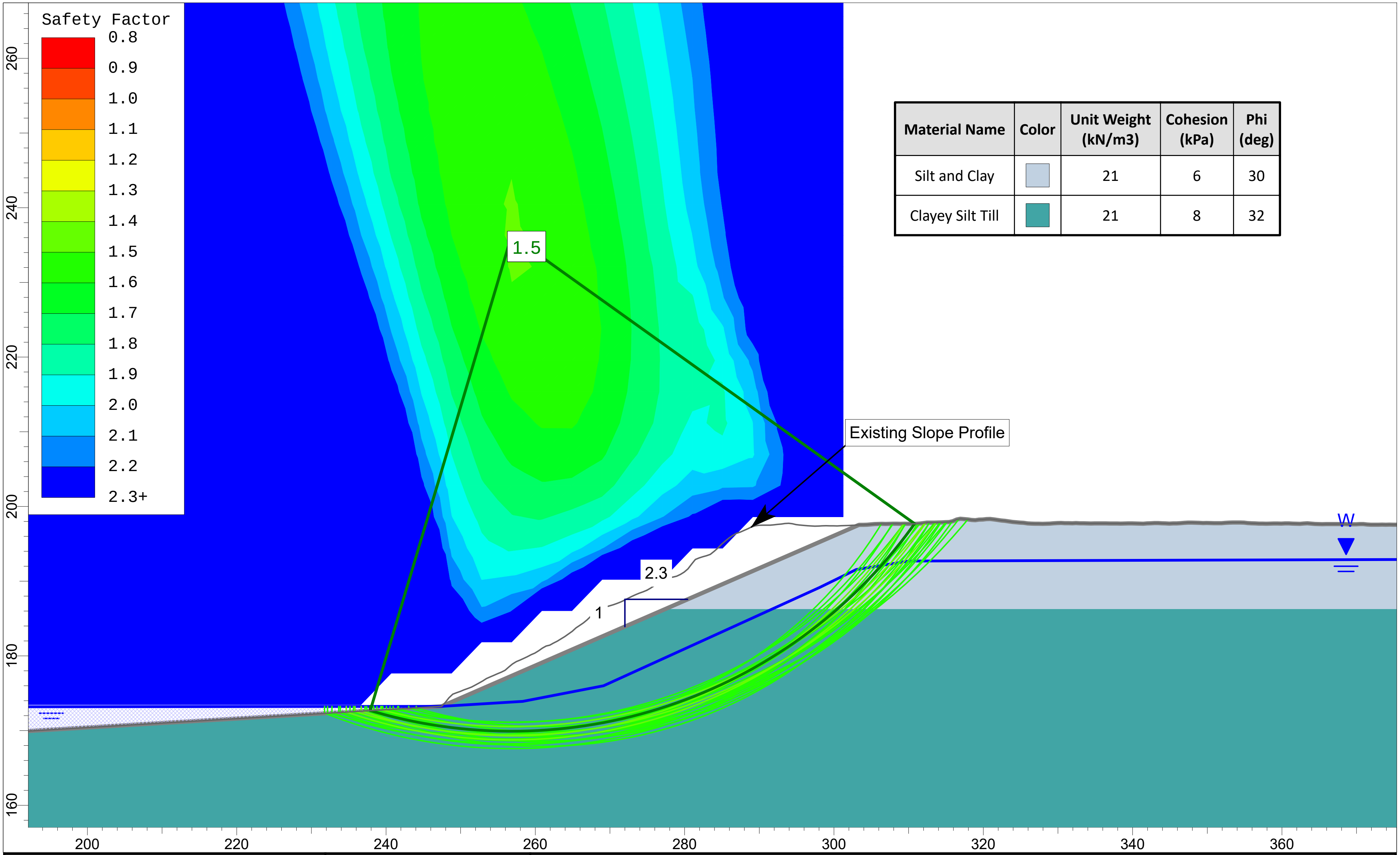
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T13 LTSSC, Master Scenario

Date 8/1/2019
Scale 1:350
File T11 - T28.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Clayey Silt Till	🟦	21	8	32

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

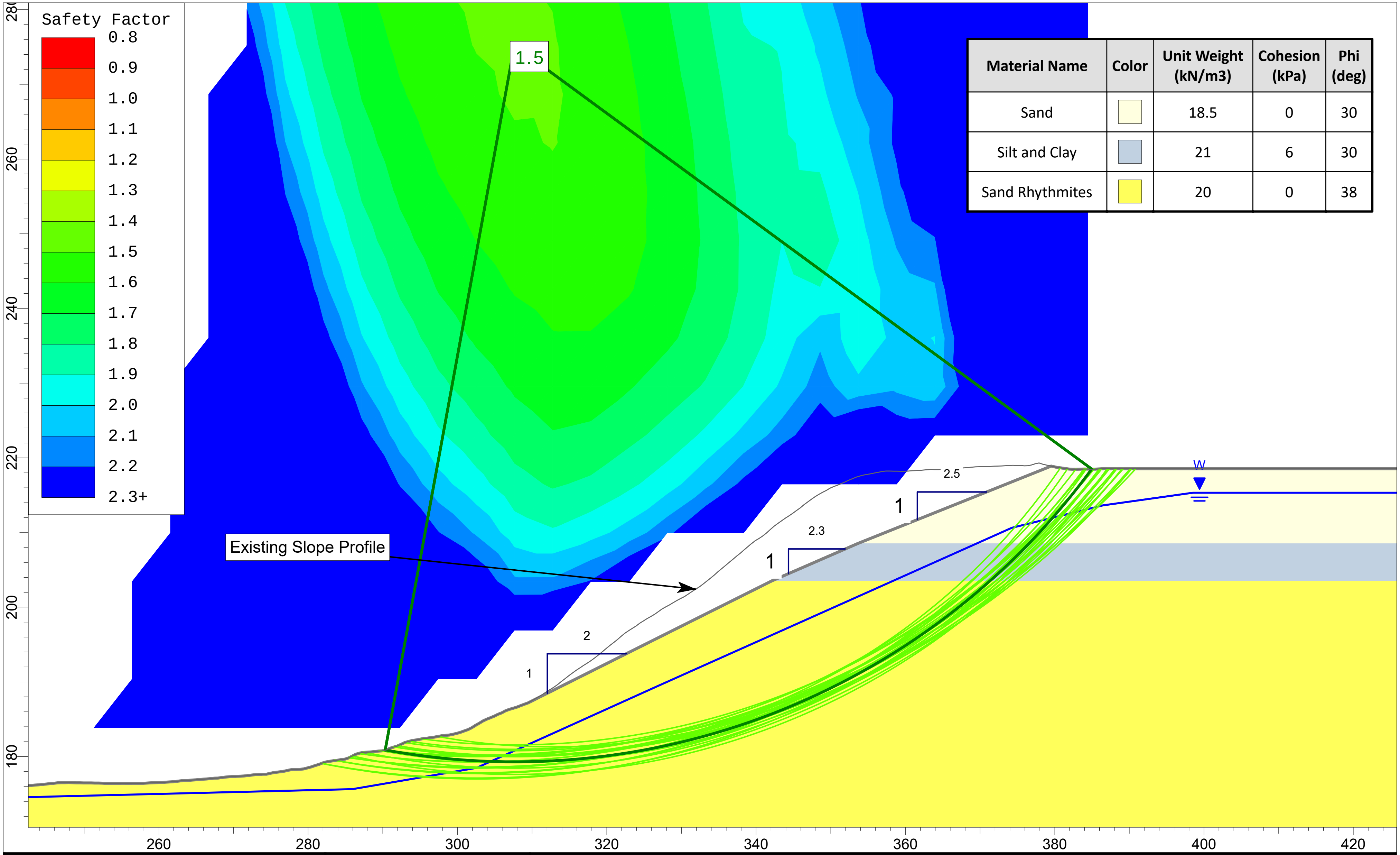
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T31 LTSSC, high gwt

Date 8/1/2019
Scale 1:700
File T31 - T32.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

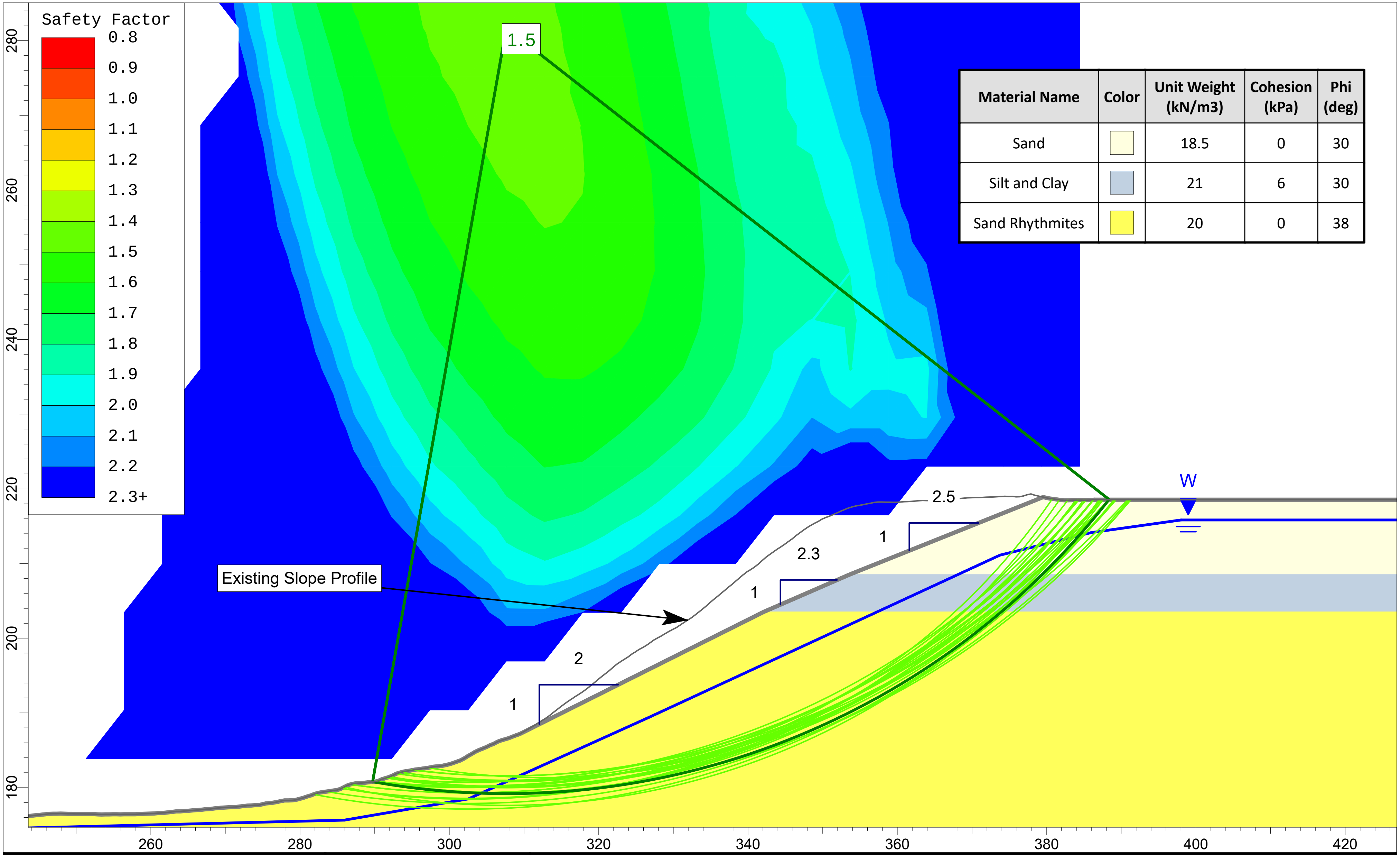
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T37 LTSSC, Master Scenario

Date 8/2/2019
Scale 1:700
File T37 - T38.slmd
By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

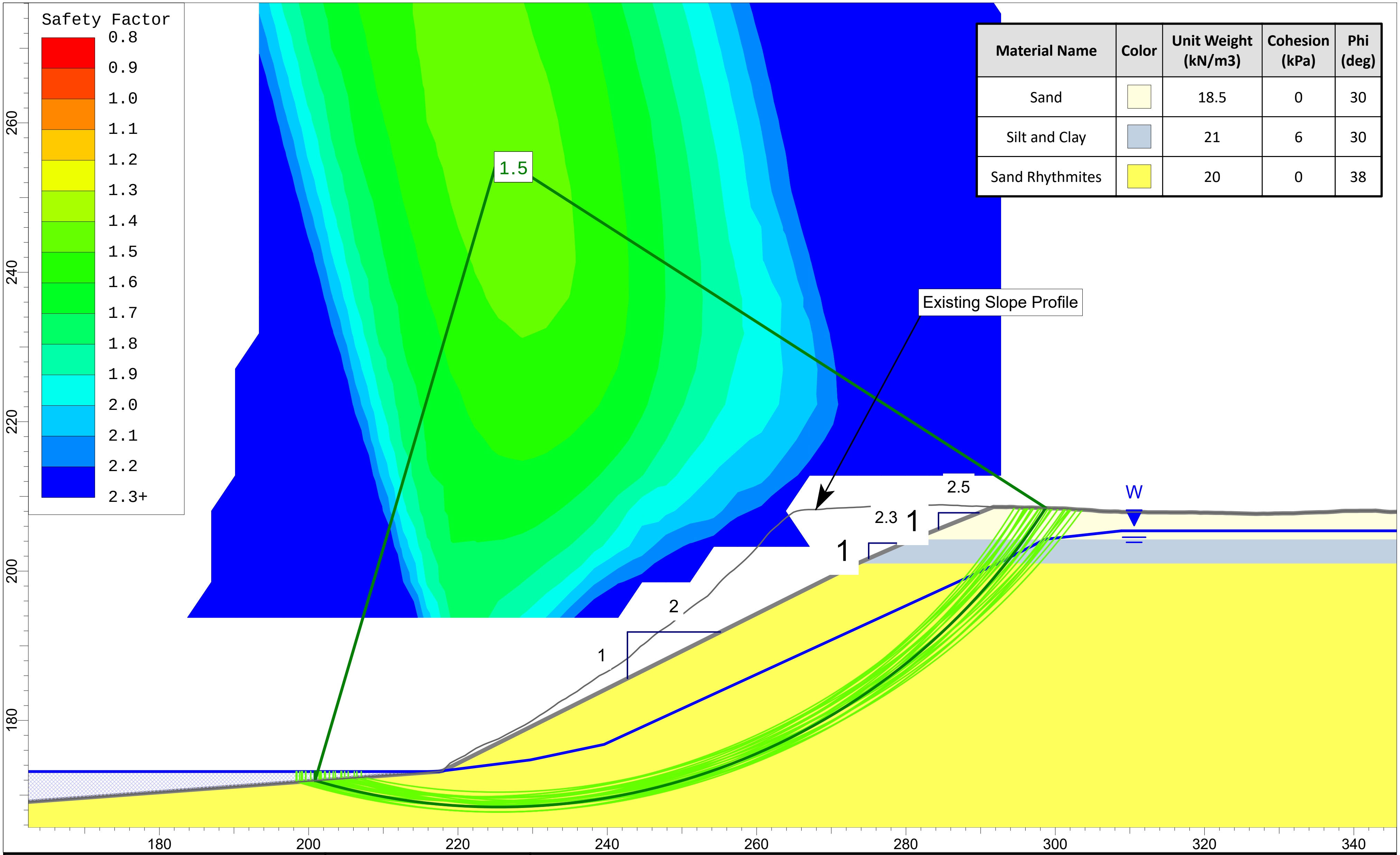
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T37 LTSSC, high gwt

Date	8/2/2019	Scale	1:700	File	T37 - T38.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

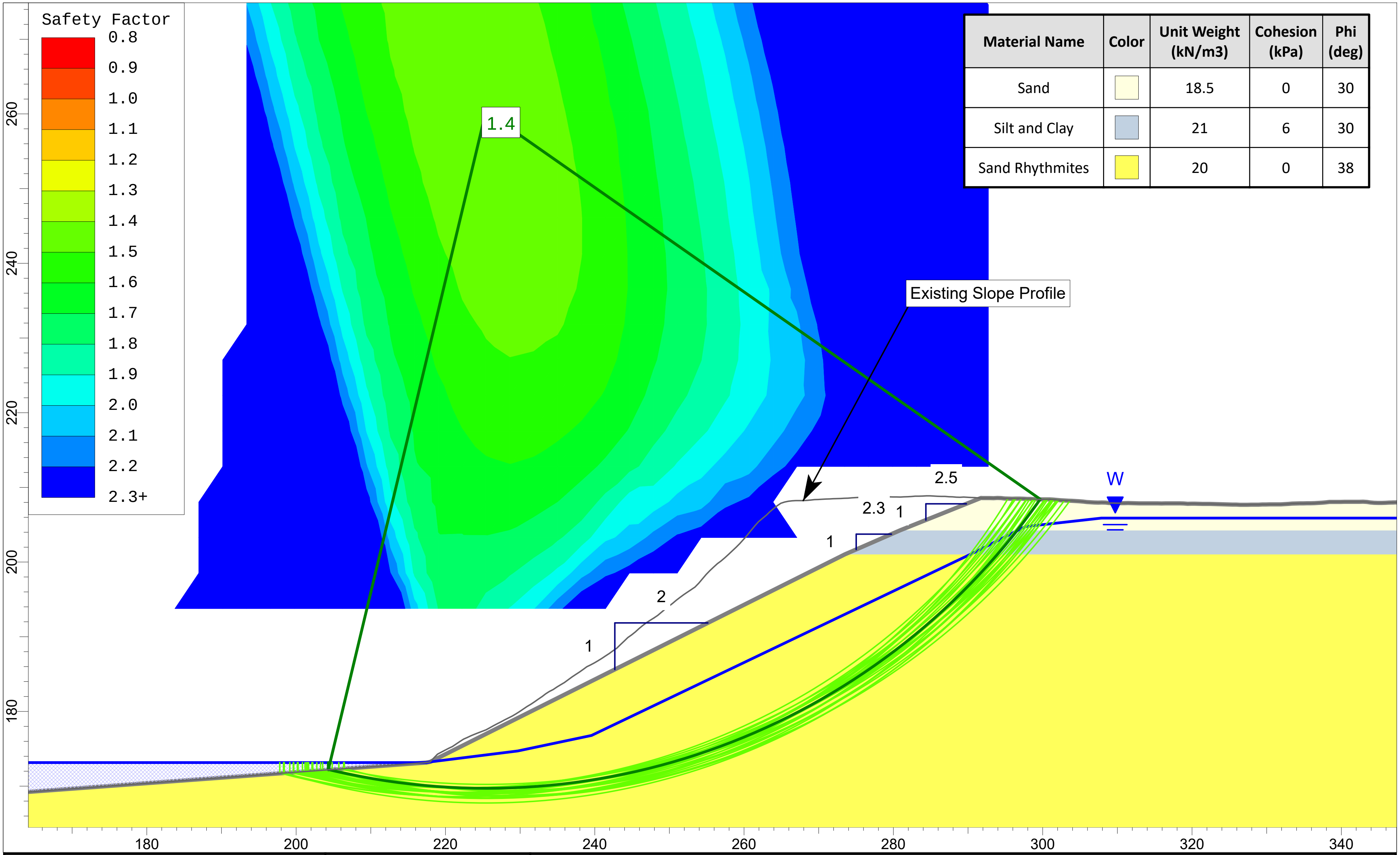
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T38 LTSSC, Master Scenario

Date 8/2/2019
Scale 1:700
File T37 - T38.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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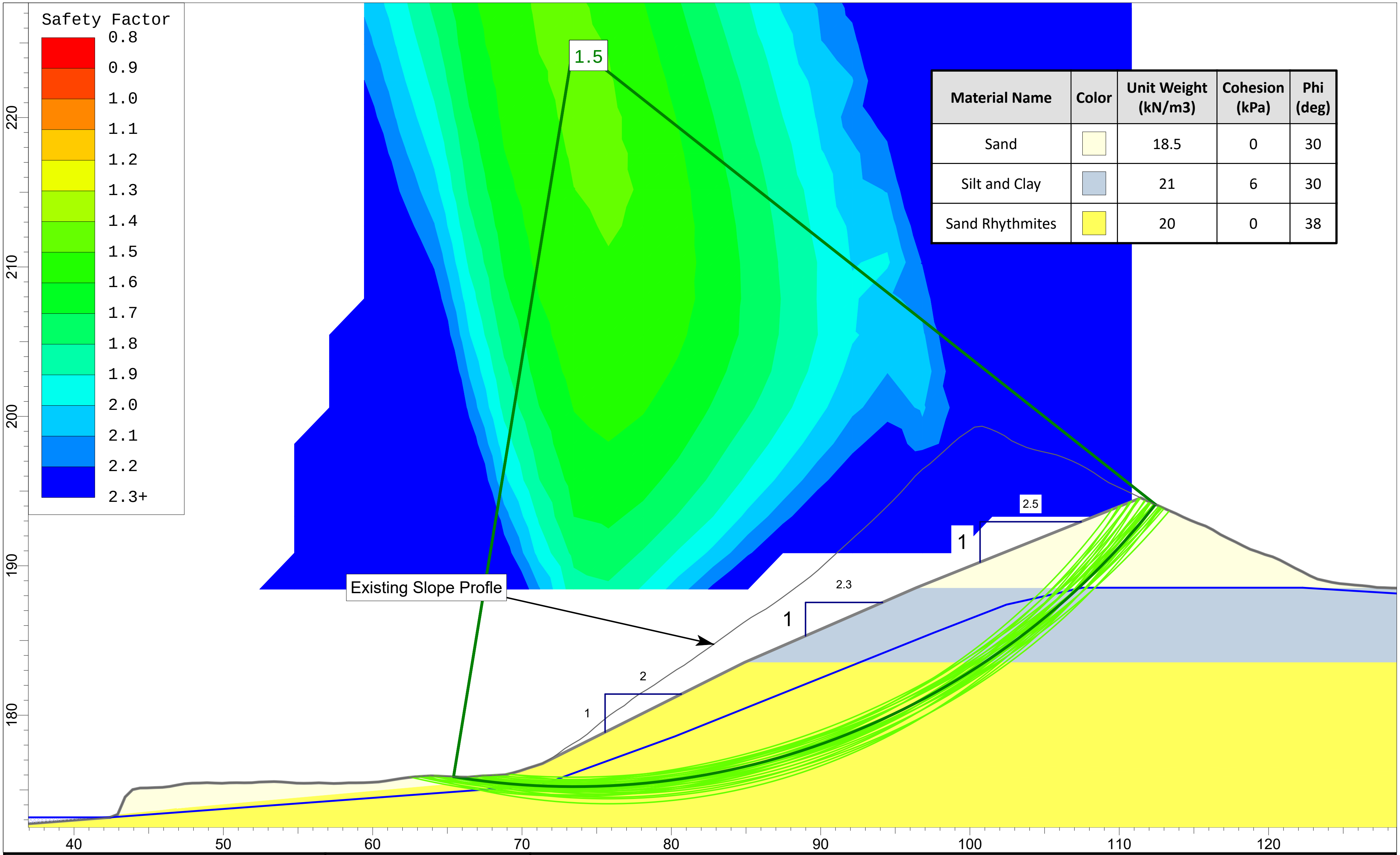
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T38 LTSSC, high gwt
Date	8/2/2019
Scale	1:700
File	T37 - T38.slmd
By	JH/JC
Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	▢	18.5	0	30
Silt and Clay	▢	21	6	30
Sand Rhythmites	▢	20	0	38

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Norfolk County Hazard Mapping | 1-19-0230-01

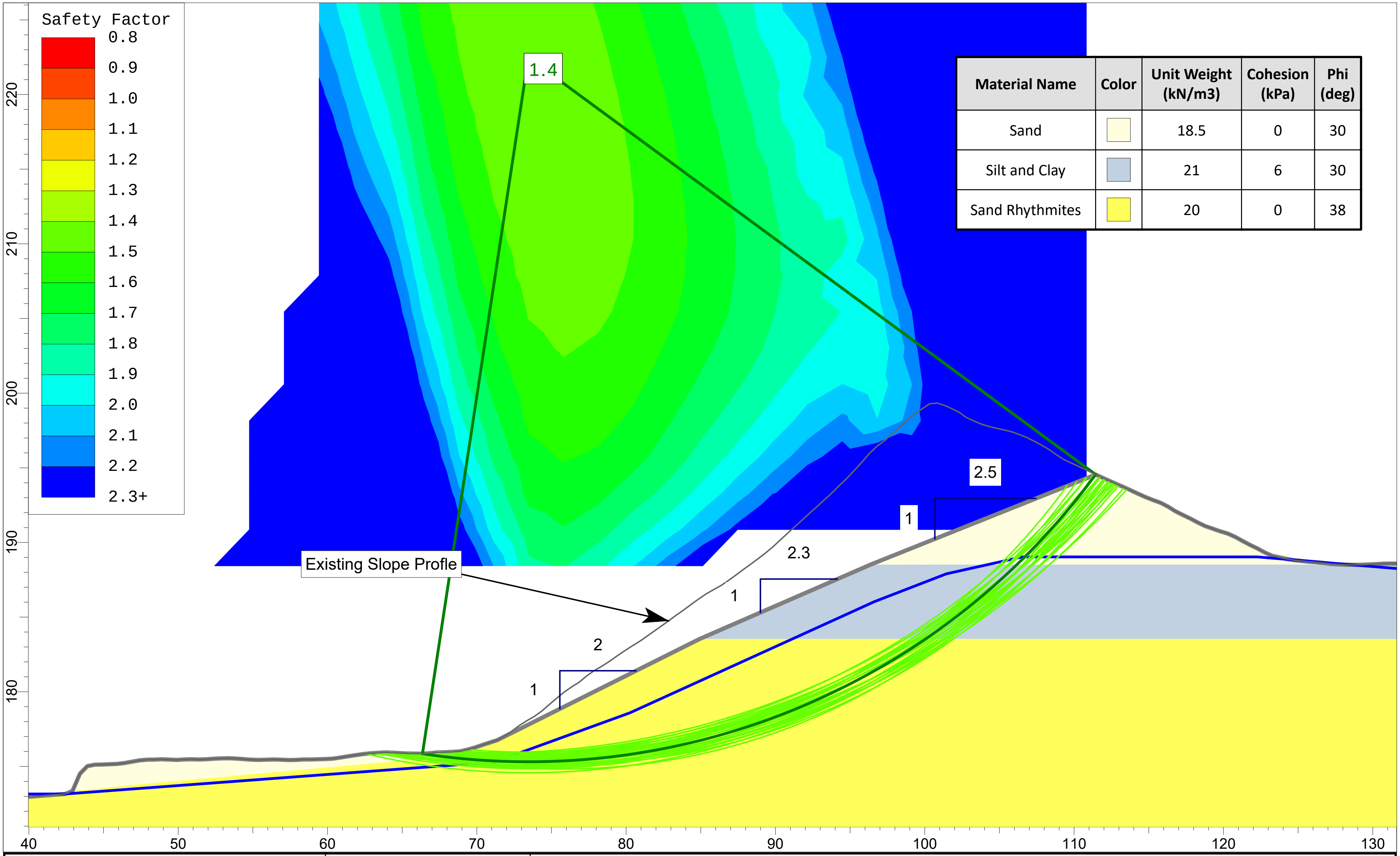
Analysis

Global Stability: T39 LTSSC, Master Scenario

Date	Scale	File
8/2/2019	1:350	T39 - T40.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T39 LTSSC, high gwt

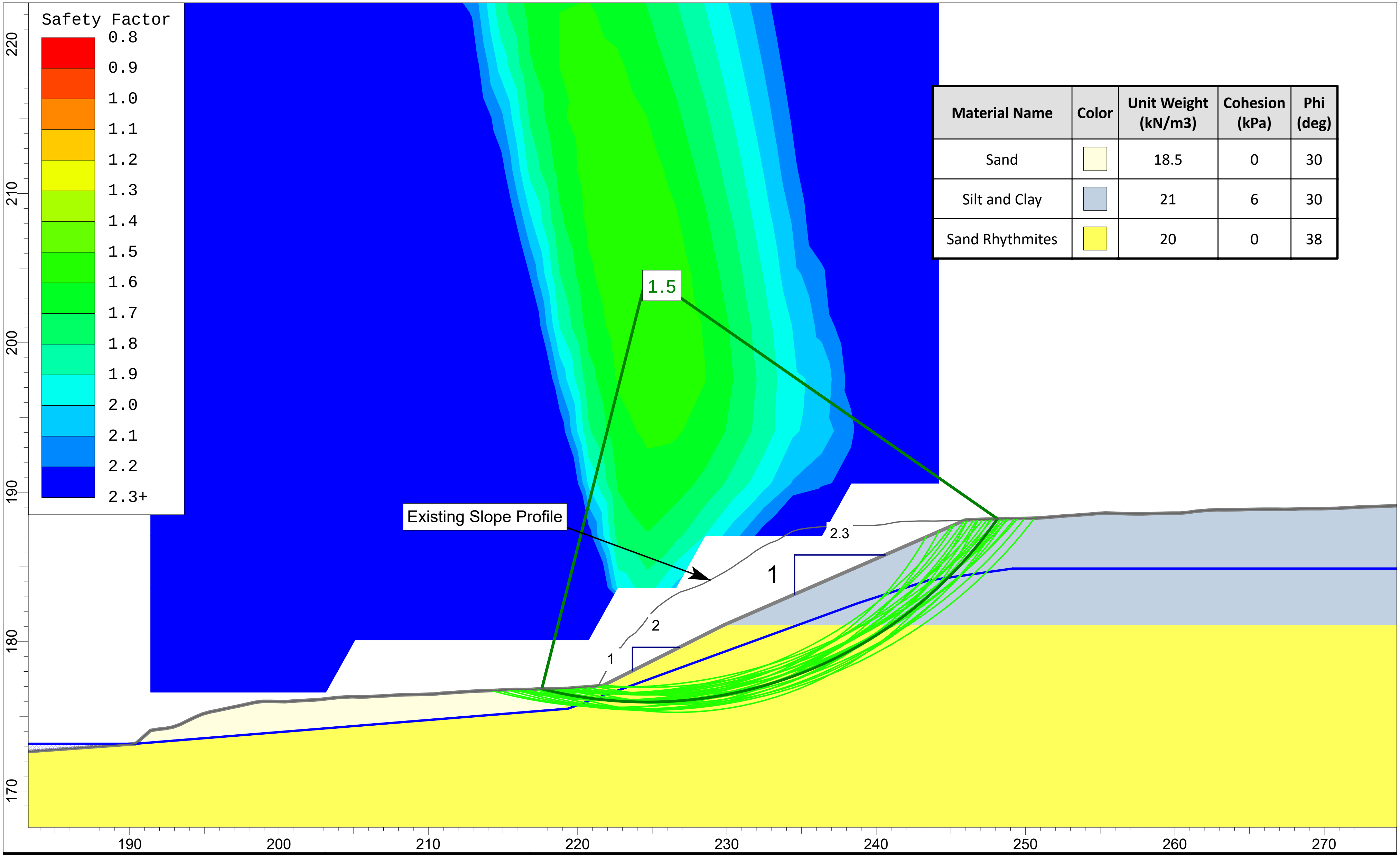
Date 8/2/2019

Scale 1:350

File T39 - T40.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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Construction Materials Inspection & Testing

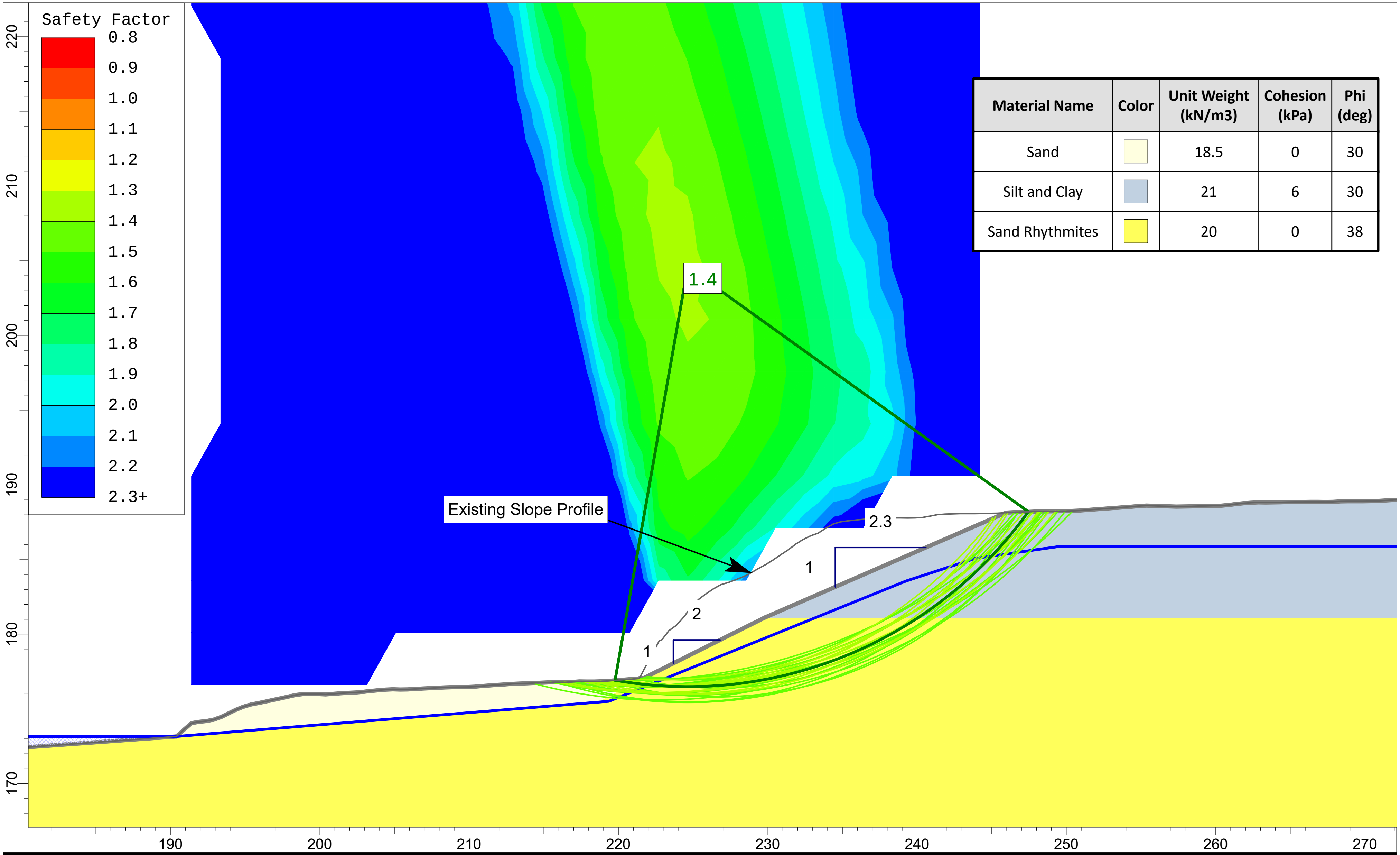
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T40 LTSSC, Master Scenario

Date 8/2/2019
Scale 1:350
File T39 - T40.slmd
By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	⬜	18.5	0	30
Silt and Clay	▨	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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SLIDEINTERPRET 8.016

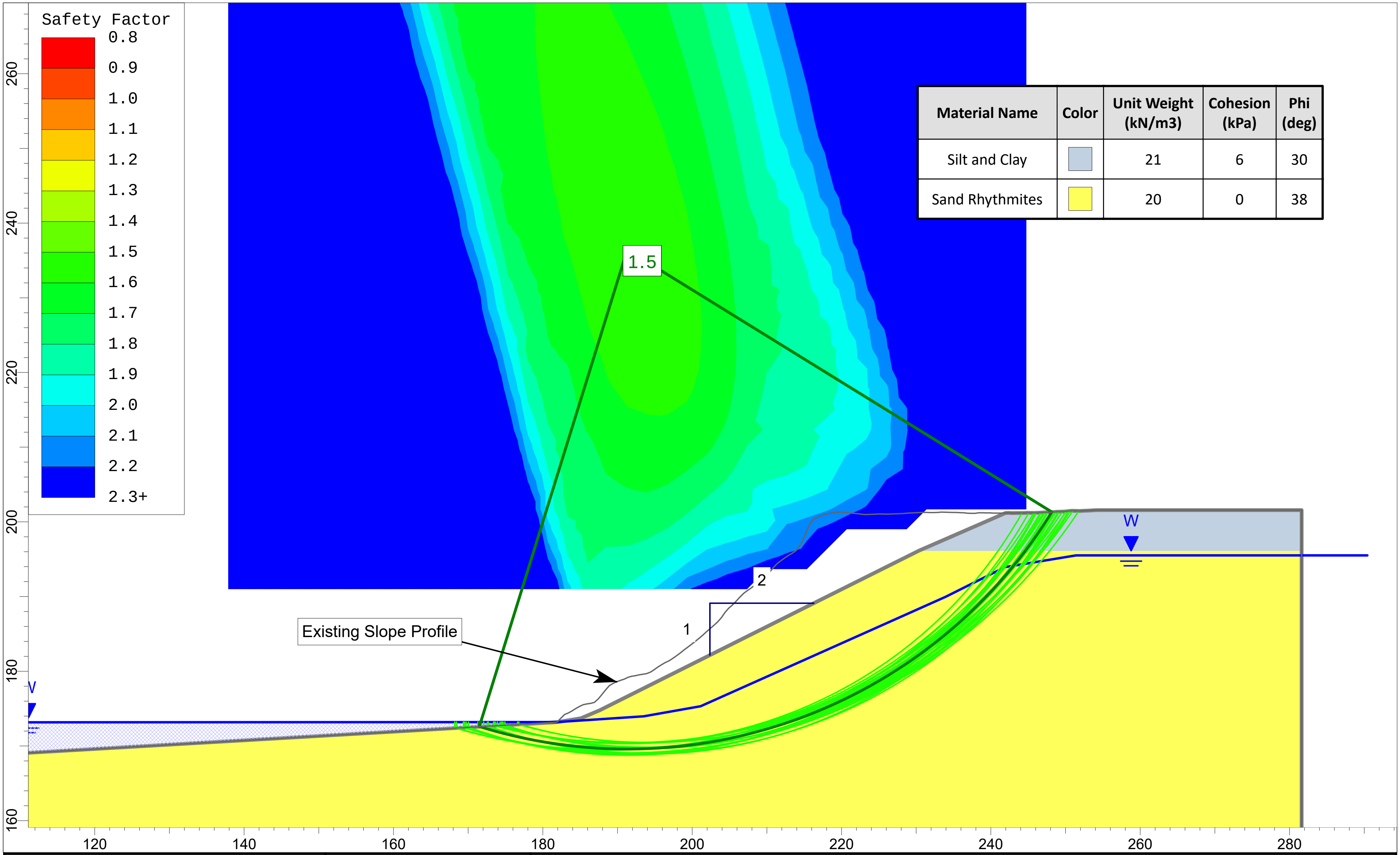
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T40 LTSSC, high gwt

Date 8/2/2019
Scale 1:350
File T39 - T40.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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Construction Materials Inspection & Testing

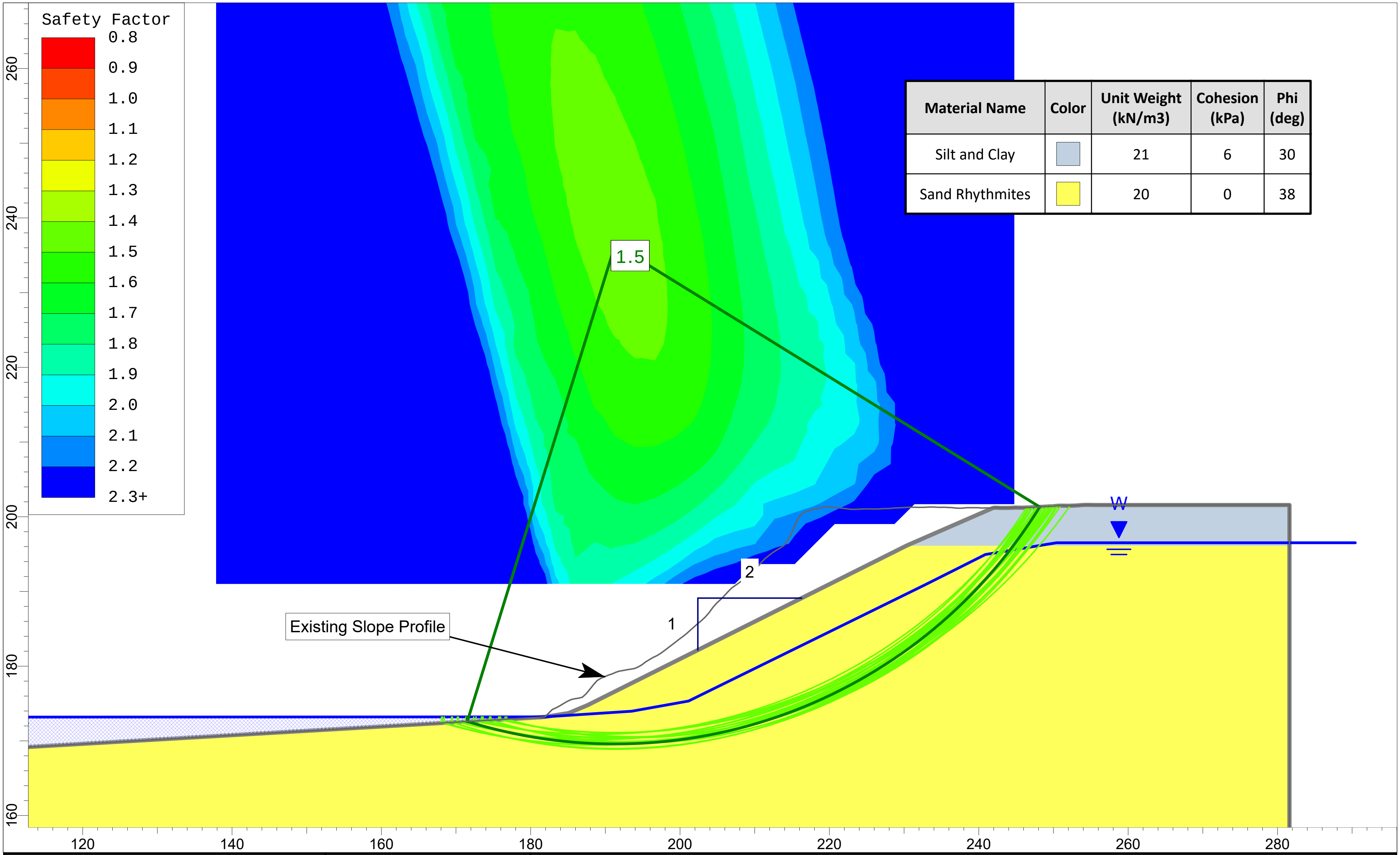
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T41 LTSSC, Master Scenario

Date	8/2/2019	Scale	1:700	File	T41 - T42.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Norfolk County Hazard Mapping | 1-19-0230-01

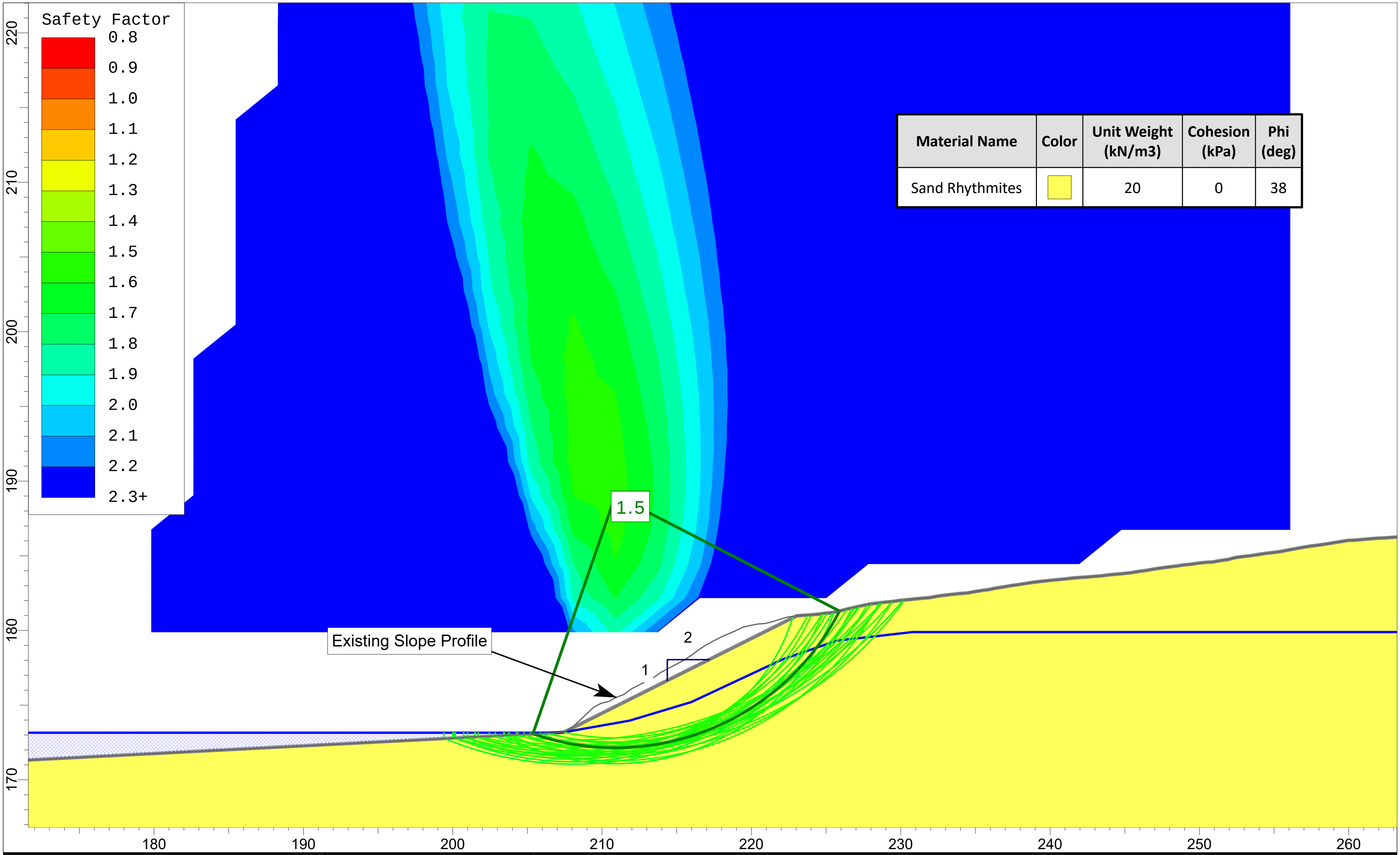
Analysis

Global Stability: T41 LTSSC, high gwt

Date	Scale	File
8/2/2019	1:700	T41 - T42.slmd

By: JH/JC

Ref.: LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand Rhythmites	🟨	20	0	38

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

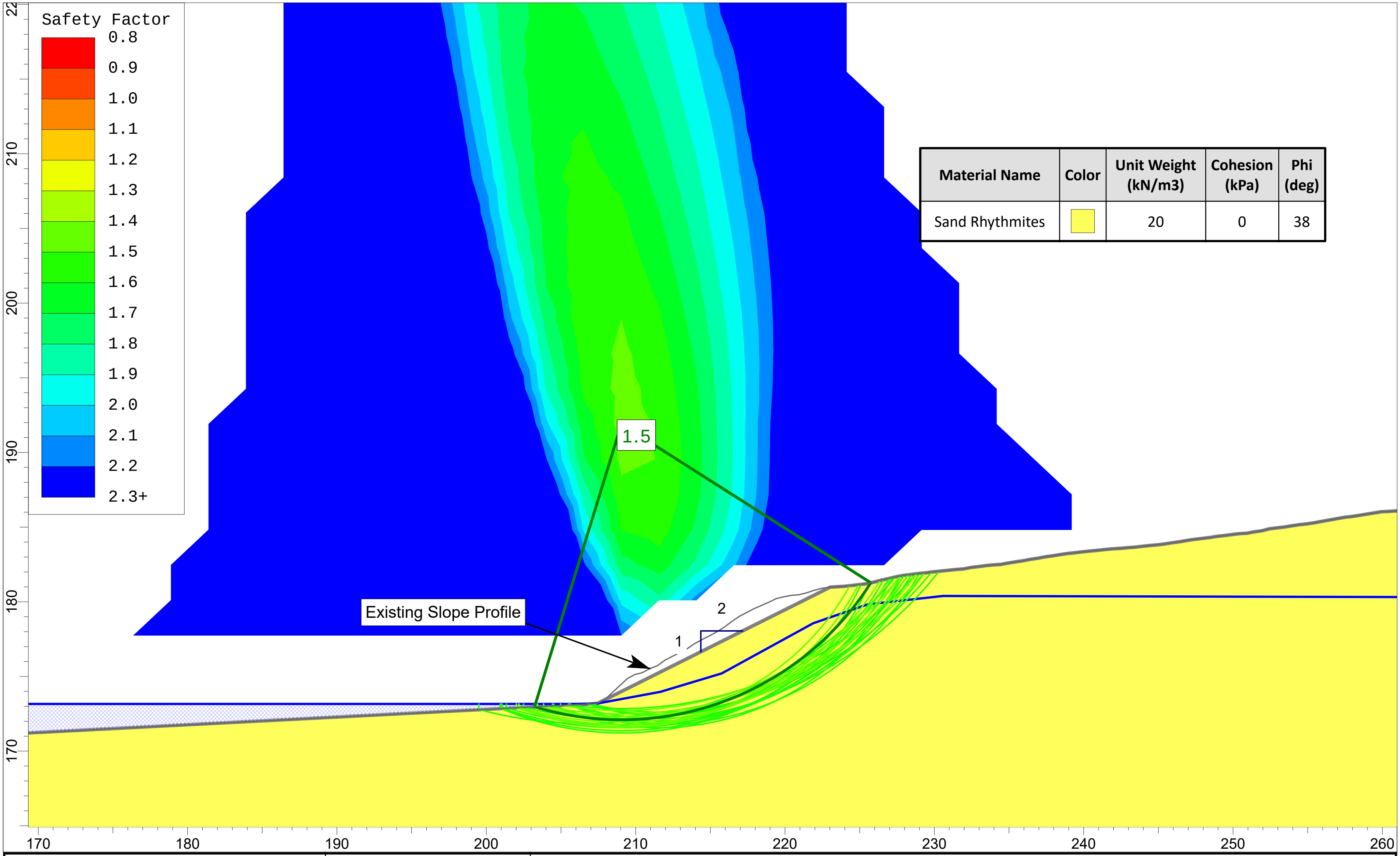
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T42 LTSSC, Master Scenario

Date 8/2/2019
Scale 1:350
File T41 - T42.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand Rhythmites	🟨	20	0	38

Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T42 LTSSC, high gwt

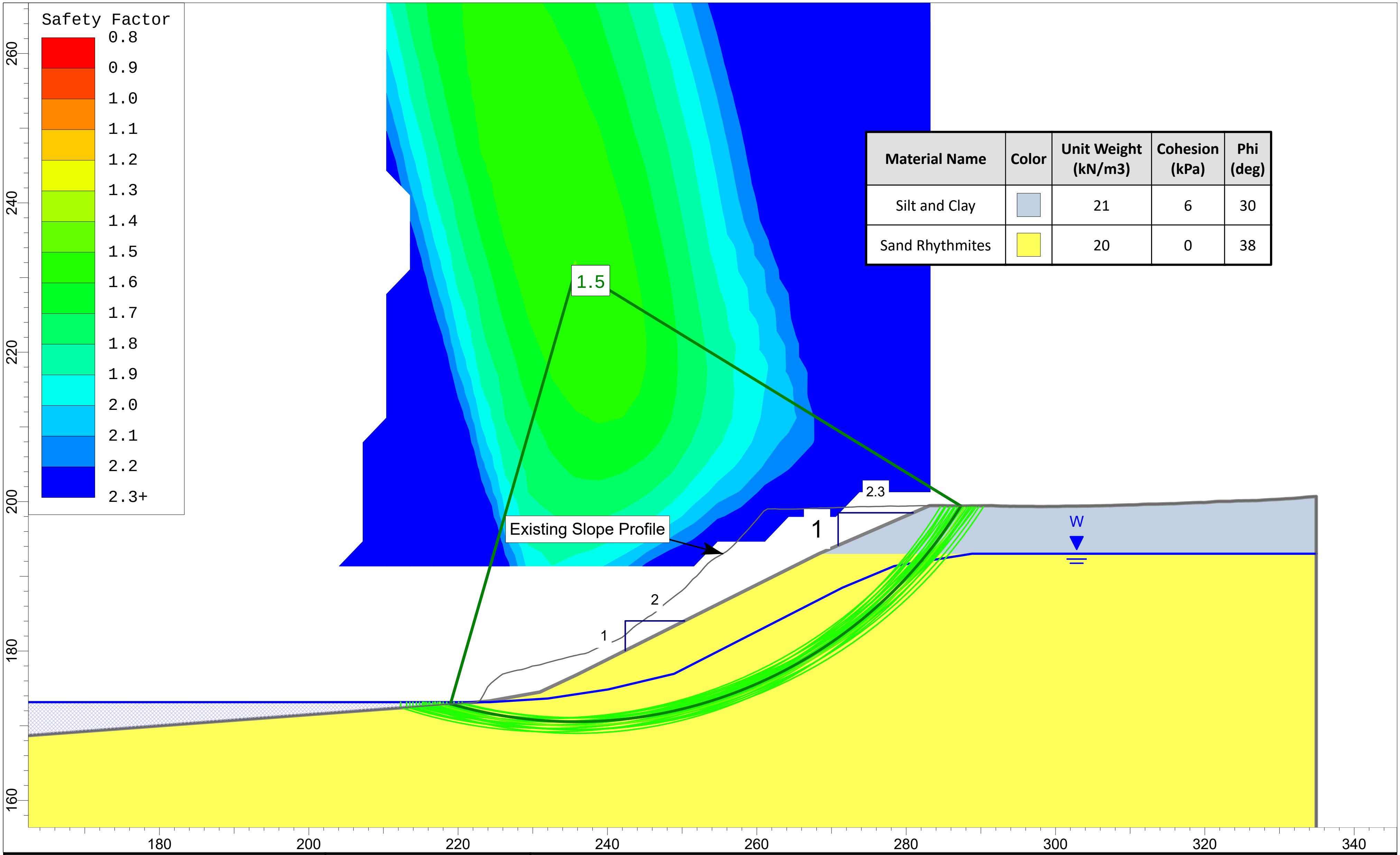
Date 8/2/2019

Scale 1:350

File T41 - T42.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	⬜	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
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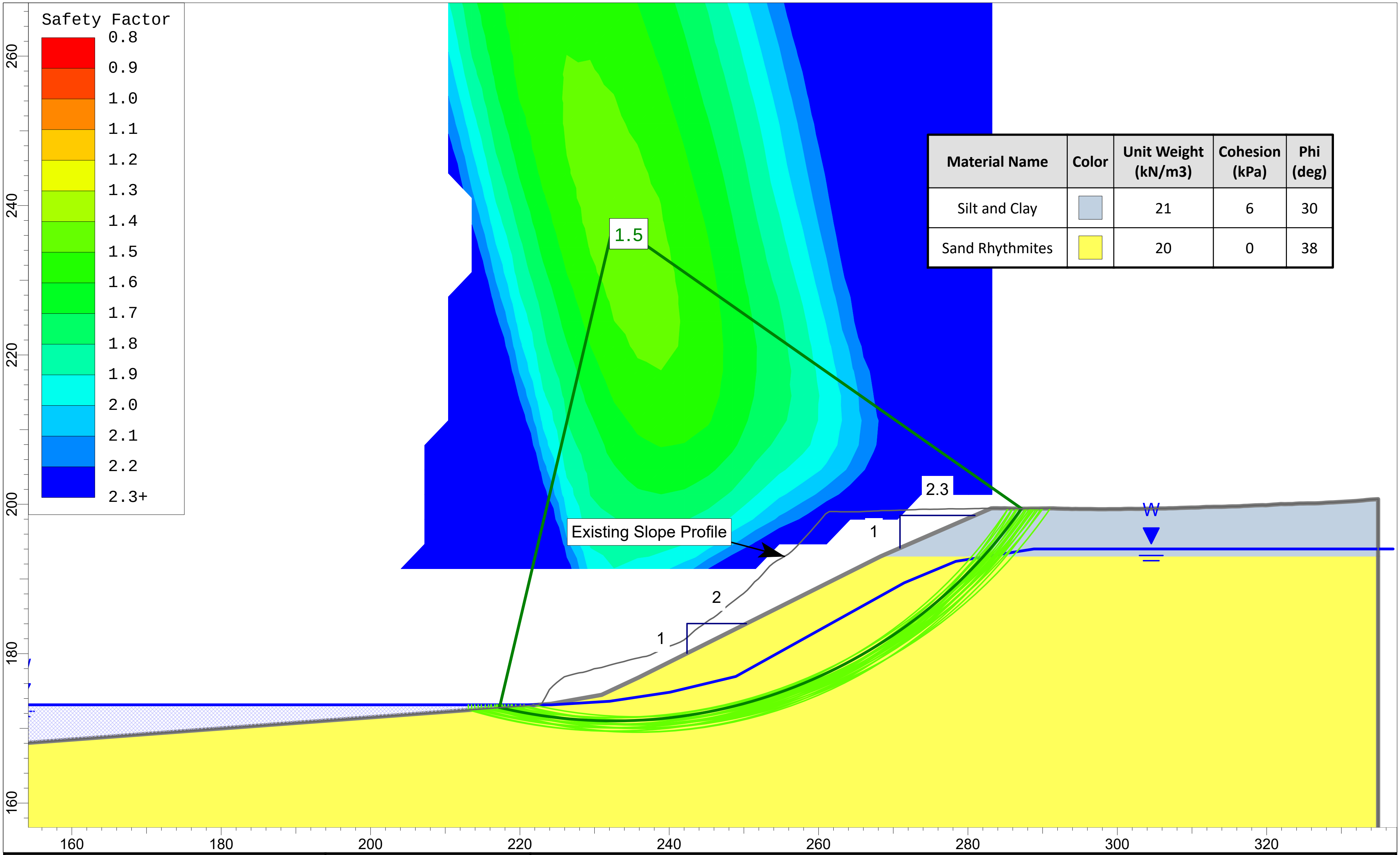
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T43 LTSSC, Master Scenario

Date	8/6/2019	Scale	1:700	File	T43 - T44.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



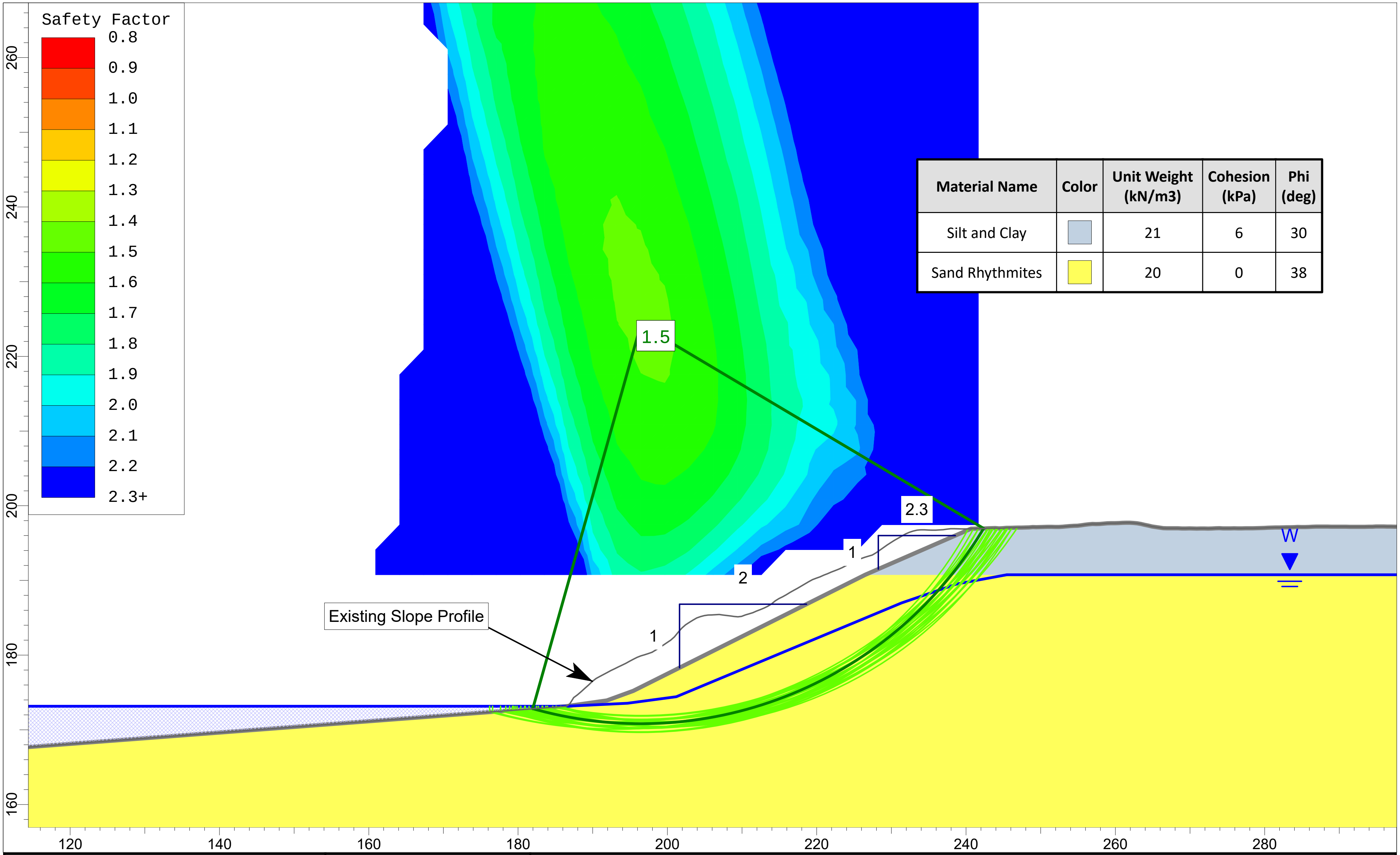
Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T43 LTSSC, high gwt
Date	8/6/2019
Scale	1:700
File	T43 - T44.slmd
By	JH/JC
Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

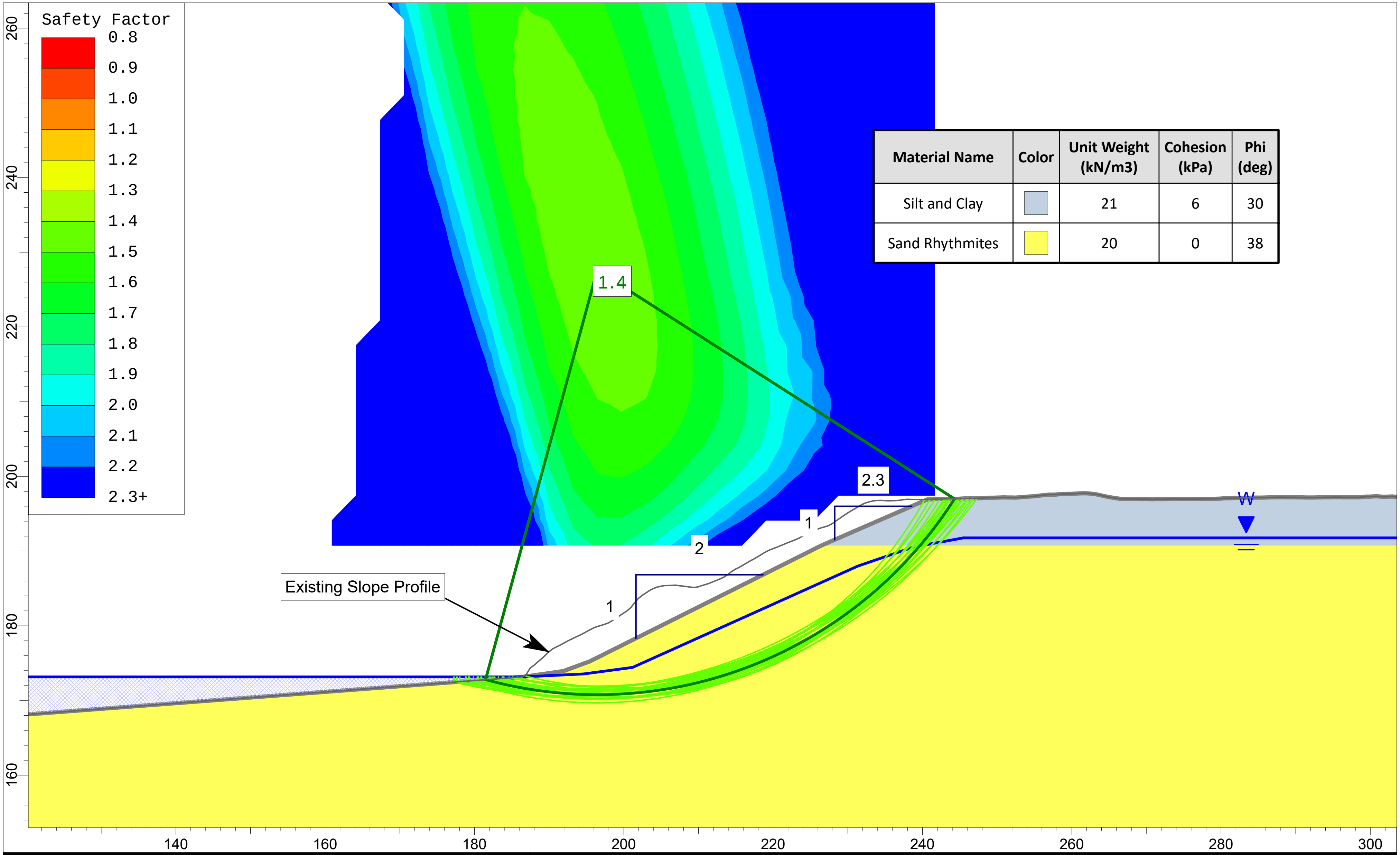
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T44 LTSSC, Master Scenario

Date	8/6/2019	Scale	1:700	File	T43 - T44.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

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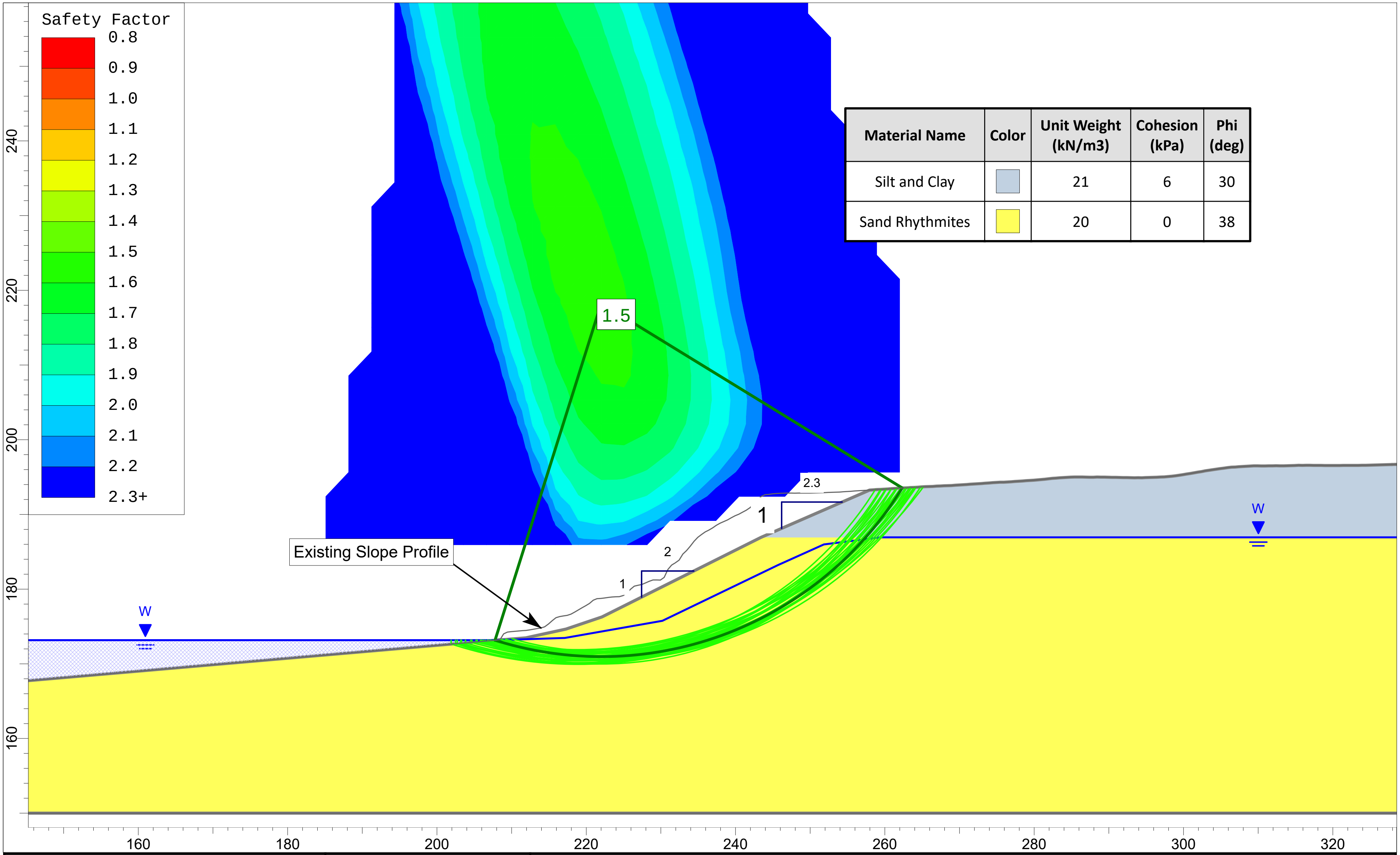
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T44 LTSSC, high gwt

Date	8/6/2019	Scale	1:700	File	T43 - T44.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

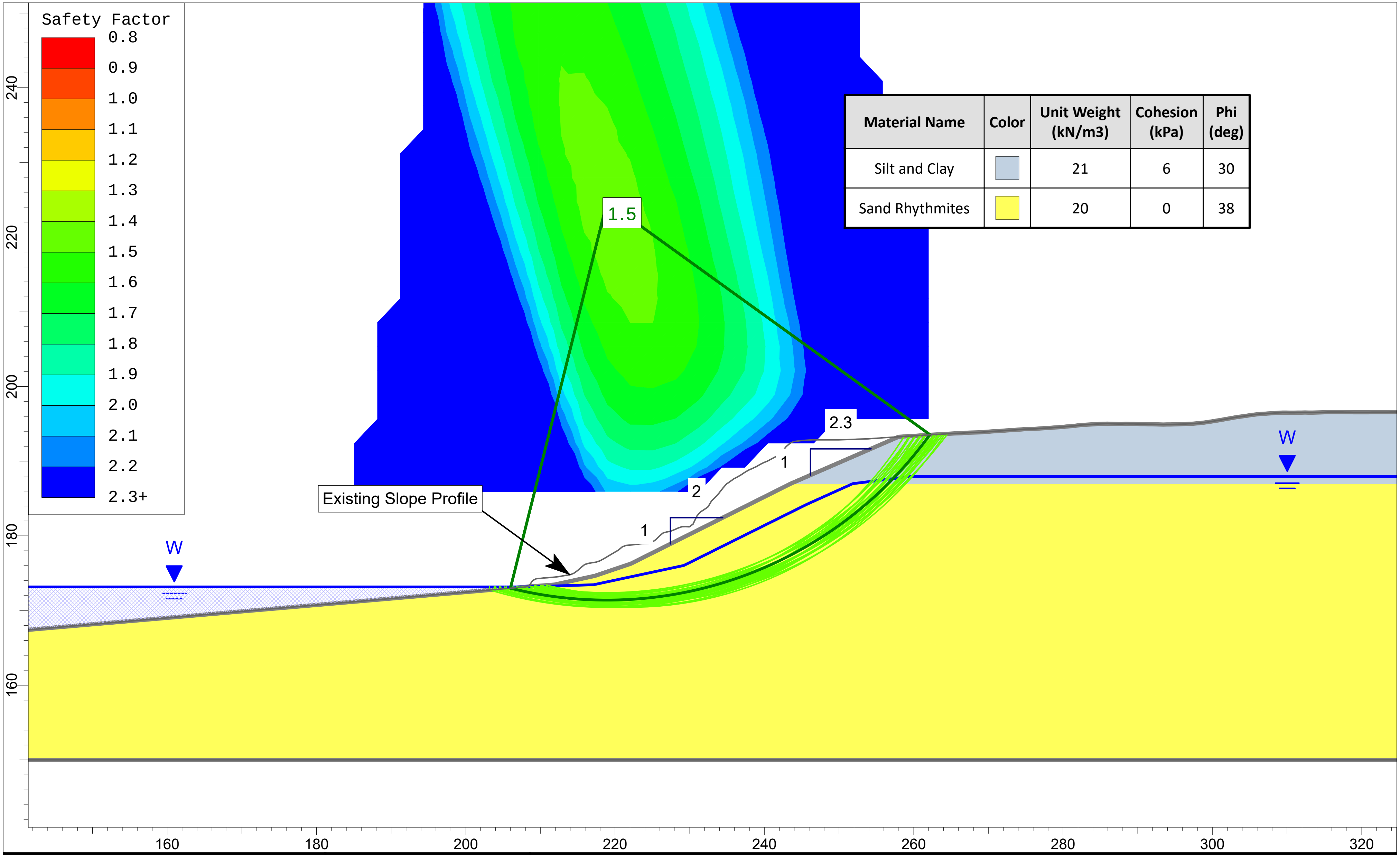
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T45 LTSSC, Master Scenario

Date 8/6/2019
Scale 1:700
File T45 - T46.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	🟦	21	6	30
Sand Rhythmites	🟨	20	0	38

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

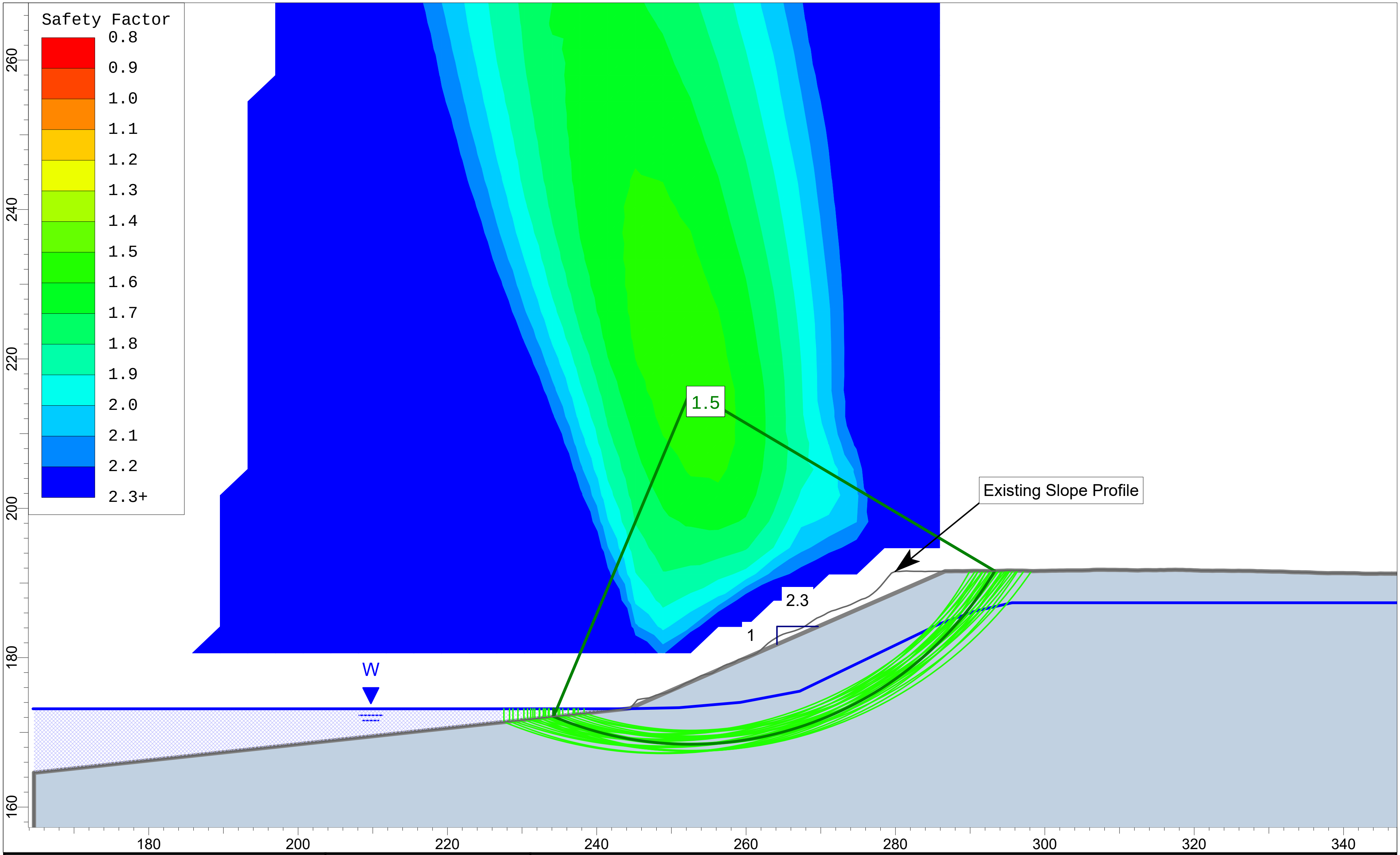
Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T45 LTSSC, high gwt

Date	8/6/2019	Scale	1:700	File	T45 - T46.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Terraprobe
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Construction Materials Inspection & Testing

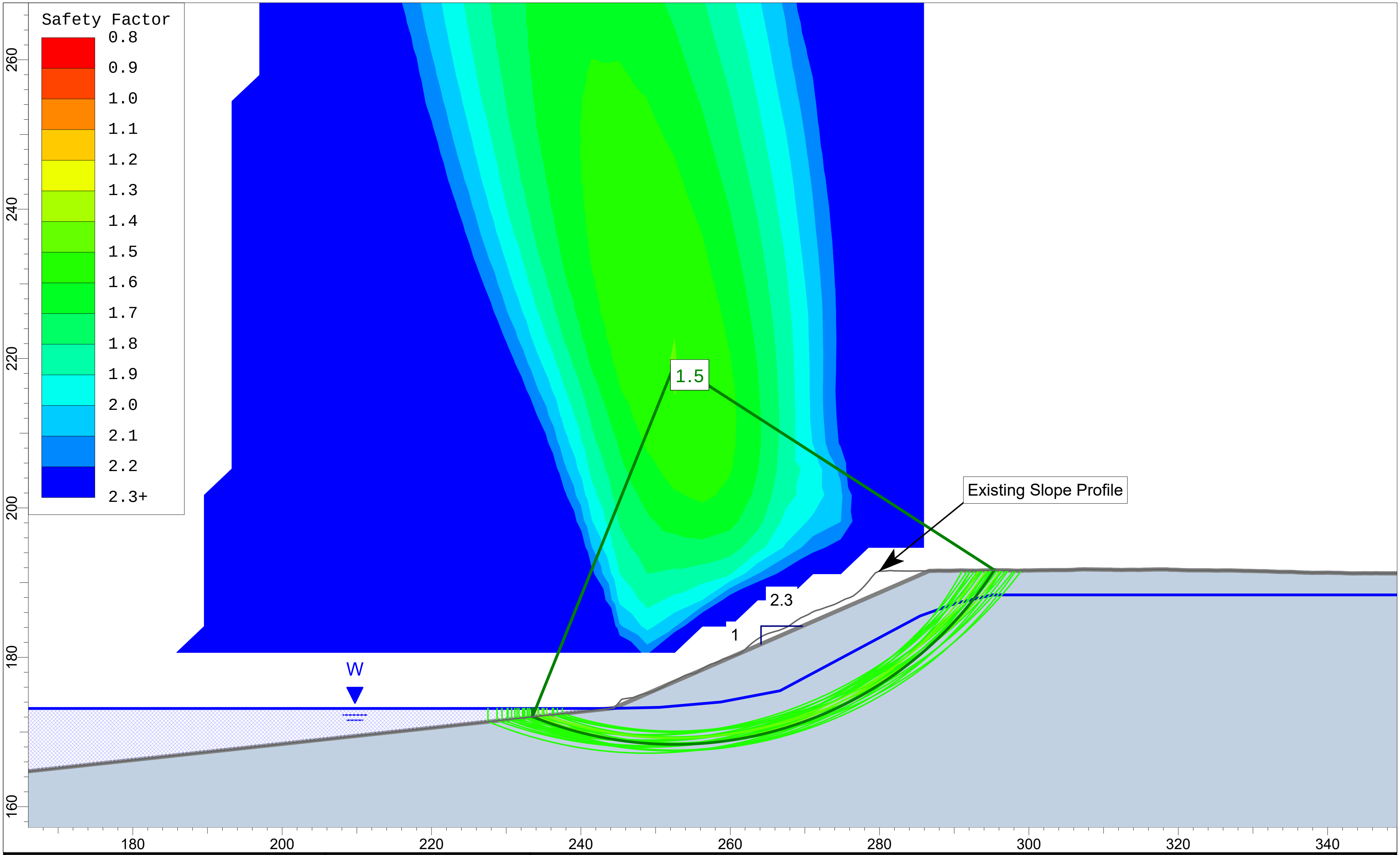
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T47 LTSSC, Master Scenario

Date 8/1/2019
Scale 1:700
File T47 - T48.slmd
By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Terraprobe

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Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T47 LTSSC, high gwt

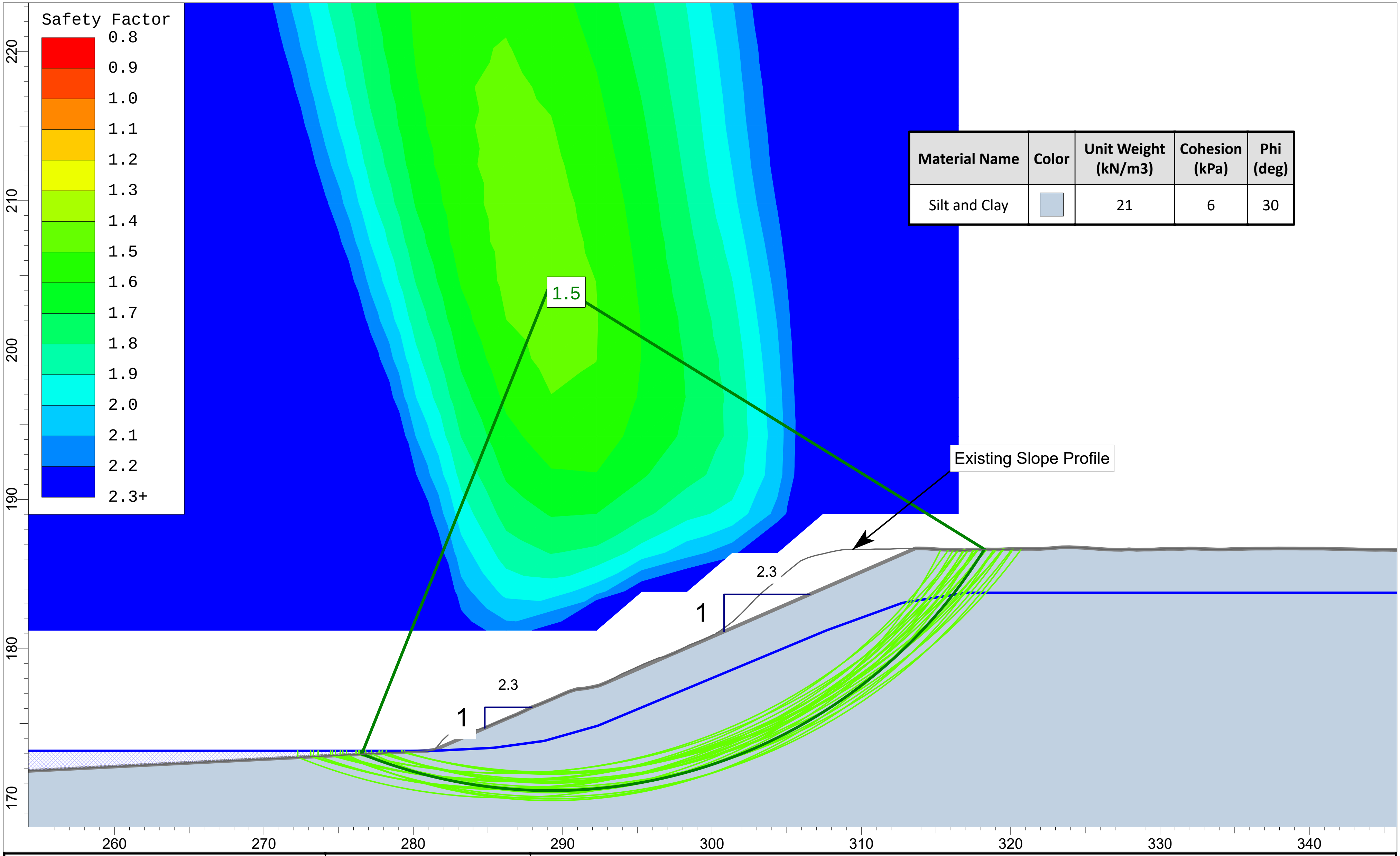
Date 8/1/2019

Scale 1:700

File T47 - T48.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

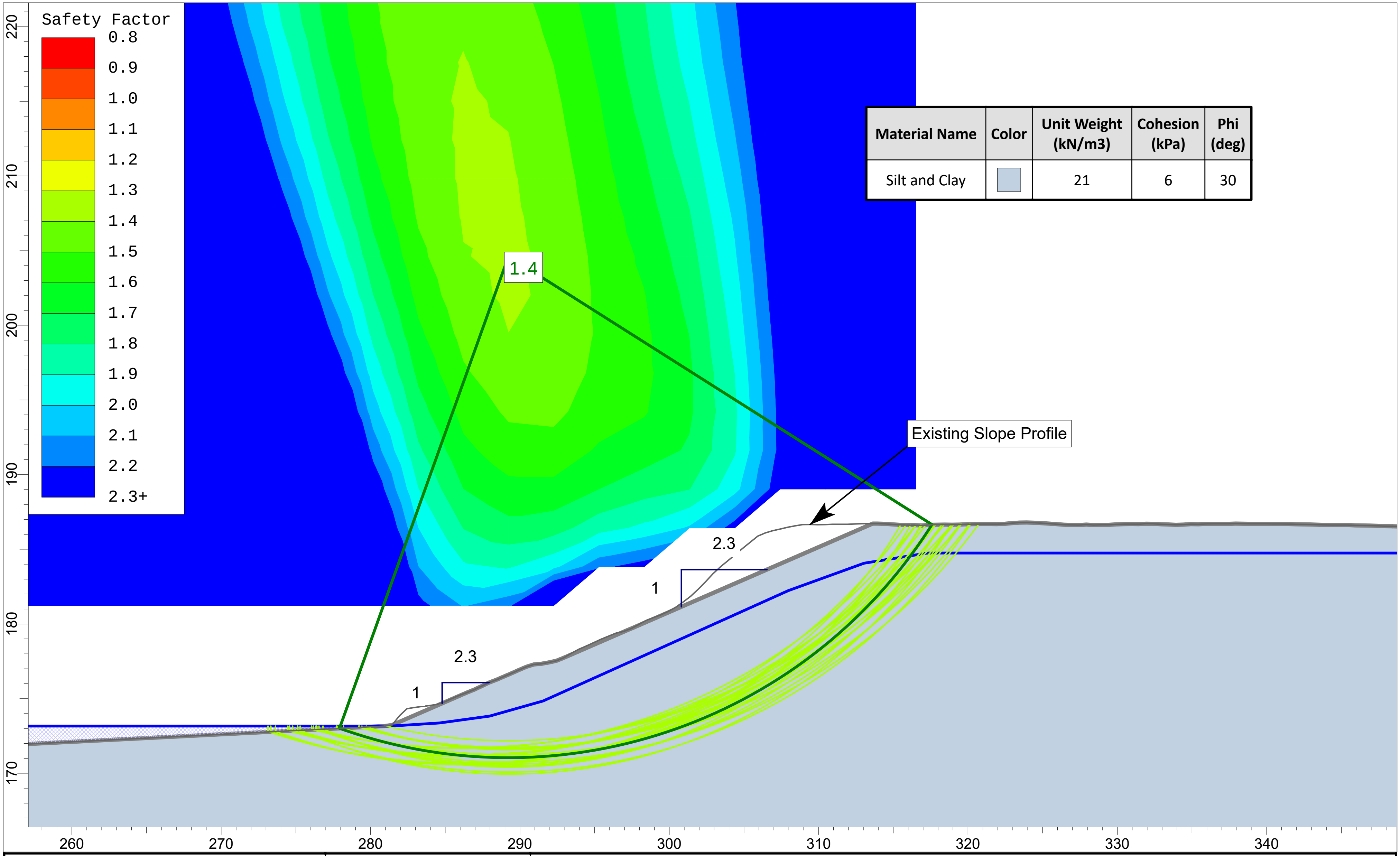
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T49 LTSSC, Master Scenario

Date	8/6/2019	Scale	1:350	File	T49 - T50.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T49 LTSSC, high gwt

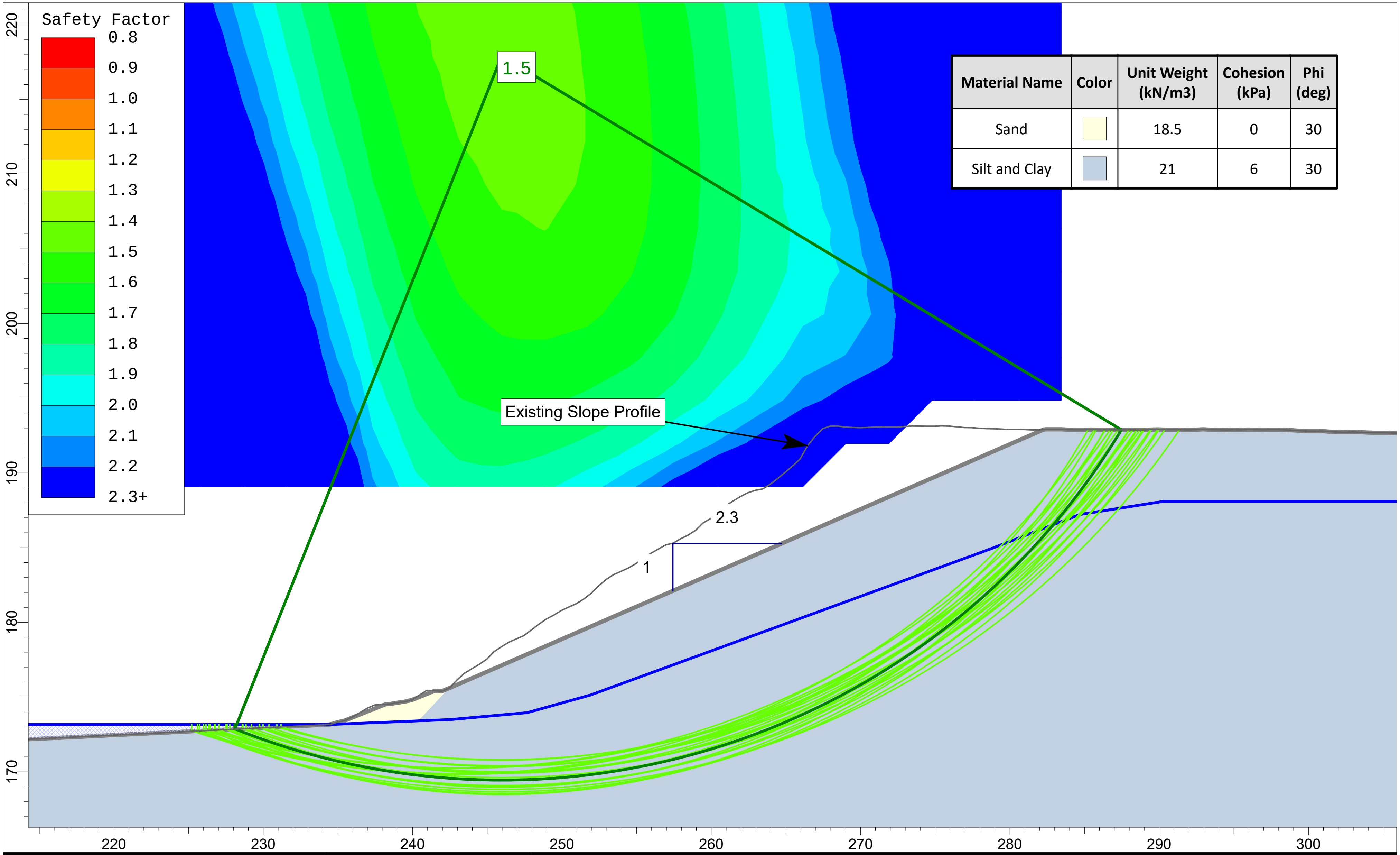
Date 8/6/2019

Scale 1:350

File T49 - T50.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	□	18.5	0	30
Silt and Clay	□	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

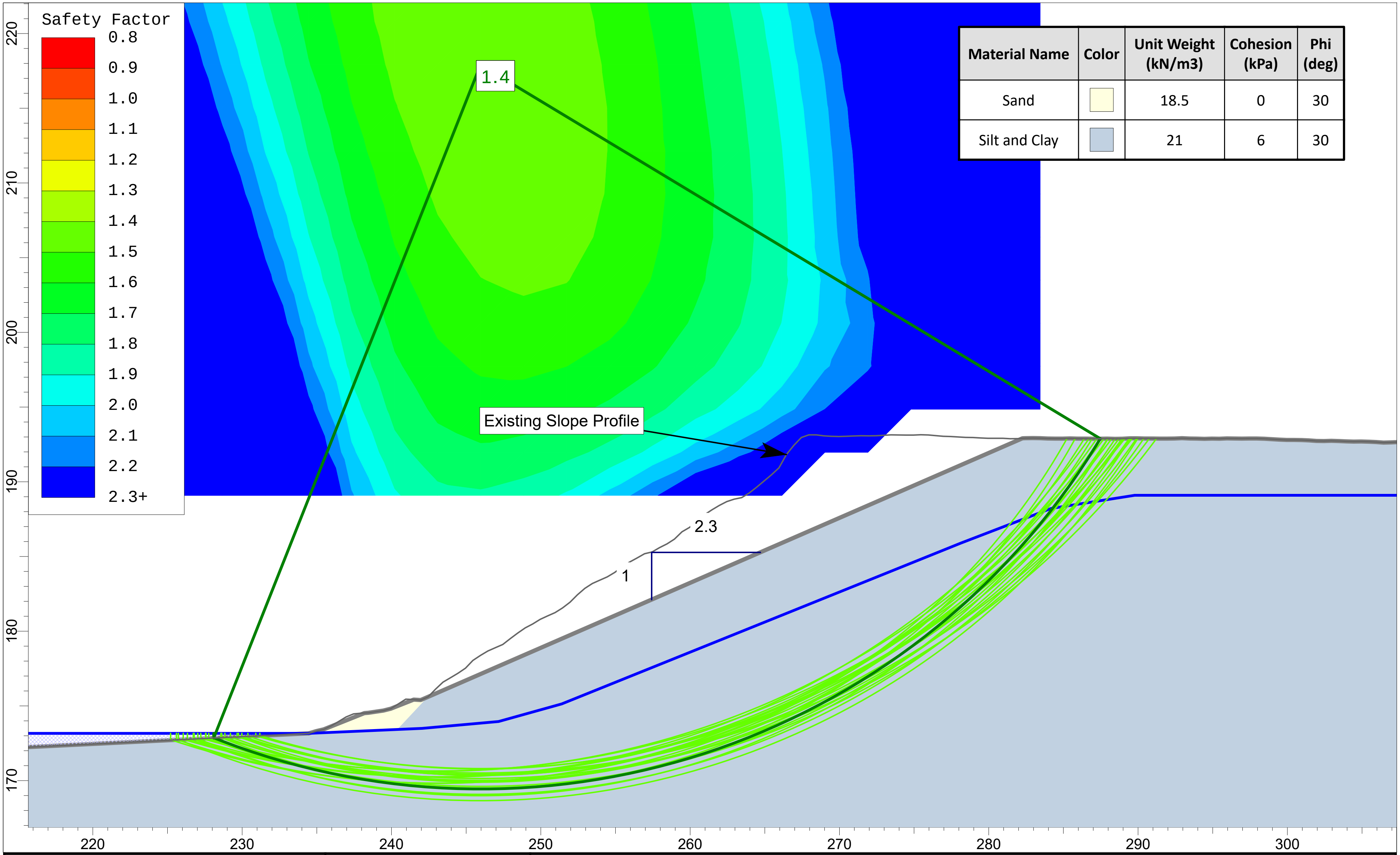
Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project: **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis: Global Stability: T50 LTSSC, Master Scenario

Date	8/9/2019	Scale	1:350	File	T49 - T50.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	▢	18.5	0	30
Silt and Clay	▨	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Norfolk County Hazard Mapping | 1-19-0230-01

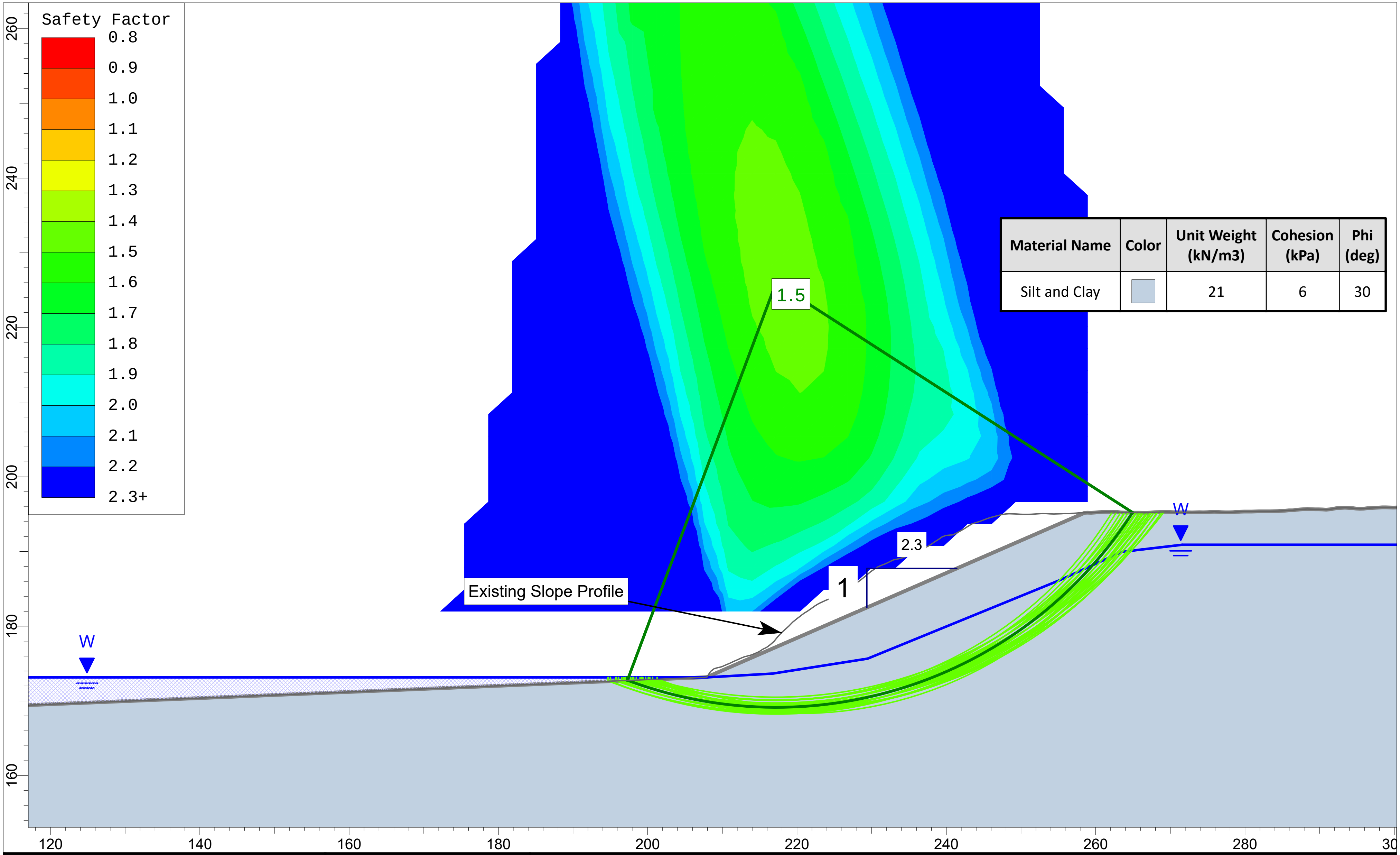
Analysis

Global Stability: T50 LTSSC, high gwt

Date	Scale	File
8/9/2019	1:350	T49 - T50.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe

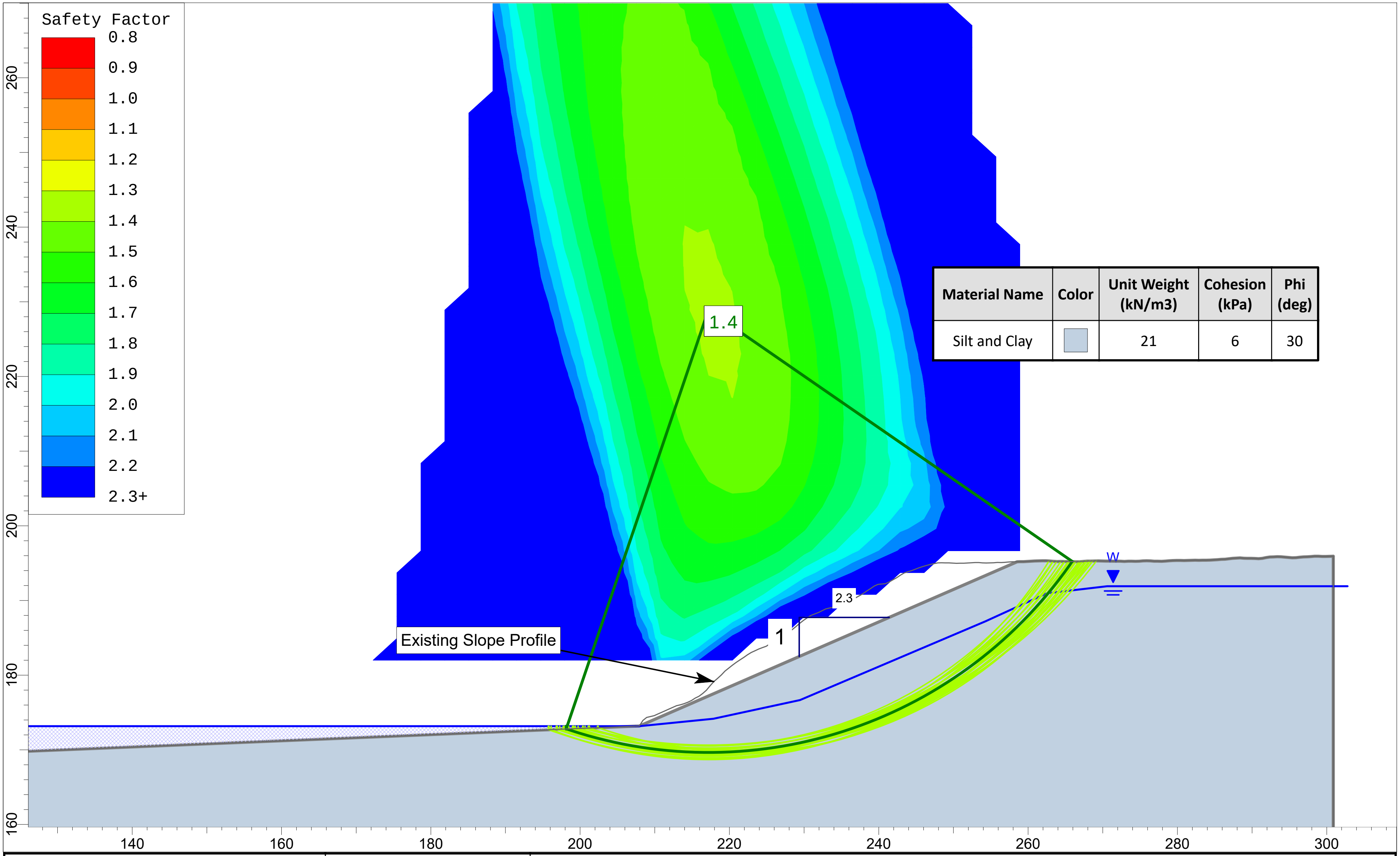
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project	**Norfolk County Hazard Mapping | 1-19-0230-01**
Analysis	Global Stability: T52 LTSSC, Master Scenario
Date	8/6/2019
Scale	1:700
File	T51 - T52.slmd
By	JH/JC
Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Silt and Clay	▨	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

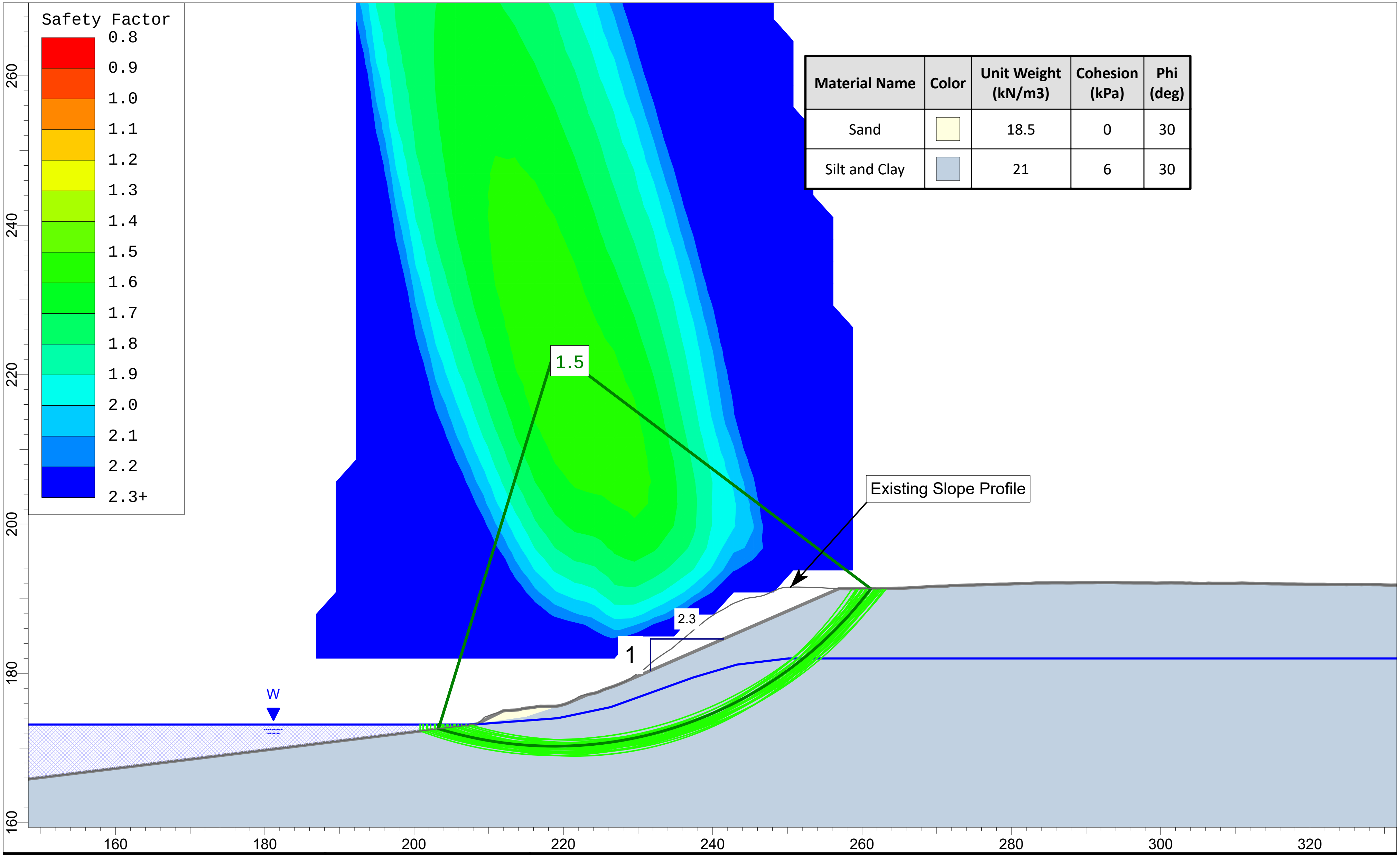
Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T52 LTSSC, high gwt

Date	Scale	File
8/6/2019	1:700	T51 - T52.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	▢	18.5	0	30
Silt and Clay	▨	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

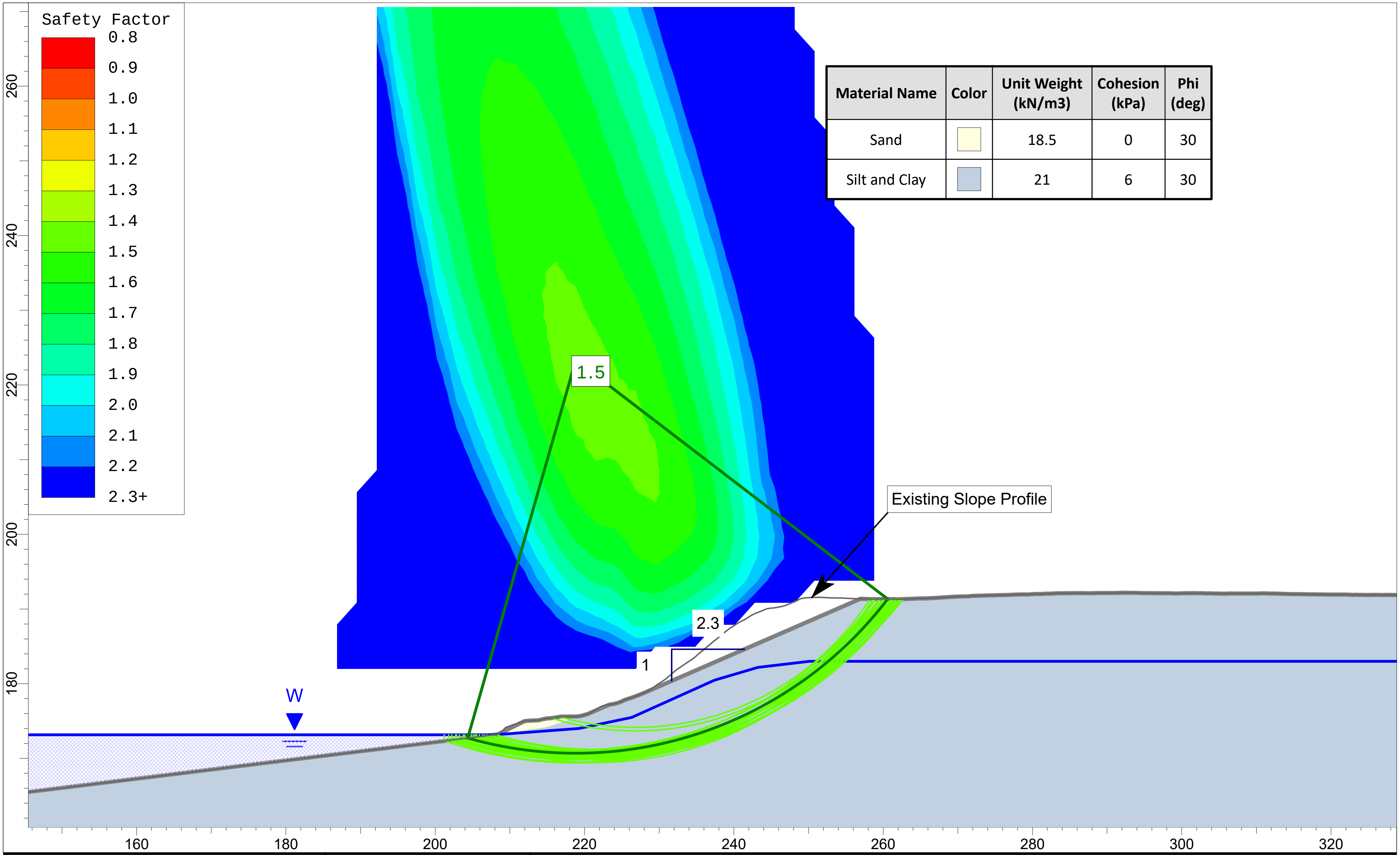
SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T54 LTSSC, Master Scenario

Date 8/6/2019
Scale 1:700
File T53 - T54.slmd
By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt and Clay	🟦	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

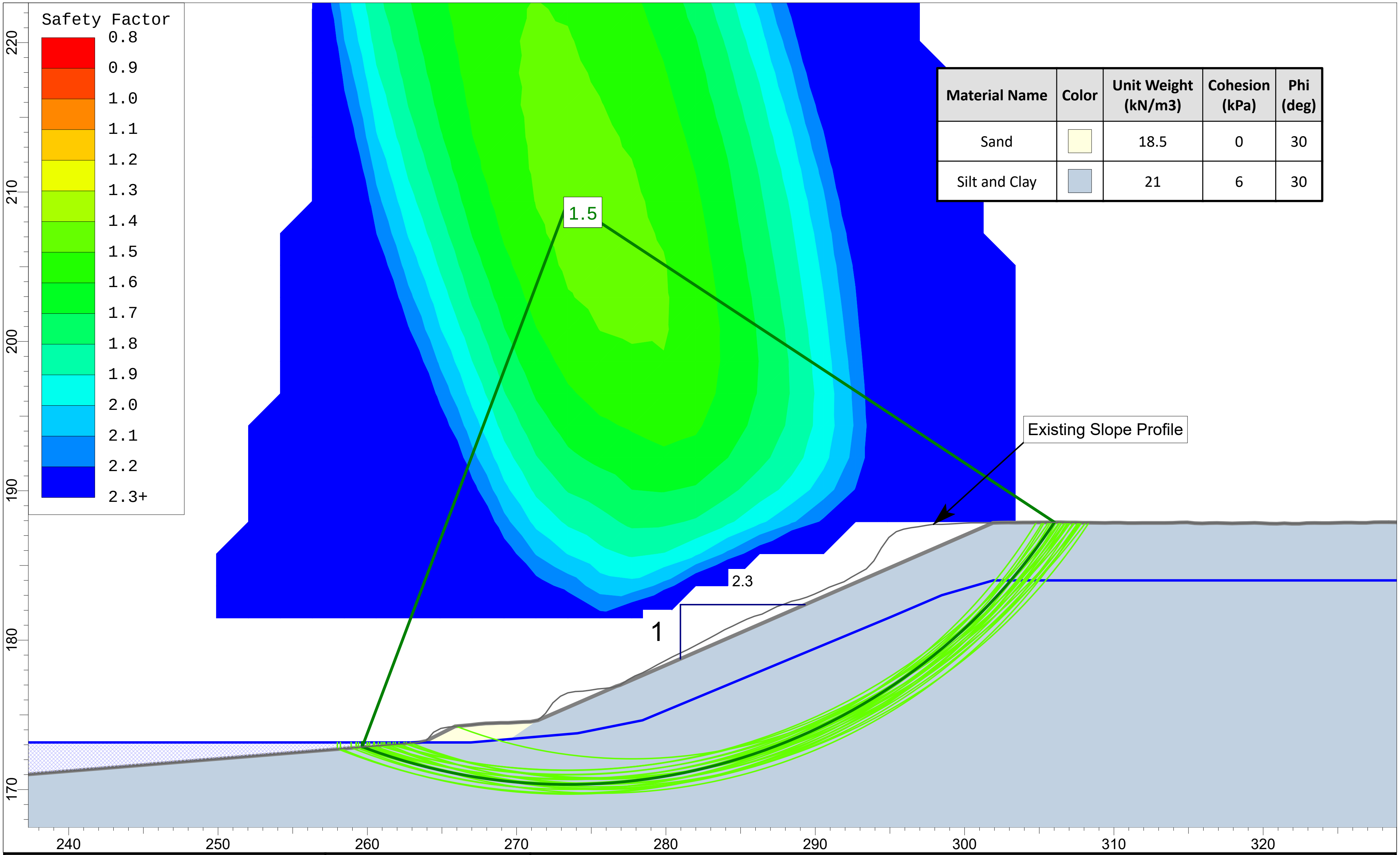
Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T54 LTSSC, high gwt

Date 8/6/2019
Scale 1:700
File T53 - T54.slmd

By JH/JC
Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt and Clay	🟦	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project **Norfolk County Hazard Mapping | 1-19-0230-01**

Analysis Global Stability: T55 LTSSC, Master Scenario

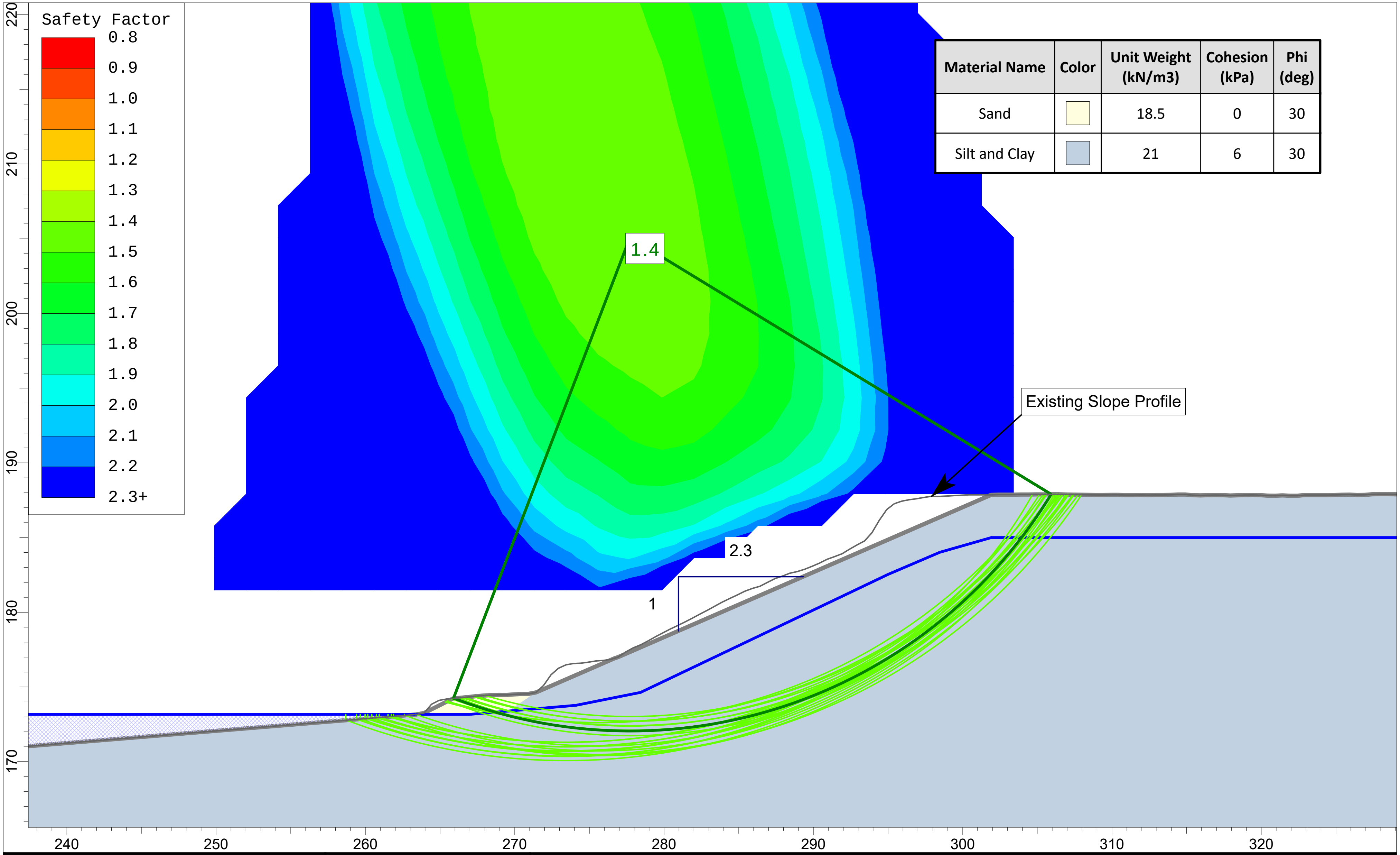
Date 8/6/2019

Scale 1:350

File T55 - T56.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	☐	18.5	0	30
Silt and Clay	▨	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Norfolk County Hazard Mapping | 1-19-0230-01

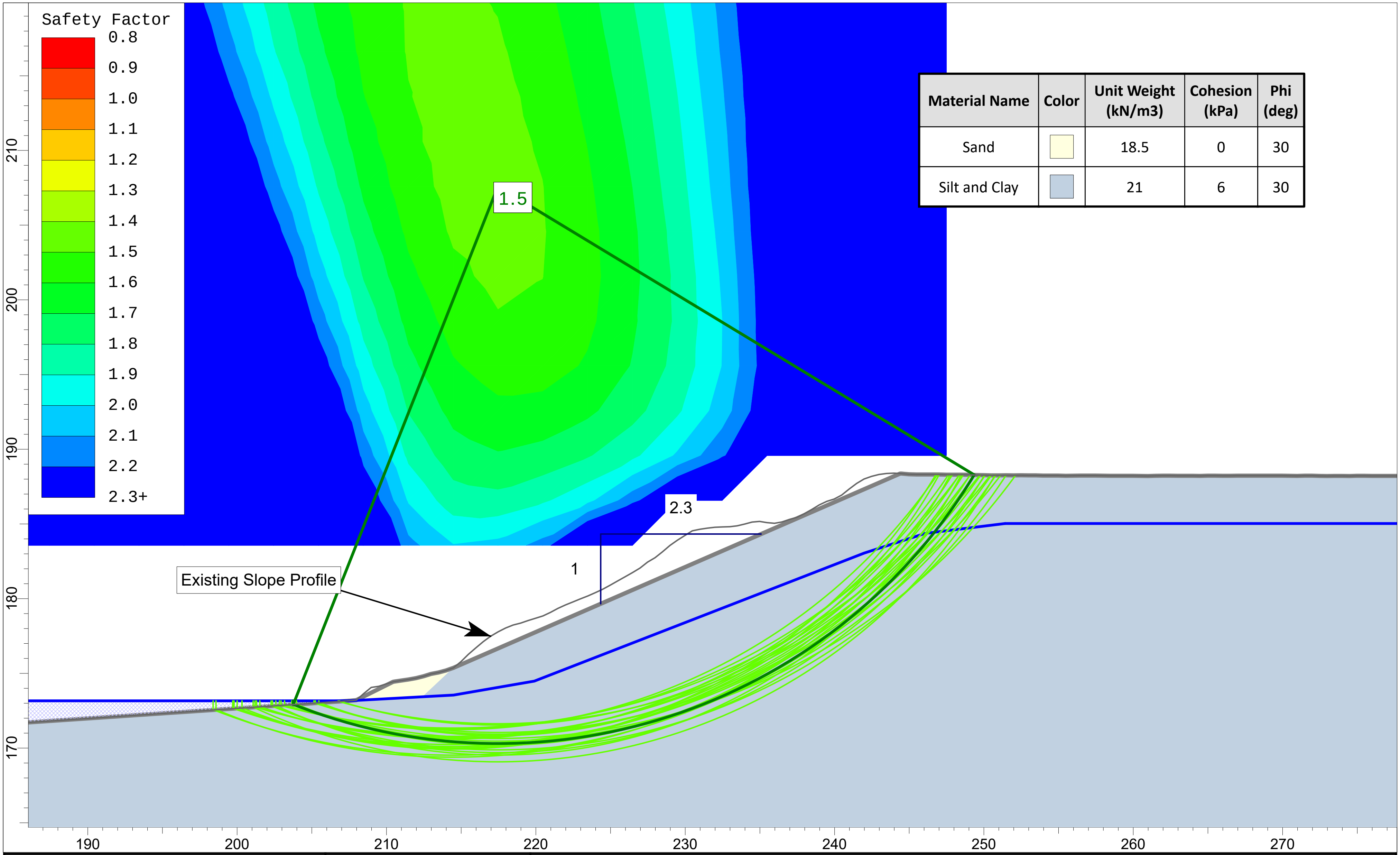
Analysis

Global Stability: T55 LTSSC, high gwt

Date	Scale	File
8/6/2019	1:350	T55 - T56.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt and Clay	🟦	21	6	30

Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes

Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

Project

Norfolk County Hazard Mapping | 1-19-0230-01

Analysis

Global Stability: T58 LTSSC, Master Scenario

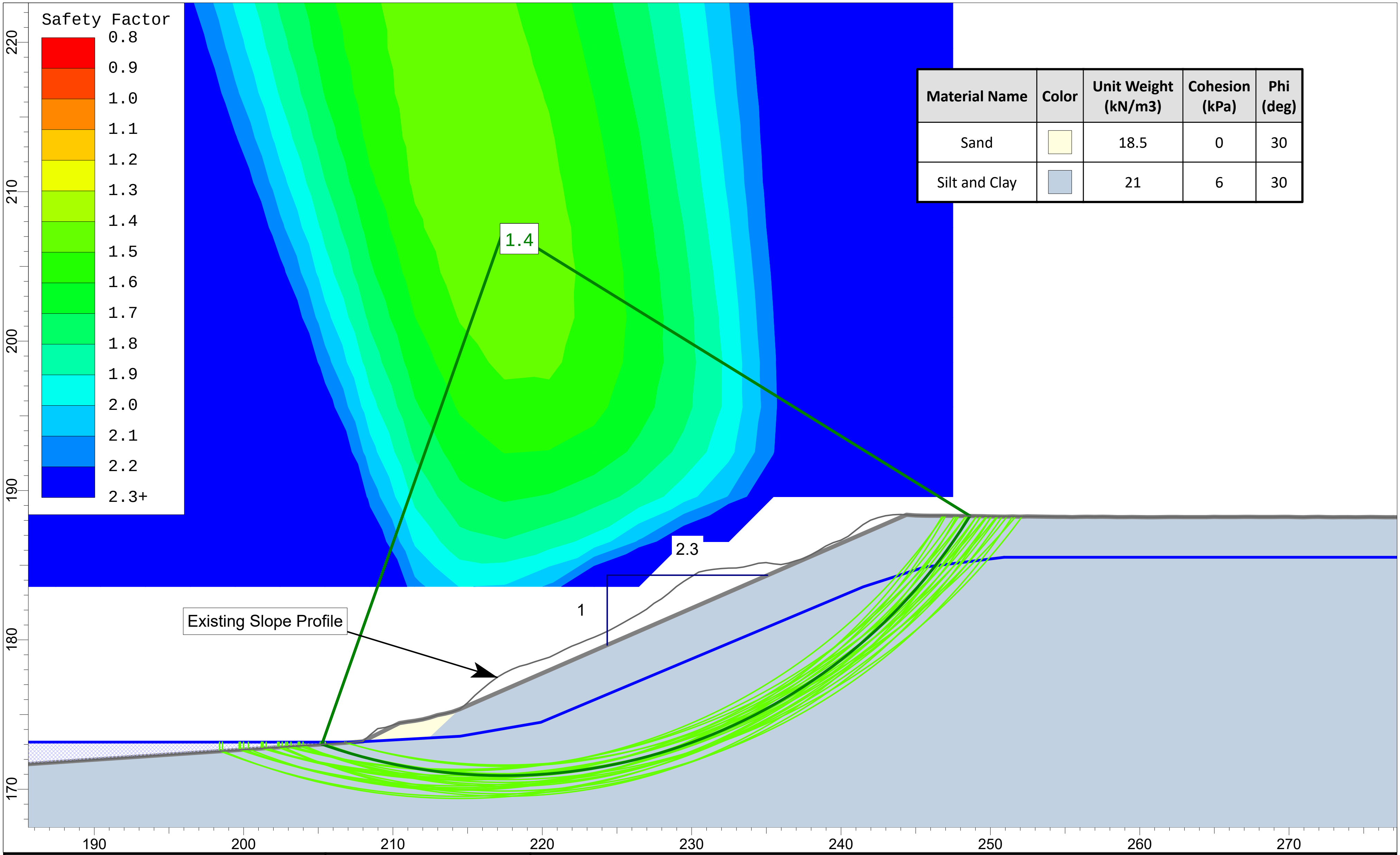
Date 8/9/2019

Scale 1:350

File T57 - T58.slmd

By JH/JC

Ref. LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019



Material Name	Color	Unit Weight (kN/m3)	Cohesion (kPa)	Phi (deg)
Sand	🟨	18.5	0	30
Silt and Clay	🟦	21	6	30

Terraprobe
Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

SLIDEINTERPRET 8.016

Notes
Refer to appended Slope Stability Analysis Explanation sheets for legend. Refer to cross-sections for inclinations and other pertinent slope information.

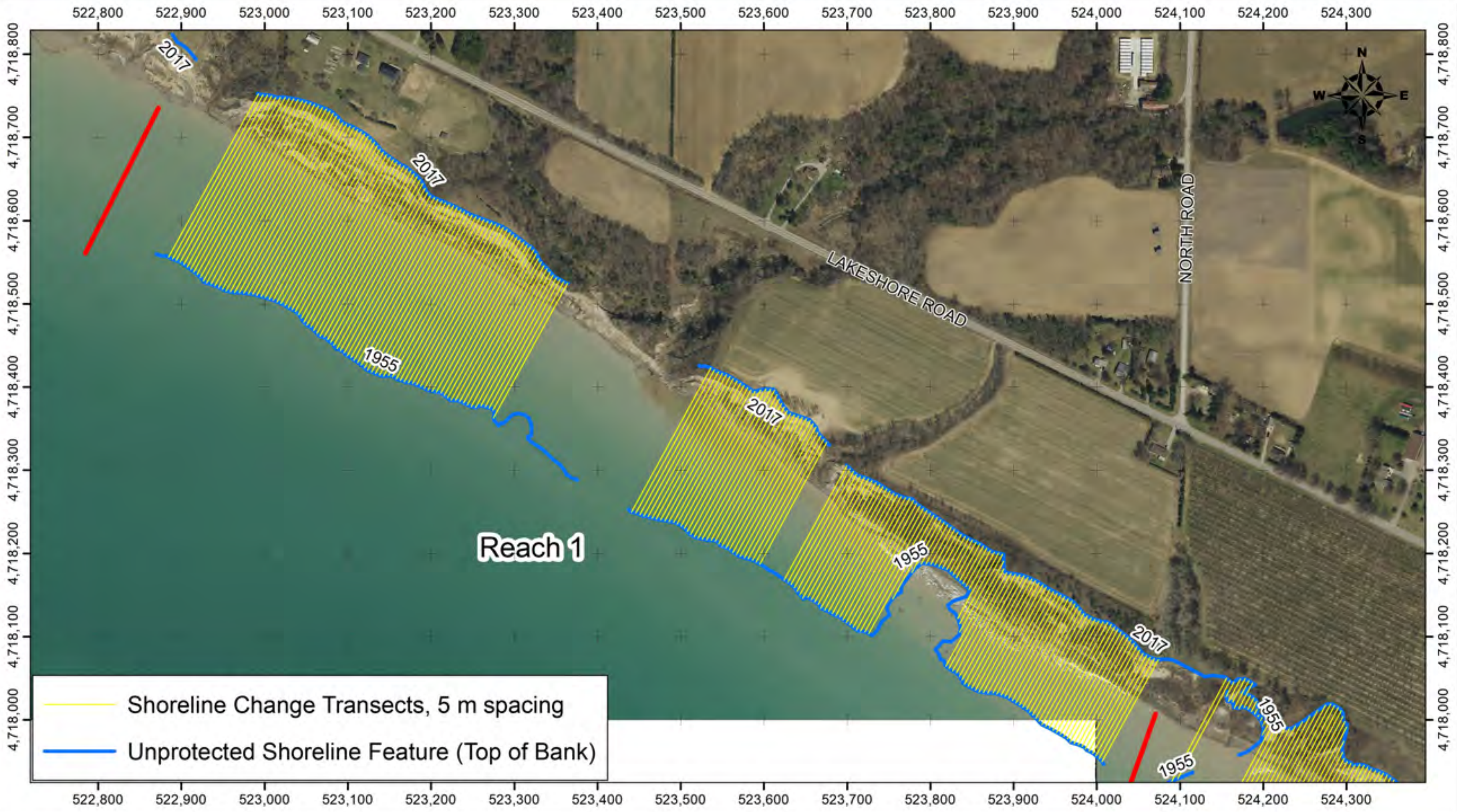
Project
Norfolk County Hazard Mapping | 1-19-0230-01

Analysis
Global Stability: T58 LTSSC, high gwt

Date	8/9/2019	Scale	1:350	File	T57 - T58.slmd
By	JH/JC	Ref.	LiDAR 2017, vertical datum CGVD2013 provided by Baird June 26, 2019		

Appendix B

Shoreline Change Maps



0 100 m

1:8,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100
m

1:8,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100 200 m

1:8,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100 200
m

1:8,000

Historic Shoreline Change

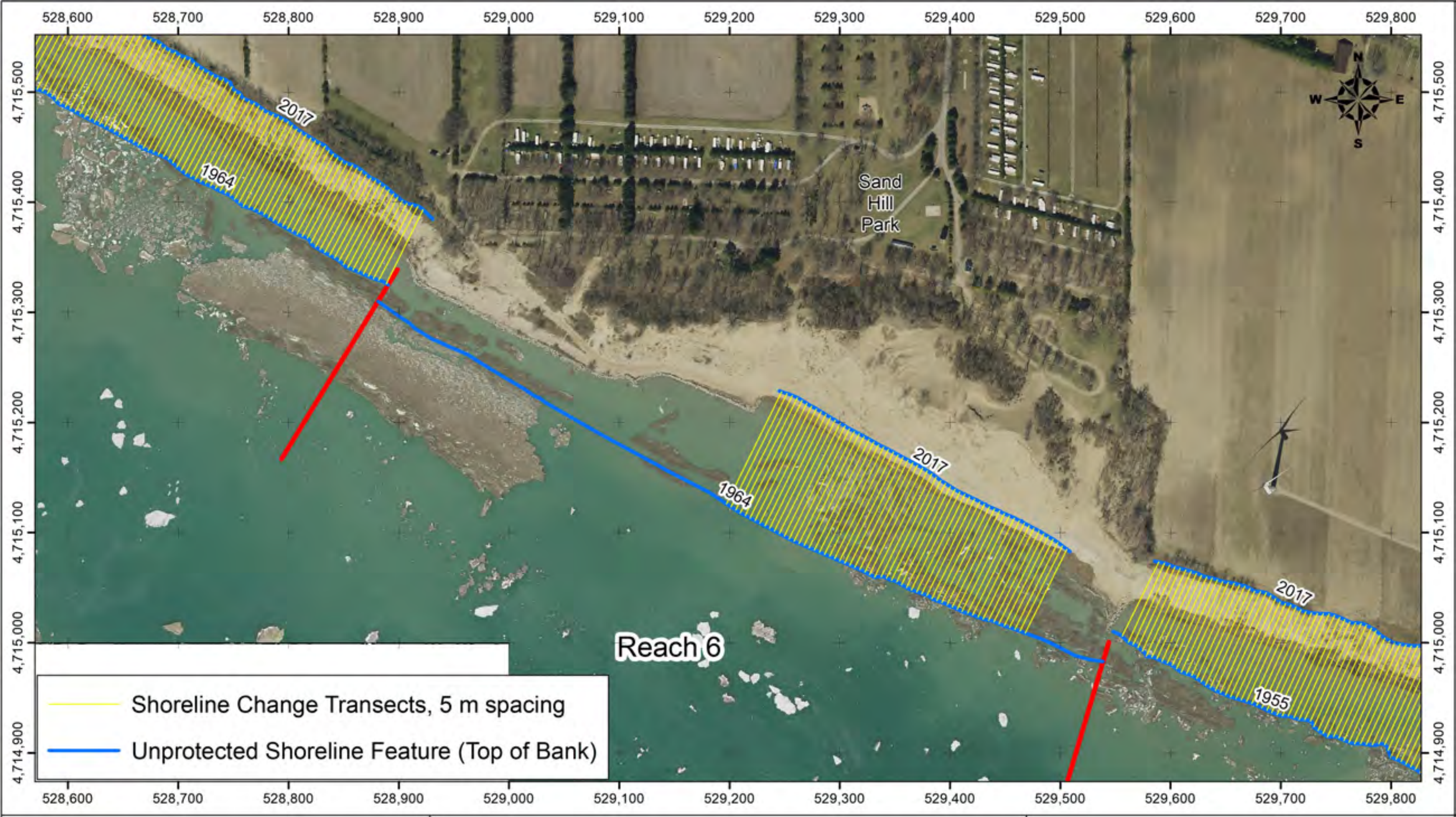
Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100 200
m

1:8,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

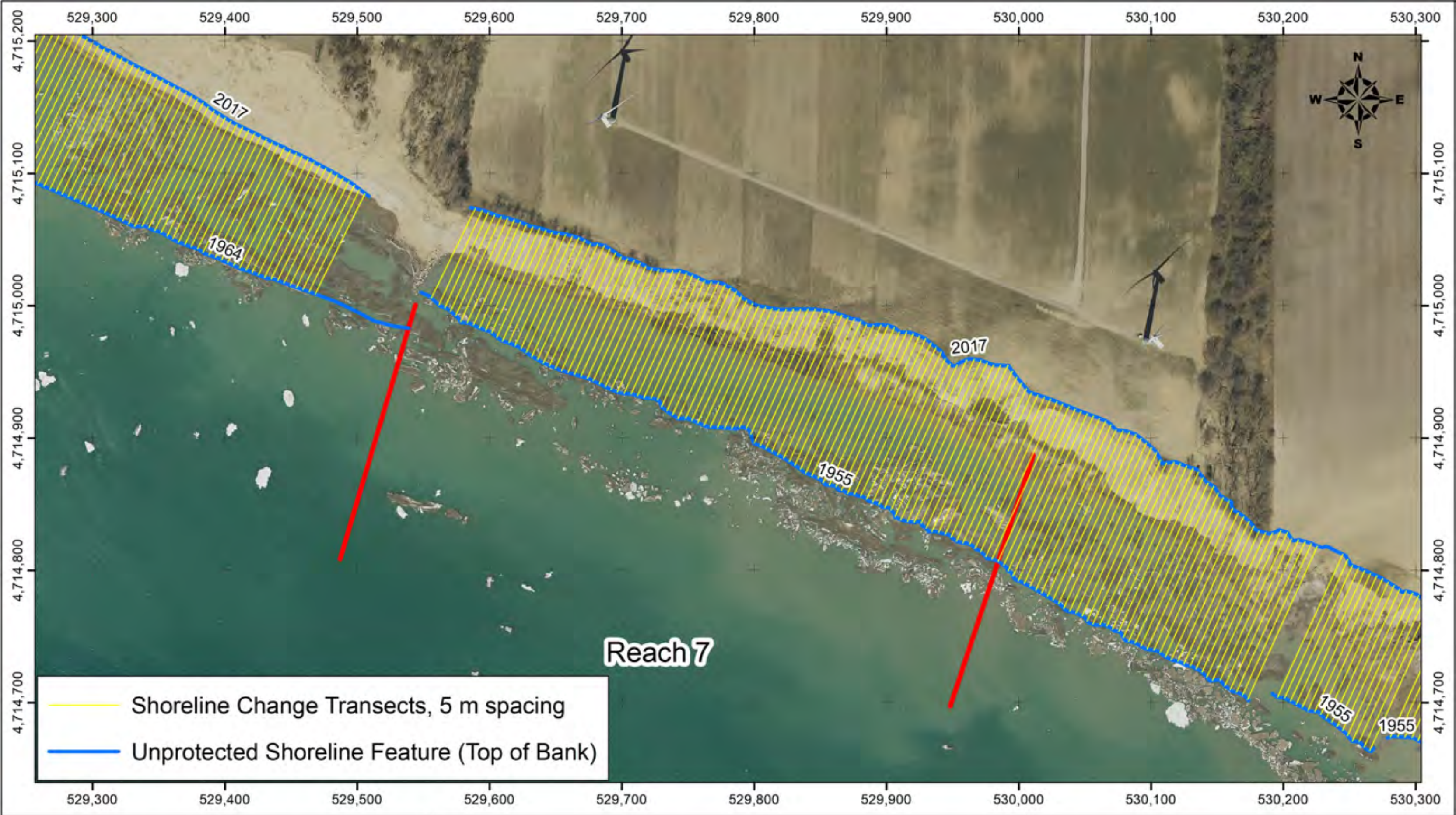


0 100 m

1:6,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 100 m

1:5,000

Historic Shoreline Change

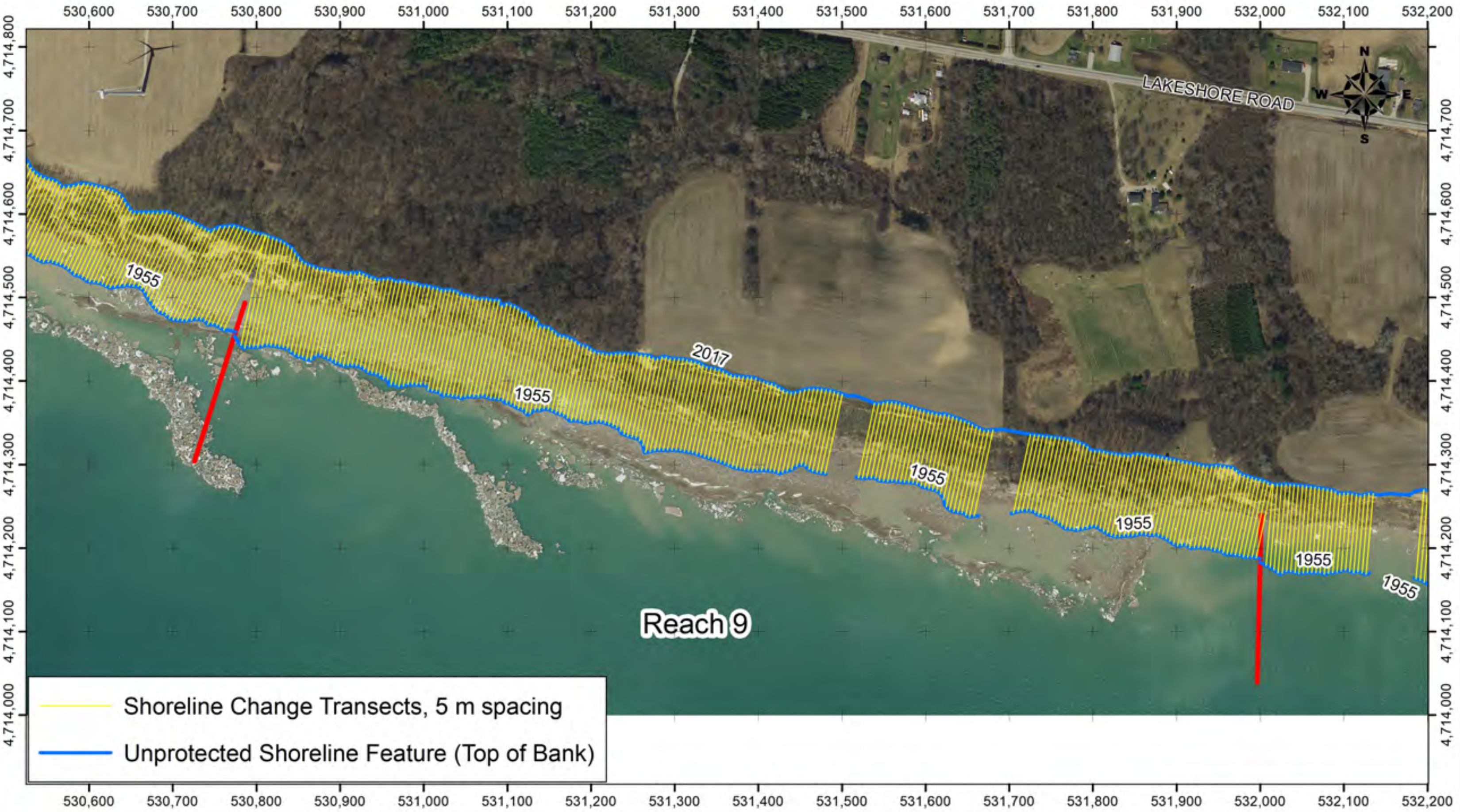
Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100
m

1:6,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 100 200 m

1:8,000

Historic Shoreline Change

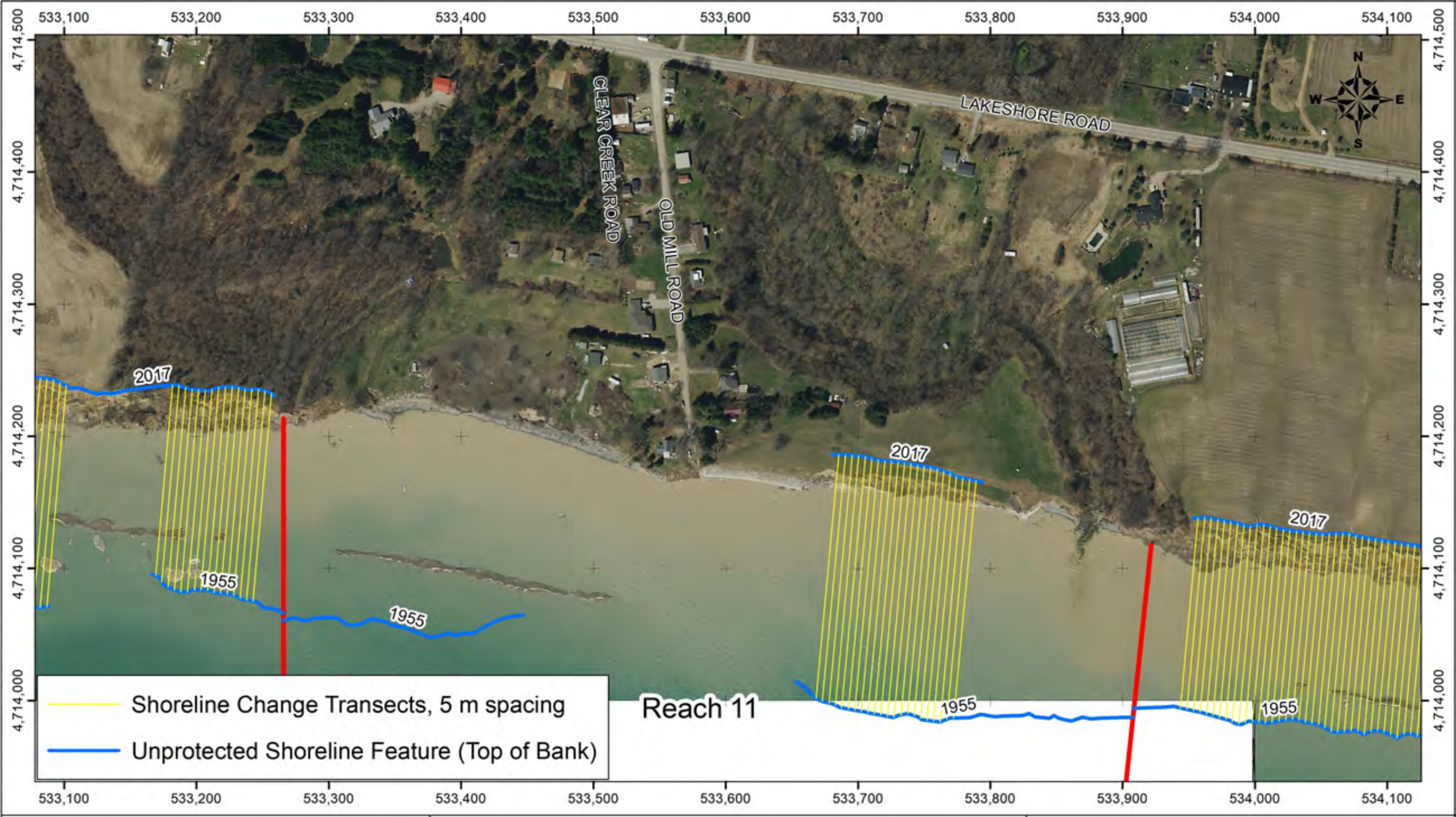
Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100 200
m

1:8,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 100
m

1:5,000

Historic Shoreline Change

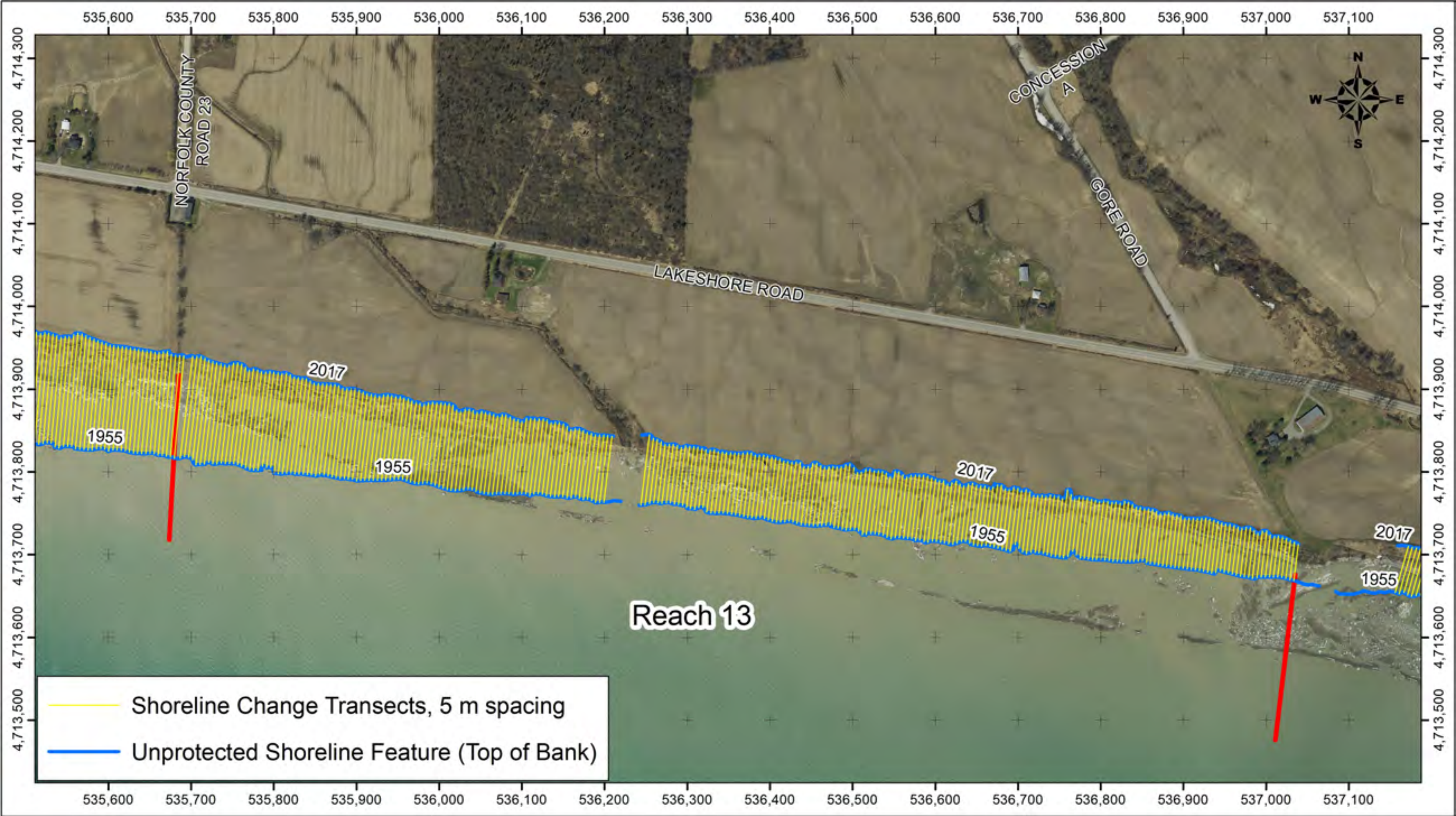
Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100 200 300
m

1:10,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 100 200
m

1:8,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100
m

1:4,000

Historic Shoreline Change

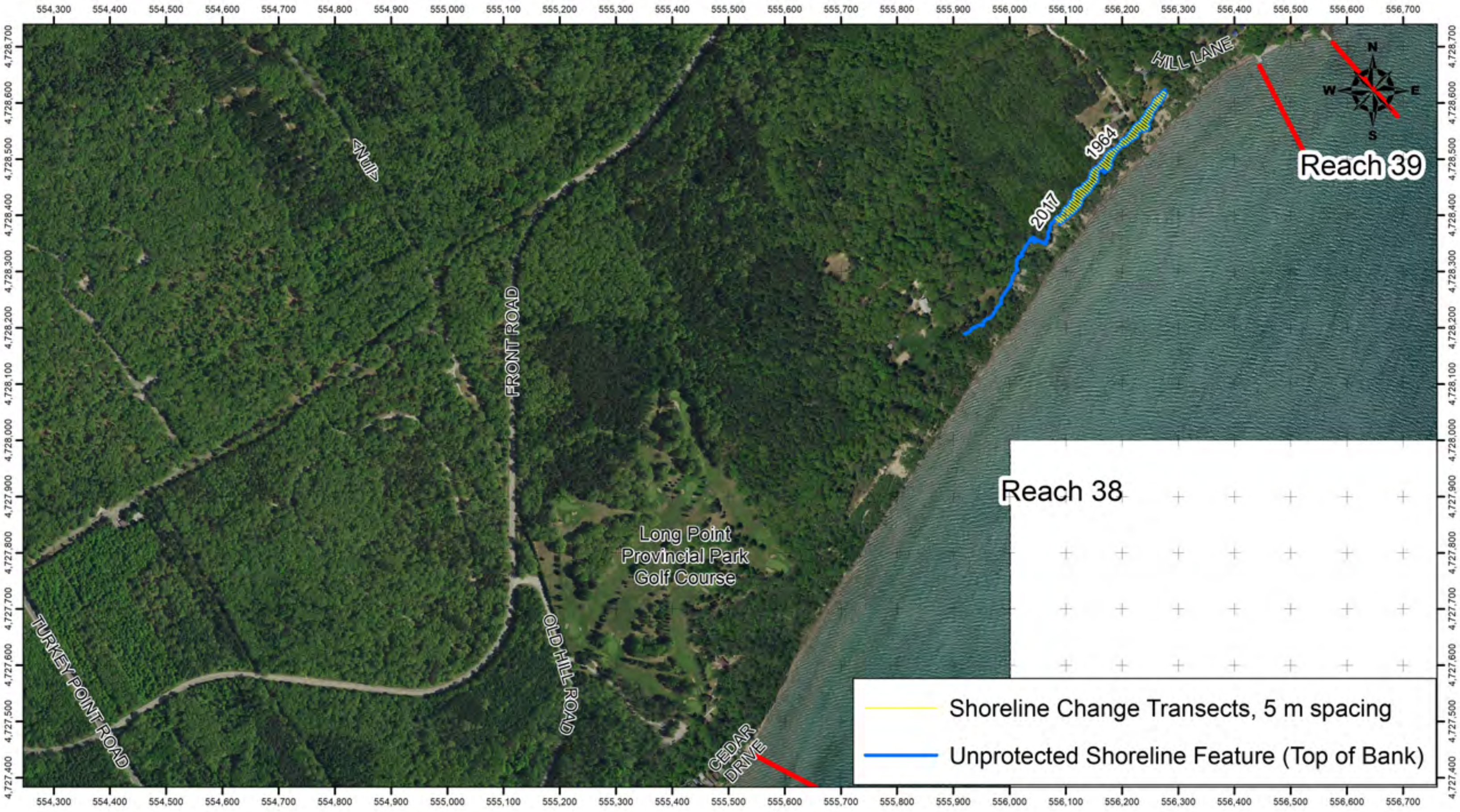
Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100
m

1:4,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

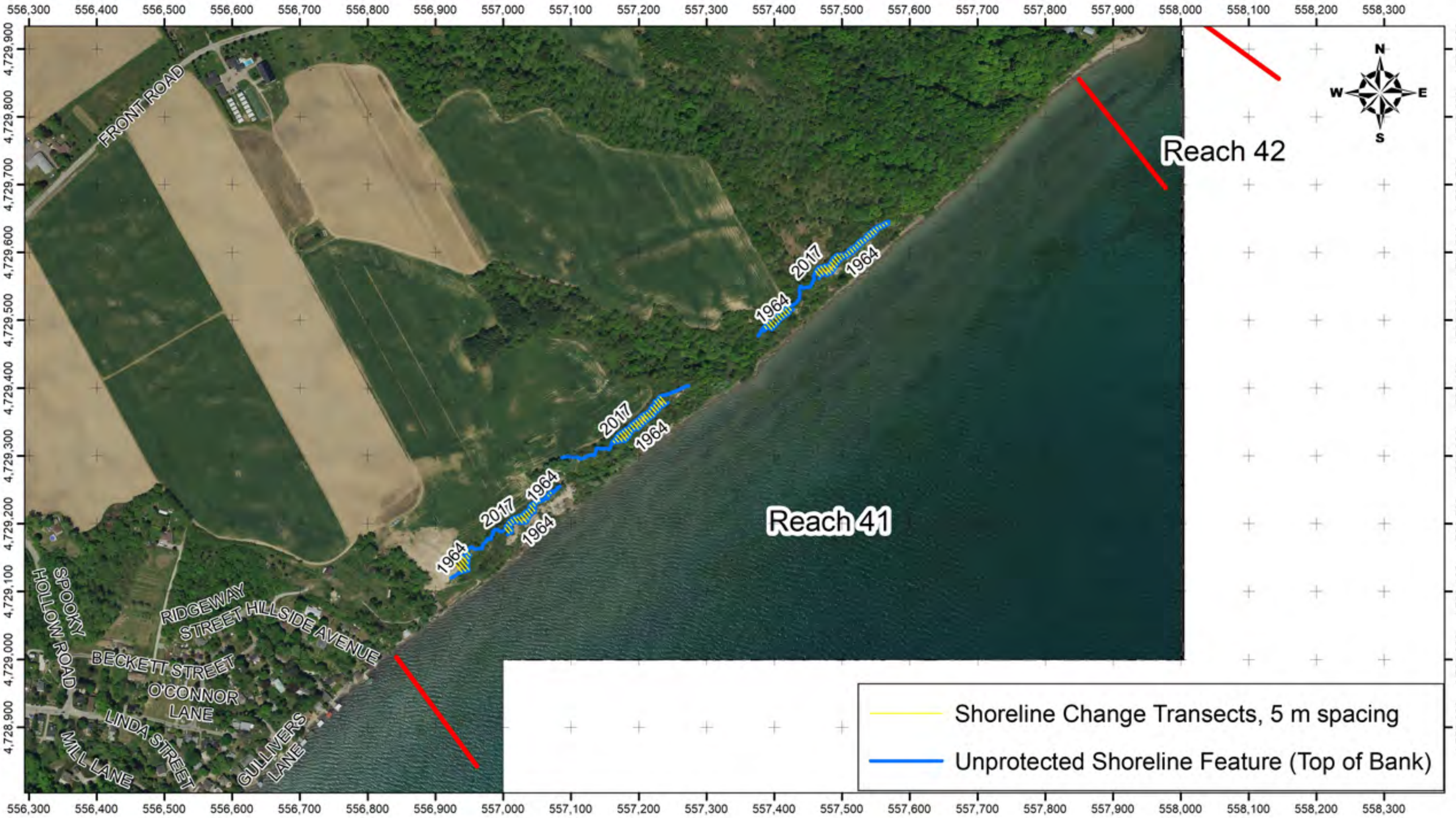


0 100 200 300
m

1:12,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

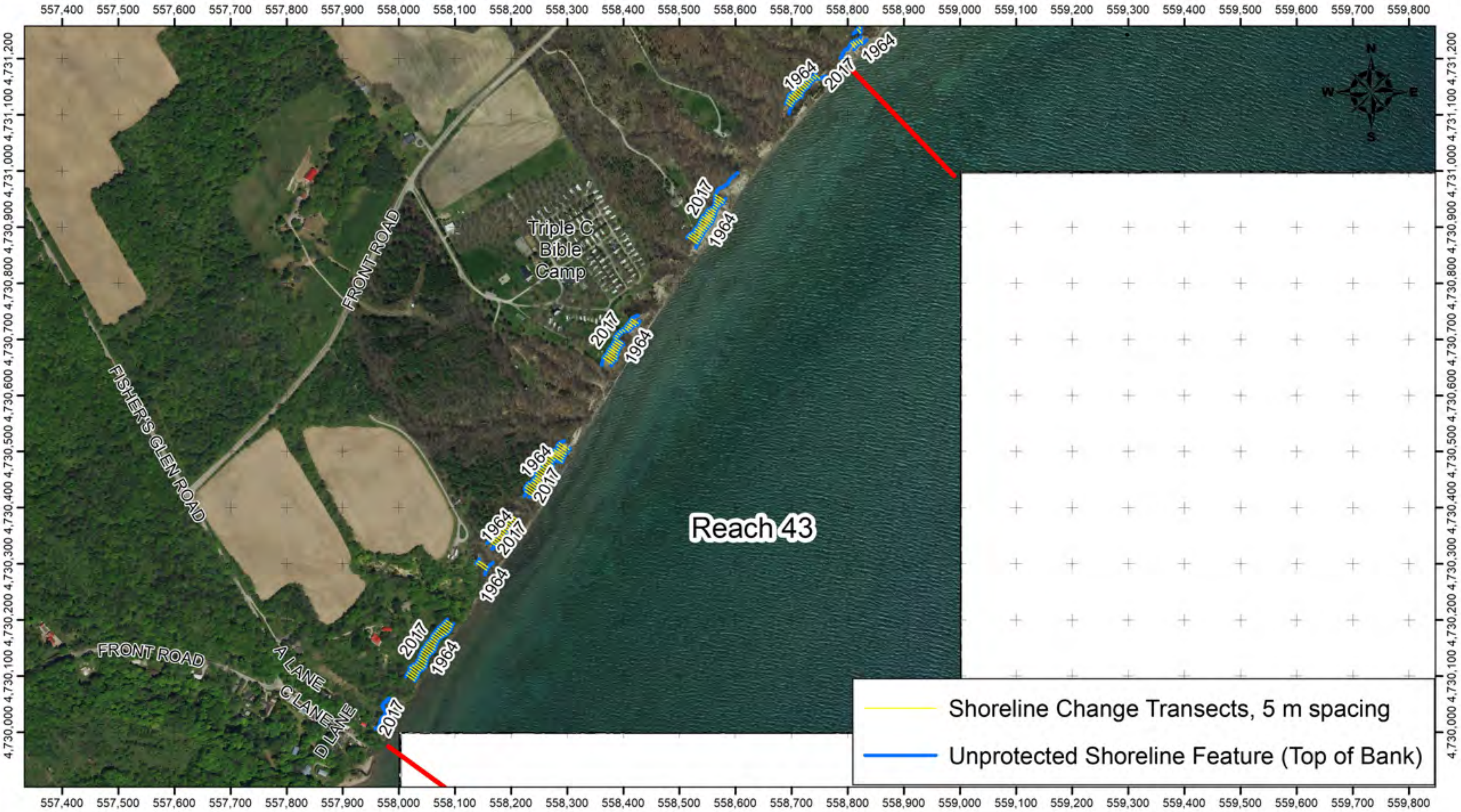


0 100 200 300 m

1:10,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 100 200 300
m

1:12,000

Historic Shoreline Change

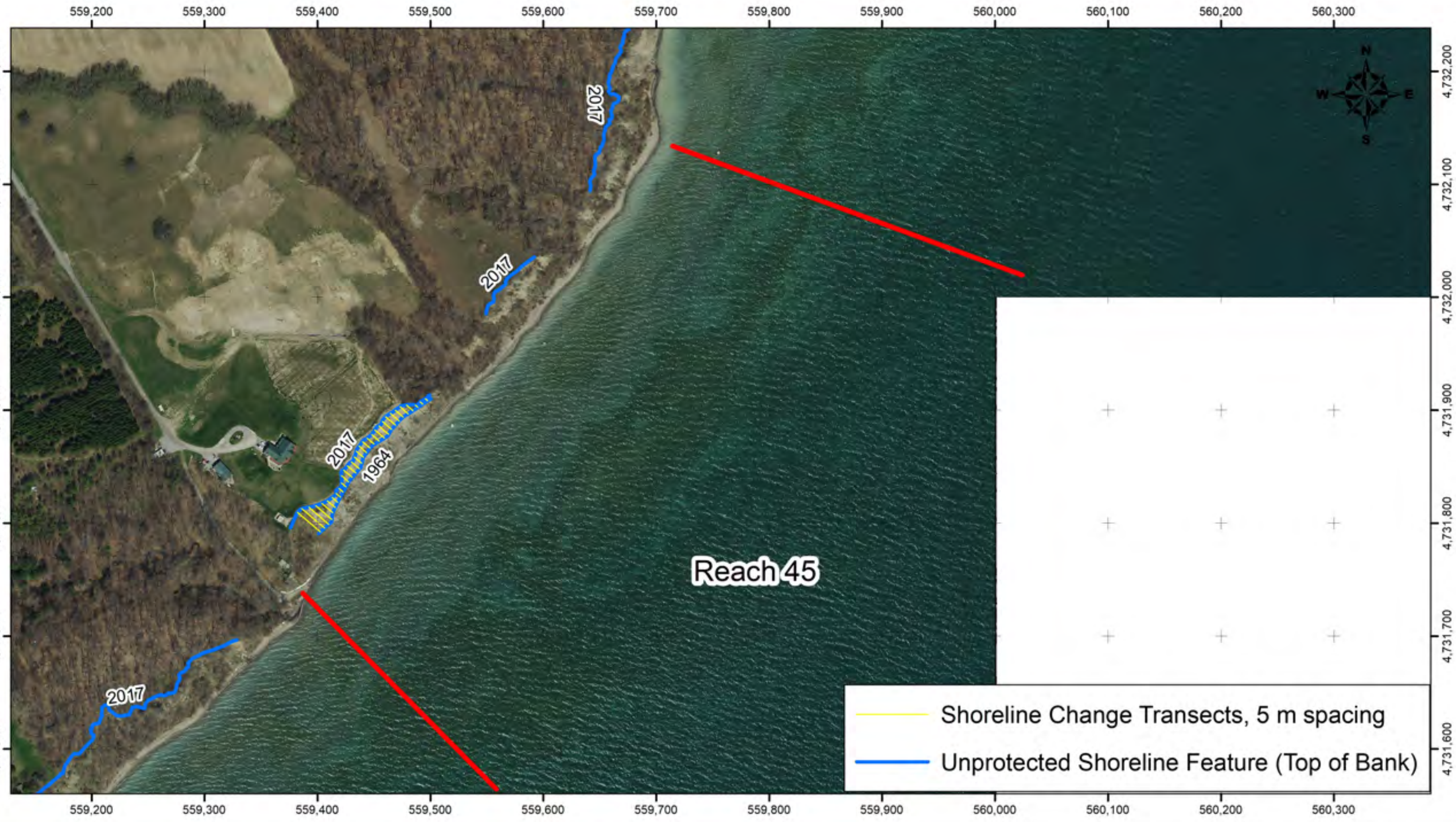
Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100 m

1:6,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

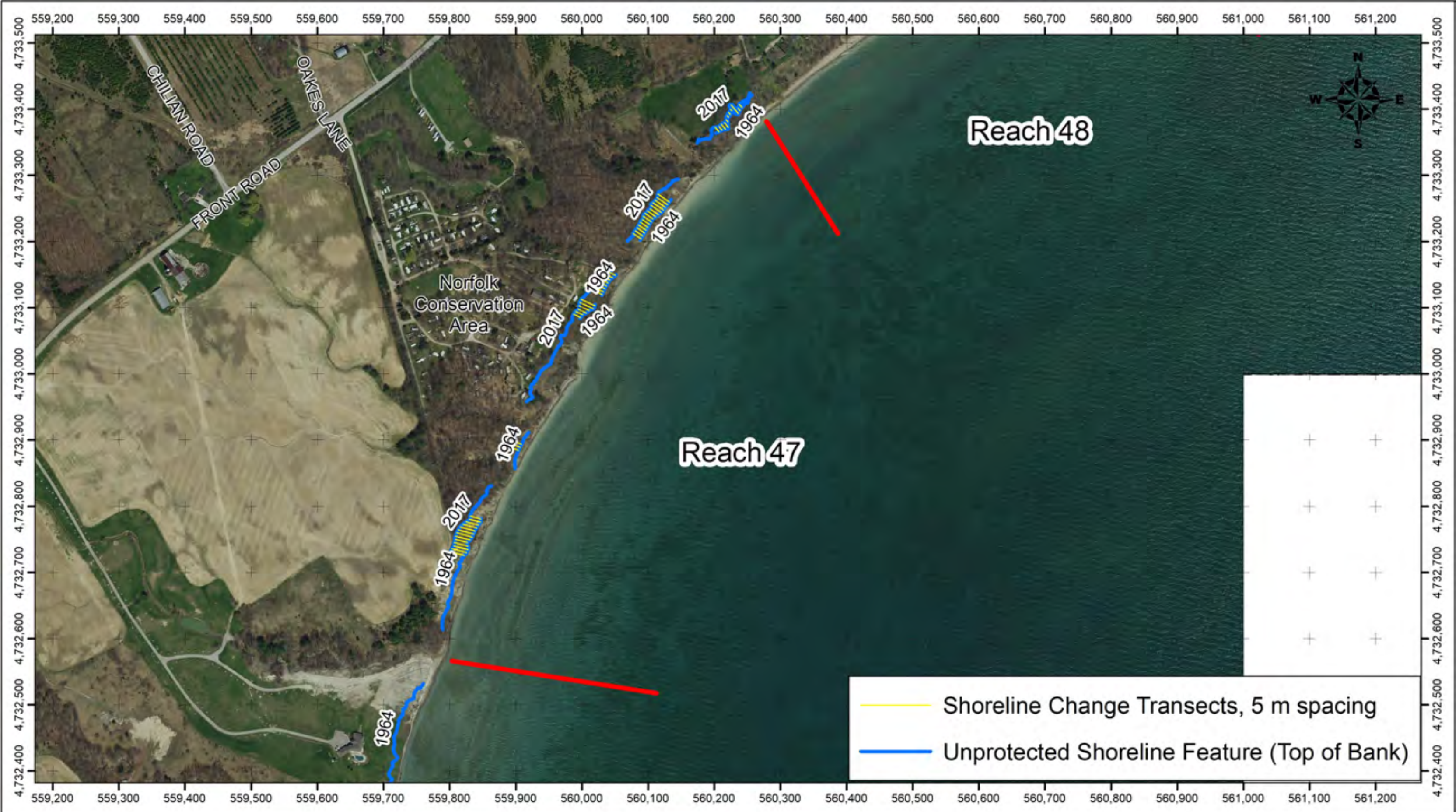


0 100
m

1:6,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

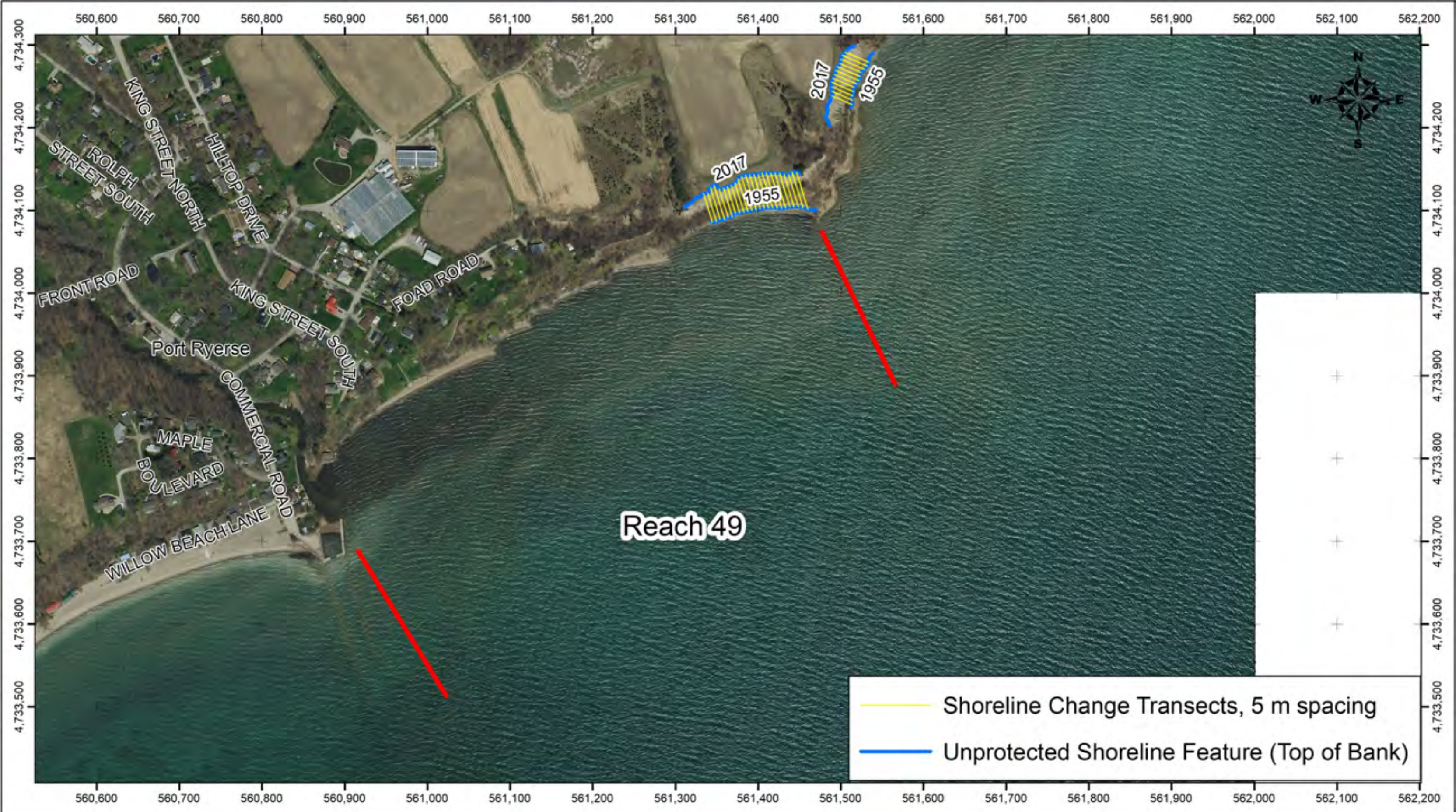


0 100 200 300 m

1:10,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

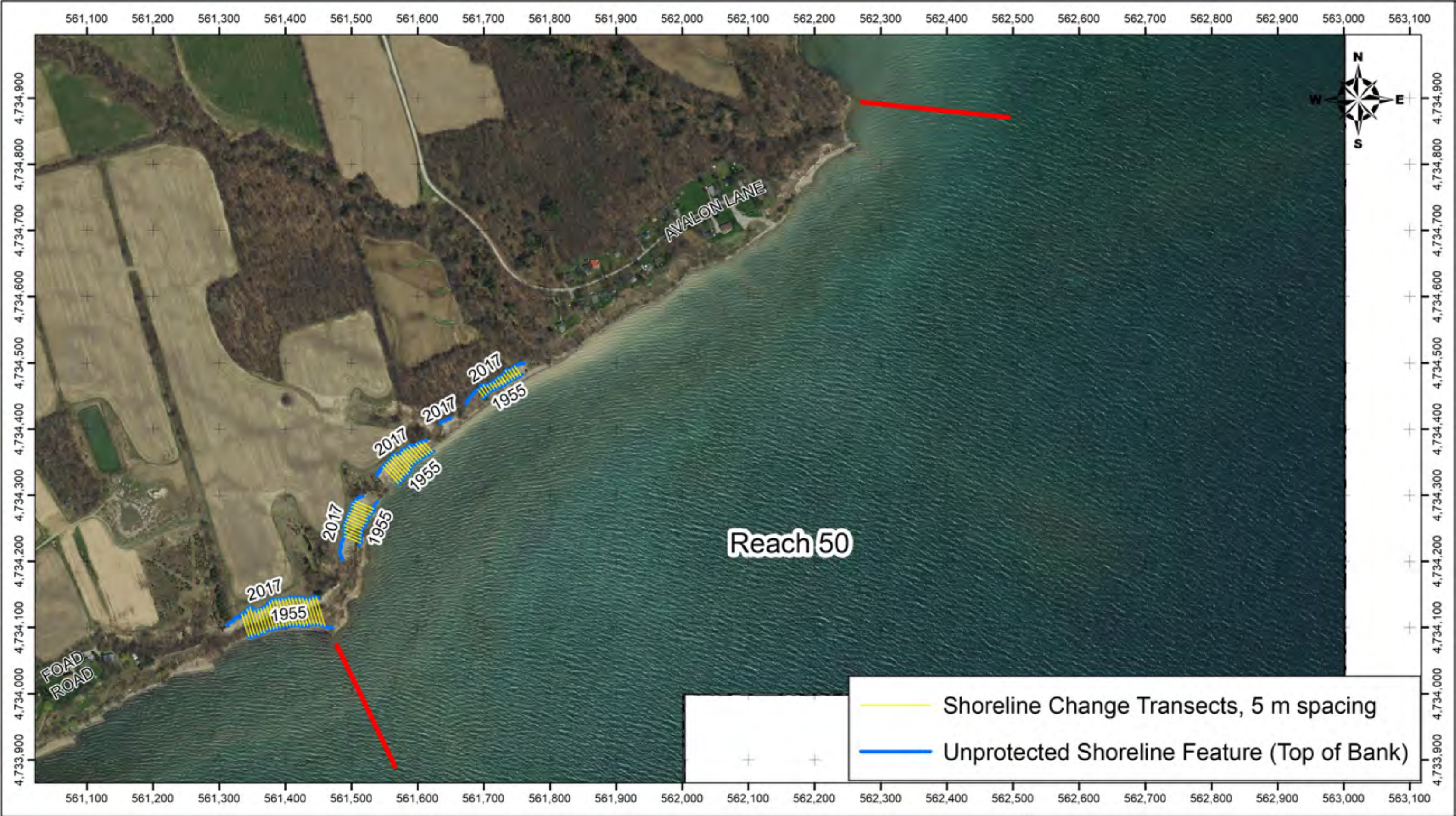


0 100 200
m

1:8,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

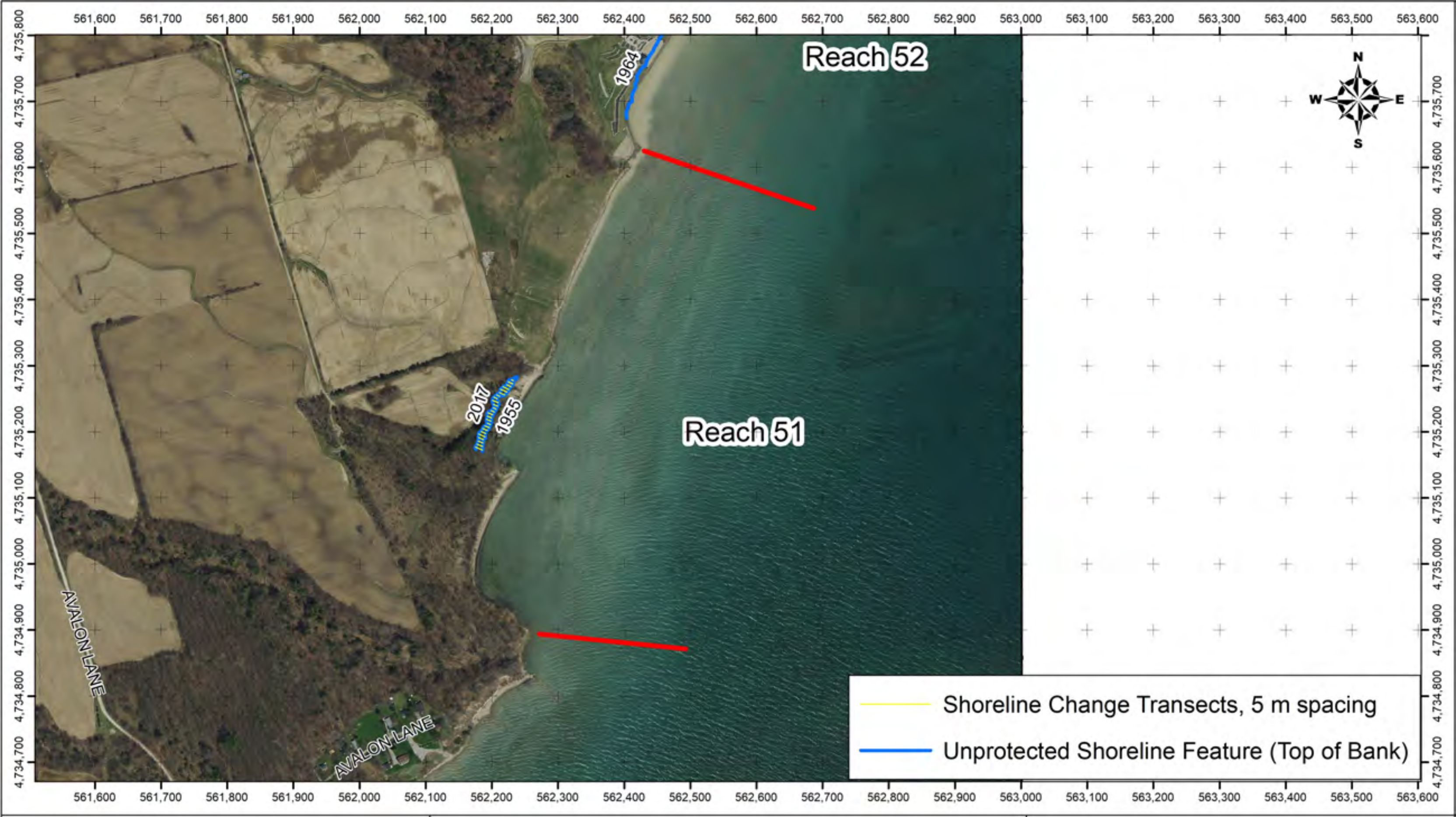


0 100 200 300 m

1:10,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

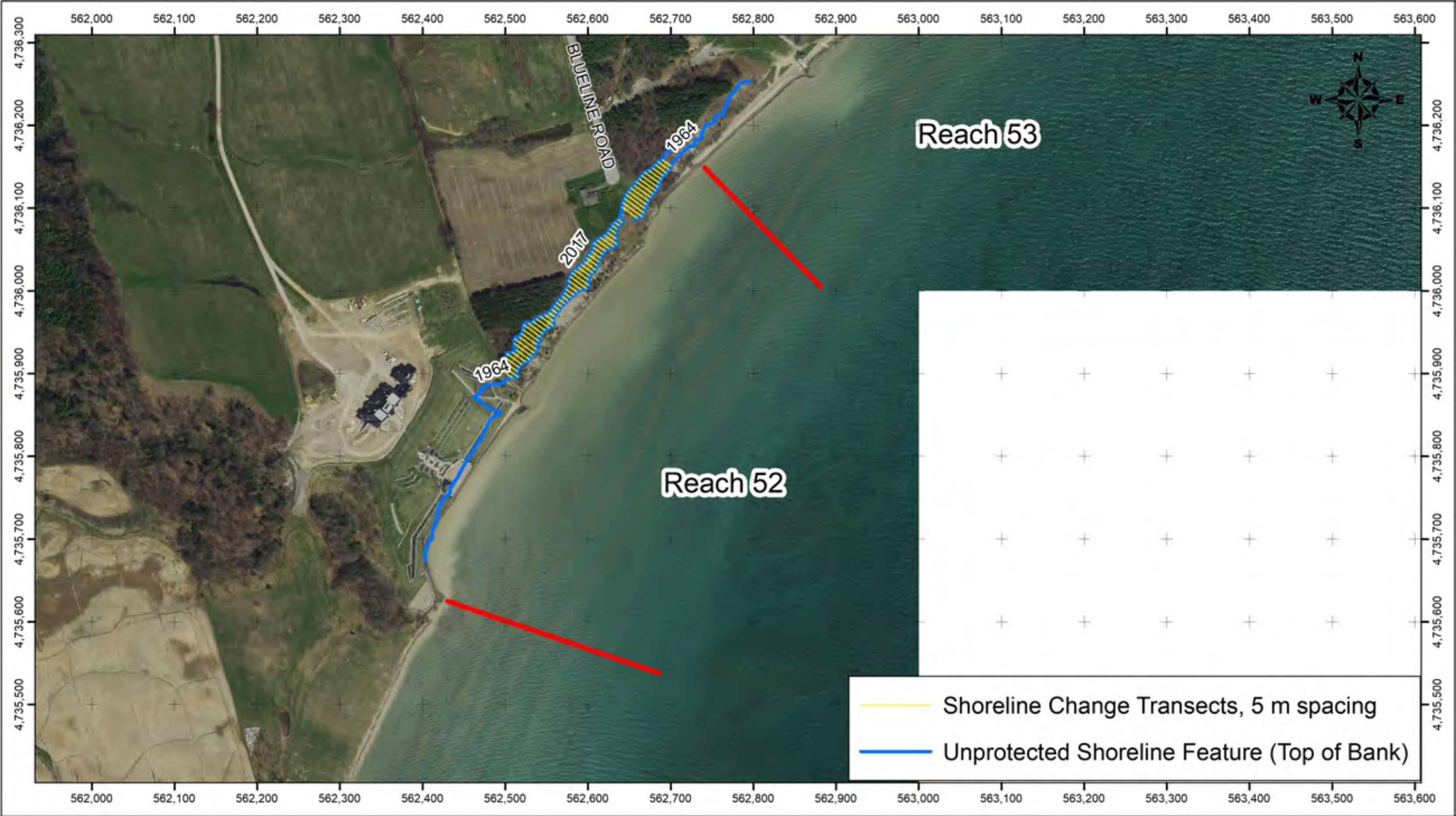


0 100 200 300 m

1:10,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N



0 100 200
m

1:8,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

0 100
m

1:6,000

Historic Shoreline Change

Imagery: SWOOP 2015
Grid Spacing: 100 metres
Spatial Reference: NAD 1983 UTM Zone 17N

Appendix C

Hazard Mapping Data

Table C.1: 100-year flood level and wave uprush allowance by reach, used to map Flooding Hazard

Reach	100 Year Flood Level (m)		Wave Uprush Elevation (m)		Top of Bluff Elevation (m)		Horizontal Wave Uprush (m)[1]
	CGVD2013	CGVD28 / IGLD85	CGVD2013	CGVD28 / IGLD85	CGVD2013	CGVD28 / IGLD85	
1	175.4	175.9	177.6	178.1	199.7	200.2	No overtopping
2	175.4	175.9	179.9	180.4	204.6	205.1	No overtopping
3	175.4	175.9	178.5	179.0	204.9	205.4	No overtopping
4	175.4	175.9	179.0	179.5	202.3	202.8	No overtopping
5	175.4	175.9	179.9	180.4	200.9	201.4	No overtopping
6	175.4	175.9	179.9	180.4	223.4	223.9	No overtopping
7	175.4	175.9	177.8	178.3	200.2	200.7	No overtopping
8	175.4	175.9	180.6	181.1	207.1	207.6	No overtopping
9	175.4	175.9	179.9	180.4	197.3	197.8	No overtopping
10	175.5	176.0	177.6	178.1	194.3	194.8	No overtopping
11	175.5	176.0	179.3	179.8	181.0	181.5	No overtopping
12	175.5	176.0	180.9	181.4	189.7	190.2	No overtopping
13	175.5	176.0	180.6	181.1	184.7	185.2	No overtopping
14	175.5	176.0	180.8	181.3	183.0	183.5	No overtopping
15	175.5	176.0	179.2	179.7	180.7	181.2	No overtopping
16	175.7	176.2	180.5	181.0	177.5	178.0	16
17	175.7	176.2	182.0	182.5	176.3	176.8	19
18	175.9	176.4	181.4	181.9	176.2	176.7	16
19	175.9	176.4	180.4	180.9	176.7	177.2	16
20	175.9	176.4	179.9	180.4	177.0	177.5	23
21	175.9	176.4	179.9	180.4	177.5	178.0	24
22	175.9	176.4	179.9	180.4	176.4	176.9	19
23	175.9	176.4	179.4	179.9	182.3	182.8	21
24	175.9	176.4	176.7	177.2	176.1	176.6	2[1]
25	175.9	176.4	176.3	176.8	176.1	176.6	4[1]
26	175.9	176.4	176.2	176.7	176.0	176.5	1[1]
27	175.9	176.4	176.8	177.3	176.0	176.5	3[1]
28	175.9	176.4	178.4	178.9	179.9	180.4	6[1]
29	175.9	176.4	178.1	178.6	182.1	182.6	No overtopping
30	175.9	176.4	179.4	179.9	176.0	176.5	5[1]
31	175.9	176.4	179.5	180.0	197.6	198.1	No overtopping
32	175.9	176.4	178.4	178.9	181.6	182.1	No overtopping
33	175.9	176.4	177.4	177.9	177.6	178.1	10[1]
34	175.9	176.4	180.7	181.2	176.0	176.5	12[1]

Reach	100 Year Flood Level (m)		Wave Uprush Elevation (m)		Top of Bluff Elevation (m)		Horizontal Wave Uprush (m)[1]
	CGVD2013	CGVD28 / IGLD85	CGVD2013	CGVD28 / IGLD85	CGVD2013	CGVD28 / IGLD85	
35	175.9	176.4	177.7	178.2	176.3	176.8	8[1]
36	175.9	176.4	179.0	179.5	176.4	176.9	11[1]
37	175.9	176.4	181.0	181.5	176.0	176.5	11[1]
38	175.9	176.4	181.4	181.9	208.7	209.2	No overtopping
39	175.9	176.4	181.0	181.5	199.5	200.0	No overtopping
40	175.9	176.4	181.7	182.2	176.4	176.9	13[1]
41	175.9	176.4	181.4	181.9	201.1	201.6	No overtopping
42	175.9	176.4	179.8	180.3	186.4	186.9	No overtopping
43	175.9	176.4	181.1	181.6	199.1	199.6	No overtopping
44	175.9	176.4	181.4	181.9	196.7	197.2	No overtopping
45	175.9	176.4	181.1	181.6	192.8	193.3	No overtopping
46	175.9	176.4	180.3	180.8	194.9	195.4	No overtopping
47	175.9	176.4	181.6	182.1	191.5	192.0	No overtopping
48	175.9	176.4	181.9	182.4	192.2	192.7	No overtopping
49	175.9	176.4	181.9	182.4	186.7	187.2	No overtopping
50	175.9	176.4	180.1	180.6	193.0	193.5	No overtopping
51	175.9	176.4	180.8	181.3	194.0	194.5	No overtopping
52	175.9	176.4	179.4	179.9	195.3	195.8	No overtopping
53	175.9	176.4	181.4	181.9	188.5	189.0	No overtopping
54	175.9	176.4	180.4	180.9	191.6	192.1	No overtopping
55	175.9	176.4	181.3	181.8	188.0	188.5	No overtopping
56	175.9	176.4	176.7	177.2	176.9	177.4	No overtopping
57	175.9	176.4	177.3	177.8	176.3	176.8	7[1]
58	176.0	176.5	181.3	181.8	190.2	190.7	No overtopping
59	176.0	176.5	181.9	182.4	187.8	188.3	No overtopping
60	176.0	176.5	182.1	182.6	187.2	187.7	No overtopping
61	176.0	176.5	182.1	182.6	184.8	185.3	No overtopping
62	176.0	176.5	181.7	182.2	183.2	183.7	No overtopping
63	176.0	176.5	180.4	180.9	183.8	184.3	No overtopping
64	176.0	176.5	180.9	181.4	186.5	187.0	No overtopping

[1] Note that all values with horizontal wave uprush calculated as less than 15 m were mapped as 15 m due to possible variability in wave exposure, nearshore slope, water depth at the toe, and bluff height within a reach.

Table C.2: Stable slope allowance used to map Erosion Hazard

Reach	Geotechnical Section	Primary Soil Type	Stable Slope Inclination (H:V)	Top of Bank Elevation (m CGVD 2013)	Stable Slope Allowance (m)
1	T01	Sand, Silt Rhythmites Silt and Clay	2.5H:1V (above Elev. 178.8 m) 2.3H:1V (below Elev. 178.8 m)	198	59.0
2	use T01			203	71.5
3	use T04			203	60.4
4	T04	Sand Sand Rhythmite	2.5H:1V (above Elev. 198.3 m) 2.0H:1V (below Elev. 198.3 m)	204	62.9
5	use T04			199	50.5
6	T06	Sand Sand Rhythmite	2.5H:1V (above Elev. 198.9 m) 2.0H:1V (below Elev. 198.9 m)	201	55.1
7	use T06			200	52.6
8	use T09			203	68.3
9	T09	Sand Clayey Silt Till	2.5H:1V (above Elev. 195.0 m) 2.3H:1V (below Elev. 195.0 m)	197	53.3
10	use T09			195	48.3
11	T11	Sand Clayey Silt Till	2.5H:1V (above Elev. 179.9 m) 2.3H:1V (below Elev. 179.9 m)	175-182	2.3-18.8
12	use T13			188	29.6
13	T13	Sand Rhythmite Clayey Silt Till	2.0H:1V (below Elev. 179.3 m) 2.3H:1V (below Elev. 179.3 m)	184	21.6
14	use T15			182	18.4
15	T15	Silt and Clay	2.3H:1V	180	13.8
16-27	No bluff, stable slope not applicable.				
28	T28	Sand	2.5H:1V	176-180	5-15
29	T29	Silt and Clay	2.3H:1V	180-184	13.8-23
30	T30	Silt and Clay	2.3H:1V	184-192	23-41.4
31	T31	Silt and Clay	2.3H:1V	194-200	46-59.8
32	T32	Silt and Clay	2.3H:1V	200-202	59.8-64.4
33	use T32	Silt and Clay	2.3H:1V	200-206	59.8-73.6
34	use T32	Silt and Clay	2.3H:1V	206-210	73.6-82.8
35	use T37	Sand Silt and Clay Sand Rhythmite	2.5H:1V (above 208.5 m) 2.3H:1V (208.5 - 203.5 m) 2.0H:1V (below 203.5 m)	192-210 174	36-74.3
36	use T37	Sand Silt and Clay Sand Rhythmite	2.5H:1V (above 208.5 m) 2.3H:1V (208.5 - 203.5 m) 2.0H:1V (below 203.5 m)	210-214	74.3-84.3

Reach	Geotechnical Section	Primary Soil Type	Stable Slope Inclination (H:V)	Top of Bank Elevation (m CGVD 2013)	Stable Slope Allowance (m)
37	T37	Sand Silt and Clay Sand Rhythmite	2.5H:1V (above 208.5 m) 2.3H:1V (208.5 - 203.5 m) 2.0H:1V (below 203.5 m)	186-218	24-94.3
38	T38	Sand Silt and Clay Sand Rhythmite	2.5H:1V (above 204.0 m) 2.3H:1V (204.0 – 201.0 m) 2.0H:1V (below 201.0 m)	204-218	60.9-95.9
39	T39	Sand Silt and Clay Sand Rhythmite	2.5H:1V (above 188.5 m) 2.3H:1V (188.5 – 183.5 m) 2.0H:1V (below 183.5 m)	182-203	34.3-66.8
40	T40	Silt and Clay Sand Rhythmite	2.3H:1V (above 181.1 m) 2.0H:1V (below 181.1 m)	180-206	12-71.5
41	T41	Silt and Clay Sand Rhythmite	2.3H:1V (above 196.1 m) 2.0H:1V (below 196.1 m)	194-206	40-67
42	T42	Sand Rhythmite	2.0H:1V	178-192	8-36
43	T43	Silt and Clay Sand Rhythmite	2.3H:1V (above 193.0 m) 2.0H:1V (below 193.0 m)	190-202	32-58.7
44	T44	Silt and Clay Sand Rhythmite	2.3H:1V (above 190.7 m) 2.0H:1V (below 190.7 m)	186-196	24-45.6
45	T45	Silt and Clay Sand Rhythmite	2.3H:1V (above 186.9 m) 2.0H:1V (below 186.9 m)	186-196	24-46.7
46	T46	Silt and Clay Sand Rhythmite	2.3H:1V (above 185.2 m) 2.0H:1V (below 185.2 m)	190-194	33.4-42.6
47	T47	Silt and Clay	2.3H:1V	188-192	32.2-41.4
48	T48	Silt and Clay	2.3H:1V	186-192	27.6-41.4
49	T49	Silt and Clay	2.3H:1V	186-192	27.6-41.4
50	T50	Silt and Clay	2.3H:1V	192	41.4
51	T51	Silt and Clay	2.3H:1V	192-194	41.4-46
52	T52	Silt and Clay	2.3H:1V	194-196	46-50.6
53	T53	Silt and Clay	2.3H:1V	192-194	41.4-46
54	T54	Silt and Clay	2.3H:1V	188-194	32.2-46
55	T55	Silt and Clay	2.3H:1V	184-188	23-32.2
56	T56	Sand	2.5H:1V	184-186	25-30
57	T57	Sand	2.5H:1V	188-190	35-40
58	T58	Silt and Clay	2.3H:1V	186-189	27.6-34.5
59	T59	Silt and Clay	2.3H:1V	182-188	18.4-32.2
60	T60	Silt and Clay	2.3H:1V	186	27.6

Reach	Geotechnical Section	Primary Soil Type	Stable Slope Inclination (H:V)	Top of Bank Elevation (m CGVD 2013)	Stable Slope Allowance (m)
61	T61	Silt and Clay	2.3H:1V	184-186	23-27.6
62	T62	Silt and Clay	2.3H:1V	184	23
63	T63	Silt and Clay	2.3H:1V	182-186	18.4-27.6
64	T64	Silt and Clay	2.3H:1V	186-187	27.6-29.9

Table C.3: Erosion allowance used to map Erosion Hazard

Reach	Erosion Allowance (m)	Basis of Erosion Allowance
1	366	Erosion measurements from historic airphotos, 62 years
2	316	Erosion measurements from historic airphotos, 62 years
3	231	Erosion measurements from historic airphotos, 53 years
4	268	Erosion measurements from historic airphotos, 53 years
5	207	Erosion measurements from historic airphotos, 53 years
6	215	Erosion measurements from historic airphotos, 53 years
7	203	Erosion measurements from historic airphotos, 62 years
8	208	Erosion measurements from historic airphotos, 62 years
9	184	Erosion measurements from historic airphotos, 62 years
10	242	Erosion measurements from historic airphotos, 62 years
11	309	Erosion measurements from historic airphotos, 62 years
12	245	Erosion measurements from historic airphotos, 62 years
13	165	Erosion measurements from historic airphotos, 62 years
14	88	Erosion measurements from historic airphotos, 62 years
15	80	Erosion measurements from historic airphotos, 62 years
16	10	Sheltered area with minimal discernible erosion based on historic air photos
17	n/a	Dynamic beach, erosion hazard not mapped
18	n/a	Dynamic beach, erosion hazard not mapped
19	n/a	Dynamic beach, erosion hazard not mapped
20	n/a	Dynamic beach, erosion hazard not mapped
21	n/a	Dynamic beach, erosion hazard not mapped
22	n/a	Dynamic beach, erosion hazard not mapped
23	n/a	Dynamic beach, erosion hazard not mapped
24	n/a	Marsh, erosion hazard not mapped
25	n/a	Marsh, erosion hazard not mapped
26	n/a	Marsh, erosion hazard not mapped
27	n/a	Marsh, erosion hazard not mapped
28	10	Sheltered area with minimal discernible erosion based on historic air photos
29	30	Default 0.3 m per year
30	10	Sheltered area with minimal discernible erosion based on historic air photos
31	30	Default 0.3 m per year
32	10	Sheltered area with minimal discernible erosion based on historic air photos
33	10	Sheltered area with minimal discernible erosion based on historic air photos
34	10	Sheltered area with minimal discernible erosion based on historic air photos
35	10	Sheltered area with minimal discernible erosion based on historic air photos
36	10	Sheltered area with minimal discernible erosion based on historic air photos

Reach	Erosion Allowance (m)	Basis of Erosion Allowance
37	10	Sheltered area with minimal discernible erosion based on historic air photos
38	32	Erosion measurements from historic airphotos, 53 years
39	30	Default 0.3 m per year
40	30	Default 0.3 m per year
41	26	Erosion measurements from historic airphotos, 53 years
42	30	Default 0.3 m per year
43	41	Erosion measurements from historic airphotos, 53 years
44	21	Erosion measurements from historic airphotos, 53 years
45	31	Erosion measurements from historic airphotos, 53 years
46	30	Default 0.3 m per year
47	40	Erosion measurements from historic airphotos, 53 years
48	30	Default 0.3 m per year
49	72	Erosion measurements from historic airphotos, 62 years
50	51	Erosion measurements from historic airphotos, 62 years
51	16	Erosion measurements from historic airphotos, 62 years
52	46	Erosion measurements from historic airphotos, 53 years
53	70	Erosion measurements from historic airphotos, 53 years
54	30	Default 0.3 m per year
55	30	Default 0.3 m per year
56	30	Default 0.3 m per year
57	10	Sheltered area with minimal discernible erosion based on historic air photos
58	30	Default 0.3 m per year
59	30	Default 0.3 m per year
60	30	Default 0.3 m per year
61	30	Default 0.3 m per year
62	30	Default 0.3 m per year
63	30	Default 0.3 m per year
64	30	Default 0.3 m per year

Table C.4: Examples of estimated flood proofing elevations by reach for selected shoreline treatments

Notes:

1. Lake Erie 100-year Static Lake Level (values from Baird analysis used, as they are more conservative):
   175.16 m IGLD85
   174.70 m CGVD2013
2. Depth limited breaking wave assumed; Tp=10s
3. Uprush on beach calculated using Stockdon et. Al. (2006)
4. All other uprush calculated using EurOTop (2018)
5. Tables provide examples only. Flood proofing elevation should be determined on a site specific basis by a Professional Engineer with experience in flood proofing.

Lake Erie 100-year Storm Surge

Reaches		Reach number from MNR (1989)	100-year storm surge (m) from MNR (1989)	100-year static lake level plus 100-year storm surge (m CGVD2013)	100-year flood level (m CGVD2013)
1 to 9	West County Limit to 1306 Lakeshore Road	E-11	1.01	175.71	175.4
10 to 15	1338 Lakeshore Road to Cove Lane	E-12	1.23	175.93	175.5
16 to 17	Lee Brown Waterfowl Mngt. Area and Hastings Drive	E-13	1.43	176.13	175.7
18 to 23	Long Point	E-14	1.74	176.44	175.9
24 to 57	Long Point Bay to Port Dover Marina	E-17	1.66	176.36	175.9
58 to 64	East of Port Dover Marina to East County Limit	E-18	1.77	176.47	176.0

Lake Erie Minimum Floodproofing Standard Elevation (m)

***Note: does not include freeboard allowance, minimum 0.3 m recommended**

Reaches	100-year static lake level plus 100-year storm surge (m CGVD2013)	Structure	Toe Elevation (m CGVD2013)	Water depth (m)	Wave Height (m)	Uprush (m)	Uprush Elevation (m CGVD2013)	Uprush Elevation (m IGLD85)
1 to 9	175.7	1:50 sloped beach	171.7	4.0	3.1	1.0	176.7	177.2
		1:10 sloped dune	174.7	1.0	0.8	2.2	177.9	178.4
		1:10 sloped dune	173.7	2.0	1.6	2.5	178.2	178.7
		1:10 sloped dune	172.7	3.0	2.3	3.0	178.7	179.2
		1:10 sloped dune	171.7	4.0	3.1	3.5	179.2	179.7
		1:2 sloped revetment	174.7	1.0	0.8	2.4	178.1	178.6
		1:2 sloped revetment	173.7	2.0	1.6	4.7	180.4	180.9
		1:2 sloped revetment	172.7	3.0	2.3	6.9	182.6	183.1
		1:2 sloped revetment	171.7	4.0	3.1	9.0	184.7	185.2
		vertical wall	174.7	1.0	0.8	3.3	179.0	179.5
		vertical wall	173.7	2.0	1.6	3.0	178.7	179.2
		vertical wall	172.7	3.0	2.3	4.5	180.2	180.7
		vertical wall	171.7	4.0	3.1	6.0	181.7	182.2
10 to 15	175.9	1:50 sloped beach	171.9	4.0	3.1	1.0	176.9	177.4
		1:10 sloped dune	174.9	1.0	0.8	2.2	178.1	178.6
		1:10 sloped dune	173.9	2.0	1.6	2.5	178.4	178.9
		1:10 sloped dune	172.9	3.0	2.3	3.0	178.9	179.4
		1:10 sloped dune	171.9	4.0	3.1	3.5	179.4	179.9
		1:2 sloped revetment	174.9	1.0	0.8	2.4	178.3	178.8
		1:2 sloped revetment	173.9	2.0	1.6	4.7	180.6	181.1

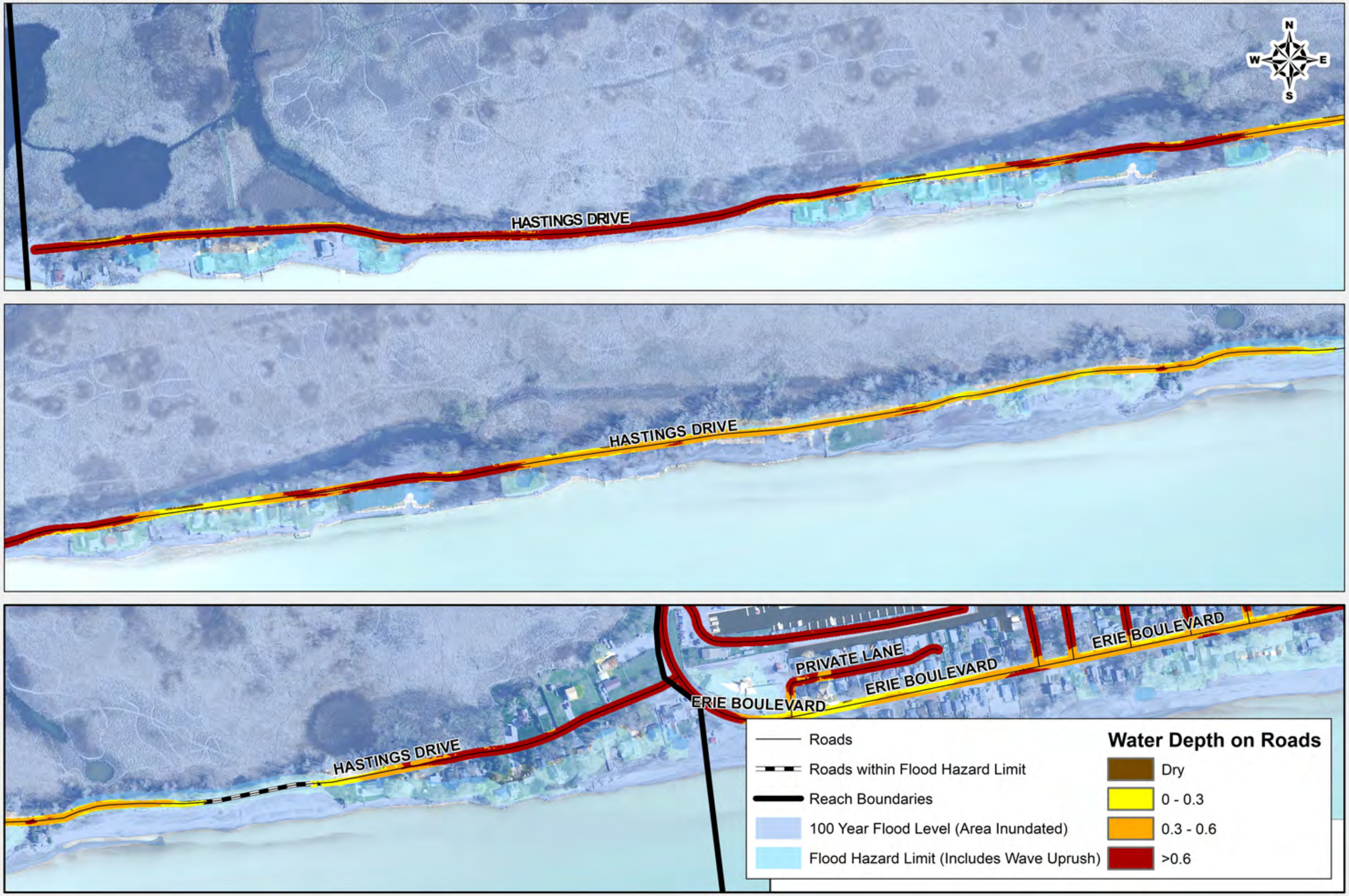
Reaches	100-year static lake level plus 100-year storm surge (m CGVD2013)	Structure	Toe Elevation (m CGVD2013)	Water depth (m)	Wave Height (m)	Uprush (m)	Uprush Elevation (m CGVD2013)	Uprush Elevation (m IGLD85)
		1:2 sloped revetment	172.9	3.0	2.3	6.9	182.8	183.3
		1:2 sloped revetment	171.9	4.0	3.1	9.0	184.9	185.4
		vertical wall	174.9	1.0	0.8	3.3	179.2	179.7
		vertical wall	173.9	2.0	1.6	3.0	178.9	179.4
		vertical wall	172.9	3.0	2.3	4.5	180.4	180.9
		vertical wall	171.9	4.0	3.1	6.0	181.9	182.4
16 to 17	176.1	1:50 sloped beach	172.1	4.0	3.1	1.0	177.1	177.6
		1:10 sloped dune	175.1	1.0	0.8	2.2	178.3	178.8
		1:10 sloped dune	174.1	2.0	1.6	2.5	178.6	179.1
		1:10 sloped dune	173.1	3.0	2.3	3.0	179.1	179.6
		1:10 sloped dune	172.1	4.0	3.1	3.5	179.6	180.1
		1:2 sloped revetment	175.1	1.0	0.8	2.4	178.5	179.0
		1:2 sloped revetment	174.1	2.0	1.6	4.7	180.8	181.3
		1:2 sloped revetment	173.1	3.0	2.3	6.9	183.0	183.5
		1:2 sloped revetment	172.1	4.0	3.1	9.0	185.1	185.6
		vertical wall	175.1	1.0	0.8	3.3	179.4	179.9
		vertical wall	174.1	2.0	1.6	3.0	179.1	179.6
		vertical wall	173.1	3.0	2.3	4.5	180.6	181.1
		vertical wall	172.1	4.0	3.1	6.0	182.1	182.6
18 to 23	176.4	1:50 sloped beach	172.4	4.0	3.1	1.0	177.4	177.9
		1:10 sloped dune	175.4	1.0	0.8	2.2	178.6	179.1
		1:10 sloped dune	174.4	2.0	1.6	2.5	178.9	179.4
		1:10 sloped dune	173.4	3.0	2.3	3.0	179.4	179.9

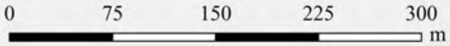
Reaches	**100-year static lake level plus 100-year storm surge (m CGVD2013)**	**Structure**	**Toe Elevation (m CGVD2013)**	**Water depth (m)**	**Wave Height (m)**	**Uprush (m)**	**Uprush Elevation (m CGVD2013)**	**Uprush Elevation (m IGLD85)**
		1:10 sloped dune	172.4	4.0	3.1	3.5	179.9	180.4
		1:2 sloped revetment	175.4	1.0	0.8	2.4	178.8	179.3
		1:2 sloped revetment	174.4	2.0	1.6	4.7	181.1	181.6
		1:2 sloped revetment	173.4	3.0	2.3	6.9	183.3	183.8
		1:2 sloped revetment	172.4	4.0	3.1	9.0	185.4	185.9
		vertical wall	175.4	1.0	0.8	3.3	179.7	180.2
		vertical wall	174.4	2.0	1.6	3.0	179.4	179.9
		vertical wall	173.4	3.0	2.3	4.5	180.9	181.4
		vertical wall	172.4	4.0	3.1	6.0	182.4	182.9
24 to 57	176.4	1:50 sloped beach	172.4	4.0	3.1	1.0	177.4	177.8
		1:10 sloped dune	175.4	1.0	0.8	2.2	178.6	179.0
		1:10 sloped dune	174.4	2.0	1.6	2.5	178.9	179.3
		1:10 sloped dune	173.4	3.0	2.3	3.0	179.4	179.8
		1:10 sloped dune	172.4	4.0	3.1	3.5	179.9	180.3
		1:2 sloped revetment	175.4	1.0	0.8	2.4	178.8	179.2
		1:2 sloped revetment	174.4	2.0	1.6	4.7	181.1	181.5
		1:2 sloped revetment	173.4	3.0	2.3	6.9	183.3	183.7
		1:2 sloped revetment	172.4	4.0	3.1	9.0	185.4	185.8
		vertical wall	175.4	1.0	0.8	3.3	179.7	180.1
		vertical wall	174.4	2.0	1.6	3.0	179.4	179.8
		vertical wall	173.4	3.0	2.3	4.5	180.9	181.3
		vertical wall	172.4	4.0	3.1	6.0	182.4	182.8
58 to 64	176.5	1:50 sloped beach	172.5	4.0	3.1	1.0	177.5	177.9

Reaches	100-year static lake level plus 100-year storm surge (m CGVD2013)	Structure	Toe Elevation (m CGVD2013)	Water depth (m)	Wave Height (m)	Uprush (m)	Uprush Elevation (m CGVD2013)	Uprush Elevation (m IGLD85)
		1:10 sloped dune	175.5	1.0	0.8	2.2	178.7	179.1
		1:10 sloped dune	174.5	2.0	1.6	2.5	179.0	179.4
		1:10 sloped dune	173.5	3.0	2.3	3.0	179.5	179.9
		1:10 sloped dune	172.5	4.0	3.1	3.5	180.0	180.4
		1:2 sloped revetment	175.5	1.0	0.8	2.4	178.9	179.3
		1:2 sloped revetment	174.5	2.0	1.6	4.7	181.2	181.6
		1:2 sloped revetment	173.5	3.0	2.3	6.9	183.4	183.8
		1:2 sloped revetment	172.5	4.0	3.1	9.0	185.5	185.9
		vertical wall	175.5	1.0	0.8	3.3	179.8	180.2
		vertical wall	174.5	2.0	1.6	3.0	179.5	179.9
		vertical wall	173.5	3.0	2.3	4.5	181.0	181.4
		vertical wall	172.5	4.0	3.1	6.0	182.5	182.9

Appendix D

Flood Depth Mapping for Flood Preparedness

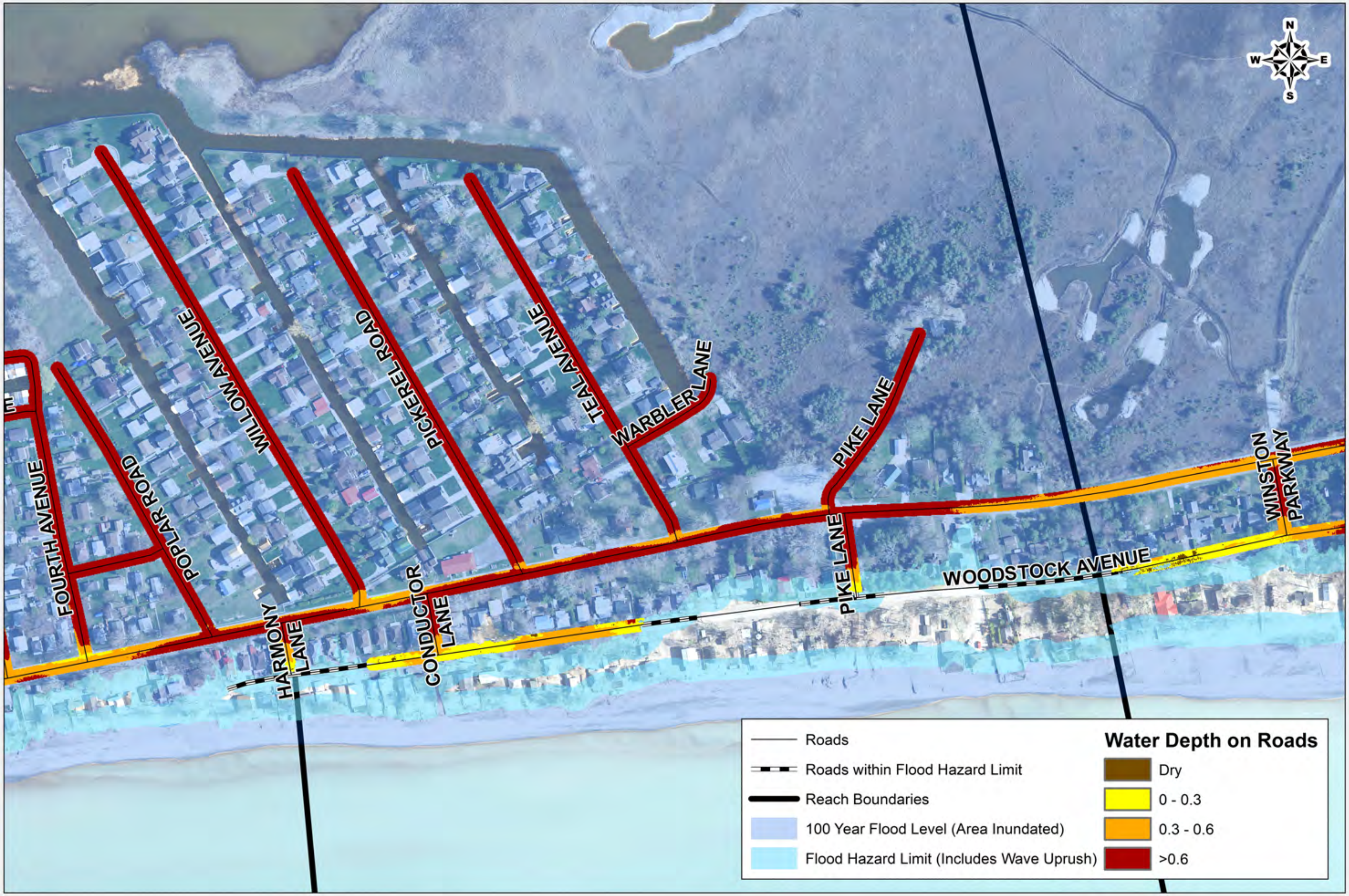




Reach 17

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

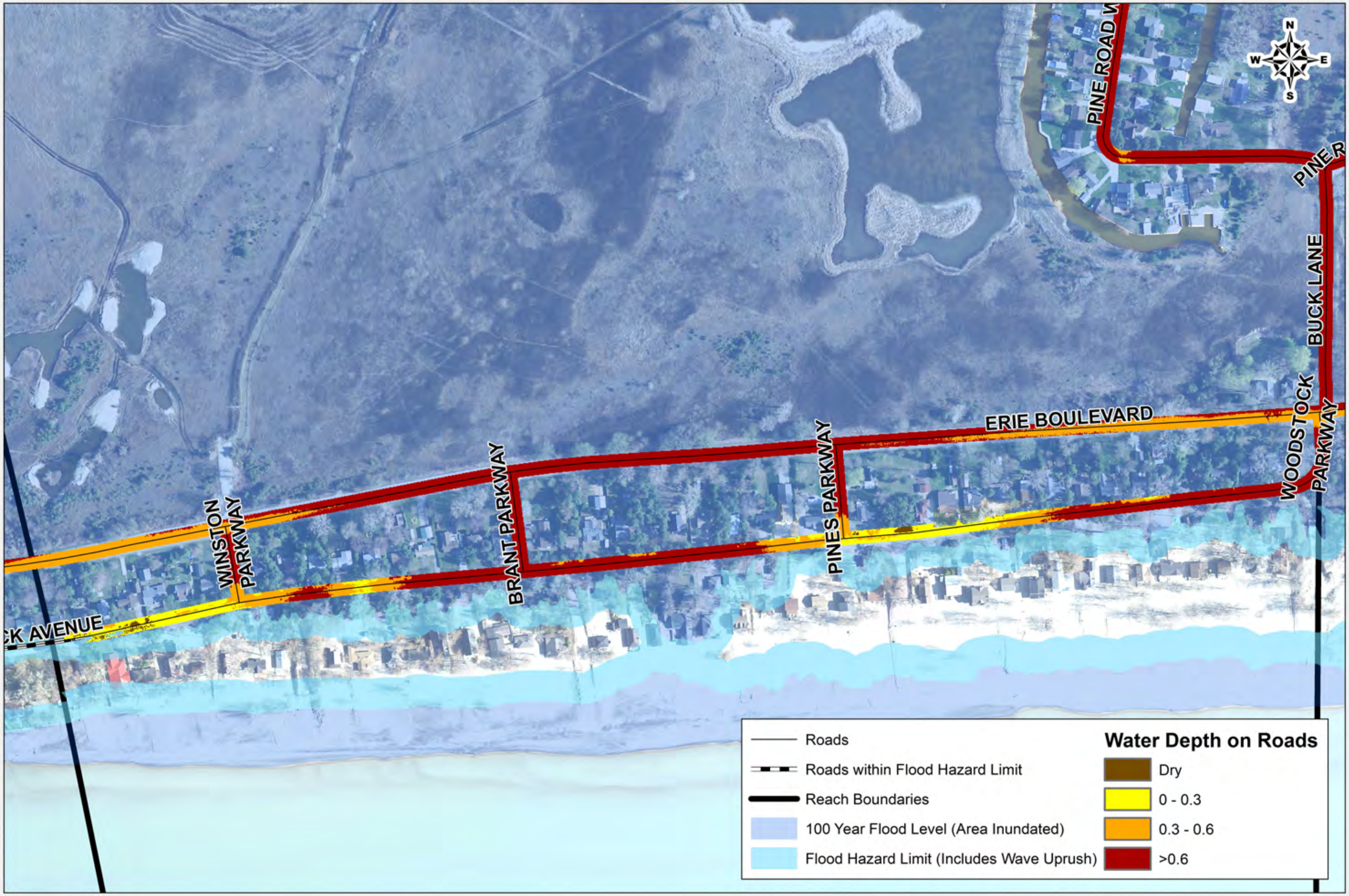
Baird.



Reach 19

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

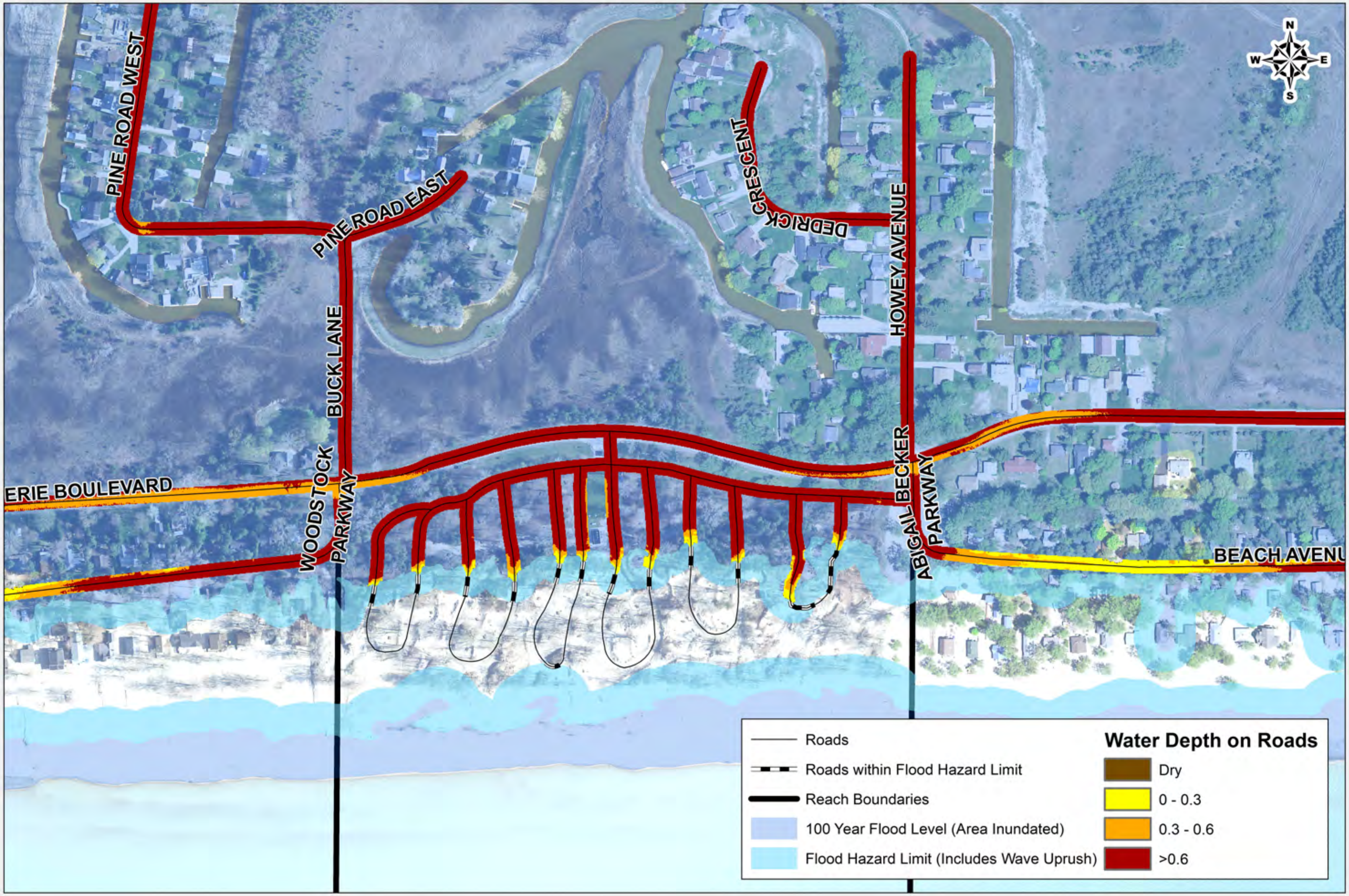
Baird.



0 50 100 150 200 m

Reach 20

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N



0 50 100 150 200
m

Reach 21

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

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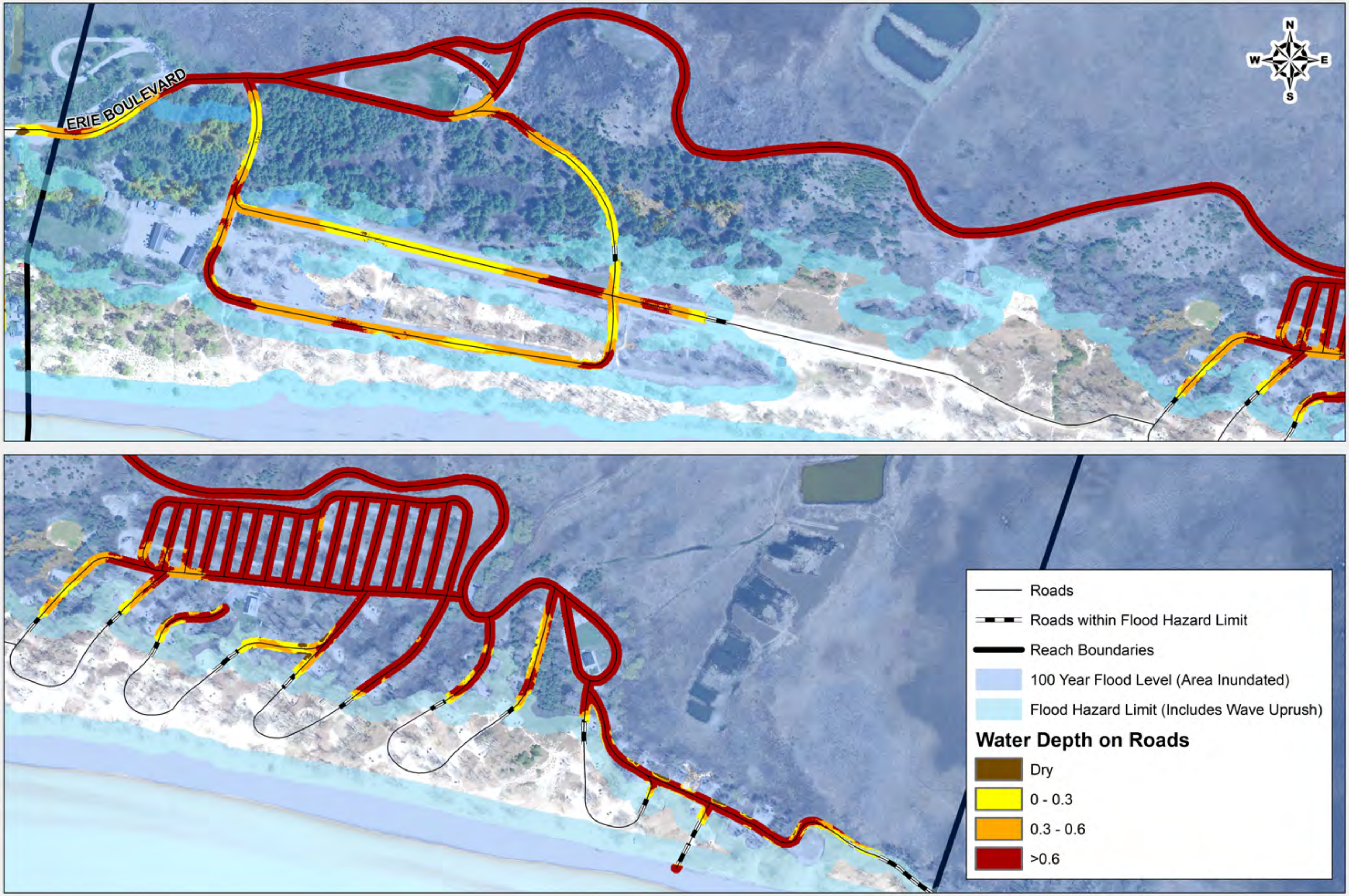

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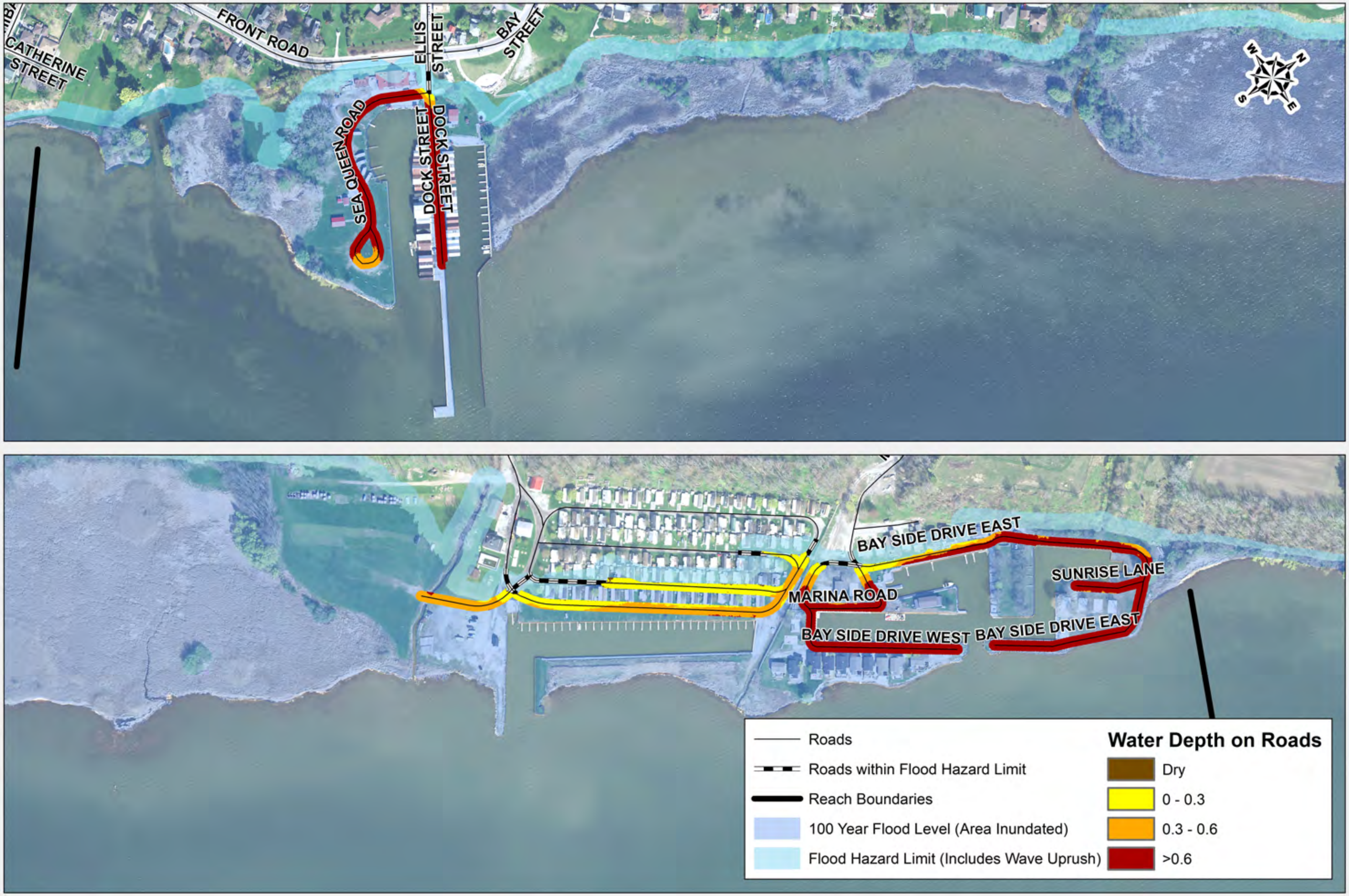
Reach 23

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.



0 50 100 150 200 m

Reach 30

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

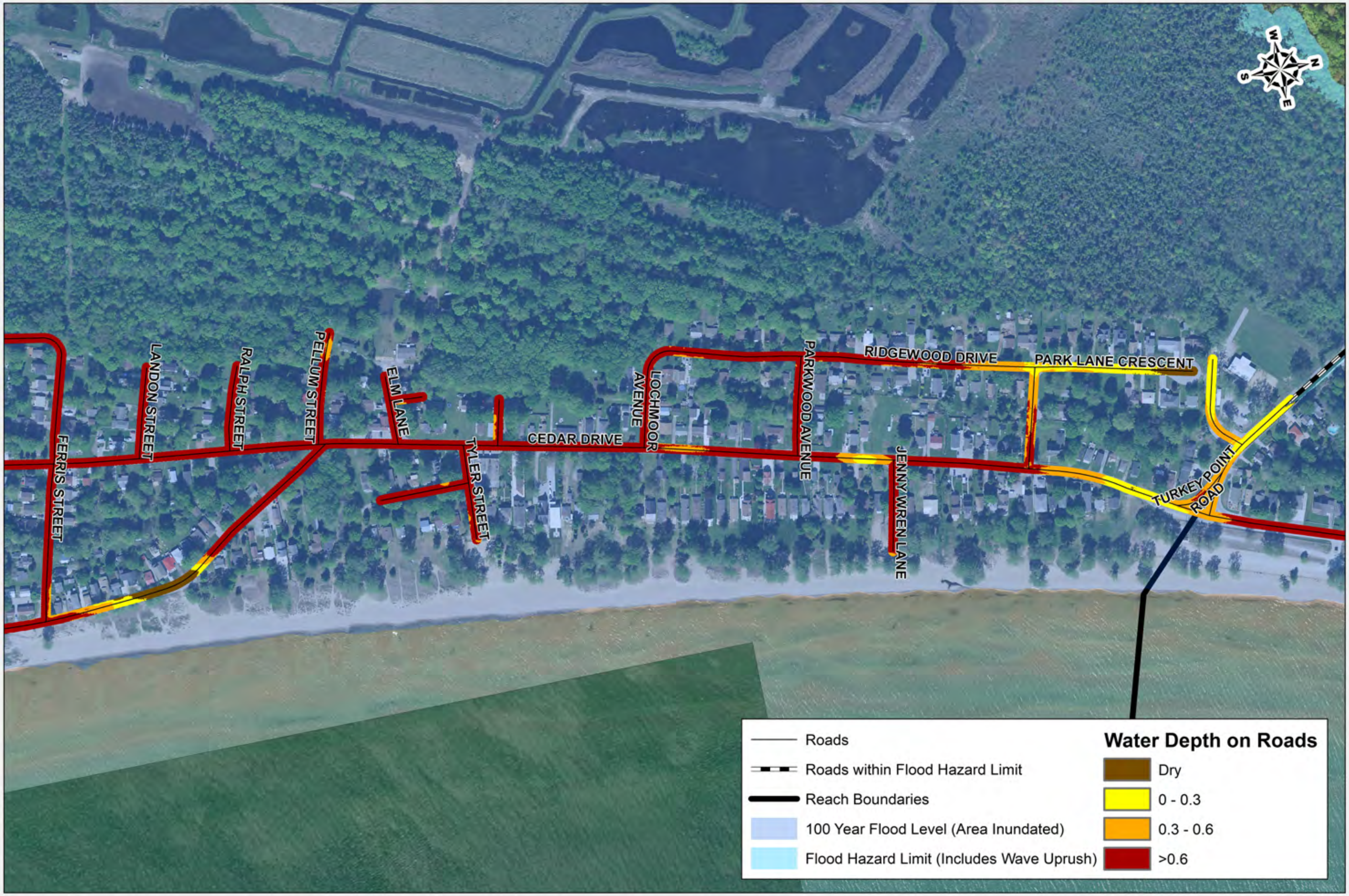
Baird.

0 50 100 150 200
m

Reach 32

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

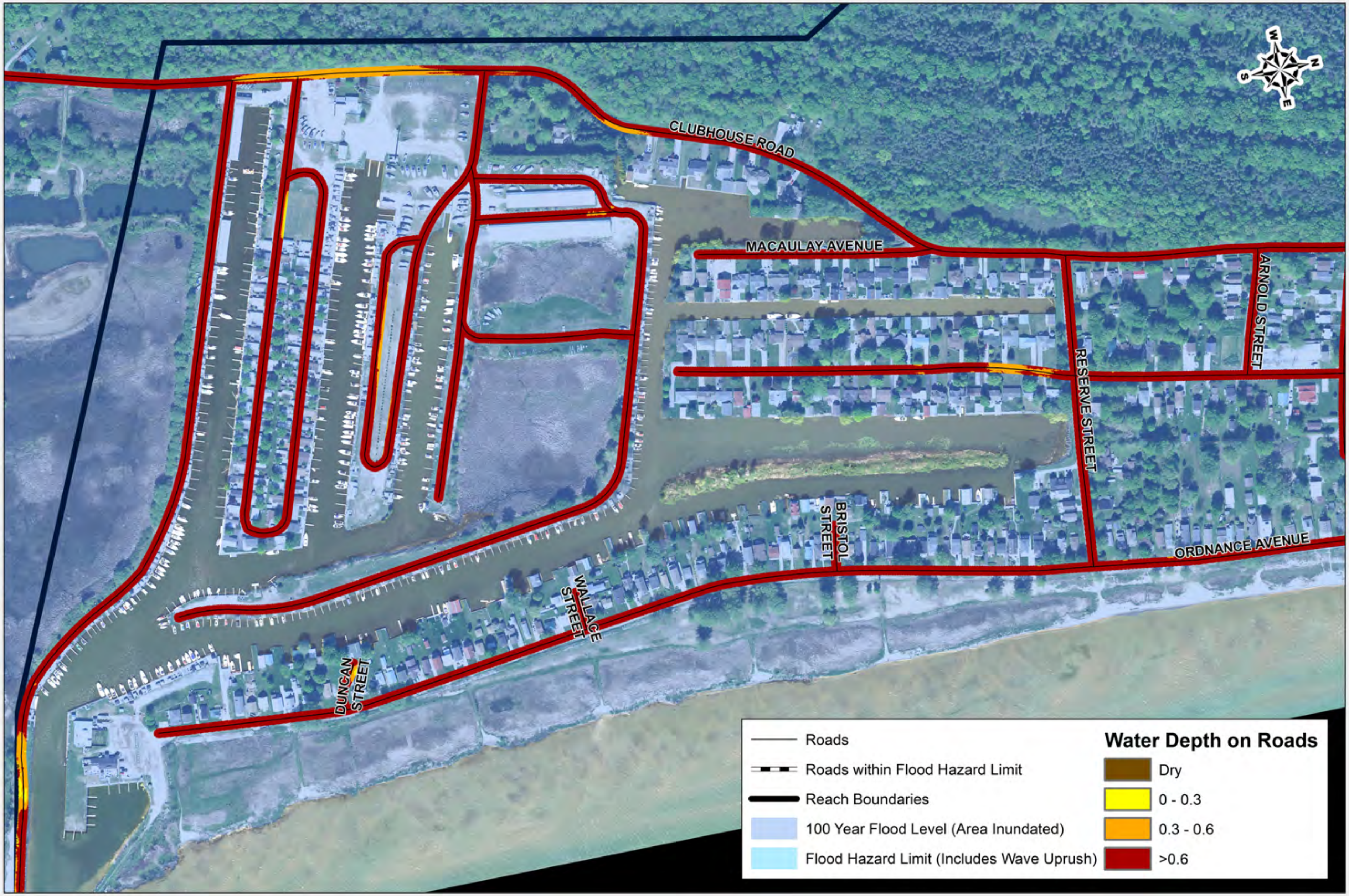
Baird.



Reach 35 (North)

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.

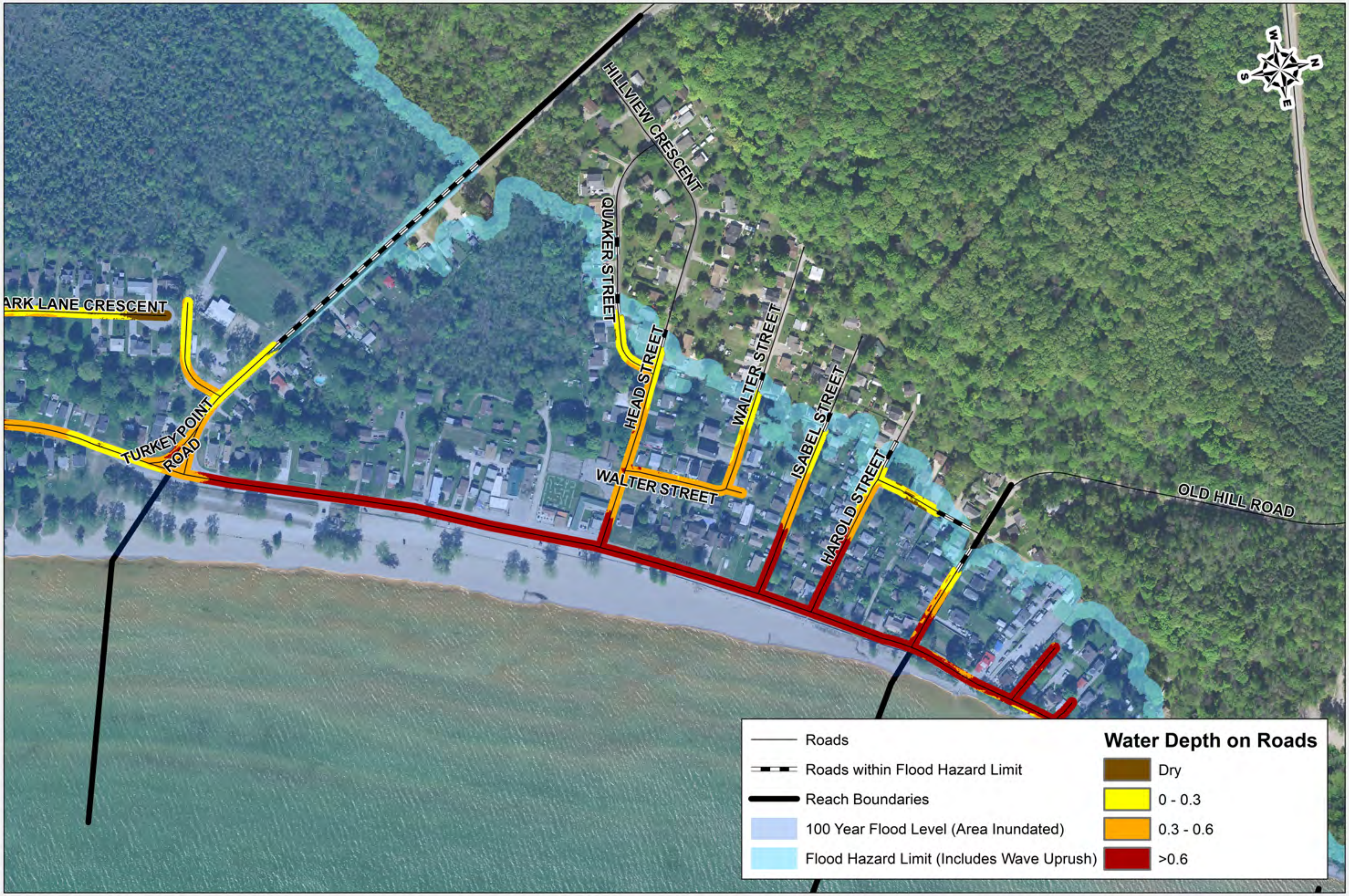


0 75 150 225 300 m

Reach 35 (South)

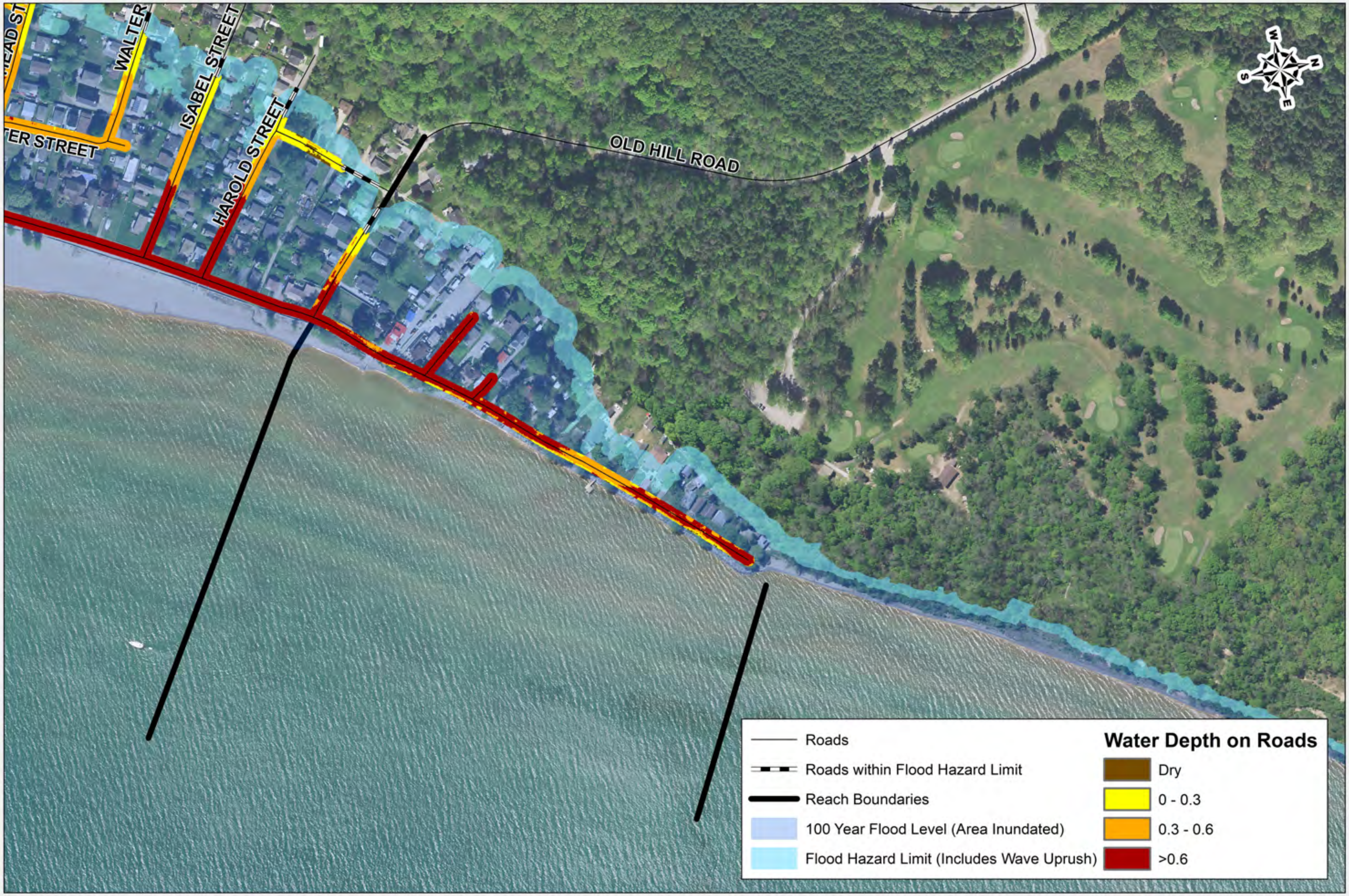
Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.



Reach 36

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N



0 50 100 150 200 m

Reach 37

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Baird.

Appendix E

Road and Building Flood Depth Mapping

Area #1 – Port Dover 100-year Flood Depths

100-yr flood level = 175.9m CGVD2013

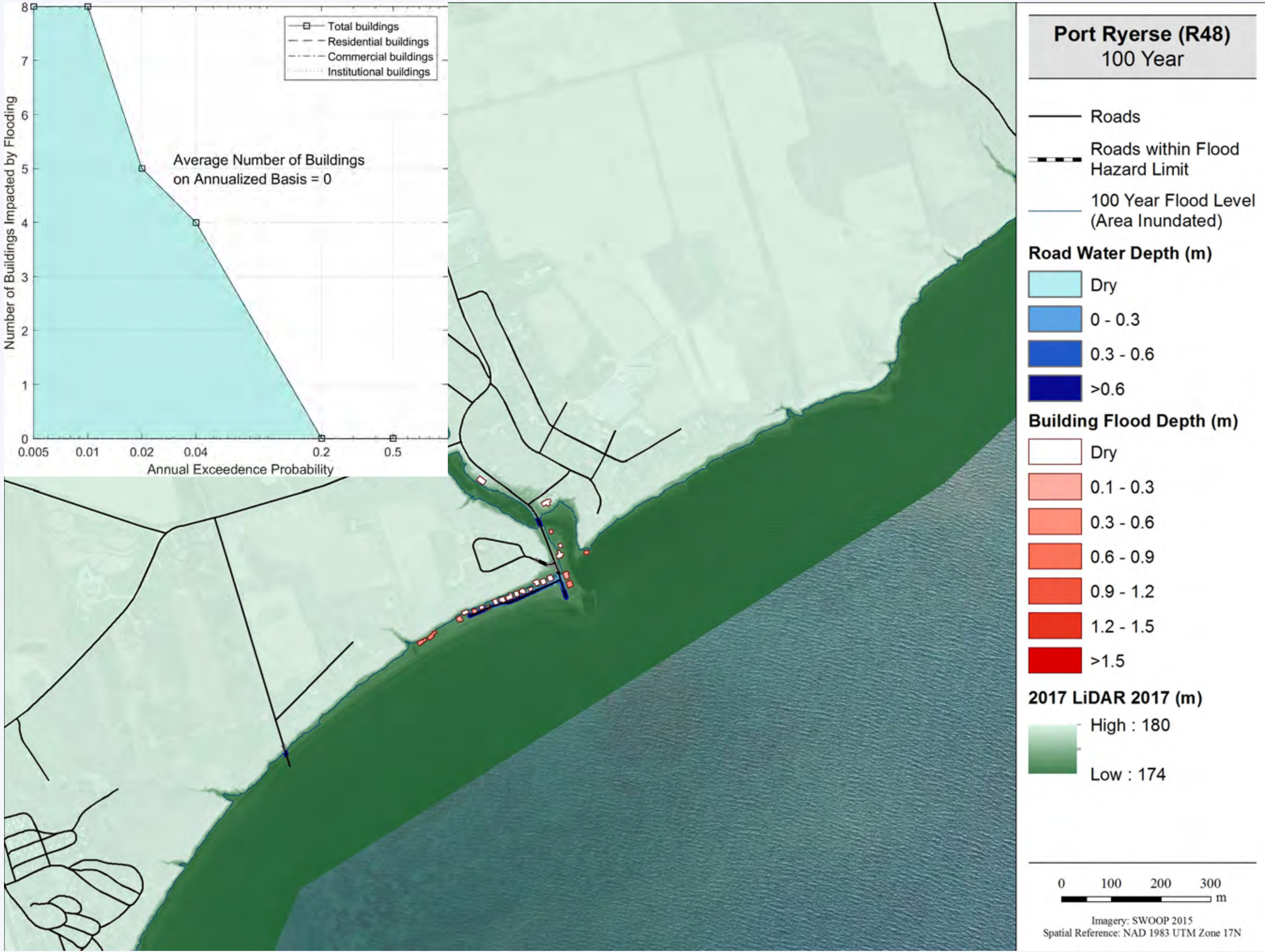
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
RIVER DRIVE	174.7	175.2
Port Dover - No Name 2	174.9	175.4
WALKER STREET	174.9	175.4
HARBOUR STREET	174.9	175.4
DREW WILLIAMSON BOULEVARD	175.2	175.7

Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Area #2 – Port Ryerse 100-year Flood Depths

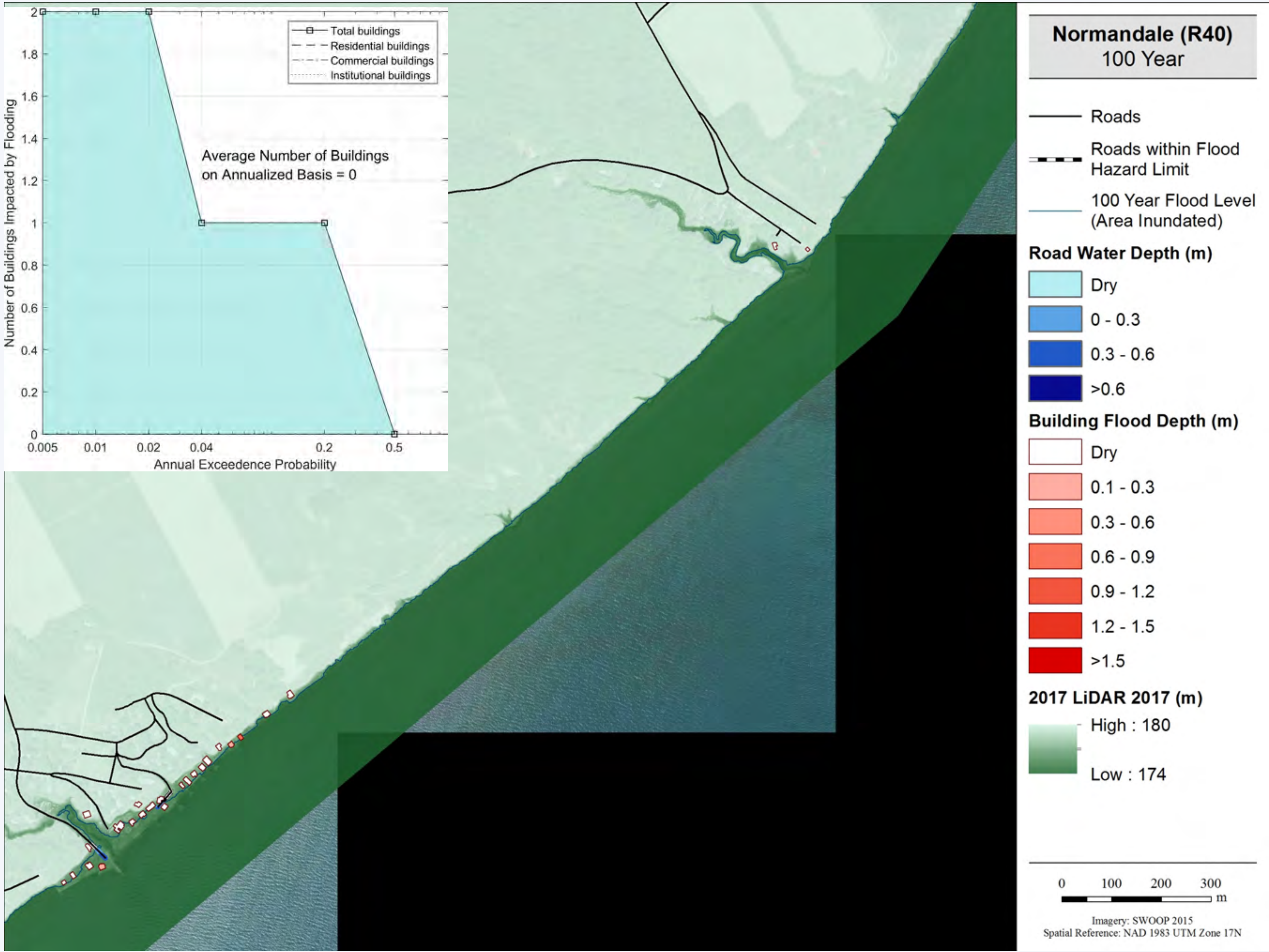
100-yr flood level = 175.9m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
WILLOW BEACH LANE	174.9	175.4



Area #3 – Normandale 100-year Flood Depths

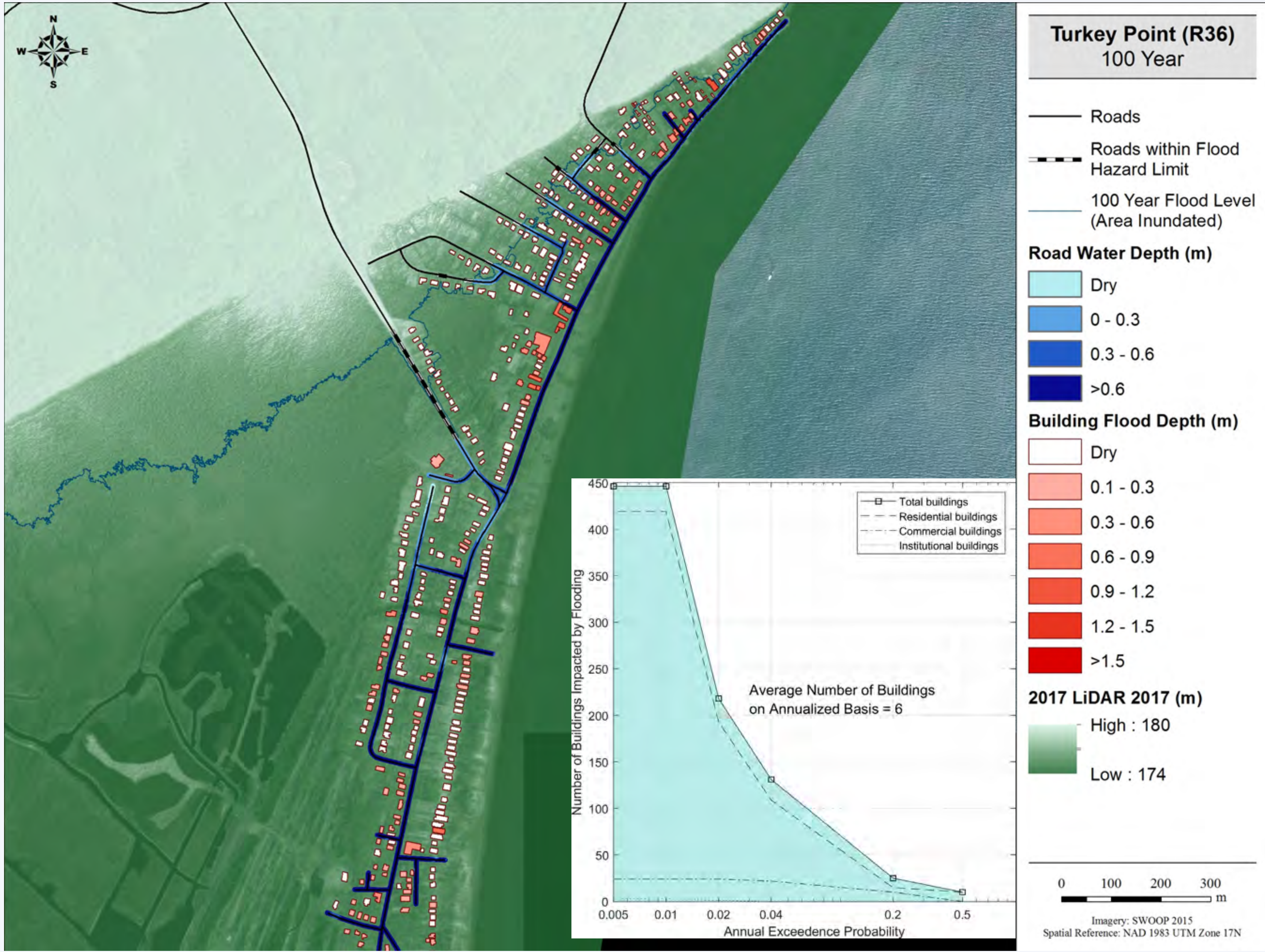
100-yr flood level = 175.9m CGVD2013



Area #4 – Turkey Point North 100-year Flood Depths

100-yr flood level = 175.9m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
CEDAR DRIVE from FERRIS STREET to TURKEY POINT ROAD	175.0	175.4
CEDAR DRIVE from TURKEY POINT ROAD to end of ROAD	174.7	175.2

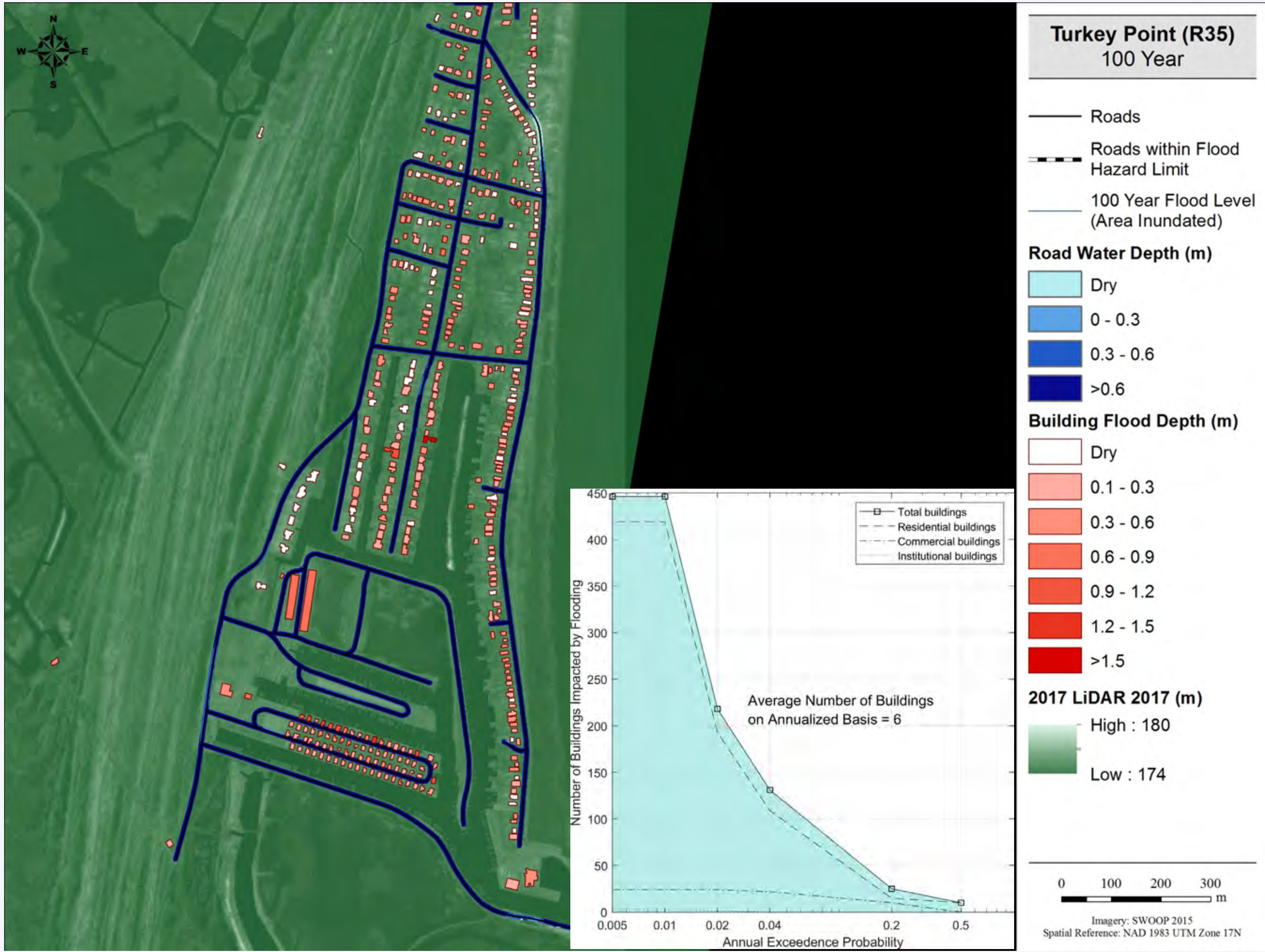


Imagery: SWOOP 2015
Spatial Reference: NAD 1983 UTM Zone 17N

Area #5 – Turkey Point South 100-year Flood Depths

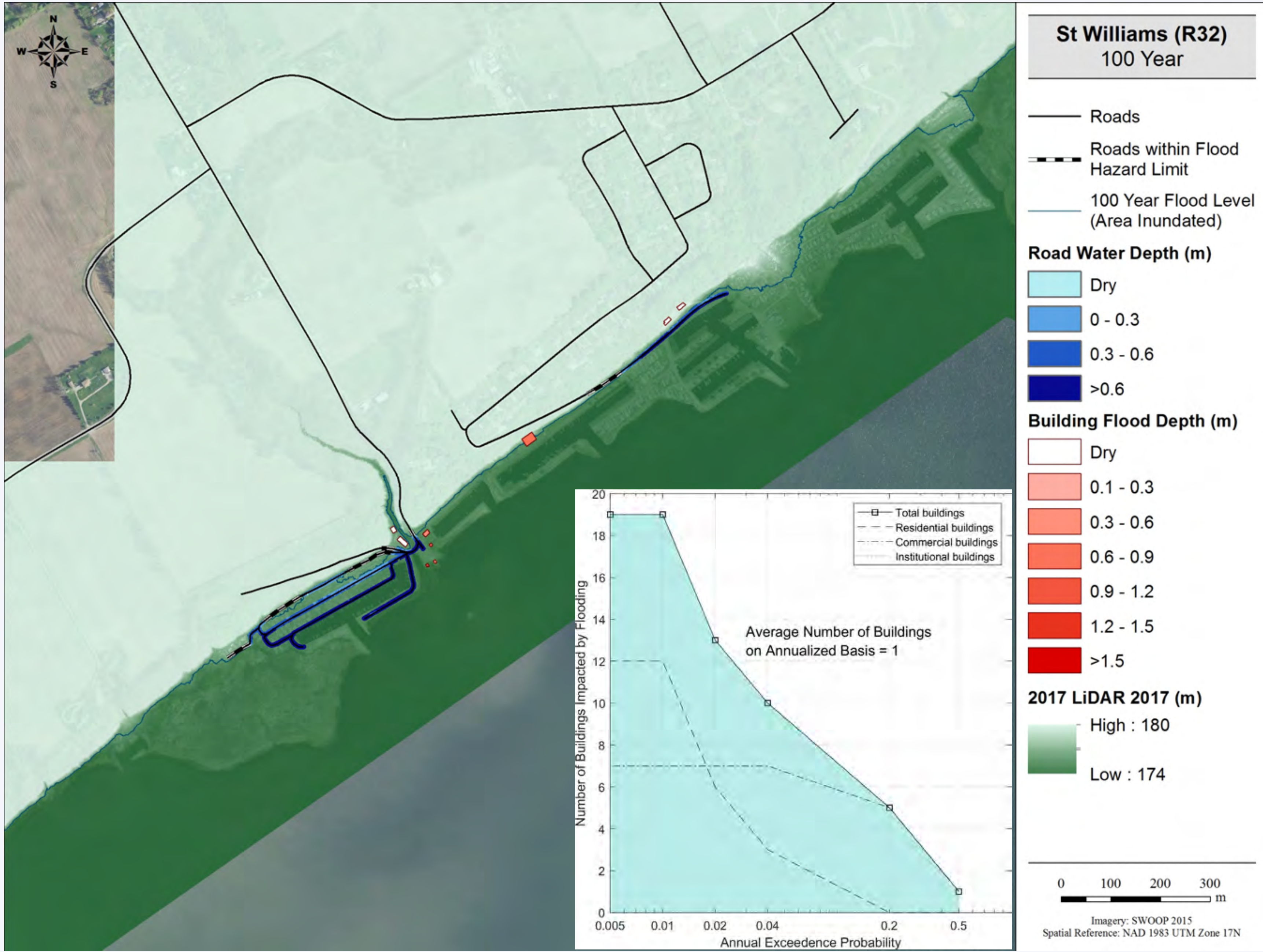
100-yr flood level = 175.9m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
CLUBHOUSE ROAD & FERRIS STREET	174.4	174.9
ORDNANCE AVENUE	174.8	175.3



Area #6 – St. Williams 100-year Flood Depths

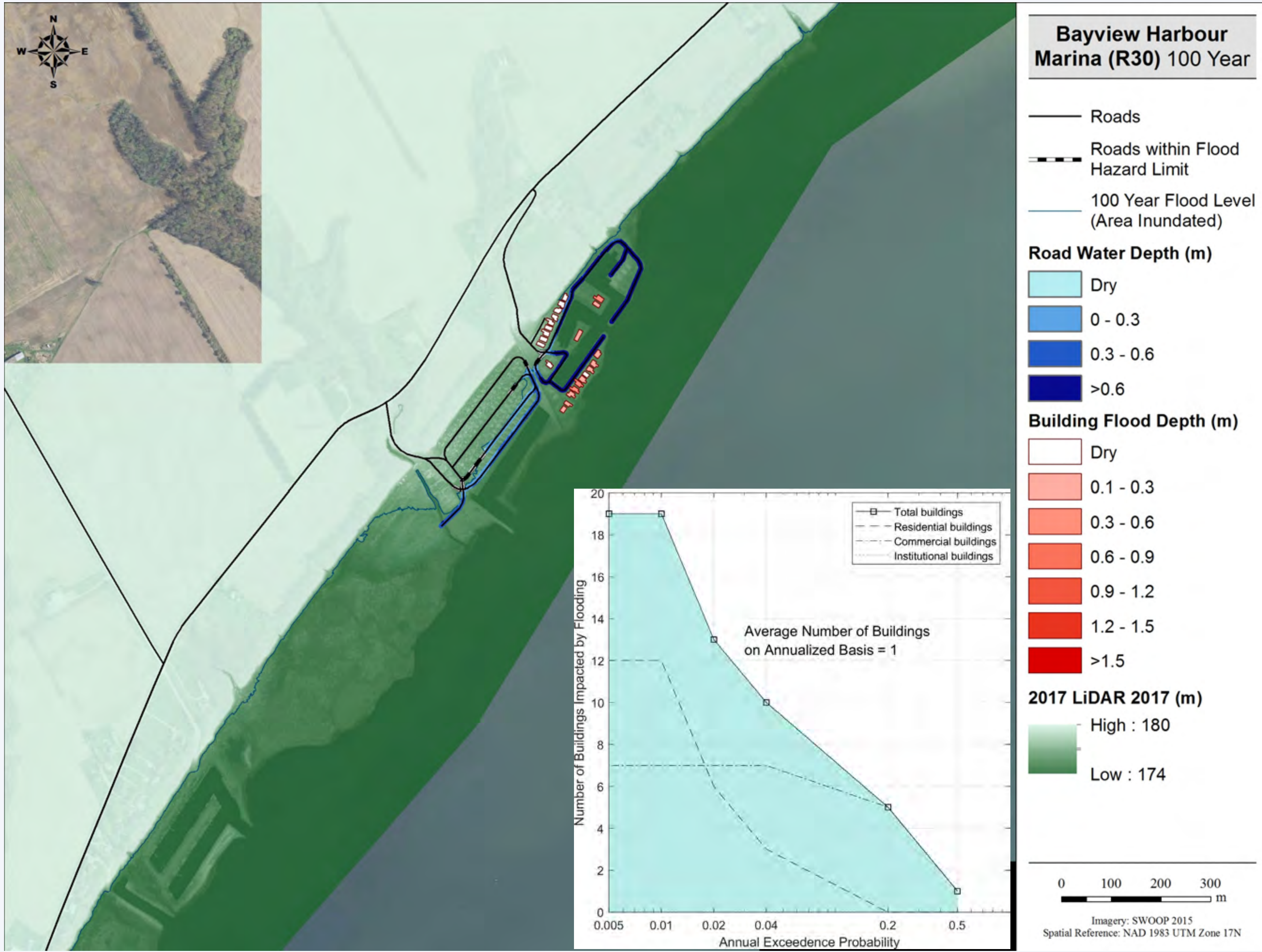
100-yr flood level = 175.9m CGVD2013



Area #7 – Bayview Harbour 100-year Flood Depths

100-yr flood level = 175.9m CGVD2013

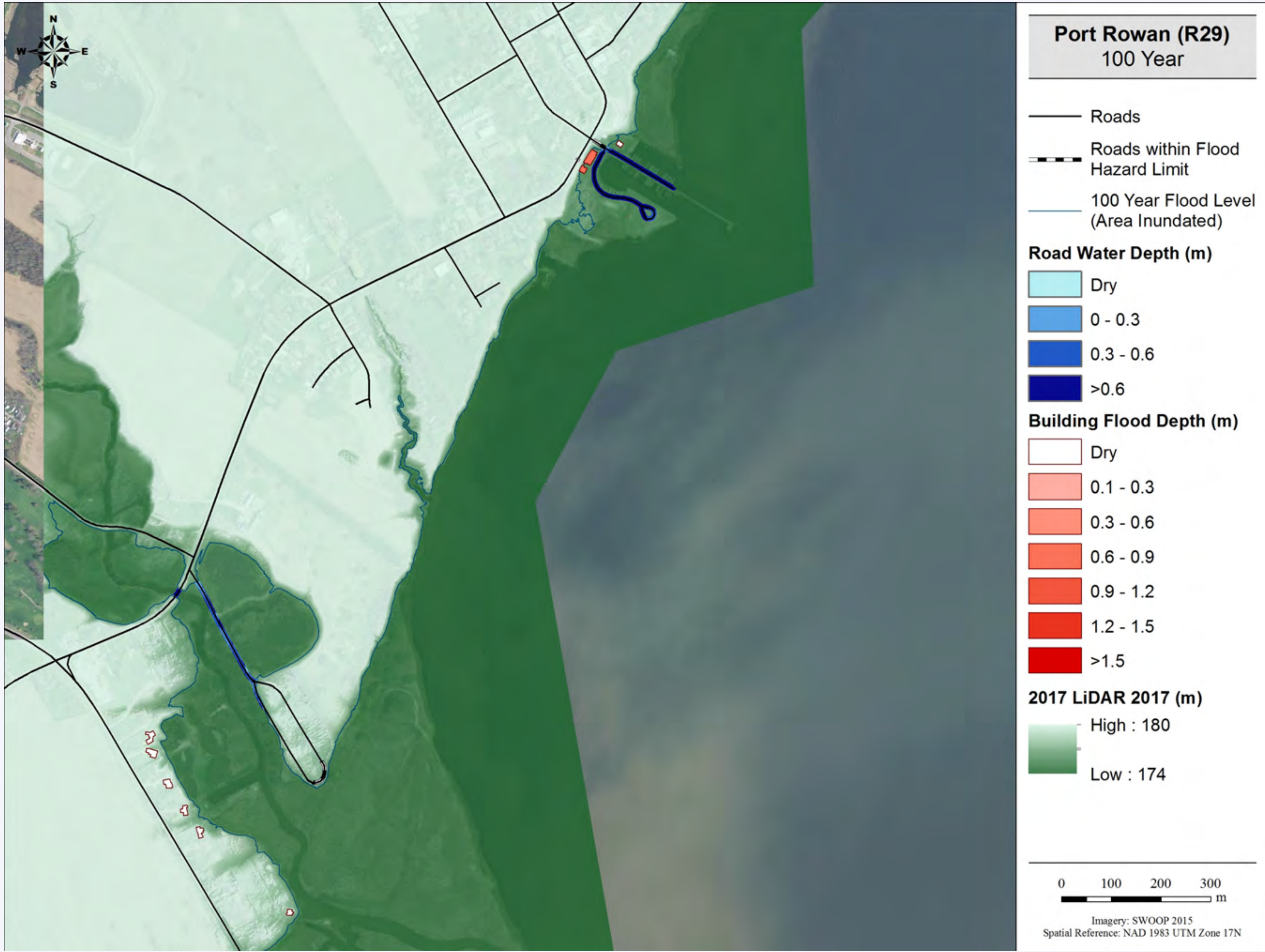
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
BAY SIDE DRIVE EAST	174.9	175.4
BAY SIDE DRIVE WEST	174.7	175.2



Area #8 – Port Rowan 100-year Flood Depths

100-yr flood level = 175.9m CGVD2013

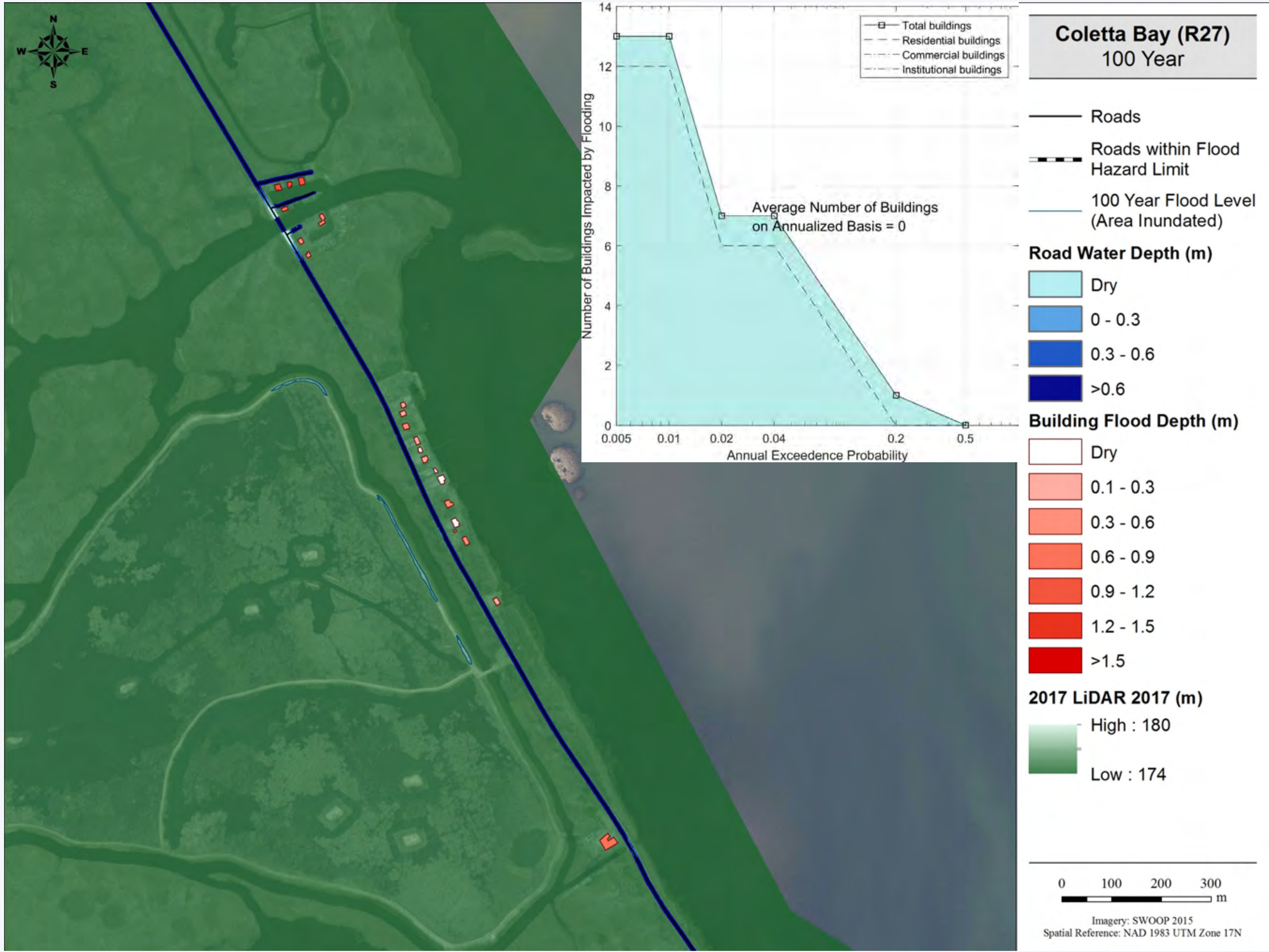
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
SEA QUEEN ROAD	174.7	175.2



Area #9 – Coletta Bay 100-year Flood Depths

100-yr flood level = 175.9m CGVD2013

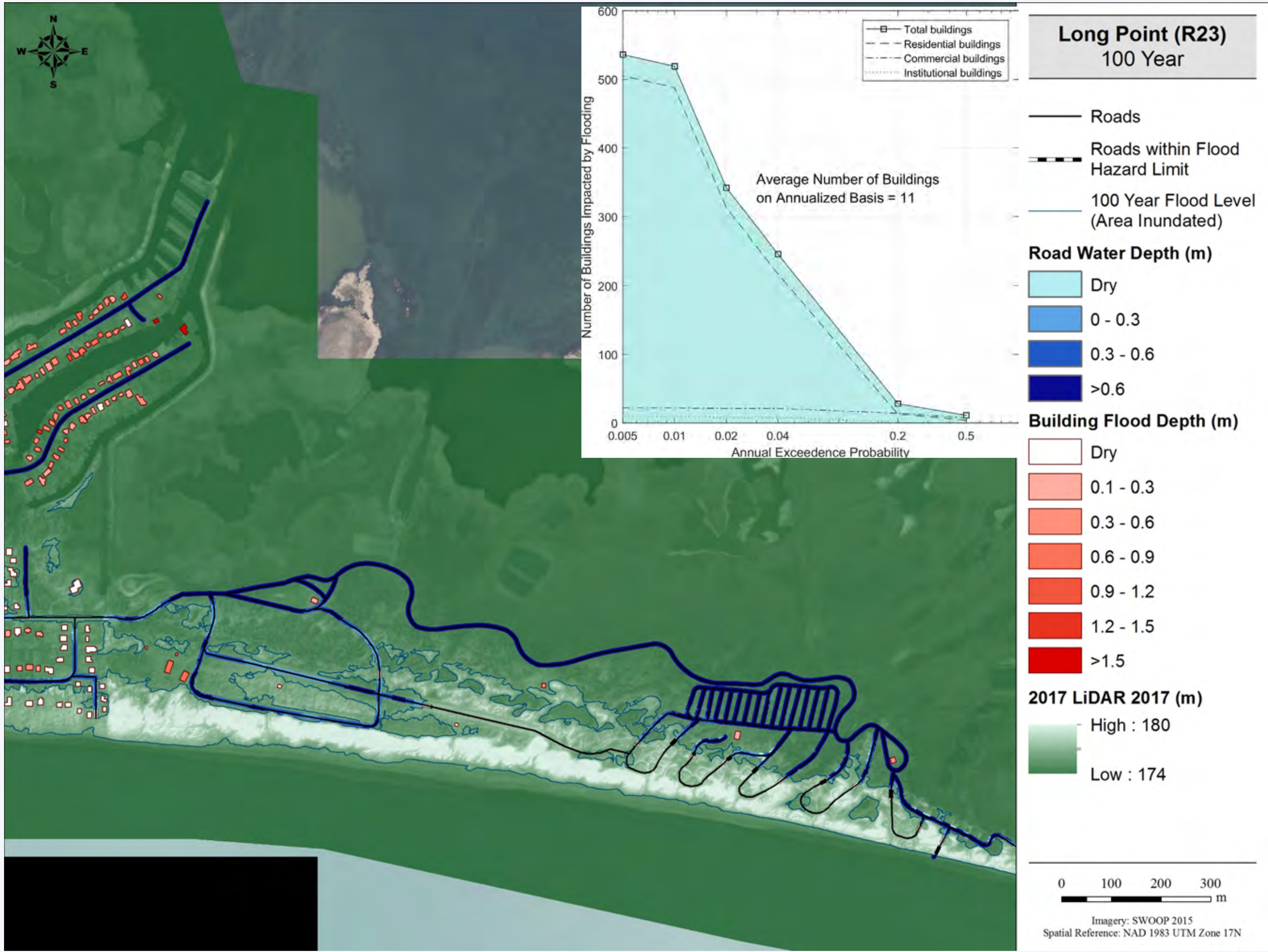
Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
HIGHWAY 59	174.9	175.3



Area #10 – Long Point 100-year Flood Depths

100-yr flood level = 175.9m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
ERIE BOULEVARD	174.4	174.9



Area #11 – Long Point 100-year Flood Depths

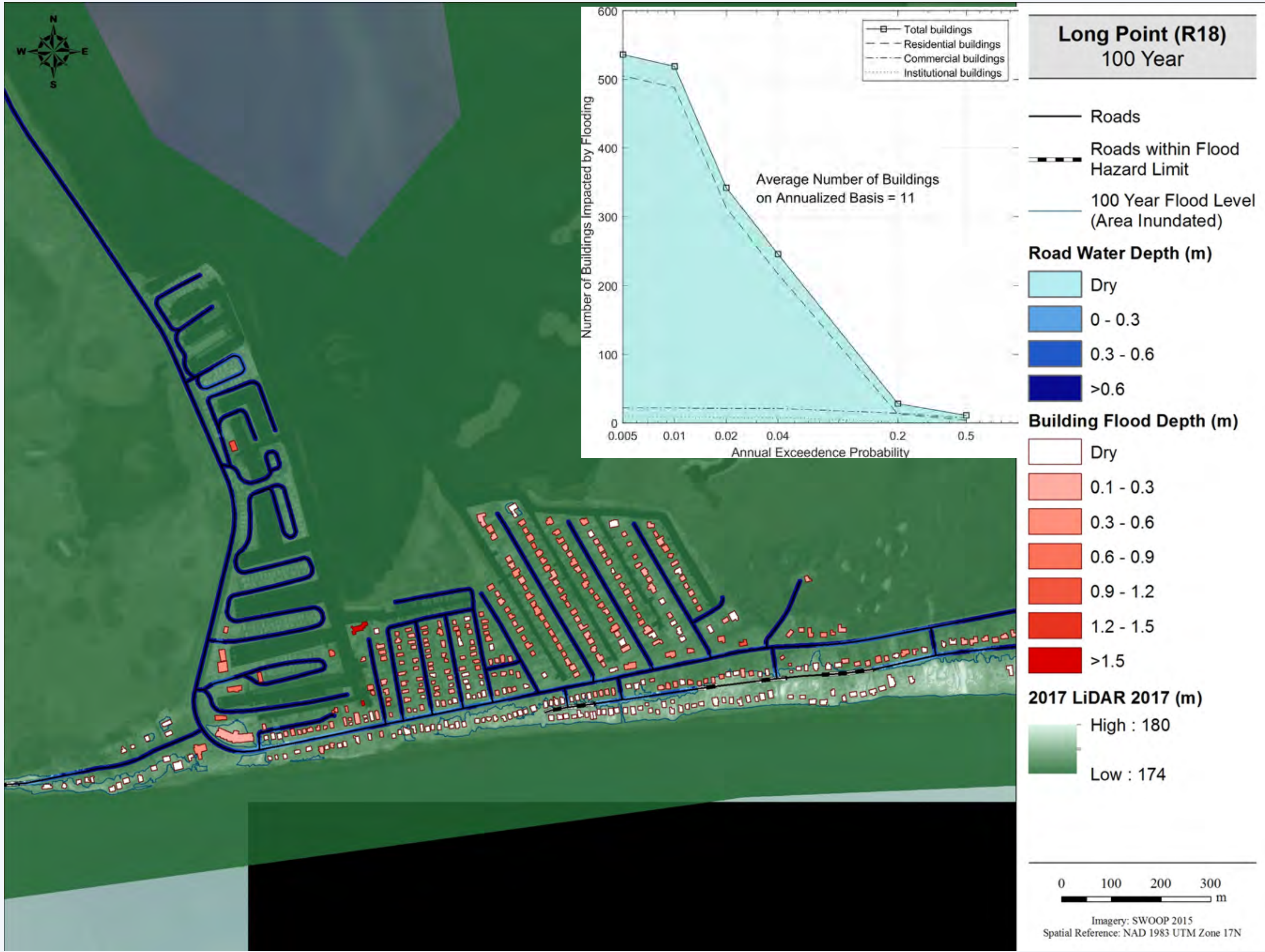
100-yr flood level = 175.9m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
ERIE BOULEVARD (up to Bluebill Ave)	175.0	175.4
OLD CUT BOULEVARD	174.7	175.2

Area #12 – Long Point 100-year Flood Depths

100-yr flood level = 175.9m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
HIGHWAY 59	174.4	174.9
ERIE BOULEVARD (up to Brant Parkway)	174.8	175.2



Area #13 – Long Point 100-year Flood Depths

100-yr flood level = 175.7m CGVD2013

Street	Flood level when street becomes impacted	
	CGVD2013	IGLD85
HASTINGS DRIVE	174.7	175.1