January 13, 2012

REPORT ON

Overview-Level Geotechnical Investigation and Assessment Ladysmith Harbour Ladysmith, BC

Submitted to:
Ministry of Forests, Lands and Natural Resource Operations
Crown Land Opportunities and Restoration Branch
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REPORT

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by the Ministry of Forests, Lands and Natural Resource Operations (the Ministry) and the Town of Ladysmith to conduct a geotechnical overview assessment of Slack Point and surrounding areas of Ladysmith Harbour (the "Site"). Authorization to proceed with the investigation was provided by Mr. Geoff Sinnett of the Ministry.

This report presents the results of the overview-level geotechnical investigation and assessment. Golder also conducted an environmental subsurface investigation within the Uplands and portions of the Foreshore concurrent with the geotechnical investigation undertaken on Slack Point. The geotechnical aspects of the environmental investigation are also reported herein.

The objectives of this study are generally as follows:

- To obtain an understanding of the subsurface conditions at the Site;
- To identify and comment on potential geotechnical hazards that could impact future development of the Site; and
- To provide preliminary geotechnical engineering input to planning of feasible forms of development and ground improvement options, including recommendations for additional investigation as development planning advances.

To accomplish these objectives, Golder's scope of work includes the following tasks:

- Task 1: Collection and review of available information;
- Task 2: Site reconnaissance;
- Task 3: Subsurface investigation and laboratory testing; and
- Task 4: Assessment and Reporting.

Although preliminary concepts about proposed development schemes have been considered, no details are available at the time of preparing this report. At this stage, development of the Site is envisaged as an iterative process from concepts to detailed plans, with progressive stages of investigation and design. Development of the Site will require care in planning and execution in order to satisfy the requirements of the National and BC Building Codes, specifically as they pertain to seismic hazards.

This report summarizes the results of the above tasks and provides geotechnical engineering comments and recommendations for consideration in the overall preliminary planning of development at the site. The titles of sources referenced in the study are provided in the References section following the text of this report. Records of borehole, test pit and monitoring well logs from the Geotechnical and Environmental investigations are contained in Appendices A and B, respectively. Results of geotechnical laboratory testing are contained in Appendix C. Rock core photographs are contained in Appendix D.

The reader's attention is specifically drawn to Section 8 of this report as it contains important information and limitations on the use of this report.

2.0 SITE DESCRIPTION

The Site is located in Ladysmith, BC and includes the area bounded by the Government Wharf to the northwest; the former Esquimalt and Nanaimo EN Railway and Trans Canada Highway to the southwest; by Transfer Beach Park to the south and Ladysmith Harbour to the north. The Site is generally oriented in a northwest to southeast position. The latitude and longitude of the site is approximately 48º 59' 44" North; 123º 48' 54" West.

The Site is understood to have an area of approximately 372,500 m² (37.25 ha). The land portions of the Site cover approximately 22.75 ha, or 63 percent of the Site; the water lot area comprises approximately 14.5 ha or 37 percent of the Site. The Site includes approximately 500 metres of water lot along the Foreshore and about 650 m of shoreline around Slack Point. Figure 1 (Key Plan) shows the overall Site and surrounding area. Figure 2 shows the Site with specific properties and features identified.

There are a number of subdivided properties which collectively make up the Site. For the purposes of this report, however, the Site is divided into three regions: Slack Point, the Uplands and the Foreshore. Slack Point is located at the southeast portion of the Site and is recognizable by its triangular shape in plan and elongated point. It forms the southeast boundary of Ladysmith Harbour. The property boundary does not include the parking lot in the southeast corner of the peninsula (see Figure 2).

Slack Point is generally flat and relatively low lying, with isolated mounds of fill material at surface. Along the southwest side of Slack Point, the ground surface rises where it joins the Uplands areas. It has discontinuous vegetative cover, including trees, grass and shrubs.

The Foreshore is a relatively narrow strip of land extending some 600 m along the shore from the western inner corner of Slack Point to the government wharf at the far northwest end of the site. It comprises a parcel of filled foreshore land connecting Slack Point and the railway. The Foreshore consists of slope ground and beach, together with reclaimed land.

The Uplands comprise the areas southwest of Slack Point and the Foreshore. It extends approximately 1 km parallel to the Foreshore. The Uplands area of the Site forms a terrace some 10 m to 15 m higher in elevation than Slack Point and the Foreshore. The Uplands has low lying vegetation, shrubs and grass. There are also roadways and buildings present, including a former locomotive and railcar repair shop now occupied by Ladysmith Maritime Society and various businesses, a washroom, and various sheds. The former EN Railway siding extends through the lot.

Details of the property designations, their individual area, and summary descriptions are provided in Table 1, below.

Table 1: Property Details

Region	Legal Address	Associated PIDs	Approximate Area (ha)
Slack Point	DL 16G, Oyster District	009-695-001	5.329
Uplands	Lot 4 and Lot 1, Plan except for VIP64405, Oyster District (previously referred to as Lot 4 and Lot 1, Oyster District and DL 24 and DL 56, Cowichan District)	010-208-828, 023-652-926, 006-088-597, 006-088-571	8.5
Uplands	DL 2016 Block A and Block B, Oyster District (previously referred to as Blocks A and B BL 41G)	-	0.451
Foreshore	DL 8G, 11G and 17G, Oyster District	009-695-079	0.257

3.0 REVIEW OF INFORMATION

3.1 Previous Studies and Reference Materials

Golder's first task was to review available information on the surface and subsurface conditions at the Site. The purpose of this was to understand the regional and surficial geology in order to provide a greater understanding of the subsurface conditions; to aid in the planning of our investigation; and to supplement the data collected. The sources included published information from the Geological Survey of Canada (GSC), the University of BC, the Township of Ladysmith, as well as reports produced by others on geotechnical and environmental investigations, and historical studies of the Site. A complete list of sources is provided in the References section at the end of this report. The following sections summarize the results of the information review.

3.2 Geology

Information on the regional geology of the area was reviewed using published information obtained from the Geological Survey of Canada (GSC). GSC Map 1553A for Victoria (1979-80) indicates that Ladysmith is underlain by sedimentary rock of the Nanaimo Group, including conglomerate, sandstone, siltstone, shale and mudstone (argillite). To the south and west of the Site, these sedimentary formations are in contact with intrusive granodiorite and quartz diorite, as well as pillow lava and breccia of augite porphyry, basic tuff, and chlorite-actinilite schist of the Nitnat formation.

The surficial geology of the Site includes glacial soils, consisting of till, overlain by post-glacial silt, sand and gravel deposits in the Uplands. The natural soils within the Harbour consist of marine sands and silts, in turn underlain by extensive deposits of sand and gravel which formed part of the deltaic fan from the ancient Haslam Creek.

3.3 Historical Information and Aerial Photographs

Based on historical information summarized in reports by Dames and Moore (1990a), the harbour was used to bring coal mined from the area to market from the late 1800's to the 1930's. In the 1930's, coal mining in the area declined and the site was used in the logging industry, mainly as a land sort and for handling, dumping and storage of logs until about 1987. During coal mining activities, the foreshore of Ladysmith Harbour was extended by filling. In addition, Slack Point was formed by the deposition of coal waste, derived from the washing of coal mine and coal smelter wastes. Based on historical information, the coal waste likely extends to more than 15 m in depth (Hardy BBT, 1990a) and consists of black coal, carbonaceous shales, grey siltstone and some mineral gravel, sand, woodwaste, and other debris. Based on review of the previous studies noted above, up to 2 m of wood waste and debris, including concrete, metal, cables and strapping, is present overlying the coal waste in Slack Point. Dredging of the harbour and the shoreline area, particularly to remove bark accumulations, has also taken place in the past.

Historical aerial photographs of the Site and the adjacent area were obtained from the University of British Columbia Geographic Information Centre. Aerial photographs from 1952 to 2007 were available for review. Table 2 provides a summary of the review of aerial photographs.

Table 2: Aerial Photograph Interpretation for the Site and Surrounding Area

Date	Aerial Photograph	Site Description and Observations	Surrounding Area
1952	BC1443:115-117	Slack Point is present, and appears cleared with roadways present and a building on the western portion of Slack Point (possible repair shop). Logging activities are apparent on the Site, including several log booms and sorting pockets in the water lots. A rail spur is observed from the Foreshore extending out onto Slack Point toward the waterlots. There appears to be a steep grade from the Uplands area toward Ladysmith Harbour. Several buildings are visible on the Uplands.	NW - A breakwater appears to have been constructed to the northwest of the Site where the government wharf is presently located. SW – The railway and highway are visible and several residential housing lots are observed within the Town of Ladysmith. Alluvial fans are visible to the north and south of the Site.
1957	BC2086:29,30	The Site appears similar to the 1952 aerial photograph; however, the photograph quality and scale prevent identification of specific features.	The photograph quality and scale prevent identification of specific features.
1962	BC5047:114,115	The railspur observed in 1952 has been replaced with what appears to be a wharf structure. The northern tip of Slack Point appears to be elongated toward the north. At least half of the sorting pockets have been removed in the water area closest to the wharf.	Similar to 1952, with the exception of more housing southwest of the Site. Alluvial fans north and south of the site appear to have changed slightly in shape, possibly due to sediment deposition and/or the action of currents.
1968	BC7076-067-068	A long breakwater is observed extending from the government Wharf into Ladysmith Harbour. It appears that more fill has been added to the northern portion of Slack Point and fewer logs, machinery and buildings were observed. Several small structures are present on Lot 1 in the Uplands.	NW – the long breakwater northwest of the Site has been removed, that area has been further filled and now appears to consist of logging operations on the filled portion (possible dry land sort)

Date	Aerial Photograph	Site Description and Observations	Surrounding Area
1975	BC7751 – 191, 192	The Site appears generally unchanged from the previous photo, with the exception of a wide road extending through Slack Point from Lot 4.	NW – It appears that more filling has occurred northwest of the Site. At least two areas appear paved and utilized for log sorting.
1984	BC84029: 135, 136	The Site appears generally unchanged from the previous photo except the road through Slack Point observed in 1975 is less prominent in the 1984 aerial photograph.	NW – It appears that the two paved areas identified in 1975 were expanded and more fill added to this area.
1993	BCB93093 No. 229, 230	The majority of the logging operations have ceased at the Site. A small marina has been constructed in the centre of the Site; a few scattered log booms remain. The sorting pockets have been removed. The area around the base of the Government Wharf (closest to the foreshore) has been further in filled; it appears to be paved and utilized as a storage area. Slack Point is further vegetated, and the repair shop building has been removed. The northern tip of Slack Point has been further expanded and appears slightly rounded.	NW – Extensive infilling in the harbour has occurred, connecting the two paved areas identified above.
1998	30BCC98037 No. 014 and 015	The small marina has been expanded and includes a thin breakwater area. Several boats are visible	Appears similar to the 1993 photograph
2007	ME07 460C 0381, 0382	The marina has expanded to include at least two docks, the breakwater has been removed. Park-like features are observed southeast of Slack Point, off the site, including a park and amphitheatre. A road (Transfer Beach Blvd.) leading into the baseball area of Slack Point has been constructed.	East – Immediately east of the Site is a residential development.

Our review of historical aerial photographs indicates that the geometry of Slack Point has changed noticeably since the earliest aerial photographic record (1952) to the most recent available information (Figure 2). Specifically, there appears to be an elongation of Slack Point toward the northwest, as well as accretion of material on the harbour side of Slack Point forming noticeable bulges of the shoreline. In addition, there appears to be some loss of shoreline on the southeast side of the point toward the open water.

It is possible that these observations indicate that erosion has taken place over time on Slack Point. The coal waste material is erodible and would be susceptible to wave action and currents.

3.4 Review of Previous Reports

Previous investigations have been conducted at the site. Golder reviewed these reports to obtain additional subsurface information to supplement the information obtained during our investigation. These investigations include a number of environmental investigations, as well as a geotechnical investigation. The previous environmental studies were carried out to assess the presence of contamination from historical land uses. A summary of the findings relevant of these studies as they relate to subsurface soil, rock and groundwater information is presented below. The geotechnical investigation, conducted by Hardy BBT, was carried for the Township of Ladysmith and relates to a previously considered concept of development. It was preliminary in nature and consisted of shallow, near-surface investigation. The conclusions of the Hardy BBT report reflect the requirements of an older version of the BC Building Code.

The factual results of the previous investigations are summarized in the following sections.

In 1990, Hardy BBT Limited (Hardy BBT 1990a and b) conducted a geotechnical assessment and an environmental review of the Site with the exception of DL 2016 Blocks A, B and C. The Town of Ladysmith requested the work in order to assess the possibility of future development of the area. The purpose of the geotechnical investigation was to identify any significant foundation issues with respect to potential future development of the area for residential and/or commercial buildings.

Hardy BBT's geotechnical investigation of Slack Point and the Uplands consisted of a series of test pits ranging in depth from 3 to 4 m below existing ground surface at the time of investigation on Slack Point, and 2 to 3 m within the Uplands. Based on the report, the subsurface materials encountered in Slack Point consisted of up to 2 m of woodwaste overlying coal waste. In addition to the woodwaste and coal, some test pits encountered other debris, including scrap metal, gypsum board, ash, oil and paint cans, and hoses. The test pits advanced on the Uplands encountered fill material consisting of loose, brown, sands and gravels with cobbles from about 0.4 m to more than 2.8 m in depth, overlying native soils consisting of silts and sands. Bedrock was encountered underlying the native deposits and fill at depths varying from about 1.4 to 2.0 m.

EBA Environmental Ltd. (EBA 1994a and b) conducted a Phase 2 Environmental Site Assessment of the site which included a subsurface investigation. The investigation consisted of 14 test pit; 10 within Slack Point and four within the Foreshore area. The results of the investigation indicate that about 1 to 3 m of woodwaste and other debris, including logs, cable fragments and mineral soil, overlie the coal waste beneath Slack Point. The four test pits excavated within the Foreshore area were hand excavated to depths of 0.6 m to 0.8 m and encountered sand and gravel along with traces of unspecified organic matter. Groundwater seepage was encountered at about 2.0 m to 3.5 m below the existing ground surface within Slack Point. The report also indicates that an extensive clean up of the site to remove piles, dolphins, wharves and piers, floats, booms, surface structures and debris took place in 1992.

Levelton Engineering Ltd. (Levelton, 2000) carried out a detailed environmental site investigation consisting of 14 boreholes and five monitoring wells drilled in the Uplands area west of the Foreshore and in close proximity to the existing buildings in the area. The results of this investigation indicate that the soils underlying this portion of the Uplands area comprise generally loose to compact sands, silt/sand mixes and sand gravel mixes to depths ranging from about 0.8 m to in excess of 6.1 m below the existing ground surface. With a single exception, all of the boreholes encountered refusal at depths ranging from about 0.8 m to 4.3 m. The reason for refusal was not indicated on the logs; however, it may indicate either dense glacial soils or bedrock at these depths. Measured groundwater levels within monitoring wells ranged from about 1.2 m to 1.8 m below the existing ground surface.

In 2005 Golder conducted an environmental investigation of Slack Point which included 24 boreholes/monitoring wells and 15 test pits. The results of the investigation indicate that Slack Point is underlain by a fill layer up to 3 m thick, consisting of heterogeneous material including mineral soil, woodwaste, metal debris, concrete rubble, glass, plastic, metal wire, bricks and other material. Underlying this material, coal waste was encountered to depths ranging from about 8.5 m to 15.9 m (elevation -4.2 m to -12.0 m). Underlying the coal waste, marine silt, sand and gravel deposits were encountered.

4.0 SITE RECONNAISSANCE

Golder conducted a reconnaissance of the Site as part of our collection and review of information. The purpose of this task was to obtain information on existing physical site features and to identify constraints which might have an impact on any development at the Site. In addition, the reconnaissance provided useful information as input to planning the subsurface investigation program.

The reconnaissance was carried out on September 23, 2009 during which a walk-over of the site was performed and visual observations were made and photographs were taken. In addition, borehole locations were sited, staked and photographed. During the reconnaissance of Slack Point, Golder observed that the ground surface was generally flat, although there were isolated mounds of coal waste material, as high as 3 m to 5 m. The vegetation on Slack Point consists of a mix of mature conifers, deciduous trees, blackberry and other shrubs, and grass. Around the shoreline areas, coal waste material was exposed at surface. A number of established gravel and dirt pathways, and open gravel-covered areas were observed on Slack Point. Within the central portions of Slack Point, a large concrete pad was visible at surface. Concrete rubble was observed along the eastern shoreline (open water side) of Slack Point. Along both the eastern, and western (harbour side) shoreline of Slack Point, there were exposed areas where signs of erosion were apparent, including gully formation and sloughing.

Along the southwestern boundary of Slack Point, where it transitions into the Uplands, the ground surface rises some 13 m to the Uplands terrace. This ranges from a gentle slope of some 3 or 5 horizontal to 1 vertical to a near-vertical rock face. On the west side of Slack Point, toward the harbour, wooden pilings were observed extending out of the ground surface and in the water. In addition, metal debris was exposed along the shore in this area.

Within the Uplands there were local roadways, vegetated areas and a collection of old buildings. The Foreshore area comprises a densely vegetated slope to the water with areas of beach. Near the centre of the Foreshore area, is a parking lot and walkway to a wharf.

5.0 GEOTECHNICAL INVESTIGATION

Upon completion of the site reconnaissance and review of information, Golder carried out a geotechnical borehole investigation of Slack Point and a combined geotechnical and environmental investigation of the Uplands and the Foreshore. This information was obtained as input to the characterization of the Site and the provision of geotechnical engineering recommendations into the conceptual planning for development at the Site. This report focuses on the geotechnical investigation conducted on Slack Point and the geotechnical aspects of the combined investigation in the Uplands and Foreshore. Details of the environmental investigation and its results are reported under separate cover; however, relevant soil and groundwater data obtained from that investigation are summarized in the applicable sections below.

The investigation of Slack Point was focused on characterizing the geotechnical aspects of the fills and natural sediments underlying the point and identifying the elevation of the underlying competent strata at the location of individual borings. The investigation was carried out over six days from November 9 to 13, 2009 during which Golder drilled a total of five mud rotary boreholes on Slack Point. In addition, Golder drilled one borehole in the southeast corner of the Uplands. During drilling, the Standard Penetration Test (SPT) was carried out at 0.8 m to 3.0 m intervals within boreholes in order to collect disturbed samples of the soils encountered and to obtain penetration resistance of the soils for correlation to the relative density. Where bedrock was encountered, diamond coring was carried out to obtain rock core samples. Where reported in this document, SPT blow counts refer to the uncorrected field values, unless noted otherwise.

In addition to the above investigation, Golder carried out an environmental drilling investigation in the Uplands and Foreshore portions of the site. This included drilling 16 monitoring wells/boreholes and excavating 12 test pits. The boreholes and test pits were logged and the soil and groundwater conditions were assessed at these locations for both environmental and geotechnical purposes. In addition, five dynamic cone penetration tests (DCPTs) were conducted at the locations of selected environmental monitoring wells/boreholes, in order to assess the relative density of the subsoils. The locations and identification of all boreholes are shown on Figure 3. Borehole, monitoring well and test pit logs from the environmental investigation are contained in Appendix B.

Prior to drilling activities for both phases of investigation, a specialist contractor was retained by Golder to identify the locations of buried services near each of the proposed boreholes.

The geotechnical field drilling work was carried out under the full-time inspection of a member of Golder's geotechnical staff who identified the borehole locations in the field, logged the subsurface conditions encountered, and collected soil samples for inspection and testing. Boreholes were located approximately in the field by hand measurements using local landmarks at the time of the drilling. Borehole locations and elevations were subsequently surveyed by McElhanney Land Surveying Ltd.

A summary of the locations, depths and elevations of the individual geotechnical boreholes are provided in Table 3, below. Slack Point, the Foreshore and the Uplands were targeted for investigation as these areas have different soil, rock and groundwater conditions. Within these areas, individual borehole locations were selected to obtain information on the subsurface soil and groundwater conditions at accessible locations across the areas and to provide coverage. Although a significant amount of subsurface investigation had been conducted within Slack Point prior to the present geotechnical study, there were data gaps; specifically in areal extent of investigation, *in situ* geotechnical testing carried out, and in depth of investigation. The soil and groundwater conditions encountered in the boreholes are discussed in Section 6.0, below. Elevations referred to in this report are geodetic.

Table 3: Summary of Geotechnical Borehole Investigation

Borehole	Location	Borehole Depth (m)	Ground Surface Elevation (m)
BH09-01	Slack Point	26.5	2.2
BH09-02	Slack Point	25.6	3.4
BH09-03	Slack Point	28.0	1.9
BH09-04	Slack Point	15.8	3.3
BH09-05	Slack Point	30.9	6.1
BH09-06	Uplands South of Transfer Beach Rd.	9.2	16.6

A list of the Universal Transverse Mercator (UTM) coordinates of the individual boreholes is provided in Table 4, below.

Table 4: UTM Zone 10 Coordinates of Boreholes

Borehole	Northing	Easting
BH09-01	5427243.7	440909.6
BH09-02	427152.6	440865.2
BH09-03	5427202.1	440805.6
BH09-04	5427089.0	440713.4
BH09-05	5427010.0	440856.6
BH09-06	5426870.3	440708.6

Note: As surveyed by McElhanney.

5.1 Laboratory Testing

On completion of the field work, geotechnical laboratory testing was carried out on selected soil samples obtained from the boreholes. The tests included water content determination, particle size analyses and Atterberg Limits tests. In addition, a specific gravity test was conducted on a sample of the coal waste material. The results of these tests were used in classifying the soils and evaluating their engineering characteristics. The results are summarized in the individual sections below. Full laboratory results are contained in Appendix C.

6.0 SUBSURFACE CONDITIONS

6.1 Slack Point

The results of the geotechnical investigation indicate that Slack Point is underlain by fill, comprising a surficial and discontinuous layer of mineral soil, woodwaste and debris, overlying an extensive deposit of coal waste. Underlying the coal waste, native marine deposits of silt, sand and gravel were encountered in all boreholes drilled in Slack Point. Bedrock consisting of mudstone (argillite) was encountered in borehole BH09-04, drilled in the southwest part of Slack Point. In the sections that follow, individual soil layers are described in more detail. A summary of soil layering is presented in Table 5, below.

6.1.1 Fill

Slack Point is underlain by fill consisting of a mix of mineral materials – sand, gravel, cobbles and boulders – and also containing concrete, metal, woodwaste and other debris, which overlies a substantial thickness of coal waste. The overall thickness of the fill layer ranges from about 6.7 m to 16.6 m. The two layers of fill are discussed separately below.

6.1.1.1 Surficial Mineral Fill, Woodwaste and Debris

Within the boreholes drilled in Slack point, with the exception of borehole BH09-05, a surficial fill layer consisting of granular materials – sand, gravel and cobbles – as well as woodwaste was encountered. The mineral soil portions varied in composition from gravelly sand to sandy gravel. Cobbles were also inferred to have been encountered, based on observations during drilling. The woodwaste observed in the boreholes consisted of dark brown to black fibrous and decomposed wood debris. At individual borehole locations, this surficial layer extends to depths of 0.2 m to 1.4 m (elevation 0.9 m to 3.1 m).

Based on observations made during the site reconnaissance, and the review of previous investigations, this layer is discontinuous and variable in composition.

6.1.1.2 Coal Waste

Underlying the surficial fills, and also exposed at surface in areas, a deposit of very loose to loose, moist to wet, black coal waste was encountered in every borehole drilled in Slack Point. The particle composition of the coal waste material varied from silt-sized to gravel-sized particles, but was typically of sand-sized particles. The individual particles were observed to be angular in geometry and friable. There were also traces of woodwaste encountered within this deposit. The coal waste extended to depths ranging from about 13.7 m to 16.6 m (elevation -10.5 m to -11.8 m); however, within borehole BH09-04, drilled along southwest portion of the point, it only extended to about 6.7 m (elevation -3.3 m). During drilling, a noticeable organic odour was observed in samples obtained from the bottom of the deposit in boreholes BH09-03 and BH09-05.

SPT blow counts recorded within this layer ranged from 1 to 10 blows per 300 mm penetration, indicating that it is very loose to loose.

Laboratory particle size testing was conducted on samples collected from this material. The results of the particle size testing indicate that the median particle size for the coal waste ranges from about 0.3 mm – 1.8 mm. The fines content (percent passing the USS 0.075 mm sieve size) ranged broadly from about 5 to 46 percent. Typically the percentage of fines content ranged from about 10 to 24 percent. Finer particle size distributions were observed in samples obtained from near the bottom of the coal deposit in boreholes BH09-05 and BH09-01, with a median particle size of approximately 0.1 mm. It is possible that some intermixing of the coal material with the silty sand deposit underlying it may have occurred. An envelope of particle size distribution curves for the samples tested is provided in Figure C-1 in Appendix C.

In addition to particle size testing, a single specific gravity test was also carried out. The result indicates that the coal material has a specific gravity of approximately 1.69.

6.1.2 Native Marine Deposits

Underlying the coal waste in the boreholes drilled in Slack Point, marine deposits consisting of silt, sand and gravel were encountered. Relatively small interlayers of clayey material of low to medium plasticity were also encountered in these deposits. The boreholes drilled in Slack Point were terminated in these deposits, with the exception of BH09-04, which was terminated in bedrock, described below. The individual layers of the marine sediments are described separately in the sections below.

6.1.2.1 Marine Silts and Sands

The uppermost layer of the marine deposits comprises dark grey to greenish grey silts and sands. This material was encountered in the boreholes drilled in Slack Point except borehole BH09-04. Samples obtained from this layer indicate that it varies in composition from silt and sand, to sand some silt, and also contains marine shell fragments and clayey layers. A noticeable organic odour was detected in samples obtained from the upper portions of this layer, near its contact with the coal. The thickness of this layer ranges from about 3.2 m to 6.3 m and extends to depths of 13.7 m to 22.9 m (elevation -3.3 m to -16.8 m).

SPT blow counts recorded within this layer ranged from 3 to 12 blows per 300 mm penetration, indicating generally very loose to loose relative density.

Laboratory particle size testing was conducted on selected samples collected from this layer. The results indicate that the median particle size within the coarser grained layers ranged from about 0.15 mm to 0.35 mm, with a fines content of between about 16 and 48 percent. Within the finer grained layers, fines content ranged from 65 and 70 percent. Figure C-2 in Appendix C shows an envelope of particle size distribution curves for the samples tested.

6.1.2.2 Sand and Gravel

Underlying the silts and sands were deposits of marine sands and gravels. Samples obtained from this layer indicate that it varies in composition from gravel with some sand to gravelly sand and contains traces of silt, as well as marine shell fragments. The gravel was sub-angular to subrounded in shape. All boreholes except BH09-03 and BH09-04 terminated in this layer. At these boreholes, this layer extended to depths of between 12.2 m and 25.6 m (elevation -8.9 m and -23.7 m).

SPT blow counts recorded within this layer ranged from 19 to 63 blows per 300 mm penetration. Based solely on the recorded blow counts, the material would be considered compact to very dense. However, the relative density of these deposits are not considered to be accurately represented by the SPT blow counts alone, due to the coarse-grained nature of this deposit. Based on observations during drilling, the depositional environment as well as blow counts measured in the more sandy portions of the deposit, the material is considered compact.

Particle size distribution tests conducted on samples of this material indicate that the material had a median particle size of between 3.0 mm and 4.7 mm, and a fines content of between 3.8 and 7.5 percent. Figure C-3 shows an envelope of particle size distribution curves for the samples tested.

6.1.2.3 Sandy Silt to Silt and Sand

A lower layer of dense grey sandy silt to silt and sand was encountered in BH09-03 underlying the sands and gravels at a depth of 26.5 m (elevation -23.7 m). A single SPT carried out in this layer recorded blow counts of 41 blows per 300 mm penetration, indicating that it is dense. A particle size distribution test conducted on a sample of this material indicated that it contained approximately 35 percent sand sized particles and had a fines content of 65 percent.

6.1.3 Sedimentary Bedrock

Sedimentary bedrock was encountered in one borehole drilled within Slack Point (BH09-04) at a depth of about 12.2 m (elevation -8.9 m). The rock consisted of highly fractured, moderately weathered mudstone (argillite). An attempt was made to carry out a point load test on a sample of this material; however, due to the highly fractured state of the material, it was not possible to get a suitable representative sample of intact rock to test. As such, its strength could not be accurately measured.

6.1.4 Groundwater

The groundwater levels were measured in boreholes at the time of investigation, and in monitoring wells and piezometers after the investigation. The results of the investigation indicate that the groundwater level within Slack Point is close to that of the ocean, approximately 1 m to 2 m below ground surface (about elevation 0.0 m to 0.5 m). The groundwater elevation will be strongly influenced by the tide and will also fluctuate with seasonal precipitation levels.

Table 5: Summary Soil and Groundwater Conditions – Geotechnical Boreholes

Borehole	Depth Below Ground Surface/Elevation (m)								Groundwater
	Fill			Native sediments			Bedrock		
	Sand/Gravel/ Cobbles	Woodwaste	Coal	Sand/Silt	Silty Clay	Sand/Gravel	Sandstone	Mudstone	
BH09-01	0 – 0.15 (+2.2 to +2.1)	0.15 – 1.4 (+2.1 to +0.9)	1.4 – 14.9 (+0.8 to -12.7)	14.9 – 18.1 (-12.7 to -15.9)	21.3 – 21.9 (-19.1 to -19.7)	18.1 – 27.9 (-15.9 to -27.9)		NE*	1.7 (+0.6)
BH09-02	0 – 0.3 (+3.4 to +3.1)	0.3 – 1.1 (+3.1 to +2.4)	1.1 – 15.5 (+2.4 to -12.1)	15.5 – 18.9 (-12.1 to -15.5)	NE	18.9 – 25.6 (-15.5 to -22.2)	NE	NE	3.4 (+0.1)
BH09-03	0 – 0.15 (+1.9 to +1.8)	NE	0.15 – 13.7 (+1.8 to -11.8)	13.7 – 18.1 (-11.8 to -16.2) 26.5 – 28.0 (-24.6 to -26.1)	NE	18.1 – 26.5 (-16.2 to -24.6)	NE	NE	NE
BH09-04	0 – 0.2 (+3.3 to +3.1)	NE	0.2 – 6.7 (+3.1 to -3.3)	NE	NE	6.7 – 12.2 (-3.3 to -8.9)	NE	12.2 – 15.6 (-8.9 to -12.3)	2.6 (+0.8)
BH09-05	NE	NE	0 – 16.6 (+6.1 to -10.5)	16.6 – 18.3 (-10.5 to -12.2) 18.6 – 22.9 (-12.5 to -16.8)	18.3 – 18.6 (-12.2 to -12.5)	22.9 – 30.9 (-16.8 to -24.8)	NE	NE	4.9 (+1.2)
BH09-06	0 – 1.7 (+16.6 to +14.9)	NE	NE	2.3 – 5.0 (+14.3 to +11.6)	1.7 – 2.3 (+14.9 to +14.3)	5.0 – 5.6 (+11.6 to +11.0)	5.6 – 9.2 (+11.0 to +7.5)	NE	1.2 (+15.4)

*NE - Not Encountered.

6.2 The Uplands

Golder carried out a combined geotechnical and environmental drilling investigation in the Uplands portion of the Site. This included 10 monitoring wells/boreholes and 12 test pits as part of the environmental investigation, and one geotechnical borehole (BH09-06). In addition, a total of five dynamic cone penetration tests (DCPTs) were conducted at the locations of selected environmental monitoring wells/boreholes, in order to assess the relative density of the subsoils. DCPTs were used as a method of assessing relative density, rather than SPTs, due to the drilling method utilized. The results of the investigation, together with previous investigations conducted in the Uplands, were used to characterize the subsurface soil, rock and groundwater conditions in this area. The following paragraphs summarize the subsurface conditions encountered in this investigation and based on historical studies, from a geotechnical point of view.

6.2.1 Fill

The Uplands area has experienced historical industrial activities for many years. These activities have resulted in fill placement of variable thickness and composition. The fill materials typically comprise granular mineral soil ranging in composition from silty sand to sand and gravel, and include cobbles, boulders and organics (roots and woody debris). In addition, materials including concrete and metal are also encountered within the fill. The thickness of the fill layer ranges from about 0.1 m to 1.6 m, and on average is about 0.7 m.

DCPT penetration resistance, measured by the number of blows for the probe to penetrate 300 mm, ranged from 6 to 41, and as high as 77. The material was generally compact. The higher blow counts are possibly due to the presence of coarse grained material such as gravel, cobbles and manmade debris within the fill, which can result in increased resistance to penetration.

6.2.2 Post-Glacial Native Deposits

Underlying the fill, native deposits consisting of silts, sands and gravels were encountered at the monitoring well, borehole and test pit locations. The composition of these materials ranged from sand and gravel to silt, trace sand, and contained cobbles. The depth to which these deposits extended ranged from about 0.4 m to 5.5 m, but was generally in the range of about 1.0 m to 2.0 m.

DCPT penetration resistance ranged widely from as low as 5 to in excess of 100 blows per 300 mm, but were typically within the range of 15 to 50 blows per 300 mm, indicating generally compact to dense relative density. However, as with the fill material, the higher blow counts are likely influenced by the presence of coarse grained material, such as gravel and cobbles.

6.2.3 Glacial Deposits

Glacial till-like deposits were encountered in three monitoring wells drilled in the Uplands area – monitoring wells MW09-05, MW09-06 and MW09-09. These deposits generally consisted of silty sand and gravel and also contained cobbles. Although not encountered directly in the investigation, boulders are also typical in these deposits. The depth to these deposits ranged from 1.5 m to 3.7 m below the existing ground surface. At monitoring wells MW09-05 and MW09-09, drilling extended to the bedrock underlying the glacial deposits, where the depth to the bottom of the glacial deposits was encountered at 8.1 m and 2.4 m, respectively. The DCPT penetration resistance in these materials were generally in excess of 100 blows per 300 mm, indicating a very dense state.

6.2.4 Bedrock

Underlying the native soil deposits, bedrock was encountered in 11 of the test pits and monitoring wells/boreholes drilled or excavated within the Uplands. The rock consisted of sedimentary sandstone. The depth to bedrock ranged widely from about 0.6 m to 8.1 m over all of the boreholes, monitoring wells and test pits that encountered it; however, at most locations it was generally between 1.0 and 3.0 m depth below the ground surface.

Borehole BH09-06, drilled at the south end of the Uplands area as part of the geotechnical investigation, encountered bedrock at about 5.6 m below the existing ground surface. Upon encountering bedrock, HQ diamond coring was carried out to a depth of approximately 3.5 m into the rock layer. The core was transported to our Burnaby warehouse for more detailed classification and logging. Inspection of the rock indicated that it comprises a fresh, massive, light grey, fine-grained sandstone. A Uniaxial Compressive Strength (UCS) test was conducted on a sample of the rock. The results indicate that the rock sample had a strength of approximately 103 MPa. Point load tests were conducted on 7 specimens obtained from the rock core. The results indicate that the UCS of the sandstone ranges from about 48 MPa to 120 MPa; however, all but one test ranged from about 86 MPa to 120 MPa. The Rock Strength Category of the rock (Modified from ISRM, 1981) ranges from R3 to R5, but was typically R4 to R5, indicating strong to very strong rock.

6.2.5 Groundwater

Within the Uplands area of the Site, the depth to groundwater ranged from about 0.1 m to 3.4 m below the existing ground surface (elevation 16.1 m to 20.1 m). Based on the subsurface conditions encountered, the groundwater levels may perched above the finer grained till-like deposits or rock. The regional topography surrounding the Site slopes down to the northeast. The groundwater in the area is expected to flow northeast toward Ladysmith Harbour.

6.3 The Foreshore

Monitoring wells and boreholes were drilled along the Foreshore as part of the environmental investigation. These included monitoring wells MW09-7, MW09-8 and MW09-16, and boreholes BH09-12 to BH09-15. monitoring well MW09-16 was drilled at the north end of the Foreshore near the government wharf. The other boreholes and monitoring wells were drilled within and around the existing parking area near the dock, approximately 150 m to 250 m north of Slack Point.

The subsurface conditions encountered in these monitoring wells and boreholes generally consisted of fill materials, including sand, gravel, cobbles and wood debris, overlying native deposits of silt to silty sand, or sand. monitoring well MW09-07 and boreholes BH09-13 and BH09-16 encountered till like deposits underlying the silts and sands at depths between about 4 m and 6 m. Monitoring well MW09-08 encountered fragments of mudstone, possibly representing bedrock. Boreholes BH09-14 and BH09-15 encountered and were terminated in, a layer of possible cobbles or boulders at depths of 4.4 m and 4 m, respectively. The following paragraphs summarize the subsurface conditions encountered in this investigation.

6.3.1 Fill

Fill was encountered in the boreholes and monitoring wells drilled within the Foreshore. The material consists generally of silty sand and gravel, to sand and gravel, and includes cobbles and possible boulders. Wood debris was encountered in monitoring well MW09-07 between 0.7 m and 1.1 m depth and in borehole BH09-15 at 0.45 m. The thickness of the fill at the borehole locations ranged from about 1.1 m to 3.4 m.

A DCPT test was carried out at monitoring well MW09-07. Penetration resistance ranged from 25 to 96 within the fill layer. Based on this, the material is compact to very dense; however, higher blow counts are likely due to the presence of coarse grained material, such as gravel and cobbles, and possibly manmade debris within the fill layer.

6.3.2 Native Granular Deposits

Underlying the fill, native granular deposits were encountered in the boreholes and monitoring wells drilled in the Foreshore. The composition of these deposits ranged from sandy silt to silt and sand, as well as possible cobbles and boulders. Boreholes BH09-14 and BH09-15 encountered and were terminated in a layer of possible cobbles or boulders at depths of 4.4 m and 4 m, respectively. These deposits extended to depths of between 2.7 m and 5.6 m below the ground surface (elevation -2.4 m to 1.2 m) at individual boreholes. Within MW09-07, a layer of sand and gravel was encountered between 1.1 m and 1.7 m, overlying the sandy silt deposits.

Within monitoring well MW09-16, drilled near the government wharf, a deposit of moist, light brown medium sand, with a trace of rounded gravel and a trace of silt was encountered underlying the fill layer between 2.3 m and 5.6 m depth. This deposit also contained wood debris between 2.4 m and 2.7 m depth, as well as cobbles.

Measured DCPT penetration resistance values within the sand and gravel deposit within MW09-07 were 20 and 47, indicating compact to dense; however, higher blow counts may be due to the presence of coarse grained material, such as gravel. DCPT penetration resistance within the sandy silt and silt and sand deposits within MW09-07 ranged from 10 to 35, indicating that the material is compact to dense.

6.3.3 Till-Like Deposits

Glacial till-like soils, consisting of silty sand and gravel and containing cobbles and possible boulders were encountered in MH09-07, BH09-13 and MW09-16. The depth to the top of this deposit ranged from about 4.0 m to 5.6 m (Elevation +0.2 m to -2.0 m). These deposits were found to be very dense resulting in effective refusal to penetration of the DCPT probe.

6.3.4 Bedrock

Within MW09-08 fragments of rock, possibly representing bedrock, were encountered at a depth of 5.3 m (elevation -1.3 m). The rock type was not determined conclusively, however, based on our observations it was similar in appearance to the rock encountered in BH09-04, drilled on Slack Point and may be mudstone. It should be noted that the method of drilling used may not permit accurate confirmation of the presence of rock.

6.3.5 Groundwater

Within the Foreshore area, the depth to groundwater ranged from about 2.0 m to 3.0 m below the existing ground surface (elevation 0.9 m to 1.5 m), as measured within monitoring wells. Groundwater levels within the Foreshore are expected to be tidally influenced by Ladysmith Harbour, and to vary with seasonal runoff from the south.

7.0 GEOTECHNICAL CONSIDERATIONS

7.1 General Summary

The results of the geotechnical investigation indicate that Slack Point is underlain by fill consisting of surficial mineral materials – silt, sand, gravel, cobbles and boulders – as well as, concrete, metal and woodwaste, overlying an extensive deposit of coal waste. The coal waste extends to depths of between 6.5 m to 16.6 m (elevation -3.3 to -12.7 m). At surface there are also remnants of historical structures located on the site. These include timber piles and concrete slabs. The natural sediments underlying the fill consist of marine silts and sands, followed by a deposit of sands and gravels. The extent of the sand and gravel is not known fully; however, two of the geotechnical boreholes penetrated this layer and were terminated within either an underlying dense silt/sand layer (BH09-03) at a depth of about 26.5 m (elevation -24.6 m), or bedrock (BH09-04) at a depth of 12.2 m (elevation -8.9 m). The depth to competent strata, based on resistance to penetration from SPTs, ranges from about 18 m to 23 m below the existing ground surface (about elevation -16 m) over most of Slack Point. The groundwater level within Slack Point is close to that of the ocean, within approximately 1 m to 3 m of ground surface (0.0 m to 0.5 m elevation). An interpreted stratigraphic section through Slack Point showing the soil stratigraphy is shown on Figure 4.

The Uplands is underlain by fill materials consisting of silt, sand and gravel, and also containing cobbles and boulders. In addition, organic material (roots and woody debris), isolated coal waste, and man-made materials including concrete and metal, were encountered in the fill layers. Underlying the fill are native deposits of silt, sand and gravel, and till-like deposits. The Foreshore, where investigation was conducted, is underlain by fill materials overlying native granular deposits including silt, sand and gravel. Cobbles and possible boulders were also encountered within the deposits underlying the fill.

Dense till-like soil and sedimentary rock were encountered underlying both the Uplands and possibly the Foreshore. The depth to bedrock ranged widely from 0.6 m to 8.1 m where it was encountered; however, at most locations it was generally between 1 m and 3 m depth below the ground surface in these areas.

The development of Slack Point will be considerably challenged by the presence of heterogeneous fill, and loose coal waste and marine sediments underlying the site. Based on our preliminary analysis, the coal waste and loose marine deposits are susceptible to liquefaction and associated lateral and vertical displacements under the design seismic loading. This will necessitate ground improvement and use of deep foundations, if the development of structures is considered for Slack Point. The surficial fills overlying the coal waste are heterogeneous and contain metal, concrete and woodwaste, in addition to mineral soil. The presence of such materials will complicate site and foundation preparation, and the installation of deep foundations. In addition, the review of historical aerial photographs, along with observations during our site reconnaissance, corroborates the conclusions of one previous study (Hardy 1990a) that erosion of portions of the shoreline of Slack Point is ongoing. Treatment may be required to address the erosion.

The primary geotechnical issues associated with Slack Point include the following:

- Liquefaction of the loose fill and sediments underlying Slack Point;
- Liquefaction-induced lateral displacements and settlement;
- Presence of obstructions and debris within upper fill below Slack Point;
- Depth of suitable bearing stratum below Slack Point; and
- Ongoing erosion of Slack Point.

In contrast to Slack Point, development of the Uplands and Foreshore area of the overall site would be more straightforward. Although loose fill and natural sediments underlie portions of these areas, the depth to competent bearing is relatively modest in most areas.

The following sections summarize the results of our analyses and discuss geotechnical hazards associated with the Site, and their impact on development plans. In addition, preliminary geotechnical engineering input to planning of feasible forms of development and ground improvement options are provided. Comments and recommendations for Slack Point and the Uplands and Foreshore are provided in separate sections.

7.2 Slack Point

7.2.1 Liquefaction and Lateral Displacements

The overall Site is located in an area of relatively high seismicity. Seismic design in British Columbia is defined by the 2005 National and 2006 British Columbia Building Codes (2005 NBCC and 2006 BCBC). These codes consider ground motions having a return period of 2,475 years and explicit consideration of an offshore subduction earthquake in seismic design for structures. Due to the presence of loose coal waste material below the water table within Slack Point, this area is considered vulnerable to liquefaction under the design seismic event. Liquefaction can occur in loose sediments located below the water table when they are subjected to rapid and repeated loading. This can result in a substantial loss of strength and large deformations in the material.

Golder carried out an analysis to determine if liquefaction would be triggered in the coal waste and loose marine sediments underlying Slack Point during the design seismic event. The liquefaction potential of the soil and coal waste was evaluated using Seed's simplified method of analysis by comparing the cyclic resistance of the materials with cyclic stress ratio induced by the earthquake ground motions. The cyclic resistance of soils was estimated using profiles of SPT (N1)60-cs values obtained from the boreholes and the empirical liquefaction resistance chart developed by Idriss and Boulanger (2008). The empirical cyclic resistance was corrected to reflect the design earthquake magnitude and site-specific overburden stress conditions using the correction factors proposed by Idriss and Boulanger (2008). The average fines contents (finer than USS 0.075 mm sieve size) for each soil layer was established based on laboratory particle size distributions. The design or characteristic penetration resistance, corresponding to the lower 33rd percentile of variations in penetration resistance at any given elevation, range from about 6 to 13 blows per 300 mm for the coal waste and the marine sediments together. Comparing the available penetration resistance of the coal and the marine sediments with that required to avoid liquefaction indicates that the coal and the silt/sand marine deposits are expected to liquefy under the design 1 in 2,475 year seismic event.

Lateral displacement of the ground is expected to occur at the site as a result of liquefaction in the coal waste and marine sediments. Golder has conducted a simplified preliminary analysis of lateral ground displacements under design earthquake loading using the method developed by Youd (2002). This is an empirical method which correlates soil properties and site geometrical features with lateral displacement due to earthquake acceleration. Our preliminary analysis indicates that flow failure movements due to liquefaction in the coal and marine sediments are expected at this site. This could result in lateral spread movements of several metres toward the water, greatest near the shoreline. In addition to lateral displacement, vertical settlement is also expected to occur at the site as a result of liquefaction induced consolidation. Preliminary analyses indicate that settlements on the order of 0.5 m to 1 m are possible.

7.2.2 Geotechnical Considerations for Development

7.2.2.1 Ground Improvement

At this preliminary stage, there are no detailed development plans in place for the Site; however, the Town of Ladysmith Waterfront Area Plan indicates that consideration has been given to mixed use development within Slack Point, the Uplands and the harbour. This includes parkland around the outside of Slack Point and a mix of resort, residential and commercial use within the central portions of Slack Point. The plan indicates a mix of open space, tourist, commercial/community and residential use within the Uplands. It is understood that the Town intends to undertake a comprehensive waterfront area plan as a result of community input in the development of the Town's Sustainability Plan.

Development of Slack Point for residential or commercial structures will require that fill and soils in this area be improved to limit lateral displacement due to liquefaction to tolerable limits. Given the coastal location of the point and the depth of liquefiable soils, the most feasible form of improvement would be a seismic dike. A seismic dike is an in-ground structure that resists lateral soil movement through its internal strength. There are a number of options for such structures; however, the more conventional ones include vibro-replacement and deep soil mixing.

Vibro replacement involves constructing stone columns by inserting a vibrating probe (a vibroflot) into the soil to a predetermined depth. This creates an opening into which high strength crushed angular gravel is inserted to replace the volume of loose soil displaced in the insertion process. The gravel is placed in stages and the vibroflot plunged into it, in order to densify the gravel and surrounding soil. A large number of stone columns is installed in a pattern of rows along the edge of the water front to act as a strong densified boundary (dike) to resist lateral movements. The depth of the stone columns is dependent on the depth of liquefaction. In order to resist lateral movement and improve stability, they need to penetrate through the liquefiable zone and into the underlying competent stratum. Based on the results of the investigation and our analysis, stone columns for Slack Point would have to extend to a depth of between 18 and 23 m, or more, in order to penetrate into the underlying sand and gravel. The width of the densified zone is dependent on the driving force of the laterally moving liquefied soil. Our analysis indicates that a roughly 40 m wide dike would be necessary to reduce lateral movements to within conventionally tolerable limits.

The zone of improvement should be configured to include the submarine toe of the coal waste slope, in order to provide complete restraint and to avoid loss of support in this area. This would also increase the available developable land area. Installation in this area would require the construction of a soil platform out into the water on which installation occurs. This platform could then be trimmed to form a new densified shoreline. The newly configured shoreline could be integrated into future erosion control measures.

Typical order of magnitude costs for vibro-replacement treatment range from about $20 to $25 per cubic metre of treated zone. Mobilization costs range from about $500,000 for on-land treatment, to $1.5 million for offshore treatment. Based on the existing geometry of the submarine slope, it is estimated that the treated zone would be confined to offshore areas. As such, the costs for treatment, assuming that it would extend the full perimeter of Slack Point would be on the order of $7 to $9 million.

It should be noted that conventional vibro-replacement treatment is usually carried out within mineral soils, where the technique is well established. Although it has been reported as a technique for improving culm coal waste deposits (Davie et. al., 1991), there is much less experience with its use in coal waste material than mineral soil. It is possible there could be difficulties in building the individual columns and in compacting the stone within the lightweight coal waste material. This could result in overuse of stone and inadequate compaction. It is recommended that if vibro replacement is selected as an option for ground improvement, that a test section be carried out to establish the performance of the technique within the coal waste material.

As an alternative to vibro replacement, deep soil mixing could be considered as a means of ground improvement. Deep soil mixing is a technique of mixing cement with soil, in-situ, in order to improve its strength. Similar to stone column treatment, deep soil mixing would be used to create a seismic dike that would resist the lateral forces from seismic shaking and liquefied soil. Use of this technique, however, is limited by the size of available equipment, and is generally suited for a maximum depth of about 18 m. As such, use of this technique may not be feasible at this site.

If the area is to be left in its current use as a park, ground improvement would not be necessary, provided that the potential impacts outlined above are acceptable. If, however, its use as a park is enhanced with the development of structures intended for public assembly, ground improvement would likely be necessary. Further study may be necessary to establish the requirements for ground improvement in such cases.

7.2.2.2 Foundation Support and Site Preparation Considerations

Ground improvement, once completed, would reduce lateral displacements to tolerable limits; however, the loose coal waste and underlying marine deposits within the site would still be susceptible to liquefaction, loss of strength and vertical post-liquefaction settlements. As a result, shallow foundations are not suitable for support of structures on this site. Any structures proposed for Slack Point would require deep foundations, such as conventional steel pipe piles. These would be driven to the underlying sand and gravel layer, some 18 to 23 m, or more, below the existing ground surface, depending on the requirements for support. It should be noted that the presence of potential obstructions within the fill overlying the coal, including concrete, woodwaste, existing piles and other debris, would complicate the installation of piles. It is possible that a considerable amount of preparation may be required to remove existing obstructions prior to foundation construction.

Due to the potential for significant vertical post-liquefaction settlements, critical life-line infrastructure, such as fire access roads, as well as gas utility piping may require special support in order to avoid catastrophic loss of use, or the creation of hazards.

7.2.2.3 Coastal Erosion Control

The shoreline of Slack Point is currently experiencing ongoing erosion. This is apparent on both the southeast (outer) and northwest (harbour side) of the point. The shoreline is roughly 800 m long, with about half of this exposed to the southeast. In addition, a number of incised gully formations were observed, both near the shoreline and in the interior of the point, during our most recent site visit on February 1, 2010. The coal waste material along the shoreline is granular, cohesionless and relatively lightweight, and as such is highly erodible. If left unchecked, ongoing coastal erosion could compromise the integrity of the shoreline, existing public pathways and pose a nuisance, or even a hazard.

Erosion of the shoreline is principally caused by wind-generated waves, tidal currents and water levels. The southeast shore of Slack Point is exposed to waves generated over an open water fetch approximately 25 km in length. Winds associated with winter storms are typically from the southeast. The northwest shore of Slack Point is exposed to waves generated over an open water fetch approximately 4.5 km in length. Winds associated with summer storms are typically from the northwest. The winter storms tend to be more severe than the summer storms so erosion may be expected to be more severe on the southeast shore of Slack Point. Additionally, longshore currents developed by the storm waves will tend to drive sediments from the southeast shore around Slack Point and deposit them on the northeast shore. Currents associated with summer storms will tend to drive sediments south. Small spits have developed along the northwest shore indicating that this transport of material is occurring. These spits also indicate that the net drift is to the northwest. This is an expected outcome due to the severity of winter storms compared with summer storms.

The material transported and deposited on the northwest shore of Slack Point will include coal waste eroded from the southeast shore. It is likely that some coal waste has been transported offshore into Ladysmith harbour by these processes. Implementation of erosion protection along the shoreline would be required to mitigate the erosion hazard and reduce the potential for transport and dispersal of coal waste in the marine environment.

Example erosion protection concepts for shorelines include rock armour (riprap), sheet piling, artificial beaches (granular fill) and offshore breakwaters. Above the high tide line, dune restoration and bioengineering may be included in the concept.

- Rock armour or riprap typically consists of adequately sized boulders placed in a blanket over a filter layer of granular material. The size, surface slope, and elevation of the riprap are determined during the design phase based on coastal water levels and waves;
- Sheet piling typically consists of interlocking steel plates driven into the ground resulting in a wall that contains the erodible material. The depth of base of the sheet pile and the crest elevation are determined based on coastal water levels, waves and currents;
- Artificial beaches typically consist of adequately sized granular fill material placed on the shoreline in a blanket over the erodible material. The artificial beach material is then eroded instead of the underlying material. Structural controls (*e.g.*, rock groins and sills) may be used to retain the artificial beach. The size, surface slope and elevation of the artificial beach are determined during the design phase based on coastal water levels and waves and on the topography of the existing shoreline or nearby analogues; and
- Offshore breakwaters typically consist of adequately sized boulders placed in a mound offshore of the site to protect the shoreline from direct wave attack. The breakwaters act as artificial islands and reduce the strength of waves impacting the shoreline. The size, surface slope, and elevation of the breakwater are determined during the design phase based on coastal water levels and waves.

The intent of the erosion protection is to protect the erodible material from the action of storm waves, high water levels and surface runoff. Depending on the requirements, additional factors may be considered such as restoration of the coastal riparian zone, public access to the shoreline and habitat enhancement. Typically an assessment of coastal water levels, waves and currents is undertaken to support coastal engineering of the erosion protection concept. Coastal engineering analysis, development and cost estimation of these concepts was beyond the scope of this assessment. Typical capital costs for engineered coastal erosion protection are of the order of $3,000 to $8,000 per metre of shoreline, depending on the nature of the site and the favoured protection concept.

Permitting of coastal erosion protection is the responsibility of Fisheries and Oceans Canada (DFO) and the Coast Guard. The works are typically regulated under Section 35.2 of the Fisheries Act and under the Navigable Waters Act. Installation of erosion protection works may be evaluated as a HADD and may require additional environmental assessment and/or compensation. Typically a coastal erosion protection concept is developed and submitted to DFO for review and comment. The evaluation of permitting and/or compensation requirements associated with coastal erosion protection was also beyond the scope of this assessment.

It is understood that consideration may be given to capping the surface of Slack Point in order to provide a barrier between the surface and the underlying coal waste material. Integration of the surface capping design and the coastal erosion protection design would be preferable. We have previously developed a conceptual design of surface capping and coastal erosion protection for a similar low-lying coal waste deposit on the east side of Vancouver Island. It would also be beneficial to promote the growth of vegetation on the terrestrial surface of Slack Point in order to reduce the potential for surface erosion. Enhanced vegetative cover would also allow restoration of the coastal riparian zone and potentially provide a habitat benefit.

7.2.2.4 Coastal Flood Hazard

Low-lying portions of Slack Point may be subject to coastal flooding by marine waters during extreme tides and storm events. The funnel-shaped nature of Ladysmith Harbour, the constriction of the width of the harbour at Slack Point, and the north-westerly to south-easterly alignment of the harbour indicate that storm surges associated with south-easterly winter storms and sea level rise could result in flooding. The typical tidal range of Ladysmith Harbour is approximately 4.3 m above Chart Datum with a mean sea level of 2.5 m above Chart Datum. Mean sea level is approximately equivalent to geodetic elevation, thus typical high tide is approximately equivalent to 1.8 m Geodetic. Storm surge and seasonal, cyclic and progressive variations in sea level (*e.g.*, sea level rise) may increase local tide height by a significant amount (*e.g.*, 0.5 m to 1.0 m) depending on the combination of events. This could result in coastal flooding at elevations above 1.8 m Geodetic. Assessment of the coastal flood hazard was beyond the scope of this assessment but would need to be undertaken as part of the analysis to evaluate conceptual erosion protection options for the shoreline.

7.3 The Uplands and The Foreshore

The depth to competent bearing strata within the Uplands, consisting of native deposits or rock, typically ranges from about 1.0 m to 3.0 m. Given the relatively shallow depth to these strata, it is anticipated that conventional foundation design and construction, including the use of individual shallow spread or continuous strip footings, would be suitable for the Uplands. If consideration is given to underground structures, such as parkades, it should be anticipated that excavations could encounter rock, potentially requiring blasting to remove. Given the significant increase in elevation to the south, toward the town, excavations to the depths required for below-ground structures may encounter seepage through more permeable zones within the underlying soil and rock. Such seepage could complicate excavation and may require special attention to groundwater control prior to or during excavation.

The depth to competent bearing strata within the Foreshore is on the order of 4 m to 5 m, or more. Depending on development plans, structures considered for the Foreshore may require pile support in order to provide suitable bearing in the underlying competent native sediments or bedrock, located below the water level. Although a seismic assessment has not been carried out on the Uplands or the Foreshore areas, the Foreshore is underlain by granular fill and native sediments below the watertable that may be susceptible to liquefaction.

The existing rock bluff located along the southwest corner of Slack Point has not been assessed for stability or rock fall hazard potential as part of this study. Measures for stabilization, maintenance of the bluff, or building setbacks may be needed as part of future development plans.

8.0 LIMITATIONS AND USE OF THIS REPORT

This report was prepared for the exclusive use of the Crown Lands Opportunities and Restoration Branch (CLORB) of the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) and the Town of Ladysmith and is intended to provide an assessment of geotechnical-related soil and groundwater conditions at the Site.

The report is based on data and information collected during investigations conducted by Golder Associates Ltd.'s personnel and the review of reports prepared by others as listed in this report. It is based solely on the conditions of the subject property at the time of the site investigations conducted in 2009, as described in this report. The data presented in this report represents soil, groundwater, and soil vapour conditions encountered at the sampling locations tested at this time. Soil and groundwater conditions will vary with location, depth, time, and other factors. Golder Associates Ltd. makes no warranty, expressed or implied, and assumes no liability with respect to the use of the information contained in this report at the subject site, or any other site, for other than its intended purpose.

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If new information is discovered in the future, Golder Associates Ltd. should be requested to re-evaluate the conclusions of this report and provide amendments as required prior to any reliance upon the information presented herein.

9.0 CLOSURE

We trust that the information presented in this report is sufficient for your immediate requirements. If you have any questions or concerns, please do not hesitate to contact us.

Yours very truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Anthony Fuller, P.Eng.
Associate, Geotechnical Engineer

ORIGINAL SIGNED

M. Yogendrakumar, Ph.D., P.Eng.
Principal, Senior Geotechnical Engineer

ALF/MY/js

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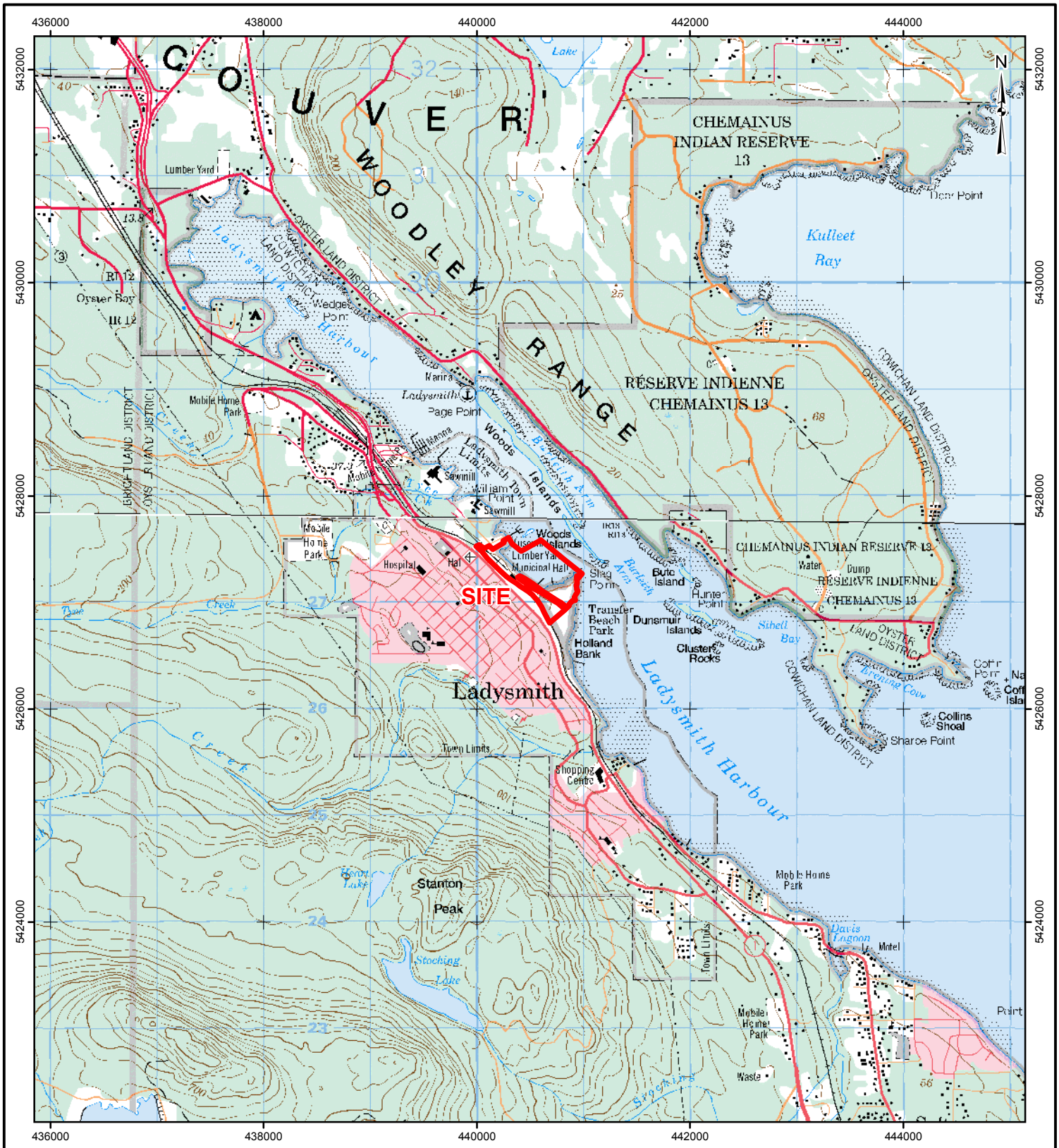


LEGEND

Site

REFERENCE

NTS Mapsheet 092G04/092B13 obtained from Natural Resources Canada.
Projection: UTM Zone 10 Datum: NAD 83

PROJECT

CROWN CONTAMINATED SITES BRANCH
MINISTRY OF FOREST, LANDS AND NATURAL RESOURCE OPERATIONS
LADYSMITH HARBOUR, LADYSMITH, B.C.

TITLE

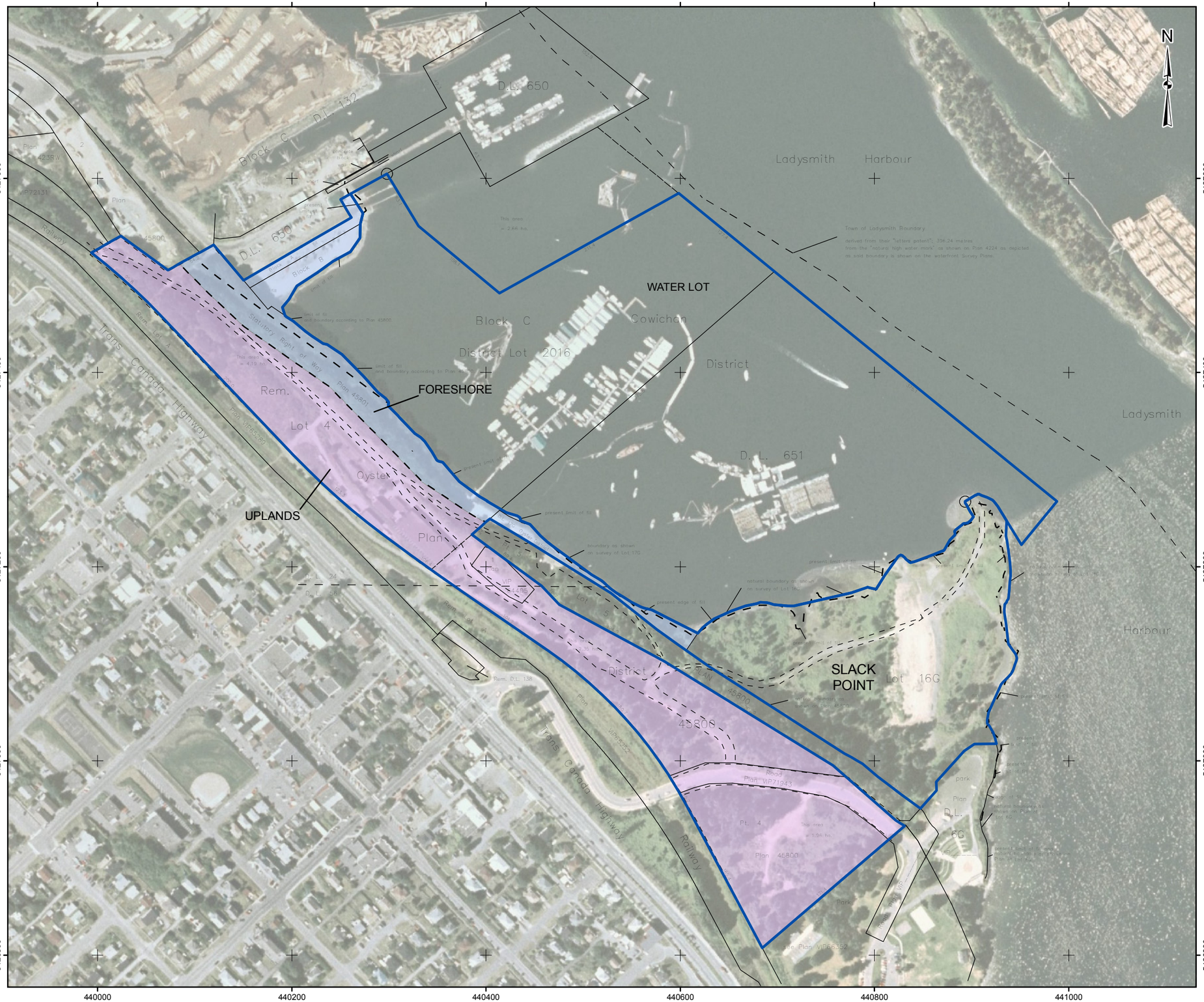
KEY PLAN

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 09-1436-5008			PHASE No. 6000	
DESIGN	AF	13JAN10	SCALE AS SHOWN	REV. 0
GIS	CDB	13JAN10		
CHECK	AF	22MAR11		
REVIEW	MY	22MAR11		

FIGURE 1

N:\Bur-Graphics\Projects\2009\1436\09-1436-5008\GIS\projects\6000\figure-01_key-plan.mxd



LEGEND

- Site
- Foreshore
- Uplands

REFERENCE

Base features obtained from McElhanney Associates Land Surveying Drawing 91501-1 SLACKPOINT.DWG, dated march 3, 2011.
Other features obtained from W.R. Hutchinson Land Surveying Ltd.
Image obtained from Google Earth Pro.
Projection: UTM Zone 10 Datum: NAD 83

100 0 100
SCALE 1:4,000 METRES

PROJECT
CROWN CONTAMINATED SITES BRANCH
MINISTRY OF FOREST, LANDS AND NATURAL RESOURCE OPERATIONS
LADYSMITH HARBOUR, LADYSMITH, B.C.

TITLE
SITE PLAN

Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 09-1436-5008			PHASE No. 6000	
DESIGN	AF	11JAN10	SCALE AS SHOWN	REV. 0
GIS	CDB	11JAN10		
CHECK	AF	22MAR11		
REVIEW	MY	22MAR11		

FIGURE 2

N:\Bur-Graphics\Projects\2009\1436\09-1436-5008\GIS\projects\6000\figure-02_site-plan.mxd

440000 440200 440400 440600 440800 441000

5427600 5427400 5427200 5427000 5426800

N

Ladysmith Harbour

Cowichan District

Block C

District Lot 2016

D.L. 650

Rem. Lot 4

D.L. 651

Trans Canada Highway

Railway

Plan 45800

MW09-05 13.27
MW09-16 3.4
MW09-11 19.87
MW09-04 23.51
MW09-10 19.5
MW09-11 19.32
TP09-06
TP09-05
MW09-09 17.84
MW09-03 3.88
MW09-07 4.42
MW09-01 19.43
TP09-07
TP09-08
TP09-01
TP09-03
TP09-02
TP09-04
MW09-09 19.18
MW09-03 18.65
MW09-02 18.78
MW09-06 17.62
TP09-09
TP09-10
TP09-12
TP09-11
BH09-01 2.15
BH09-02 3.44
BH09-03 1.9
BH09-04 3.34
BH09-05 6.1
BH09-06 16.63

LEGEND

- Geotechnical Borehole (Golder 2009)
- Environmental Monitoring Well (Golder 2009)
- Environmental Testpit (Golder 2009)
- Surface Soil Sample (Golder 2009)
- Sediment Sample (Golder 2009)
- Boreholes, Monitoring Wells, and Test Pits (by others)
- Historic Sample

REFERENCE

Borehole locations obtained from McElhanney Associates Land Surveying Ltd.
Other features obtained from W.R. Hutchinson Land Surveying Ltd.
Image obtained from Google Earth Pro.
Projection: UTM Zone 10 Datum: NAD 83

100 0 100
SCALE 1:4,000 METRES

PROJECT
CROWN CONTAMINATED SITES BRANCH
MINISTRY OF FOREST, LANDS AND NATURAL RESOURCE OPERATIONS
LADYSMITH HARBOUR, LADYSMITH, B.C.

TITLE
BOREHOLE AND MONITORING WELL LOCATION PLAN

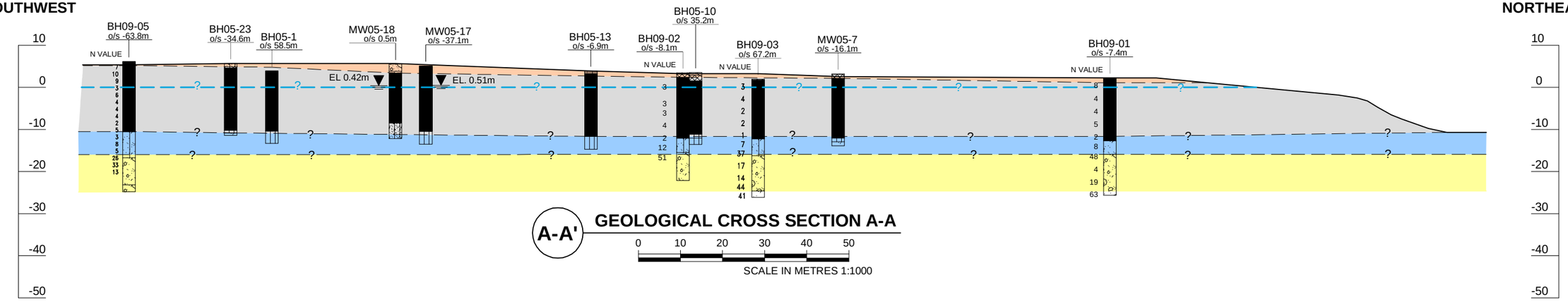
Golder Associates
Greater Vancouver Office, B.C.

PROJECT No. 09-1436-5008			PHASE No. 6000	
DESIGN	AF	26JAN10	SCALE AS SHOWN	REV. 0
GIS	MH	26JAN10		
CHECK	AF	22MAR11		
REVIEW	MY	22MAR11		

FIGURE 3

N:\Bur-Graphics\Projects\2009\1436\09-1436-5008\GIS\projects\6000\figure-03_borehole-location-plan_rev3.mxd

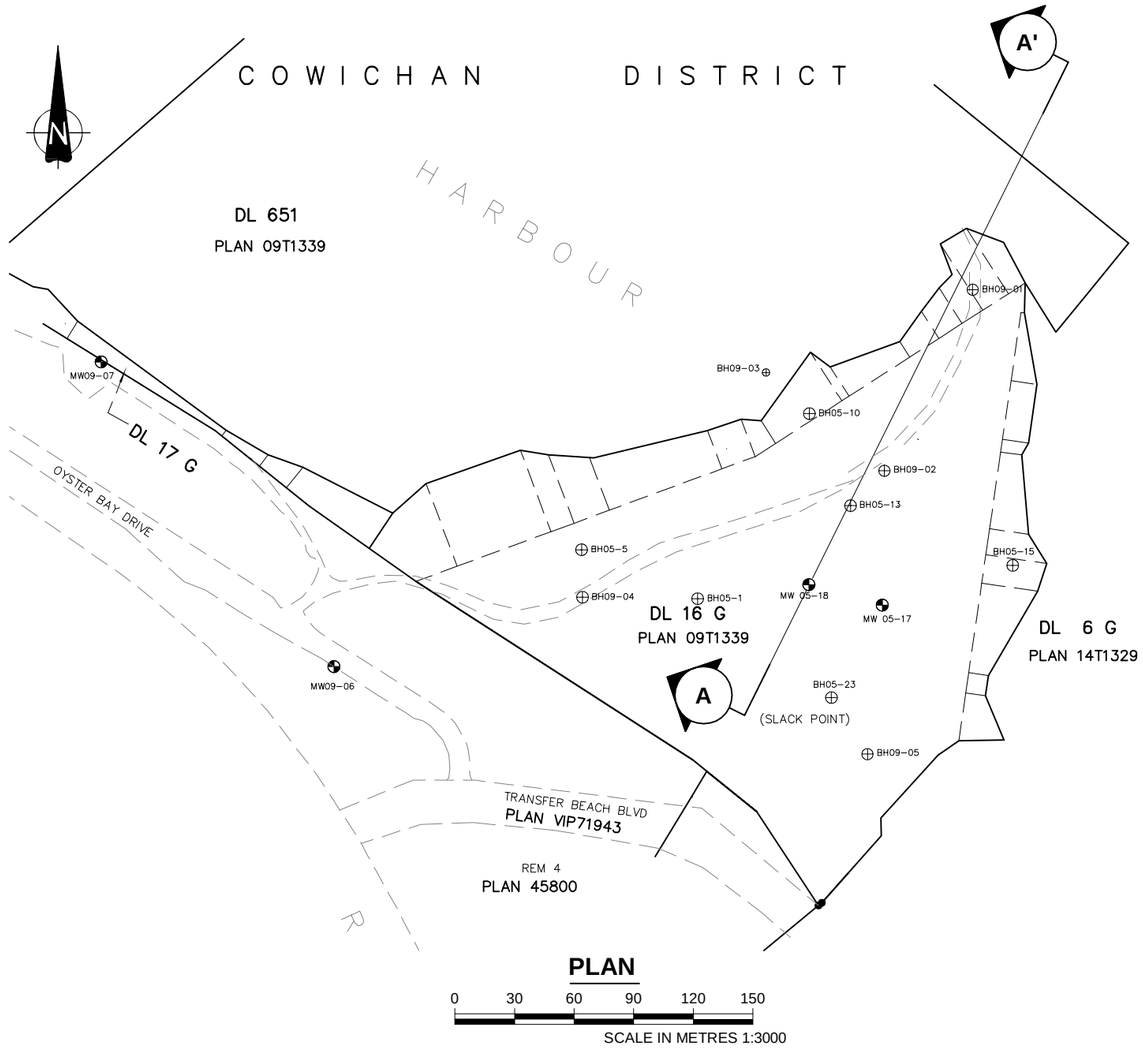
A — **SOUTHWEST** — **A'** — **NORTHEAST**



A-A' GEOLOGICAL CROSS SECTION A-A

0 10 20 30 40 50

SCALE IN METRES 1:1000



PLAN

0 30 60 90 120 150

SCALE IN METRES 1:3000

LEGEND

TEST HOLE LOCATION SHOWING STRATIGRAPHY DATA.
(FOR DETAILED STRATIGRAPHY REFER TO RECORD OF BOREHOLE LOGS)

TEST HOLE
o/s - OFFSET

FILL
COAL FILL
SILT
SAND
CLAY
GRAVEL

SURFICIAL MINERAL FILL, WOODWASTE AND DEBRIS
COAL WASTE
MARINE SILTS AND SANDS
MARINE SAND AND GRAVEL

— —?— — INFERRED STRATIGRAPHIC BOUNDARY

— —?— — INFERRED GROUNDWATER LEVEL

REFERENCE

1. BASE PLAN PROVIDED BY "MCELHANNEY ASSOCIATES CONSULTING LTD."
   FILE NO. 2232-91501-1
   DRAWING NO. 91501-1 SLACK POINT.DWG
   DATED: JANUARY 2010.

SPECIAL NOTE: DATA CONCERNING THE VARIOUS STRATA HAVE BEEN OBTAINED AT TEST HOLE LOCATIONS ONLY. THE SOIL STRATIGRAPHY BETWEEN TEST HOLES HAS BEEN INFERRED FROM GEOLOGICAL EVIDENCE AND MAY VARY FROM THAT SHOWN.

PROJECT
CROWN CONTAMINATED SITES PROGRAM,
CROWN LAND OPPORTUNITIES AND RESTORATION BRANCH
B.C. MINISTRY OF FORESTS, LANDS AND NATURAL RESOURCE OPERATIONS
LADYSMITH HARBOUR, LADYSMITH, BC

TITLE

GEOLOGICAL CROSS SECTION A-A

Golder Associates
Greater Vancouver Office, BC

PROJECT No. 09-1436-5008			PHASE No.		6000
DESIGN	AF	20JAN10	SCALE AS SHOWN	REV.	–
CADD	SRR/GG	20JAN10			
CHECK	AF	08AUG11			
REVIEW	MY	08AUG11			

FIGURE 4

APPENDIX A

Geotechnical Borehole Logs

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Slack Point, Ladysmith Harbour

RECORD OF BOREHOLE: BH09-01

SHEET 1 OF 2

DATUM: Geodetic

DRILLING DATE: November 12, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl; NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		2.23							
		Loose to compact, moist, grey SAND and GRAVEL, contains cobbles. [FILL]		0.15							
		Dark brown, moist WOODWASTE FIBRES (0-silt sizes). [FILL]		0.86	1	AS					
				1.37	2	DO	8				Water level observed in open hole during drilling
2											
					3	AS					
4											
					4	DO	4			M	
6											
		Very loose to loose, moist to wet, black COAL (silt, sand and gravel size particles). [FILL] - trace wood pieces between 1.5m - 2.1m depth.			5	DO	4				
8	B-80, Truck Mounted Auger Drill (to 6.1m depth) Mud Rotary (below 6.1m depth)										
10					6	DO	5				Enviro Grout
12											
					7	DO	2			M	
14				-12.71							
		Very loose, wet, green-grey, fine to medium SAND, some silt, contains seashell fragments. - material is black in colour and contains coal particles.		14.94	8	DO	8			M	
16											
18				-15.91							
		Compact to dense, gravelly SAND to sandy GRAVEL, trace to some silt.		18.14	9	DO	48				Bentonite Seal
20		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: RB

CHECKED:

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Slack Point, Ladysmith Harbour

RECORD OF BOREHOLE: BH09-01

SHEET 2 OF 2

DATUM: Geodetic

DRILLING DATE: November 12, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20											
	B-80, Truck Mounted Auger Drill (to 6.1m depth) Mud Rotary (below 6.1m depth)	Compact to dense, gravelly SAND to sandy GRAVEL, trace to some silt. *(continued)*		-19.11							Bentonite Seal
		Firm, wet, grey CLAYEY SILT, trace fine sand.		21.34 -19.72	10	DO	4		W		
22				21.95							Sand and Pea Gravel
24		Compact to dense, gravelly SAND to sandy GRAVEL, trace to some silt.			11	DO	19			M	
26											Slotted PVC Pipe
				-25.66	12	DO	63				
28		End of Borehole.		27.89							
30											
32											
34											
36											
38											
40											

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: RB

CHECKED:

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\6000\COMBINED 09-1436-5008.GPJ Output Form:BC_BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdrozdiak 03/22/11

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Ladysmith Harbour

RECORD OF BOREHOLE: BH09-02

SHEET 1 OF 2

DATUM: Geodetic

DRILLING DATE: November 11, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Ground Surface		3.44							
0	B-80, Truck Mounted Auger Drill (to 6.1m depth) / Mud Rotary (below 6.1m depth)	Loose, moist, brown, sandy GRAVEL, trace silt. (FILL)		3.14							
		Loose, moist, brown, fibrous WOODWASTE, trace coal. (FILL)		0.30	1	AS					
				2.37							
				1.07							
2					2	AS					
					3	DO	6				Water level observed in open hole during drilling
4					4	AS				M	
					5	AS					
6					6	DO	3				
8		Very loose to loose, moist to wet, black COAL, silt, sand and gravel sized particles. (FILL)			7	DO	3				
10											
12					8	DO	4			M	
14											
				-12.10	9	DO	2				
				15.54							
16		Very loose to compact, dark grey, silty SAND to SAND, some silt, trace seashell fragments. - moderate organic-like odour at 15.70m depth.			10	DO	12			M	
18				-15.46							
		Compact to dense, wet, brown to grey GRAVEL, some sand, trace to some silt.		18.90							
20					11	DO	23				
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 100

LOGGED: RB

CHECKED:

Golder Associates

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PROJECT No.: 09-1436-5008 (6000)

LOCATION: Ladysmith Harbour

RECORD OF BOREHOLE: BH09-02

SHEET 2 OF 2

DATUM: Geodetic

DRILLING DATE: November 11, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20											
22	B-80, Truck Mounted Auger Drill (to 6.1m depth) Mud Rotary (below 6.1m depth)	Compact to dense, wet, brown to grey GRAVEL, some sand, trace to some silt. *(continued)*			11	DO	23				
24					12	DO	51			M	
				-22.16							
26		End of Borehole.		25.60							
28											
30											
32											
34											
36											
38											
40											

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: RB

CHECKED:

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\6000\COMBINED 09-1436-5008.GPJ Output Form:BC_BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdrozdiak 03/22/11

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Ladysmith Harbour

RECORD OF BOREHOLE: BH09-03

SHEET 1 OF 2

DATUM: Geodetic

DRILLING DATE: November 16, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		1.90							
		Loose to compact, moist, grey SAND and GRAVEL. (FILL)		0.15							Water level observed in open hole during drilling
2	B-80, Truck Mounted Auger Drill (to 4.6m depth) Mud Rotary (below 4.6m depth)				1	DO	3				
					2	AS				M	
4					3	DO	4				
6		Very loose, wet, black COAL, silty sand and gravel sized particles. (FILL) - organic-like odour from 10.7m - 11.3m depth.									
8					4	DO	2				
10											
					5	DO	2			M	
12				-11.82							
				13.72	6	DO	1				
14		Very loose to loose, wet, dark grey SILT and fine SAND to silty fine SAND, trace seashell fragments. - strong organic odour. - black in colour from 13.7m - 14.2m depth.									
					7	DO	7			M	
16											
				-16.24							
18				18.14							
		Compact to dense, wet, grey GRAVEL, trace to some sand, trace silt. - sand and gravel layers from 21.3m - 21.9m depth.			8	DO	37			M	
20											

CONTINUED NEXT PAGE

DEPTH SCALE

1 : 100

LOGGED: RB

CHECKED:

Golder Associates

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Ladysmith Harbour

RECORD OF BOREHOLE: BH09-03

SHEET 2 OF 2

DATUM: Geodetic

DRILLING DATE: November 16, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20											
22	B-80, Truck Mounted Auger Drill (to 4.6m depth) Mud Rotary (below 4.6m depth)	Compact to dense, wet, grey GRAVEL, trace to some sand, trace silt. - sand and gravel layers from 21.3m - 21.9m depth. *(continued)*			9	DO	17			M	
24					10	DO	14				
26					11	DO	44				
				-24.62							
		Dense, wet, grey SILT to SILT and SAND.		26.52							
28				-26.14	12	DO	41			M	
		End of Borehole.		28.04							
30											
32											
34											
36											
38											
40											

DEPTH SCALE

1 : 100

LOGGED: RB

CHECKED:

Golder Associates

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\6000\COMBINED 09-1436-5008.GPJ Output Form:BC_BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdrozdiak 03/22/11

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Ladysmith Harbour

RECORD OF BOREHOLE: BH09-04

SHEET 1 OF 2

DATUM: Geodetic

DRILLING DATE: November 13 and 17, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Ground Surface		3.34							
0	B-80, Truck Mounted Auger Drill (to 4.6m depth) Mud Rotary (below 4.6m depth)	Loose to compact, moist, grey, gravelly SAND. (FILL)		3.14 0.20	1	AS					
2		Very loose to loose, moist to wet, black COAL. (FILL) - sand and fine gravel particle sizes, some silt.			2	DO	6				Water level observed in open hole during drilling
4					3	DO	3			M	
					4	AS					
6				-3.31 6.65	5	DO	3				
8		Loose to compact, wet, grey sub-angular to sub-rounded GRAVEL layers, some sand, trace silt and seashell fragments.			6	DO	6				
10					7	DO	11				
12				-8.85 12.19	8	DO	14				
		MUDSTONE		-10.40 13.74	9	DO	>50				
14		Bedrock Encountered. Refer to Record of Drillhole log for continuation of rock description.			10	DO	>50				
16											
18											
20											

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: RB

CHECKED:

PROJECT No.: 09-1436-5008

LOCATION: Ladysmith Harbour

RECORD OF DRILLHOLE: BH09-04

SHEET 2 OF 2

DATUM:

DRILLING DATE: November 13 and 17, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	FLUSH / % RETURN / COLOUR	RECOVERY: TOTAL CORE %	RECOVERY: SOLID CORE %	R.Q.D. %	FRACT. INDEX PER 0.3	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	ROCK STRENGTH INDEX	WEATHERING INDEX	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Cont'd from Record of Borehole.														
14	Truck Mounted Auger Drill B-80. Mud Rotary	Fresh, micro fractured, black, fine grained, medium strong BASALT. - joints preferred orientation ~50 degrees, some joints near parallel to core axis.		**13.74**	1 2 3 4 5											
16		End of Drillhole.		15.65												

Type: JN-Joint, FLT-Fault, SH-Shear, VN-Vein, FR-Fracture, BD-Bedding, FO-Foliation, CO-Contact, OR-Orthogonal, CL-Cleavage

Shape: PL-Planar, CU-Curved, UN-Undulating, ST-Stepped, IR-Irregular

Roughness: PO-Polished, K-Slickensided, SM-Smooth, Ro-Rough, VR-Very Rough

Infilling: Br-Brocken Rock, Bt-Biotite, Cl-Clay, Ch-Chlorite, Ca-Calcium, Ep-Epidote, Fe-Iron, Go-Gouge, Gr-Gravel, He-Hematite, Py-Pyrite, Qz-Quartz, Sa-Sand, Se-Sericite, Si-Silt, Su-Sulphide

DEPTH SCALE

1 : 100

LOGGED: RB

CHECKED:

Golder Associates

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Ladysmith Harbour

RECORD OF BOREHOLE: BH09-05

SHEET 1 OF 2

DATUM: Geodetic

DRILLING DATE: November 10, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Ground Surface		6.10							
0	B-80, Truck Mounted Auger Drill (to 6.1m depth) Mud Rotary (below 6.1m depth)			0.00							
					1	AS					
					2	DO	7				
2					3	AS					
					4	DO	10			M	
4					5	AS					
					6	DO	9				Water level observed in open hole during drilling
					7	AS					
6					8	DO	3				
		Loose, moist to wet, black COAL. (FILL) - silty sand, some gravel particle sizes. - slight organic odour from 7.62m - 8.08m depth.			9	DO	6			M	
8											
					10	DO	4				
10											
					11	DO	4				
12											
					12	DO	4			M	
14											
					13	DO	2				
16				-10.52							
				16.61	14	DO	5				
		Loose, wet, dark green-grey SILT and SAND deposits, trace clay seams, trace gravel, some seashell fragments. - strong organic odour at contact. - layer of wet, green-grey SILTY CLAY from 18.29m - 18.59m depth.									
18					15	DO	3				
20					16	DO	8				
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 100

LOGGED: RB

CHECKED:

Golder Associates

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Ladysmith Harbour

RECORD OF BOREHOLE: BH09-05

SHEET 2 OF 2

DATUM: Geodetic

DRILLING DATE: November 10, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
20	B-80, Truck Mounted Auger Drill (to 6.1m depth) / Mud Rotary (below 6.1m depth)	Loose, wet, dark green-grey SILT and SAND deposits, trace clay seams, trace gravel, some seashell fragments. - strong organic odour at contact.			16	DO	8				
22					17	DO	5			M	
				-16.76							
		Compact to dense, wet, brown-grey, sandy, subangular GRAVEL, some silt, trace shell fragments. - sandy layers from 25.0m - 25.9m depth.		22.86	18	DO	26				
24					19	DO	33			M	
26					20	DO	13				
28				-23.16							
		Very dense, wet, grey, subangular GRAVEL, some sand, trace silt.		29.26							
30				-24.84	21	DO	>50				
		End of Borehole.		30.94							
32											
34											
36											
38											
40											

DEPTH SCALE

1 : 100

LOGGED: RB

CHECKED:

Golder Associates

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\6000\COMBINED 09-1436-5008.GPJ Output Form:BC_BOREHOLE (AUTO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdrozdiak 03/22/11

PROJECT No.: 09-1436-5008 (6000)

LOCATION: Ladysmith Harbour

RECORD OF BOREHOLE: BH09-06

SHEET 1 OF 2

DATUM: Geodetic

DRILLING DATE: November 10, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W WI, NP - Non-Plastic) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Ground Surface		16.63							
0	B-80, Truck Mounted Auger Drill (to 1.5m depth) Mud Rotary (below 1.5m depth)	Grey, fine to coarse SAND. (FILL)									
		Black TOPSOIL. (FILL)		0.18							
		Loose to compact, wet, brown SAND, some gravel, trace silt. (FILL)			1	AS					Water level observed in open hole during drilling
				15.26							
2		Stiff, moist, mottled, brown-grey SILTY CLAY, with sand, trace gravel. (Possible weathered till) - silty clay layers from 2.21m - 2.29m depth.		1.37	2	AS	7		W		
				14.34							
				2.29							
					3	AS	42				
4		Dense, wet, grey, silty SAND, trace gravel with layers of silty clay.			4	AS	5			M	
					5	AS	9				
				10.99							
6		Bedrock Encountered. Refer to Record of Drillhole log for continuation of rock description.		5.64							
8											
10											
12											
14											
16											
18											
20											

DEPTH SCALE

1 : 100

Golder Associates

LOGGED: RB

CHECKED:

PROJECT No.: 09-1436-5008

LOCATION: Ladysmith Harbour

RECORD OF DRILLHOLE: BH09-06

SHEET 2 OF 2

DATUM:

DRILLING DATE: November 10, 2009

DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

Type: JN-Joint, FLT-Fault, SH-Shear, VN-Vein, FR-Fracture; BD-Bedding, FO-Foliation, CO-Contact, OR-Orthogonal, CL-Cleavage

Shape: PL-Planar, CU-Curved, UN-Undulating, ST-Stepped, IR-Irregular

Roughness: PO-Polished, K-Slickensided, SM-Smooth, Ro-Rough, VR-Very Rough

Infilling: Br-Brocken Rock, Bt-Biotite, Cl-Clay, Ch-Chlorite, Ca-Calcium, Ep-Epidote, Fe-Iron, Go-Gouge, Gr-Gravel, He-Hematite, Py-Pyrite, Qz-Quartz, Sa-Sand, Se-Sericite, Si-Silt, Su-Sulphide

DEPTH SCALE METRES	DRILLING RECORD	DESCRIPTION	SYMBOLIC LOG	ELEV. / DEPTH (m)	RUN No.	PENETRATION RATE (m/min)	COLOUR % RETURN / FLUSH	RECOVERY: TOTAL CORE % (80 60 40 20)	RECOVERY: SOLID CORE % (80 60 40 20)	R.Q.D. % (80 60 40 20)	FRACT. INDEX PER 0.3 (5 10 15 20)	DISCONTINUITY DATA: DIP w.r.t. CORE AXIS (0 30 60 90)	DISCONTINUITY DATA: TYPE AND SURFACE DESCRIPTION	ROCK STRENGTH INDEX (R5 R4 R3 R2 R1)	WEATHERING INDEX (W1 W2 W3 W4)	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Cont'd from Record of Borehole.														
6	B-80, Truck Mounted Auger Drill, Mud Rotary	Fresh, massive, light grey, fine grained, weak to medium strong (R2-R3) SANDSTONE.		5.64	1							•	JN,PL,Ro Weathered			
												•	JN,PL,Ro Clean			
8					2											
					3							•	JN,UN,Ro Clean			
												•	JN,PL,Ro Clean			
		End of Drillhole.		9.12												
10																
12																
14																
16																
18																
20																
22																
24																

DEPTH SCALE

1 : 100

LOGGED: RB

CHECKED:

APPENDIX B

Monitoring Well, Borehole and Test Pit Logs
Environmental Investigation

PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427179 E: 440443.2

RECORD OF MONITORING WELL: MW09-01

DRILLING DATE: November 10, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		18.55									
	PB 320 Mini Tracked Sonic Sonic	Moist, dark brown, silty, gravelly SAND, organics (roots). (FILL)		0.00 18.25	1	CC				⊕			Concrete
		Dry to moist, brown SAND, silty, gravelly, contains rootlets. - at 0.45m dark brown - at 0.81m moist		0.30 17.34	2	CC		1	100	⊕			Bentonite Seal
2		Grey, slightly weathered, SANDSTONE. - at 1.67m fracture (~45°) - at 2.28m fracture (~30°) orange-rust staining in fracture planes. No water return below 2.28m.		1.21 14.14				2	100				Sand
3								3	100				Slotted PVC Pipe
4		End of Monitoring Well.		4.41									

OVM ppm scale: 10 20 30 40 / 100 200 300 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m scale: 20 40 60 80
WATER CONTENT PERCENT: Wp — W — Wl; 10 20 30 40

DEPTH SCALE
1 : 50

LOGGED: A.K.
CHECKED: D.F.

Golder Associates

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\4000\09-1436-5008 (4000).GPJ Output Form:BOREHOLE (ENVIRO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdrozdiak 19/7/10

PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427182 E: 440410.3

RECORD OF MONITORING WELL: MW09-02

DRILLING DATE: November 10, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		18.87									
	PB 320 Mini Tracked Sonic / Sonic	Moist, grey, angular GRAVEL and SAND(roadbase). (FILL)		18.72									
				0.15	1	CC							Concrete
		Moist, dark brown, SAND and GRAVEL, subrounded, trace to some silt.		18.47									Bentonite Seal
				0.40									
		Moist, grey, coarse grained SAND, trace silt.		18.11	2	CC							
1				0.76				1					Sand
		Moist, brown and grey banded, sandy SILT. Sand is fine grained. - at 0.91 and 1.11m - 5cm thick layers of blue-grey and rusty-orange silt - at 1.52m trace to some subrounded gravel, becoming wet			3&4	CC							Slotted PVC Pipe
2				16.89									
		End of Monitoring Well.		1.98									
3													
4													
5													
6													
7													
8													
9													
10													

OVM ppm: 10 20 30 40 / 100 200 300 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
WATER CONTENT PERCENT: Wp W Wl; 10 20 30 40

DEPTH SCALE
1 : 50

LOGGED: A.K.
CHECKED: D.F.

Golder Associates

PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427220 E: 440377.7

RECORD OF MONITORING WELL: MW09-03

DRILLING DATE: November 10, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		18.74									
		Moist to wet, dark brown SILT and TOPSOIL, with organics. (FILL)		18.59 / 0.15									Cement
		Moist, brown-grey, medium grained SAND, some silt, and subrounded gravel. - below 0.60m rock (boulder)		17.83	1	CC		1	100				Sand
1				0.91				2	100				
	PB 320 Mini Tracked Sonic / Sonic	BEDROCK.			2	CC		3	100				Bentonite Seal
								4	100				Sand
3					3	CC		5	100				Slotted PVC Pipe
4				14.33									
		End of Monitoring Well.		4.41									
5													
6													
7													
8													
9													
10													

OVM ppm: 10 20 30 40 / 100 200 300 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
WATER CONTENT PERCENT: Wp — W — Wl; 10 20 30 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427330 E: 440206.4

SAMPLER HAMMER, 64kg; DROP, 762mm

RECORD OF MONITORING WELL: MW09-04

DRILLING DATE: November 11, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0	PB 320 Mini Tracked Sonic Sonic	Ground Surface		22.62										
		Dense, wet, dark brown, coarse, subrounded, SAND and GRAVEL, trace silt, with organics. (FILL)		0.00 22.40	1	CC				⊕				Cement
				0.22										
		Very dense, dry to moist, brown SAND , some gravel, trace to some silt, with rootlets.		22.02 0.60	2	CC				⊕				Sand
1		No recovery. Possible cobble obstructing core barrel. Inferred SILT.						1	22					
2				19.88										Bentonite Seal
		Loose to compact, moist, light brown-tan, fine grained, silty SAND to SAND, some silt. - at 3.15m rounded cobble ~0.13m		2.74 19.40	3	CC				⊕				
3				3.22	4&5	CC					⊕			Sand
4		Dense to very dense, wet, grey-brown, medium grained SAND. - below 3.65m wet, grey, medium to coarse						2	100					
					6	CC				⊕				Slotted PVC Pipe
5				17.14										
		End of Monitoring Well.		5.48										
6														
7														
8														
9														
10														

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427471 E: 440102.6

SAMPLER HAMMER, 64kg; DROP, 762mm

RECORD OF MONITORING WELL: MW09-05

DRILLING DATE: November 11, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
		Ground Surface		18.40									
0	PB 320 Mini Tracked Sonic Sonic	Compact, wet, dark brown, SILT and SAND, trace to some angular gravel. Contains organics (roots).		18.25 / 0.15	1	CC				⊕			Cement
		Loose to compact, moist, light brown, sandy SILT, some coarse rounded gravel, trace wood debris. - solvent-like odour			2	CC				⊕			Sand
1				16.90	3	CC		1	94	⊕			
		Very dense, dry, light brown to light grey, silty SAND and GRAVEL. (Till-like) - cobbles below 1.42m - below 2.13m trace to some coarse sand		1.50									Bentonite Seal
2					4	CC				⊕		118 / 107	
				15.66									
3		Moist, grey-brown, silty SAND, some gravel.		2.74 / 15.00									
		Moist, brown, sandy SILT to silty SAND.		3.40	5	CC				⊕			
				14.59									
4		Moist, brown SAND, some angular gravel.		3.81				2	100				Sand
					6	CC				⊕			
5				13.49									
		Moist, light brown, angular, silty SAND and GRAVEL, contains cobbles. (Till-like) - below 5.18m moist, dark brown		4.91 / 12.61									Bentonite Seal
6		Moist, grey SILT, some to trace angular gravel, trace coarse sand.		5.79									
				12.16	7	CC				⊕			
		Moist, grey GRAVEL, some coarse sand, contains cobbles.		6.24				3	87				Sand
7				11.39									
		Moist, dark grey, fine grained, silty SAND, trace angular gravel. (Till-like) - cobble at 7.4 - 7.6m		7.01	8	CC		4	100	⊕			Slotted PVC Pipe
8				10.28	9	CC		5	100	⊕			
		BEDROCK.		8.12									Bentonite Seal
				9.56									
9		End of Monitoring Well.		8.84									
10													

DEPTH SCALE
1 : 50

LOGGED: A.K.
CHECKED: D.F.

Golder Associates

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427054 E: 440588.4

SAMPLER HAMMER, 64kg; DROP, 762mm

RECORD OF MONITORING WELL: MW09-06

DRILLING DATE: November 12, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		17.75									
		Roadbase (FILL).		0.07									Cement
		Dense, moist, brown, SAND and GRAVEL.		17.27	1	CC							Sand
		Dense, moist, dark brown, sandy SILT, trace to some subrounded gravel, grey banding below 0.76m.		0.48 16.79	2	CC							
1				0.96									Bentonite Seal
								1	100				
2		Compact, moist, light brown, silty, fine SAND, trace to some gravel. - below 1.82m grey and rusty orange banding			3	CC							Sand
3	PB 320 Mini Tracked Sonic Sonic			14.71 3.04									
		Dense, moist, grey and brown, medium SAND.		14.10	4	CC							Bentonite Seal
4		Dense to very dense, moist to wet, grey, silty SAND and GRAVEL. (Till-like) - wet below 4.57m		3.65	5&6	CC		2	100				Sand Slotted PVC Pipe
5				12.47									
		Very dense, moist, grey SAND and GRAVEL. - angular cobbles encountered below 5.8m.		5.28 11.81	7	CC							Bentonite Seal
6		End of Monitoring Well.		5.94									
7													
8													
9													
10													

OVM ppm: 10, 20, 30, 40 / 100, 200, 300, 400

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20, 40, 60, 80

WATER CONTENT PERCENT: Wp — W — Wl; 10, 20, 30, 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427207 E: 440471.1

SAMPLER HAMMER, 64kg; DROP, 762mm

RECORD OF MONITORING WELL: MW09-07

DRILLING DATE: November 12, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT (Wp, W, Wl)	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0	PB 320 Mini Tracked Sonic Sonic	Ground Surface		4.52									
		Roadbase (FILL).		4.37									
		Wood debris. (FILL).											
		Compact to dense, dry to moist, grey-brown SAND and GRAVEL, trace silt. (FILL)		3.81	1	CC				⊕			Cement
1		Wood debris. (FILL)		0.71 / 3.38									Sand
		Compact to dense, moist to wet, grey-brown SAND and GRAVEL, subrounded, trace silt.		1.14	2	CC		1	94	⊕			Bentonite Seal
2		Compact to dense, moist, dark brown, sandy SILT, trace to some rounded gravel. - below 2.03m becoming wet		2.85 / 1.67	3	CC				⊕			
		Compact to very dense, moist, brown-grey, medium SILT and SAND, trace rounded gravel. - faint hydrocarbon-like odour		1.78 / 2.74	4	CC		2	100	□			Sand
3					5	CC				⊕			Slotted PVC Pipe
		Very dense, dry, grey, SAND and GRAVEL, angular, with broken rock and cobble. (Possible Till)		0.16 / 4.36				3	100				Bentonite Seal
4				-0.50									
5		End of Monitoring Well.		5.02									
6													
7													
8													
9													
10													

OVM ppm: 10, 20, 30, 40 / 100, 200, 300, 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20, 40, 60, 80
WATER CONTENT PERCENT: Wp, W, Wl; 10, 20, 30, 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\4000\09-1436-5008 (4000).GPJ Output Form:BOREHOLE (ENVIRO) Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdrozdiak 19/7/10

PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427236 E: 440444.4

RECORD OF MONITORING WELL: MW09-08

DRILLING DATE: November 13, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		4.06									
		Roadbase (FILL).		3.93									
		Dry to moist, dark brown SAND and GRAVEL, trace silt, contains rootlets. [FILL]		0.12	1	CC				⊕			Cement
				3.61									Sand
		Dry to moist, light brown, silty SAND, some gravel to gravelly.		3.46	2	CC				⊕			
		Light grey GRAVEL.		0.60									
1				3.00									
		Dry, light brown, silty SAND and GRAVEL (possible pulverized rock). [FILL] - at 2.28 to 2.60m dry, light brown, silty sand		1.06				1	39				Bentonite Seal
2	PB 320 Mini Tracked Sonic Sonic			1.32									Sand
				2.74									
3					3&4	CC				⊕			
		Moist to wet, black, silty SAND, some subrounded, coarse gravel, with wood debris (chunks, fibrous wood material). - at 2.74 to 3.96m very odourous, black, viscous product and wood debris, some silt, free product - at 3.04m wet, sheen			5	CC				□			Slotted PVC Pipe
4					4			2	100				
					6	CC				□			
5				-1.27									
		Wet, grey and brown MUDSTONE.		5.33									
				-1.73									Bentonite Seal
6		End of Monitoring Well.		5.79									
7													
8													
9													
10													

OVM ppm: 10 20 30 40 / 100 200 300 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
WATER CONTENT PERCENT: Wp W Wl; 10 20 30 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427257 E: 440307

RECORD OF MONITORING WELL: MW09-09

DRILLING DATE: November 13, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		19.33									
	PB 320 Mini Tracked Sonic Sonic	Roadbase. (FILL)		19.18									Concrete
		Moist, brown-grey, angular, sandy GRAVEL, with wood debris. (FILL)		19.03	1	CC				⊕			Sand
				0.30									Bentonite Seal
1		Moist to wet, brown and grey, medium SAND, trace to some silt. - below 1.52m orange-brown banding, becoming wet						1	100				Sand
					2	CC				⊕			Slotted PVC Pipe
2				17.35									
		Moist, grey, silty SAND and GRAVEL. (Till-like)		1.98	3	CC				⊕			
				16.90									Bentonite Seal
		ROCK (Bedrock).		2.43									
				16.59									
		End of Monitoring Well.		2.74									
3													
4													
5													
6													
7													
8													
9													
10													

OVM ppm scale: 10 20 30 40 / 100 200 300 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m scale: 20 40 60 80
WATER CONTENT PERCENT: Wp — W — Wl; 10 20 30 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427278 E: 440283.8

SAMPLER HAMMER, 64kg; DROP, 762mm

RECORD OF MONITORING WELL: MW09-10

DRILLING DATE: November 13, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		19.62										
		Roadbase. (FILL)		19.47										Concrete
		Loose, brown, sandy GRAVEL, containis roots. (FILL)		0.15										Sand
				18.86	1	CC				⊕				Bentonite Seal
1		Loose, grey, with brown banding, sandy SILT, trace fine gravel.		18.66	2	CC				⊕				
	PB 320 Mini Tracked Sonic			0.96										Sand
		Compact to dense, moist, grey, silty SAND, trace to some subrounded gravel. - at 1.52m wet			3	CC		1	100	⊕				
2														Slotted PVC Pipe
				16.78										
		Dry to moist, grey, silty SAND and GRAVEL, possible bedrock.		2.84	4	CC				⊕				Bentonite Seal
3				16.27										
		End of Monitoring Well.		3.35										
4														
5														
6														
7														
8														
9														
10														

OVM ppm: 10, 20, 30, 40 / 100, 200, 300, 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20, 40, 60, 80
WATER CONTENT PERCENT: Wp — W — Wl; 10, 20, 30, 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427271 E: 440294

RECORD OF MONITORING WELL: MW09-11

DRILLING DATE: November 13, 2009

DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		19.48									
	PB 320 Mini Tracked Sonic Sonic	Roadbase. (FILL)		19.33									Concrete
		Moist, dark brown, sandy GRAVEL, angular. Constains wood debris. (FILL)		0.15 19.08	1	CC				⊕			Sand
				0.40									Bentonite Seal
1		Moist, grey, with orange-rust banding, fine grained, sandy SILT. - below 1.52m seams of wet, grey, medium sand ~2.5cm wide			2	CC		1	100	⊕			Sand
					3	CC				⊕			Slotted PVC Pipe
				17.66									
2		Possible BEDROCK.		1.82 17.35									
		End of Monitoring Well.		2.13									
3													
4													
5													
6													
7													
8													
9													
10													

OVM ppm: 10 20 30 40 / 100 200 300 400

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80

WATER CONTENT PERCENT: Wp W Wl; 10 20 30 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427243 E: 440433.2

RECORD OF BOREHOLE: BH09-12

DRILLING DATE: November 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		3.98									
		Roadbase. (FILL)		3.83									
		Dry to moist, grey SAND and GRAVEL, trace silt. [FILL]		0.15	1	CC				⊕			
				3.48									
	PB 320 Mini Tracked Sonic Sonic			0.50									
1		Dry to moist, light brown, angular, silty SAND and GRAVEL, contains cobbles. (FILL)			2	CC		1	93	⊕			Bentonite Seal
2				1.55				2	100				
		Moist to wet, black, silty SAND, trace gravel. Contains wood debris, black product, sheen (viscous).		2.43									
				1.24	3	CC				□			
				2.74									
3		End of Borehole.											
4													
5													
6													
7													
8													
9													
10													

OVM ppm: 10 20 30 40 / 100 200 300 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
WATER CONTENT PERCENT: Wp W Wl / 10 20 30 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427249 E: 440420.3

RECORD OF BOREHOLE: BH09-13

DRILLING DATE: November 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		3.99										
	PB 320 Mini Tracked Sonic Sonic	Dry to moist, brown-grey SAND and GRAVEL, trace silt. (FILL)		0.00										
		Dry to moist, light brown to orange SAND, trace to some silt, some gravel. (FILL)		3.46 0.53										
1				3.18 0.81				1	100					
2		Dry to moist, light grey, silty SAND and GRAVEL, angular, coarse. (Contains possible pulverized cobbles). (FILL)												Bentonite Seal
3				0.95										
		Wet, black, sandy SILT, with wood debris, trace gravel, black product. - sheen - strong hydrocarbon-like odour		3.04 0.49	1	CC		2						
		Moist, dark grey and black SILT, some fine sand, trace wood debris, black viscous product. - sheen - hydrocarbon-like odour		3.50 0.03	2	CC								
4				3.96	3	CC								
		Possible BEDROCK.						3						
				-0.88	4	CC								
5		End of Borehole.		4.87										
6														
7														
8														
9														
10														

OVM ppm: 10, 20, 30, 40
OVM ppm: 100, 200, 300, 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20, 40, 60, 80
WATER CONTENT PERCENT: Wp, W, Wl; 10, 20, 30, 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427227 E: 440453.2

RECORD OF BOREHOLE: BH09-14

DRILLING DATE: November 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	SAMPLES: CORE No.	SAMPLES: CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		4.16										
		Roadbase (FILL).		4.01										
		Dry to moist, light orange-brown SAND, some angular gravel, trace silt. Contains roots. (FILL)		0.15										
				3.71	1	CC				⊕				
				0.45										
1		Moist, brown, medium to coarse SAND and subrounded GRAVEL (FILL)			2	CC		1	100					
				2.18										
2		Moist, light brown, sandy GRAVEL, trace silt. (FILL)		1.98										
				1.42										
		Moist, brown, angular, silty SAND and GRAVEL. (FILL)		2.74	3	CC				⊕				
3				0.81										
		Moist, blue-grey GRAVEL, some silt, some coarse sand, contains cobbles. - sheen - hydrocarbon-like odour		3.35				2	100					
					4	CC				□				
4				-0.20										
				4.36	5	CC				⊕				
		Possible BEDROCK.												
5				-1.32										
		End of Borehole.		5.48										
6														
7														
8														
9														
10														

PB 320 Mini Tracked Sonic
Sonic

OVM ppm: 10, 20, 30, 40 / 100, 200, 300, 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20, 40, 60, 80
WATER CONTENT PERCENT: Wp — W — Wl; 10, 20, 30, 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427255 E: 440406.7

RECORD OF BOREHOLE: BH09-15

DRILLING DATE: November 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m / WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		4.20									
		GRAVEL. (FILL)		4.05									
		Dry to moist, light brown to orange-brown SAND, some gravel to gravelly, some silt. (FILL) - at 0.45m wood debris		0.15	1	CC				⊕ 10 20 30 40	20 40 60 80		
				3.75 / 0.45									
1					2	CC				⊕ 100 200 300 400	Wp W Wl 10 20 30 40		
		Dry to moist, light brown, silty SAND and GRAVEL. - below 1.21m gravel and rock flour to 2.74m						1	100				Bentonite Seal
2	PB 320 Mini Tracked Sonic												
	Sonic												
3				1.16									
		Wet, grey to black, sandy SILT, with wood debris, trace gravel, sheen, viscous product. - strong hydrocarbon-like odour		3.04	3&4	CC		2		□			
4				0.19									
		Possible BEDROCK.		4.01	5	CC							
				-0.67									
5		End of Borehole.		4.87									
6													
7													
8													
9													
10													

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 (4000)

LOCATION: Ladysmith Harbour, B.C.
N: 5427479 E: 440179.9

RECORD OF BOREHOLE: MW09-16

DRILLING DATE: November 14, 2009
DRILLING CONTRACTOR: Mud Bay Drilling Co. Ltd.

SHEET 1 OF 1
DATUM: Local

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	CORE No.	CORE RECOVERY %	OVM ppm	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m	WATER CONTENT PERCENT	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE OR THERMISTOR INSTALLATION
0		Ground Surface		3.54										
	PB 320 Mini Tracked Sonic Sonic	Moist, brown SAND and GRAVEL, trace silt. [FILL]		0.00										Concrete
				3.24										
		Wet, brown, sandy GRAVEL, trace silt. (FILL)		0.30 / 3.04	1	CC				⊕				
				0.50										Sand
1		Moist, light brown, angular SAND and GRAVEL, some silt. [Possible FILL] - below 1.82m black and dark brown, some silt			2	CC		1	100					Bentonite Seal
2				1.26										
				2.28	3	CC								
														Sand
3					4&5	CC								
		Moist, light brown, medium SAND, trace rounded gravel, trace silt. - at 2.40 to 2.70m wood debris - at 2.74m cobles, ~20cm (broken) - below 3.35m wet												
4								2	90					Slotted PVC Pipe
5				-2.04										
		Moist, brown SILT, trace to some sand, some gravel. - at 5.63m possible till		5.58 / -2.40	6	CC				⊕				Bentonite Seal
6		End of Borehole.		5.94										
7														
8														
9														
10														

OVM ppm: 10 20 30 40 | 100 200 300 400
DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
WATER CONTENT PERCENT: Wp — W — Wl; 10 20 30 40

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: A.K.
CHECKED: D.F.

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PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.
N: ~5426933.72 E: ~440693.92
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

RECORD OF TEST PIT: TP09-01

EXCAVATION DATE: December 15, 2009
EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1
DATUM:
TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	Medium dense, dry, light brown, silty SAND, trace to some gravel. (FILL) - contains cobbles and boulders below 0.4m depth. - metal debris (pipe, metal plates and rust staining) at 0.6m depth.		0.00	1	GS		⊕							
1		Dense, moist, dark brown SAND, some silt, with rootlets, trace angular gravel. - Refusal on Bedrock at 1.3m depth.		1.10	2	GS		⊕							
		End of Test Pit.		1.30											
2															
3															

PHOTOGRAPH OF TP09-01

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: AK
CHECKED:

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\4000\TEST PIT LOGS (4000)\09-1436-5008 TP (4000).GPJ Output Form:TESTPIT WITH PHOTO TemplateBC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdroz/ak 19/7/10

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-02

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	Compact, dry, light brown, silty SAND, some angular gravel, with rootlets. (FILL) - concrete debris, ~5cm thick broken slab pieces at 0.3m depth. - cobbles below 0.5m depth.		0.00	1	GS		PID ⊕							
1		Loose to compact, moist, blue-grey, silty fine SAND, trace gravel. - moderate to strong hydrocarbon-like odour. - wet, groundwater seep into test pit, sheen on water at 1.6m depth.		1.30	2/3	GS		PID ⊕ 580							
2		Loose, wet, blue-grey SILT, some fine sand. - strong hydrocarbon-like odour, slight sheen. - water seep at 1.6m depth, test pit sloughing in rapidly. - End of test pit at 2.5m due to stability concerns.		2.00	4	GS		PID ⊕ 810							
		End of Test Pit.		2.50											
3															

PHOTOGRAPH OF TP09-02

DEPTH SCALE

1 : 25

Golder Associates

LOGGED: AK

CHECKED:

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\4000\TEST PIT LOGS (4000)\09-1436-5008 TP (4000).GPJ Output Form:TESTPIT WITH PHOTO TemplateBC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdrozdiak 19/7/10

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-03

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	Compact, dry, light brown SAND, some gravel, trace to some silt, with rootlets. (FILL) - metal debris (pipe) at 0.3m depth.		0.00	1	GS		⊕							
1		Soft to firm, moist, blue-grey SILT, some coarse sand. - strong hydrocarbon-like odour, - becoming wet at 1.5m depth. - trace to some angular gravel below 1.6m depth. - refusal (Bedrock) at 1.9m depth.		1.30	2	GS			⊕760						
					3	GS			⊕550						
2		End of Test Pit.		1.90											
3															

PHOTOGRAPH OF TP09-03

DEPTH SCALE

1 : 25

Golder Associates

LOGGED: AK

CHECKED:

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.
N: ~5427036.17 E: ~440573.64
Note: Northing and Easting Coordinates have been determined by GPS in the field and are approximate only.

RECORD OF TEST PIT: TP09-04

EXCAVATION DATE: December 15, 2009
EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1
DATUM:

TEST PIT DIMENSIONS:
1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	Compact, dry, light brown, silty SAND, some angular gravel, with rootlets. (FILL) - cobbles at 0.3m depth.		0.00	1	GS		⊕							
1		Firm, moist, brown and orange-tan mottled SILT, trace fine sand, with wood debris (chips) and coal fragments. (FILL) - Refusal on Bedrock at 2.0m depth.		0.61	2	GS		⊕							
		Firm, moist, dark brown SILT, trace to some sand, trace to some gravel. - Refusal on Bedrock at 2.0m depth.		1.20	3	GS		⊕							
2		End of Test Pit.		2.00											
3															

PID ppm ⊕
50 100 150 200
WATER CONTENT PERCENT
Wp W Wl
10 20 30 40

PHOTOGRAPH OF TP09-04 NOT AVAILABLE

DEPTH SCALE
1 : 25

Golder Associates

LOGGED: AK
CHECKED:

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\4000\TEST PIT LOGS (4000)\09-1436-5008 TP (4000).GPJ Output Form:TESTPIT WITH PHOTO Template:BC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdroz/dak 19/7/10

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-05

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	TOPSOIL (organics, rootlets).		0.00											
		Compact, moist, dark brown, silty SAND, trace to some gravel, with rootlets. (FILL)		0.10	1	GS		⊕							
1		Firm, moist, blue-grey SILT. - moderate hydrocarbon-like odour. - blue-grey colour, no odour at 1.0m depth.		0.61	2	GS		⊕260							
		Soft moist, light brown to grey, fine SAND, trace to some silt. - becoming wet at 1.6m depth. - Refusal at 2.0m depth (maximum excavator reach and sloughing in).		1.20	3	GS		⊕							
2		End of Test Pit.		2.00											
3															

PHOTOGRAPH OF TP09-05

DEPTH SCALE

1 : 25

Golder Associates

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CHECKED:

File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\4000\TEST PIT LOGS (4000)\09-1436-5008 TP (4000).GPJ Output Form:TESTPIT WITH PHOTO TemplateBC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdroxdak 19/7/10

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-06

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	Roadbase. (FILL)		0.00											
		Compact, moist, dark brown SAND and GRAVEL, trace to some silt, with rootlets.		0.30	1	GS		⊕							
1		Soft, moist, blue-grey SILT, trace fine sand. - moderate hydrocarbon-like odour.		0.70	2/3	GS			⊕410						
		Firm, moist, brown with blue-grey banding SILT, trace fine sand. - becoming stiff below 1.6m depth.		1.20	4	GS									
2		End of Test Pit.		2.00											
3															

PHOTOGRAPH OF TP09-06

DEPTH SCALE

1 : 25

Golder Associates

LOGGED: AK

CHECKED:

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-07

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	TOPSOIL (organics, grass).		0.00											
		Compact, dry, brown, silty SAND, some angular gravel. (FILL) - angular cobbles below 0.6m depth. - refusal (Bedrock) at 1.1m depth.		0.30	1	GS		⊕							
1					2	GS		⊕							
		End of Test Pit.		1.10											
2															
3															

WATER CONTENT PERCENT: 10 20 30 40

PHOTOGRAPH OF TP09-07 NOT AVAILABLE

DEPTH SCALE

1 : 25

Golder Associates

LOGGED: AK

CHECKED:

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-08

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl; 50 100 150 200; 10 20 30 40)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	TOPSOIL (organics, grass, roots).		0.00											
		Compact, dry, brown, silty SAND, some angular gravel. (FILL) - refusal (Bedrock) at 0.6m depth.		0.20	1	GS		⊕							
					2	GS		⊕							
		End of Test Pit.		0.61											
1															
2															
3															

PHOTOGRAPH OF TP09-08 NOT AVAILABLE

DEPTH SCALE

1 : 25

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LOGGED: AK

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File:N:\BUR-GRAPHICS\PROJECTS\2009\1436\09-1436-5008\DRAFTING\GINT\4000\TEST PIT LOGS (4000)\09-1436-5008 TP (4000).GPJ Output Form:TESTPIT WITH PHOTO TemplateBC REGION TEMPLATE BETA 1.GDT Library:BC REGION LIBRARY.GLB bdroztdak 19/7/10

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-09

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	TOPSOIL (organics, leaves).		0.00											
		Compact, moist, brown, silty, coarse SAND and GRAVEL, trace silt, with rootlets. (FILL) - dark brown at 0.5m depth. - cobbles below 0.6m depth.		0.30	1	GS		⊕							
1		Compact, moist, light brown, silty SAND, trace gravel. - no gravel, medium SAND below 1.4m depth. - sloughing in at 2.0m depth.		0.90	2	GS		⊕							
2					3	GS		⊕							
		End of Test Pit.		2.10											
3															

PID ppm ⊕

50 100 150 200

WATER CONTENT PERCENT

Wp W Wl

10 20 30 40

PHOTOGRAPH OF TP09-09

DEPTH SCALE

1 : 25

Golder Associates

LOGGED: AK

CHECKED:

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-10

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	Compact, moist, dark brown SAND, some gravel, some silt, with rootlets. (FILL) - cobbles below 0.6m depth. - moist to wet and rusty brown colour at 1.3m depth.		0.00	1	GS		⊕							
1		Compact, wet, coarse SAND, trace to some angular gravel. - seepage, standing water, significant sloughing at 1.7m depth. - end of test pit at 2.2m depth due to sloughing.		1.60	2	GS		⊕							
2					3	GS		⊕							
		End of Test Pit.		2.20											
3															

PHOTOGRAPH OF TP09-10

DEPTH SCALE

1 : 25

Golder Associates

LOGGED: AK

CHECKED:

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-11

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	Compact, moist, dark brown SAND, some gravel, trace silt, with rootlets. (FILL)		0.00	1	GS		⊕							
1		Soft, moist to wet, light brown SILT, some fine sand. - wet, orange-brown banding at 1.1m depth. - sloughing and saturated at 1.8m depth. - end of test pit at 1.9m depth due to sloughing.		0.61	2	GS		⊕							
2		End of Test Pit.		1.90											
3															

PHOTOGRAPH OF TP09-11

DEPTH SCALE

1 : 25

Golder Associates

LOGGED: AK

CHECKED:

PROJECT No.: 09-1436-5008 TP (4000)

LOCATION: Ladysmith Harbour, B.C.

RECORD OF TEST PIT: TP09-12

EXCAVATION DATE: December 15, 2009

EXCAVATION CONTRACTOR: Hazco Environmental

SHEET 1 OF 1

DATUM:

TEST PIT DIMENSIONS: 1.5m Length x 1m Width

DEPTH SCALE METRES	EXCAVATION METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: RECOVERY %	PID ppm / WATER CONTENT PERCENT (Wp, W, Wl; 10 20 30 40; 50 100 150 200)	GRADATION %: GRAVEL	GRADATION %: SAND	GRADATION %: FINES	PLASTICITY	FROZEN GROUND DESCRIPTION	ADDITIONAL LAB. TESTING	PIEZOMETER, STANDPIPE, THERMISTOR INSTALLATION OR SEEPAGE OBSERVATION
		Ground Surface													
0	Bobcat 335 Mini Excavator Backhoe	Compact, moist, dark brown SAND and GRAVEL, trace silt, with rootlets. (FILL)		0.00	1/2	GS		⊕							
1		Compact, moist to wet, light brown, silty SAND, trace gravel.		1.30	3	GS		⊕							
		Compact, wet, brown, coarse SAND, trace to some angular gravel. - sloughing in, seepage and standing water at 2.0m depth. - end of test pit at 2.2m depth due to sloughing.		1.60	4	GS		⊕							
2		End of Test Pit.		2.20											
3															

PHOTOGRAPH OF TP09-12 NOT AVAILABLE

DEPTH SCALE

1 : 25

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APPENDIX C

Geotechnical Laboratory Testing Results

WATER CONTENT DETERMINATION

Reference(s)
ASTM D 4959

Client:	Ministry of Agriculture and Lands	**Project No.:** 09-1436-5008 **Phase:** 6000	
Project:	Ladysmith Harbour - Site Investigation	**Lab Schedule No.:** 225	
Location:	Ladysmith, BC		

Sample Location	Sample No.	Sample Interval		Water Content (%)
		Depth (m)	Bottom (m)	
BH09-01	**10**	21.30	21.90	**25.8**
BH09-05	**15**	18.30	18.70	**35.1**
BH09-06	**2**	1.70	2.30	**25.0**

	LP	10/12/2009
	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

Reference(s)
ASTM D 4318-05

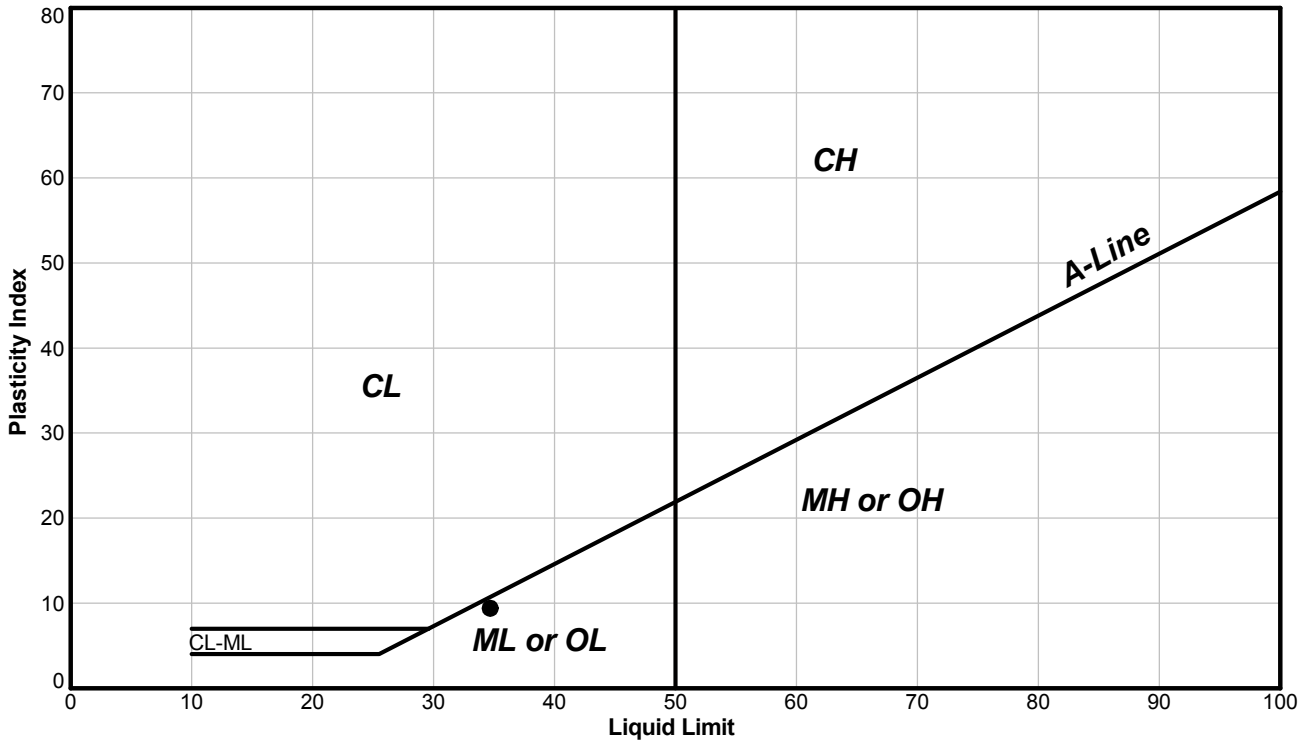
Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-01
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	10
Location:	Ladysmith, BC	**Depth Interval (m):**	21.30 to 21.90
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024849

Classification and Definition: **ML** Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.

Other Remarks: **N/A**

Test Method: A-Multi Point | **Preparation Method:Wet**

PLASTICITY CHART



Sym.	Sample Location	Sample Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	BH09-01	10	21.30	21.90	100	35	25	10	26	0.08

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

EB	10/12/2009	LP	10/12/2009
Tech	Date	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

Reference(s)
ASTM D 4318-05

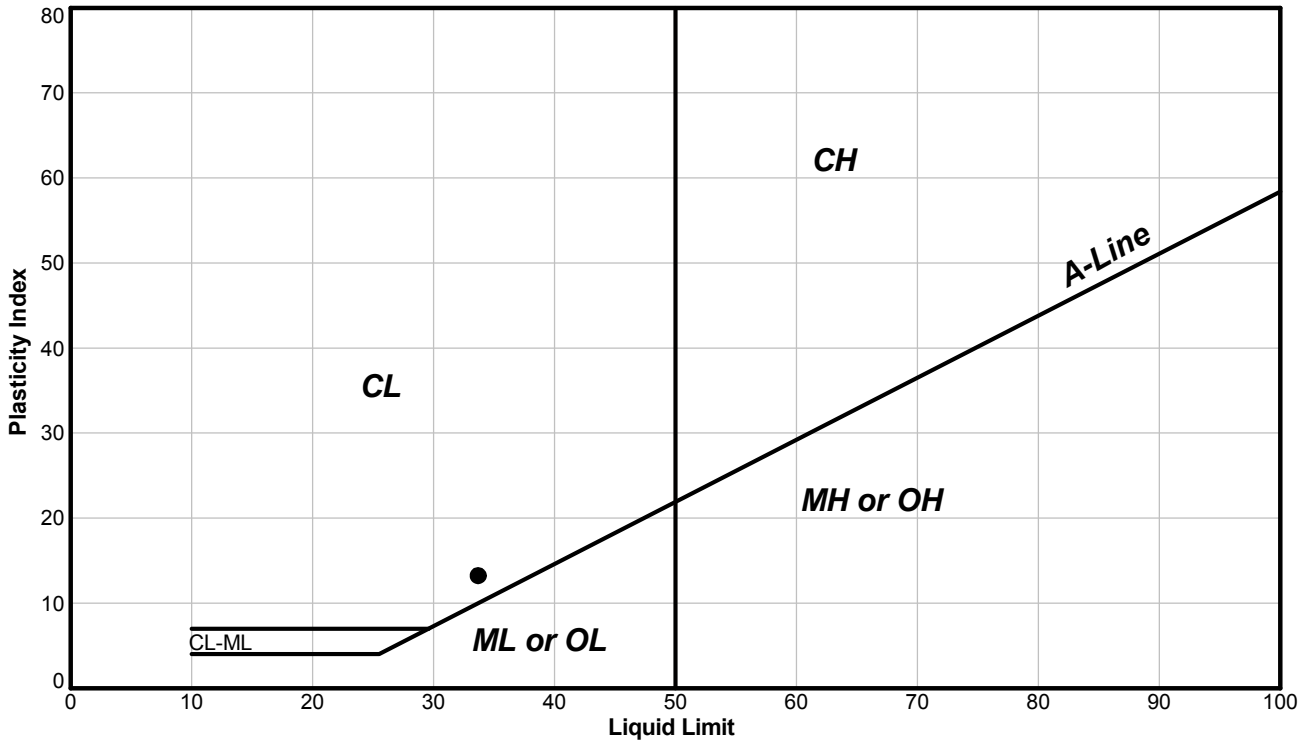
Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-05
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	15
Location:	Ladysmith, BC	**Depth Interval (m):**	18.30 to 18.70
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:**	225 **Esis No.:** BURNAS0000024906

Classification and Definition: **CL** Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.

Other Remarks: **N/A**

Test Method: A-Multi Point | **Preparation Method:Wet**

PLASTICITY CHART



Sym.	Sample Location	Sample Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	BH09-05	15	18.30	18.70	100	34	20	14	35	1.08

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

EB	10/12/2009	LP	10/12/2009
Tech	Date	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

Reference(s)
ASTM D 4318-05

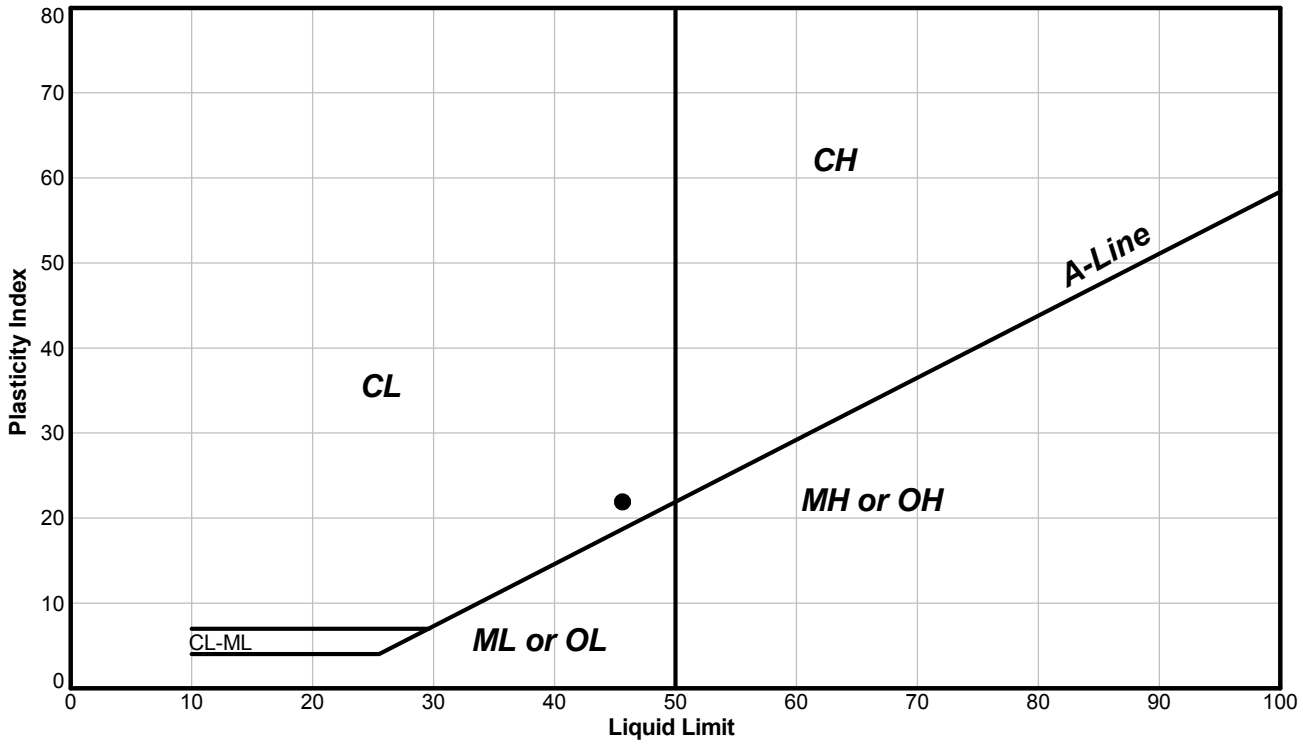
Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-06
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	2
Location:	Ladysmith, BC	**Depth Interval (m):**	1.70 to 2.30
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:**	225 **Esis No.:** BURNAS0000024914

Classification and Definition: **CL** Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays.

Other Remarks: **N/A**

Test Method: A-Multi Point | **Preparation Method:Wet**

PLASTICITY CHART



Sym.	Sample Location	Sample Number	Depth (m)	Bottom (m)	Percent Passing #40 Sieve (%)	Liquid Limit	Plastic Limit	Plasticity Index	Natural Water Content (%)	Liquidity Index
●	BH09-06	2	1.70	2.30	100	46	24	22	25	0.05

Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

EB	10/12/2009	LP	10/12/2009
Tech	Date	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

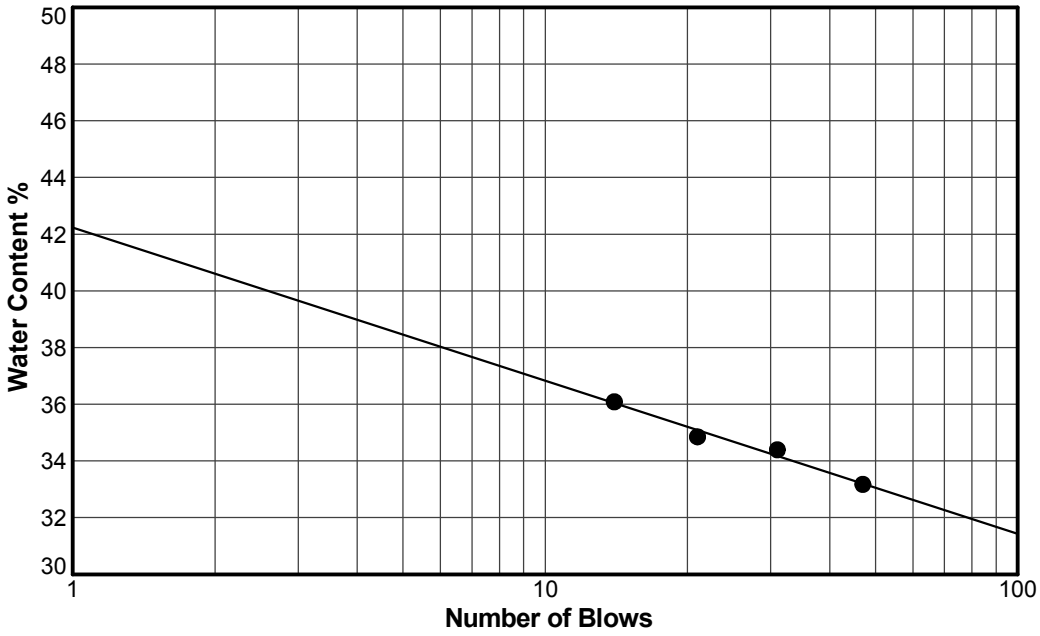
Reference(s)
ASTM D 4318-05

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-01
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	10
Location:	Ladysmith, BC	**Depth Interval (m):**	21.30 to 21.90
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:**	225 **Esis No.:** BURNAS0000024849

Other Remarks: **N/A**

Test Method: A-Multi Point | **Preparation Method: Wet**

SUMMARY	
Percent Passing #40 Sieve (%)	**100**
Liquid Limit	**35**
Plastic Limit	**25**
Plasticity Index	**10**
Natural Water Content (%)	**26**
Liquidity Index	**0.1**



Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

EB	10/12/2009	LP	10/12/2009
Tech	Date	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

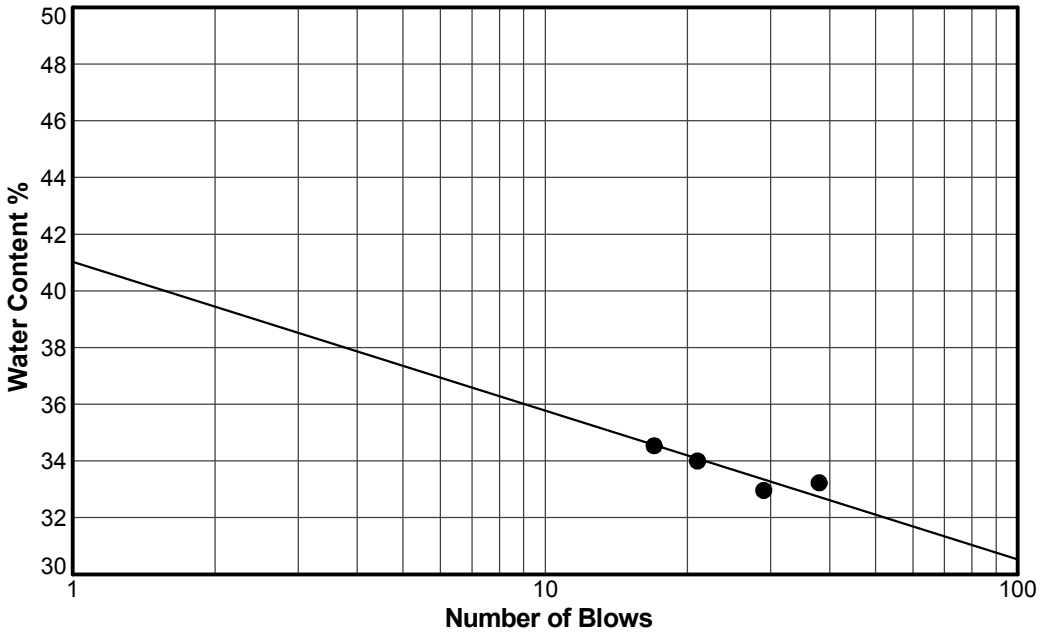
Reference(s)
ASTM D 4318-05

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-05
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	15
Location:	Ladysmith, BC	**Depth Interval (m):**	18.30 to 18.70
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:**	225 **Esis No.:** BURNAS0000024906

Other Remarks: **N/A**

Test Method: A-Multi Point	**Preparation Method: Wet**

SUMMARY	
Percent Passing #40 Sieve (%)	**100**
Liquid Limit	**34**
Plastic Limit	**20**
Plasticity Index	**14**
Natural Water Content (%)	**35**
Liquidity Index	**1.1**



Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

EB	10/12/2009	LP	10/12/2009
Tech	Date	Checked	Date

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LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS

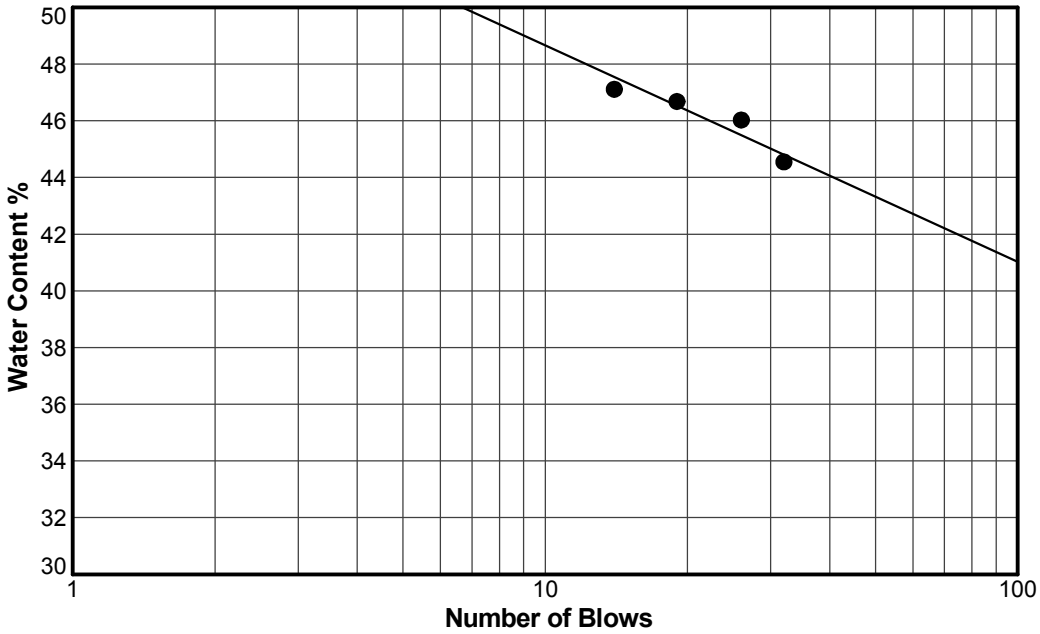
Reference(s)
ASTM D 4318-05

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-06
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	2
Location:	Ladysmith, BC	**Depth Interval (m):**	1.70 to 2.30
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:**	225 **Esis No.:** BURNAS0000024914

Other Remarks: **N/A**

Test Method: A-Multi Point | **Preparation Method: Wet**

SUMMARY	
Percent Passing #40 Sieve (%)	**100**
Liquid Limit	**46**
Plastic Limit	**24**
Plasticity Index	**22**
Natural Water Content (%)	**25**
Liquidity Index	**0.0**



Note: The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

EB	10/12/2009	LP	10/12/2009
Tech	Date	Checked	Date

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SPECIFIC GRAVITY OF SOIL SOLIDS

Reference
ASTM C 127-07
ASTM D 854-06 Method B

Project No.:	09-1436-5008/6000	**Borehole**	**BH09-2**
Client:	Ministry of Agriculture and Lands - Crown Land Restoration Branch	**Sample No.:**	5
Project:	Ladysmith Harbour - Stage 1 Preliminary Site Investigation	**Depth (m):**	5.49-5.79
Location:	Ladysmith, BC	**Lab Sch No:**	225

Specific Gravity of Fine Fraction (ASTM D 854-06)

Percentage Passing #4 sieve		100		
Test Number		1		2
Flask Number		2		8
Air Removal Method		Vacuum		Vacuum
Mass of Flask (g)		172.67		174.48
Mass of Flask + Dry Soil (g)	M_P	287.66		290.97
Mass of Dry Soil (g)		115.06		116.59
Mass of Flask + Soil + Water (g)	$M_{\rho ws,t}$	718.25		720.09
Test Temperature (g)	T_t	17.70		17.60
Mass of Flask + Water (g)	$M_{\rho w,t}$	671.40		672.87
Mass of Dish + Dry Soil (g)		488.59		469.53
Mass of Dish (g)		373.53		352.94
Mass of Oven Dry Soil (g)	M_S	115.06		116.59
Temperature Coefficient	K	1.00		1.00
Density of Solids (g/cm3)	ρ_s	1.69		1.68
Specific Gravity at Test Temperature	G_t	1.69		1.68
Specific Gravity at 20ºC	$G_{20ºC}$	1.69		1.68
AVERAGE SPECIFIC GRAVITY		**1.69**		

Specific Gravity of Coarse Fraction (ASTM C 127-07)

Percentage Retained on #4 sieve		
Mass of Sample in Water (g)	A	
Mass of Sample @ SSD (g)	B	
Mass of Oven Dryed Sample (g)	C	
Bulk G (Oven Dry)	C/(B-A)	
Bulk G (SSD)	B/(B-A)	
Apparent	C/(C-A)	
Absorbtion (%)	(B-C)/C	

Combined Specific Gravity

COMBINED SPECIFIC GRAVITY	$G_{avg\ @20ºC}$	1.69

** The test data given herein pertain to the sample provided only. This report constitutes a testing service only. Interpretation of the data can be provided upon request.*

EB	December 22, 2009	LP	December 24,2009
TESTED BY	DATE	CHECKED BY	DATE

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PARTICLE SIZE ANALYSIS OF SOILS

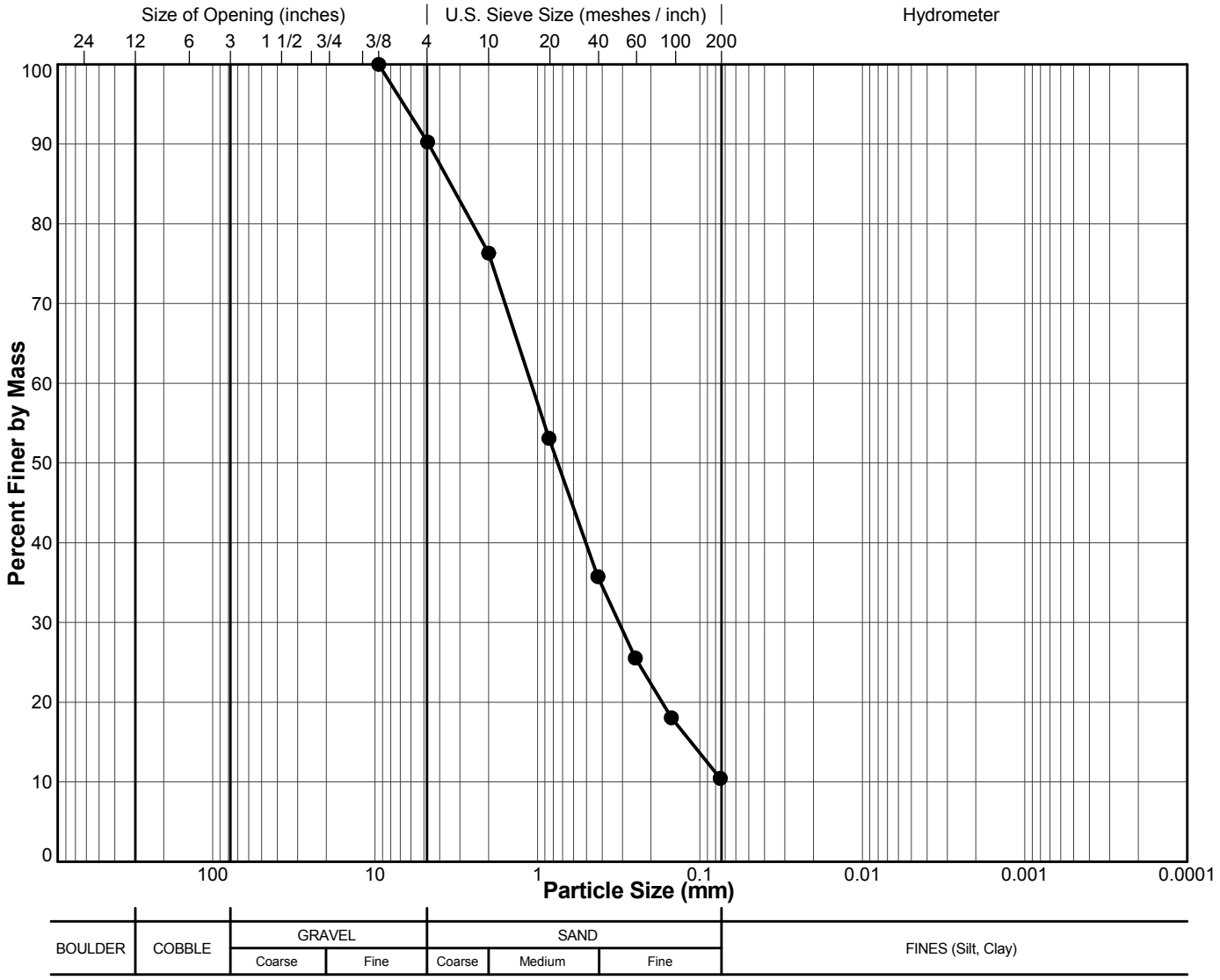
Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-01
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	4
Location:	Ladysmith, BC	**Depth Interval (m):**	4.60 to 5.20
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024843

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 9.5	**Hardness: N/A**
Method: Split, Washed	

USCS Particle Size Scale



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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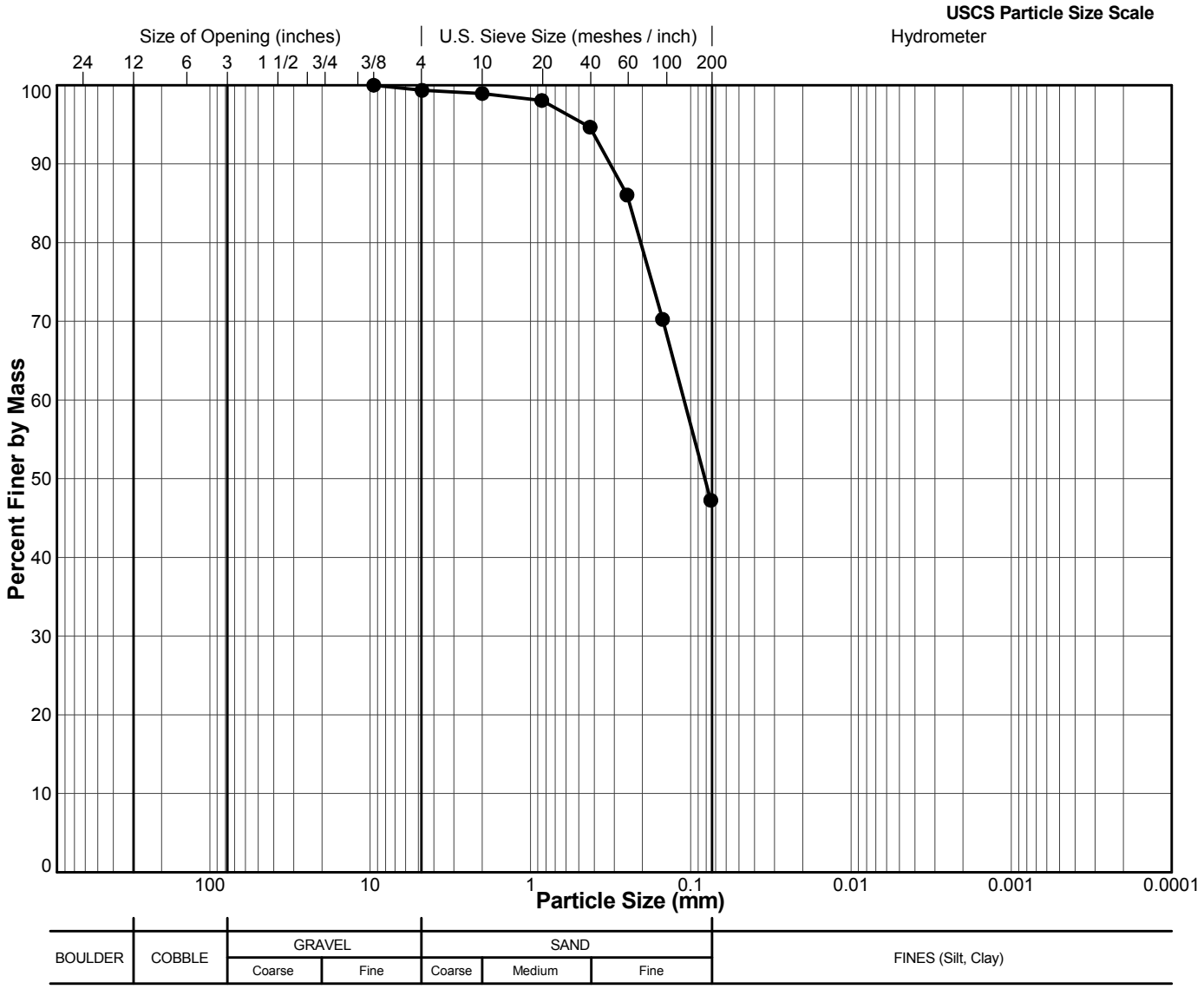
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-01
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	7
Location:	Ladysmith, BC	**Depth Interval (m):**	13.70 to 14.30
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024846

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 9.5	**Hardness: N/A**
Method: Split, Washed	



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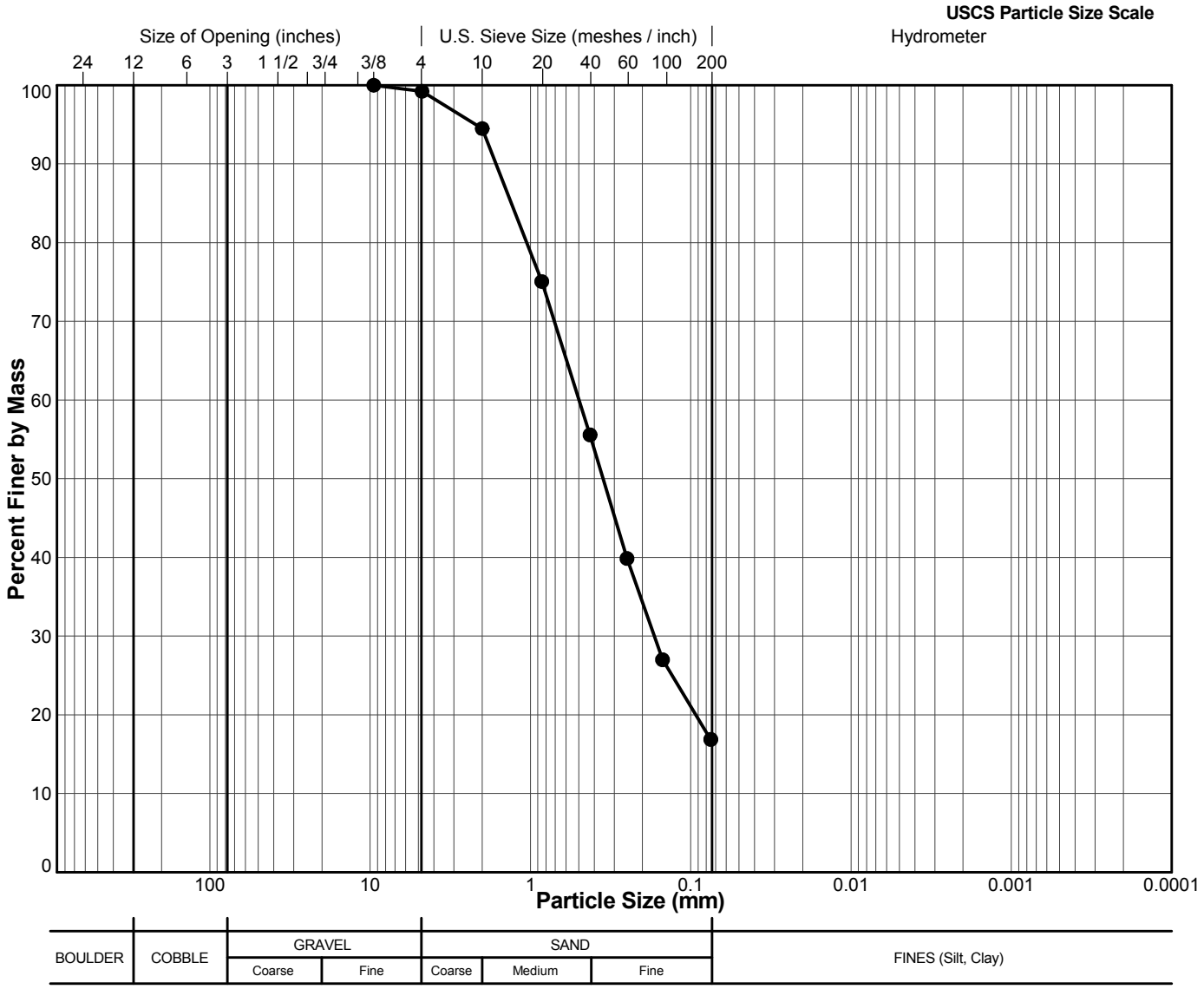
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-01
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	8
Location:	Ladysmith, BC	**Depth Interval (m):**	15.40 to 16.00
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024847

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 9.5	**Hardness: N/A**
Method: Split, Washed	



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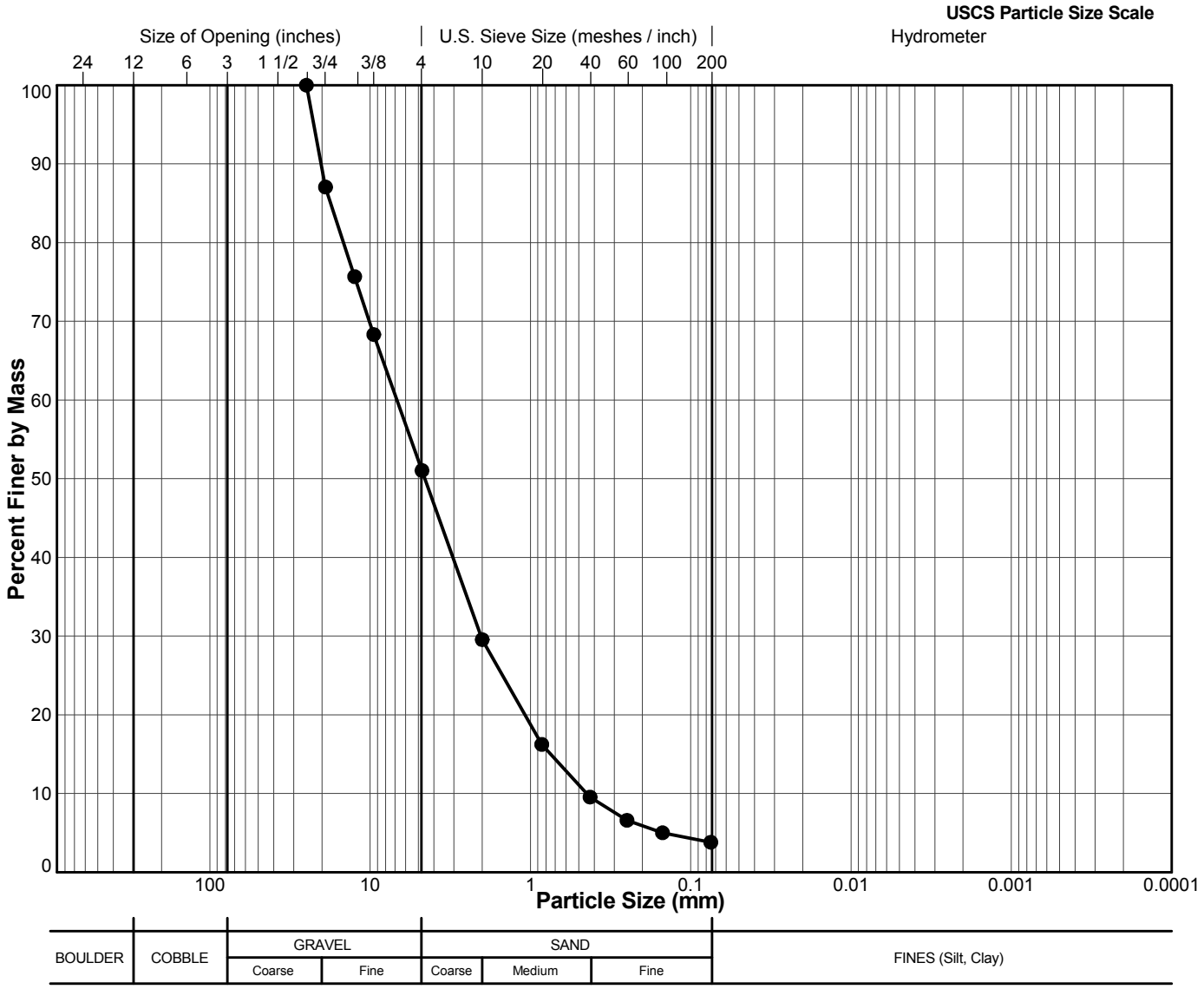
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-01
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	11
Location:	Ladysmith, BC	**Depth Interval (m):**	24.40 to 25.00
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024850

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 25	**Hardness: N/A**
Method: Combined, Washed	



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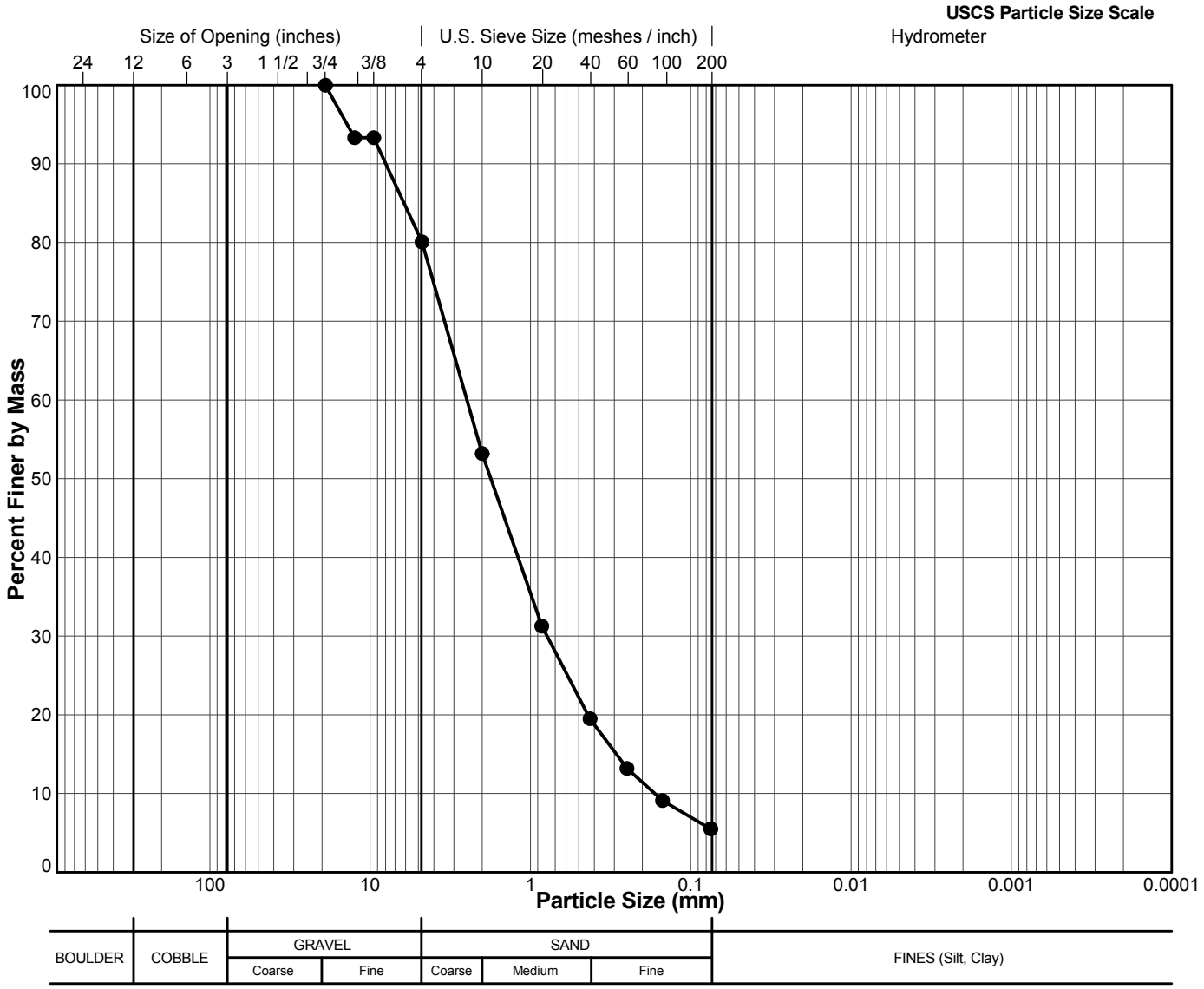
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-02
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	4
Location:	Ladysmith, BC	**Depth Interval (m):**	4.00 to 4.30
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024856

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 19	**Hardness: N/A**
Method: Split, Washed	



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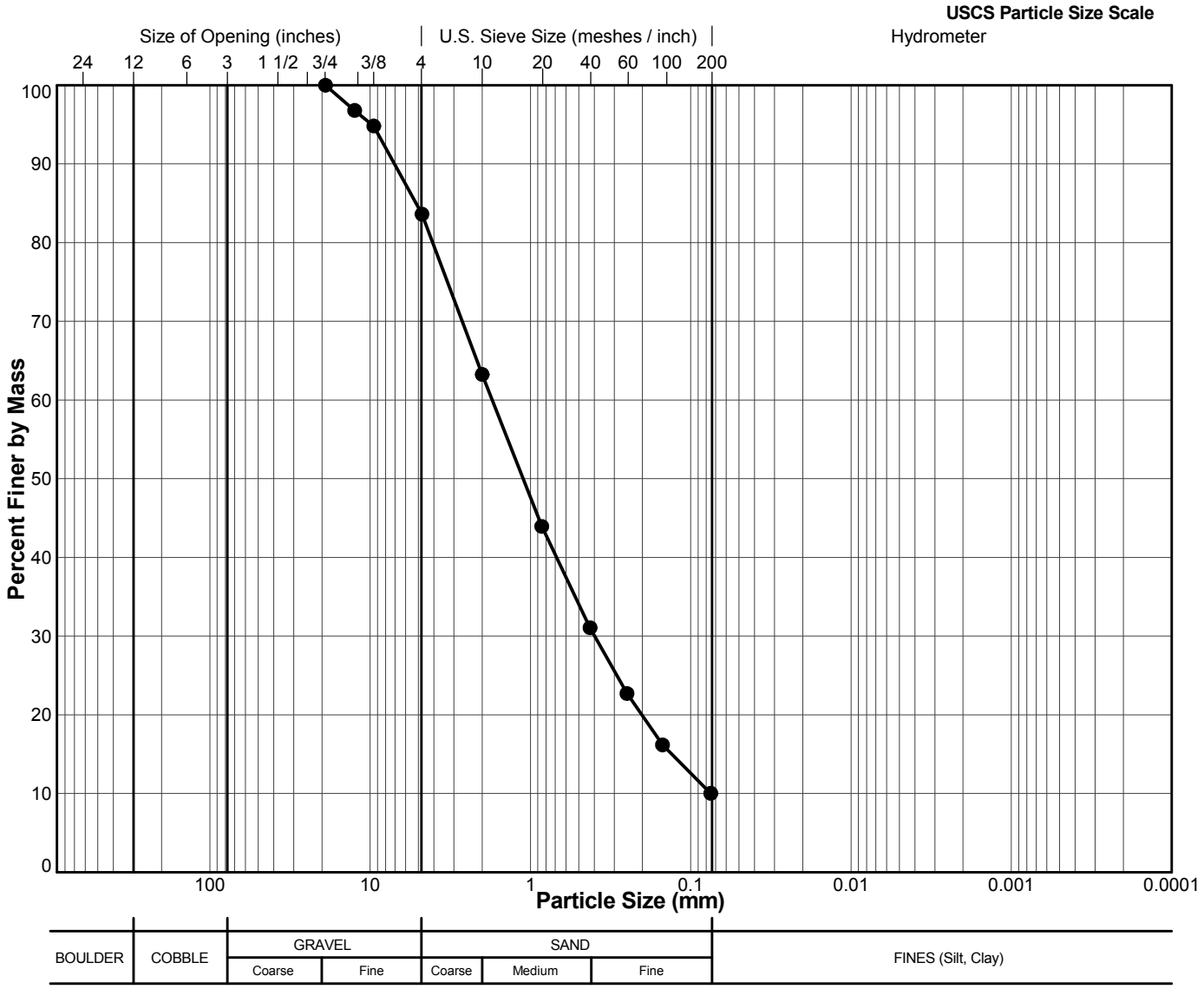
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-02
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	8
Location:	Ladysmith, BC	**Depth Interval (m):**	12.20 to 12.60
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024860

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 19	**Hardness: N/A**
Method: Split, Washed	



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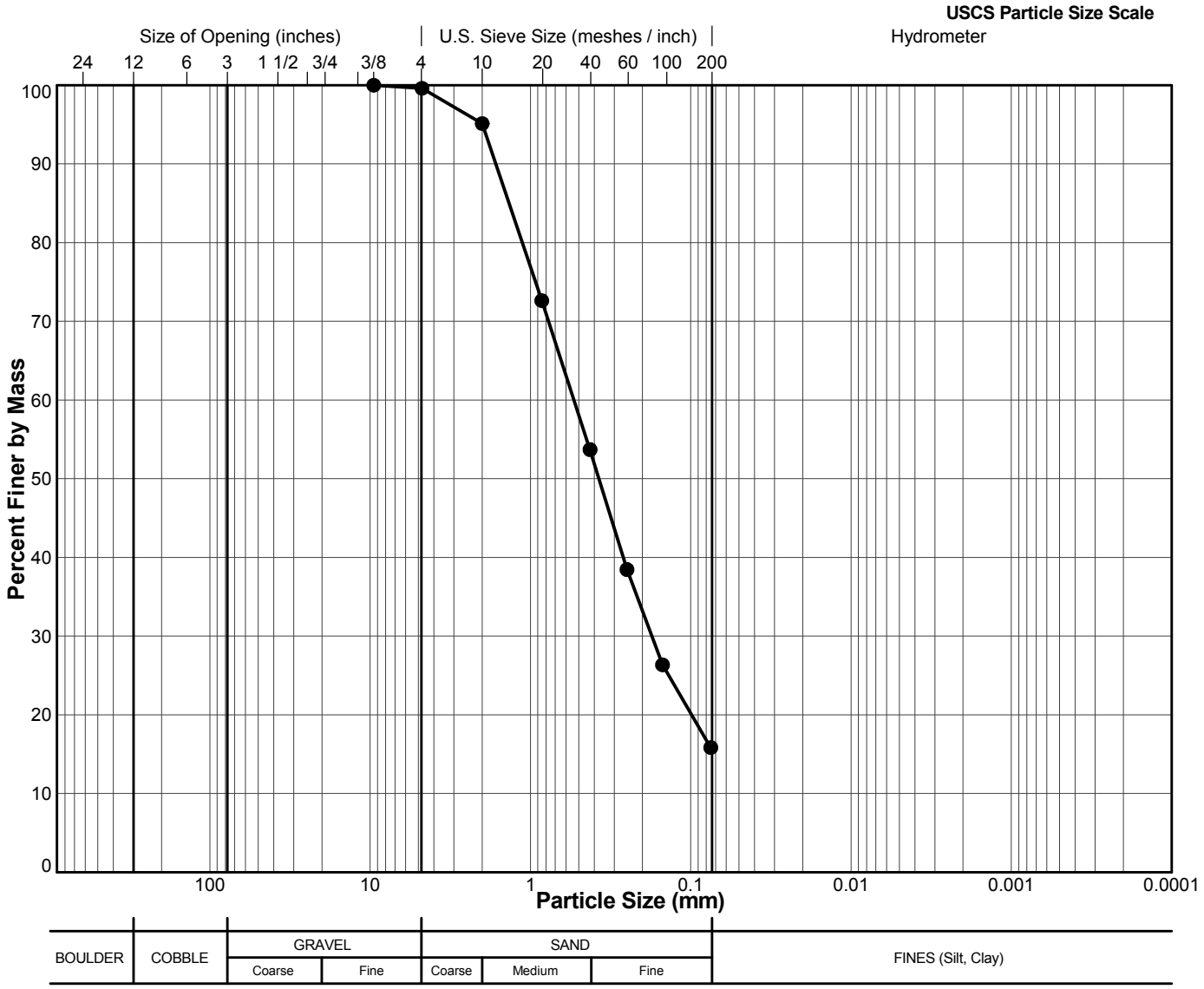
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-02
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	10
Location:	Ladysmith, BC	**Depth Interval (m):**	16.80 to 17.20
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024862

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 9.5	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
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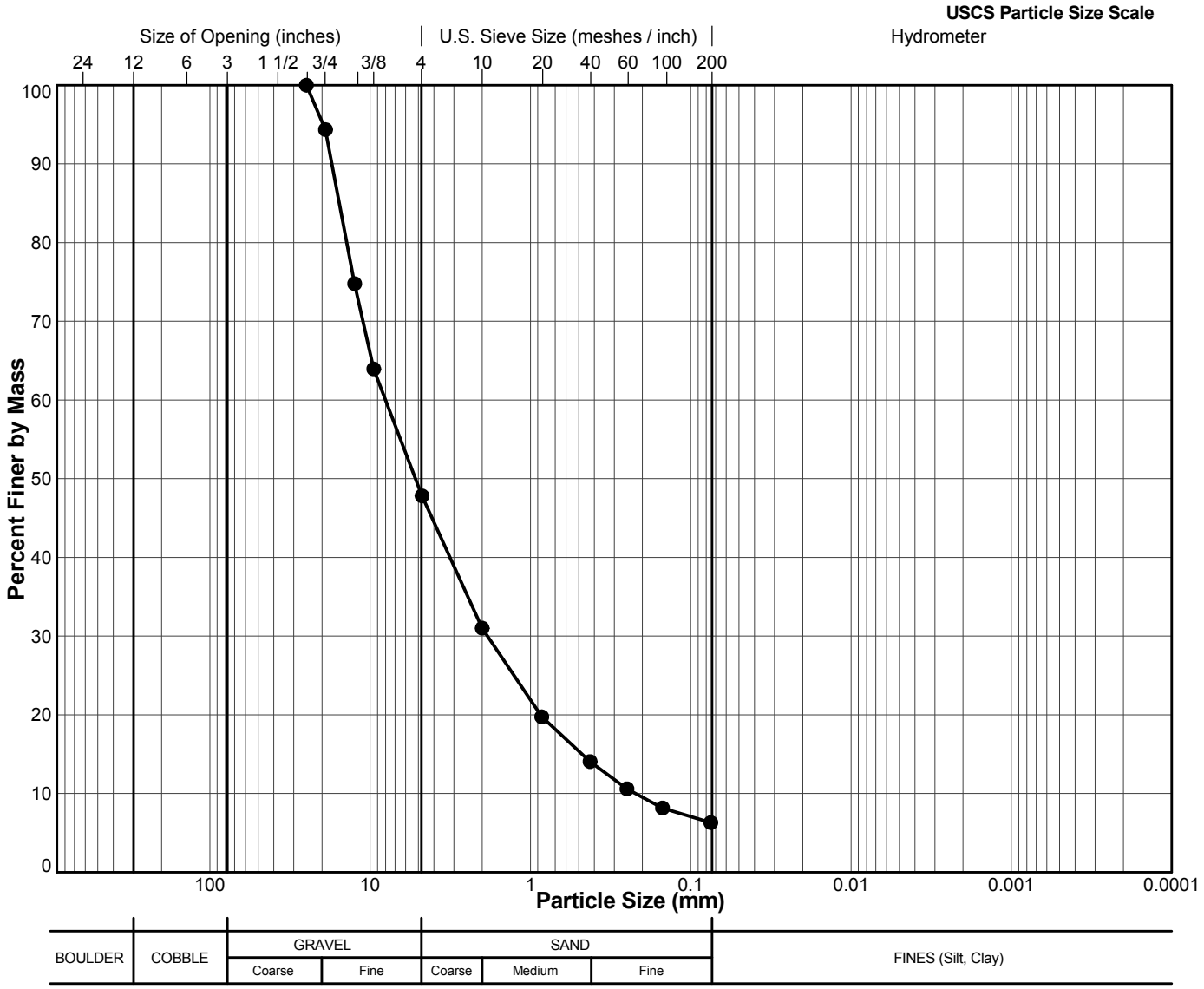
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-02
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	12
Location:	Ladysmith, BC	**Depth Interval (m):**	22.90 to 23.50
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:**	225 **Esis No.:** BURNAS0000024864

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 25	**Hardness: N/A**
Method: Split, Washed	



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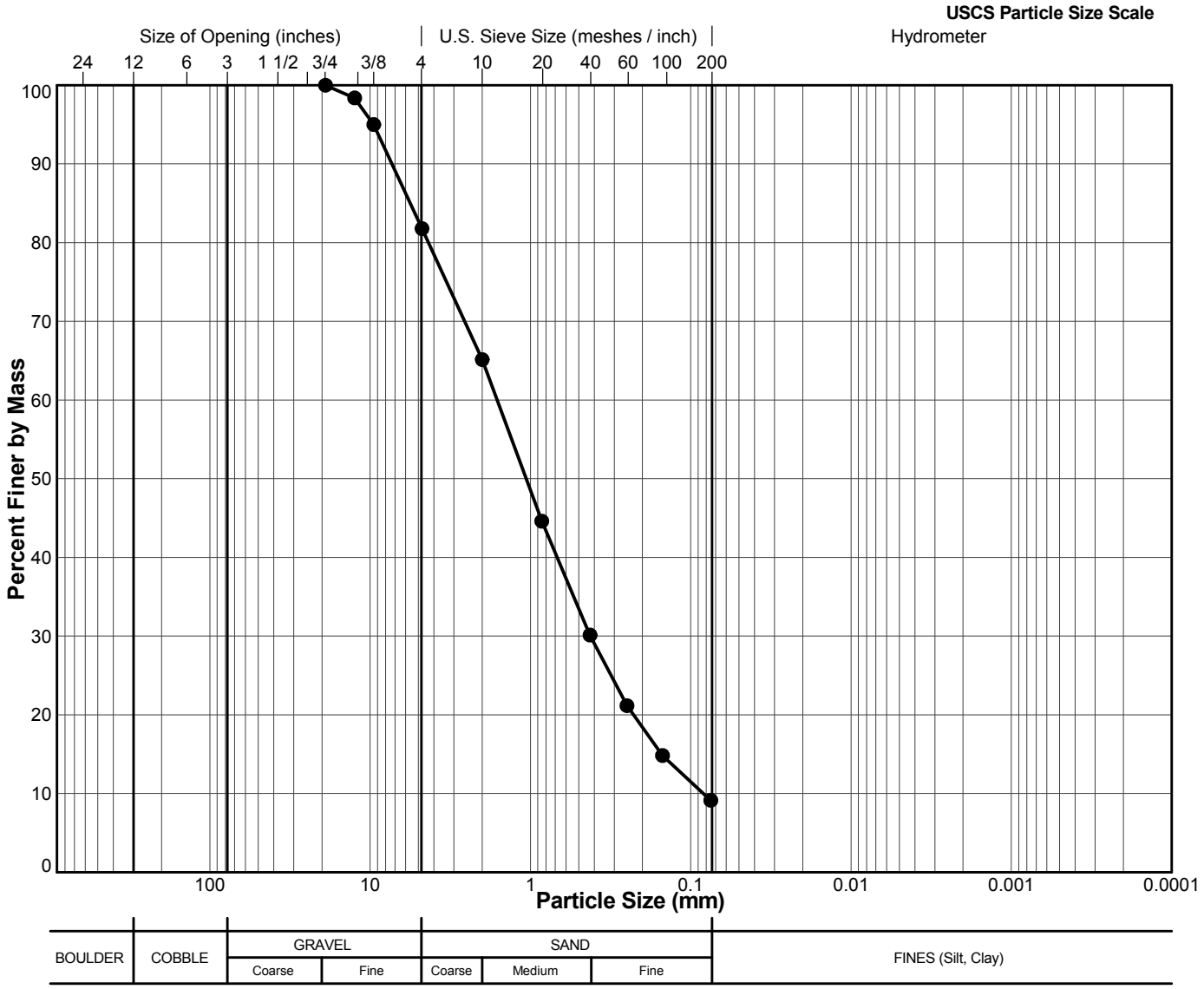
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-03
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	2
Location:	Ladysmith, BC	**Depth Interval (m):**	3.00 to 3.40
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024869

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 19	**Hardness: N/A**
Method: Split, Washed	



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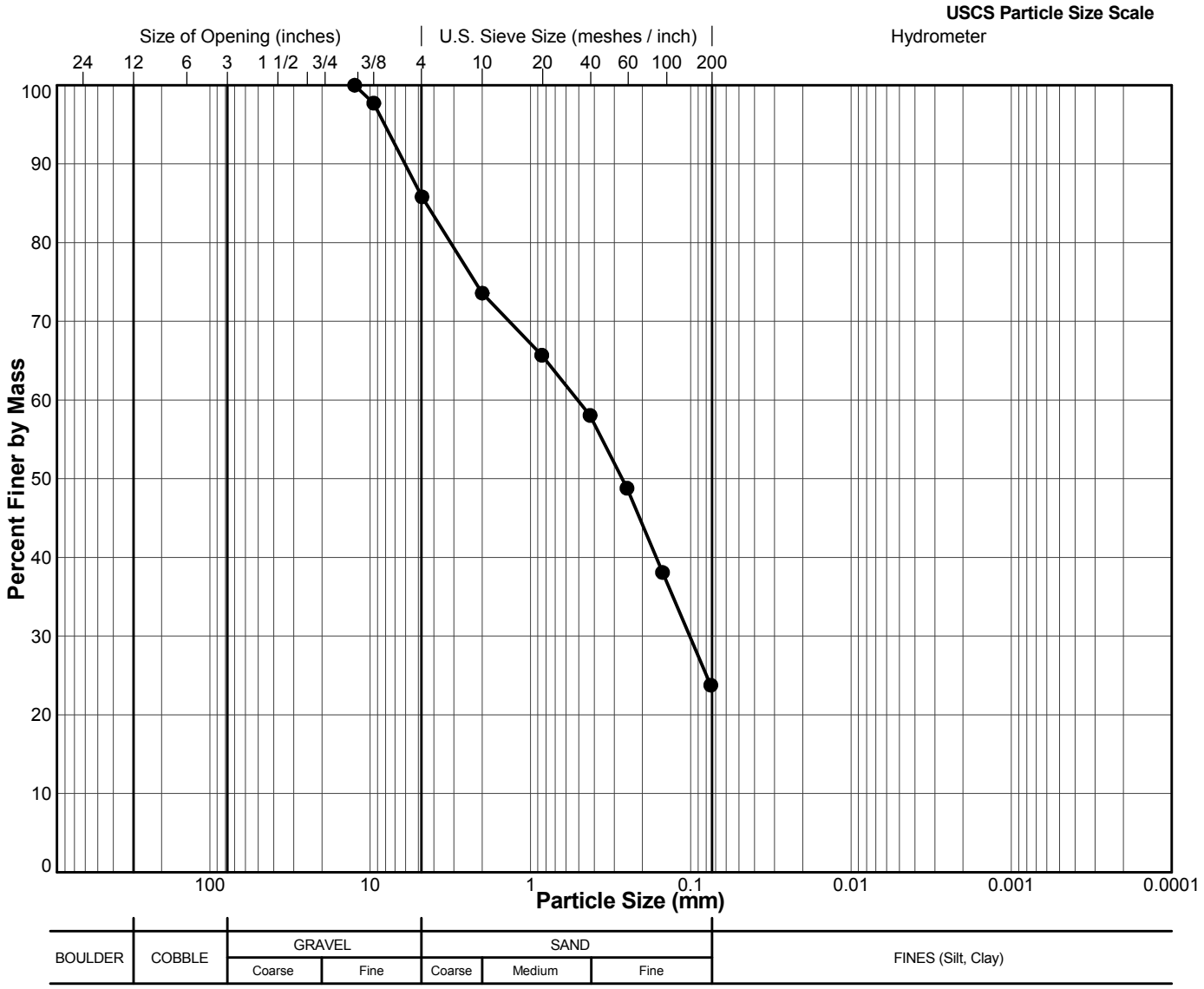
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-03
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	5
Location:	Ladysmith, BC	**Depth Interval (m):**	10.70 to 11.30
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024872

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 12.5	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
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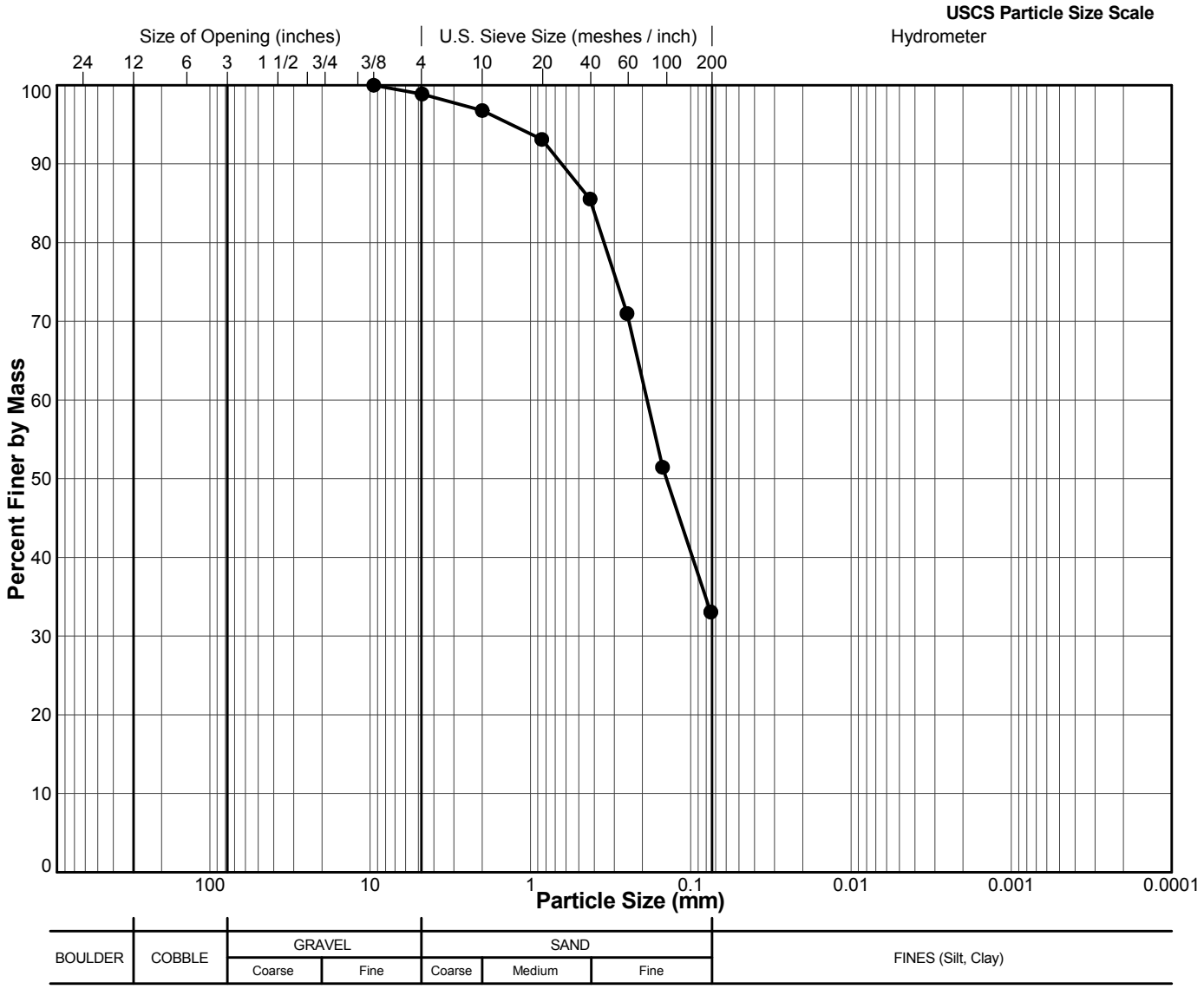
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-03
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	7
Location:	Ladysmith, BC	**Depth Interval (m):**	15.20 to 15.80
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024874

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 9.5	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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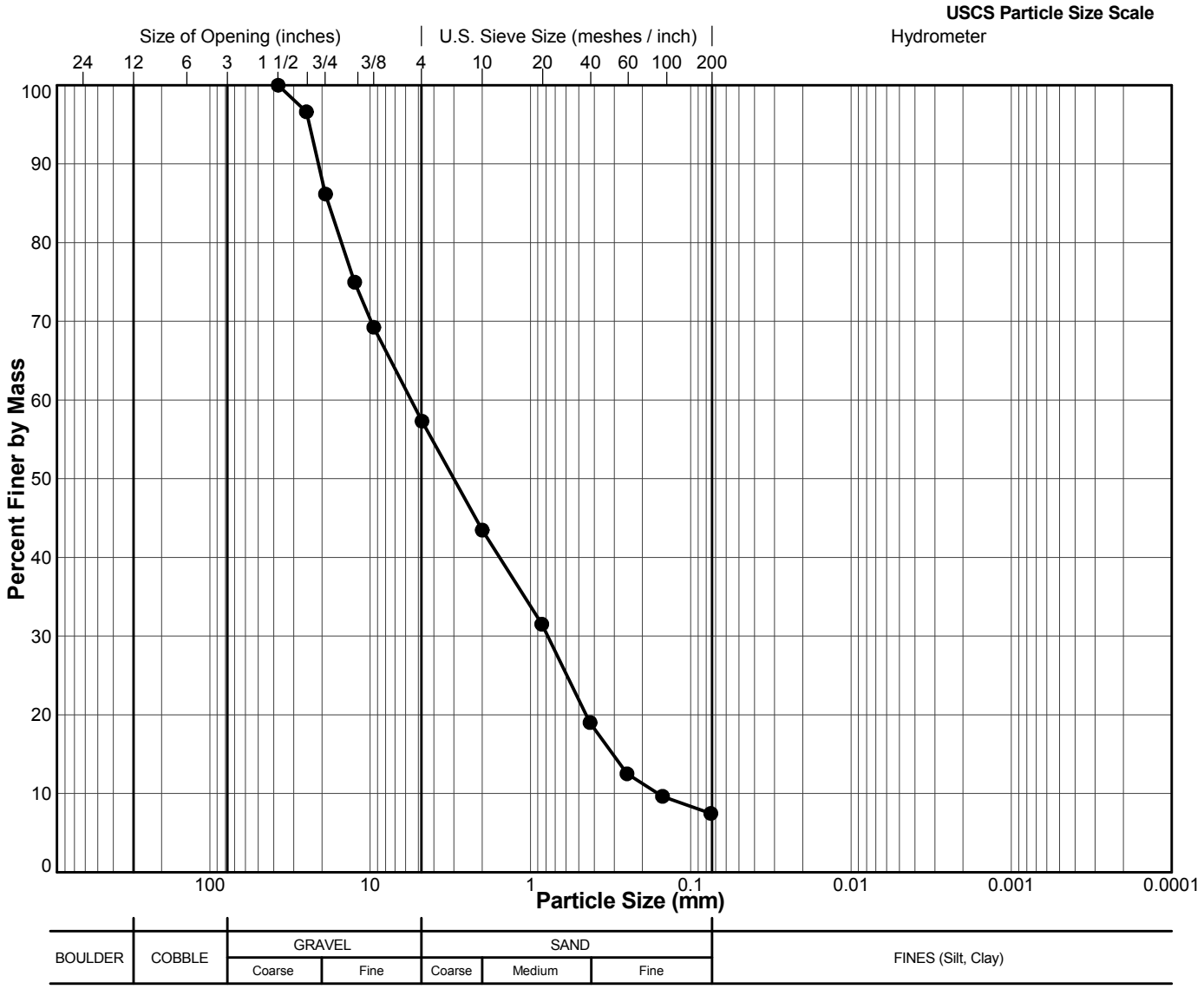
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-03
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	8+9 Combined
Location:	Ladysmith, BC	**Depth Interval (m):**	21.30 to 21.90
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024876

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 37.5	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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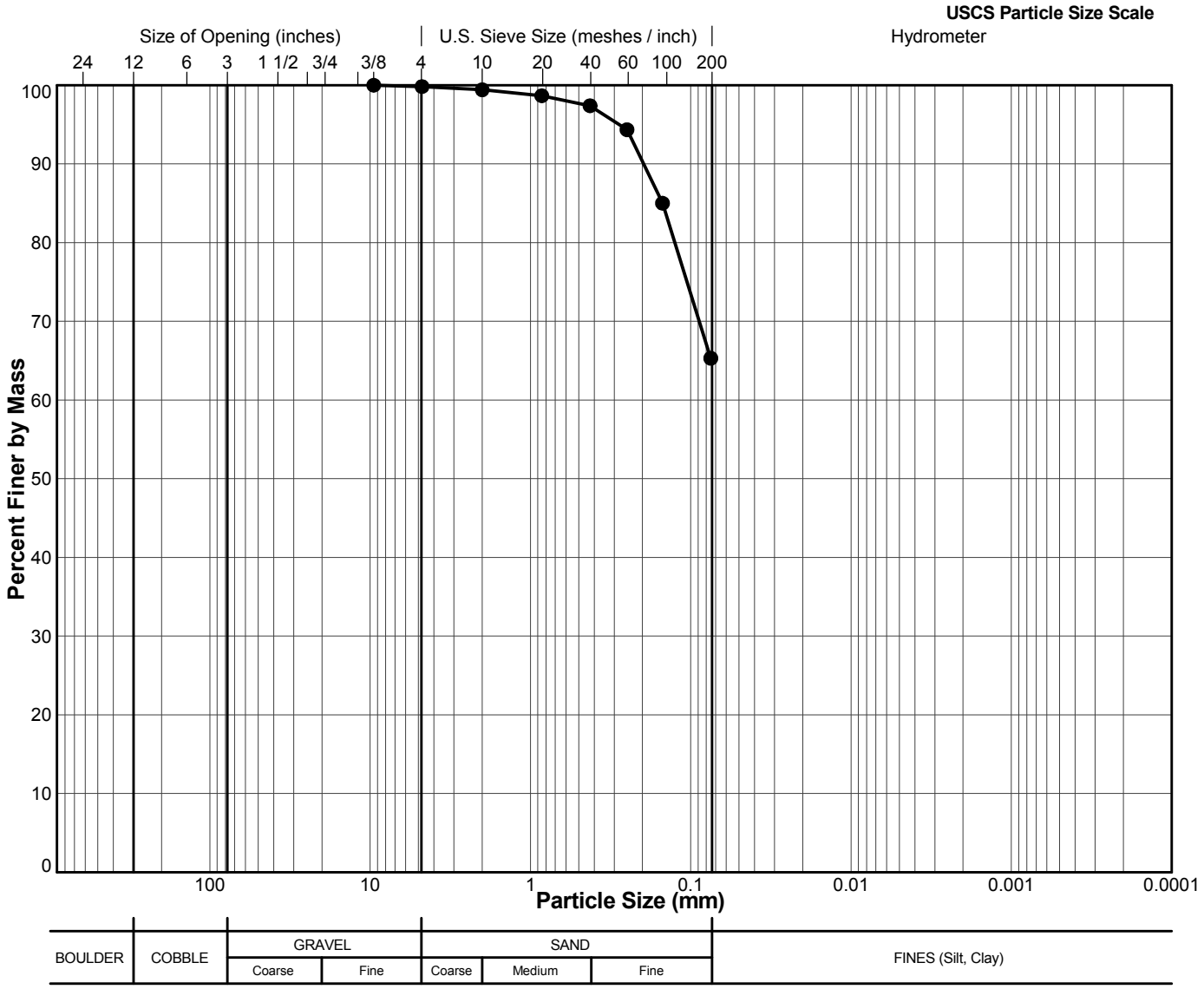
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-03
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	12
Location:	Ladysmith, BC	**Depth Interval (m):**	27.40 to 28.00
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024879

Other Remarks: **N/A**

Specific Gravity (assumed):	**Shape: N/A**
Max. Particle Size Passing (mm): 9.5	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
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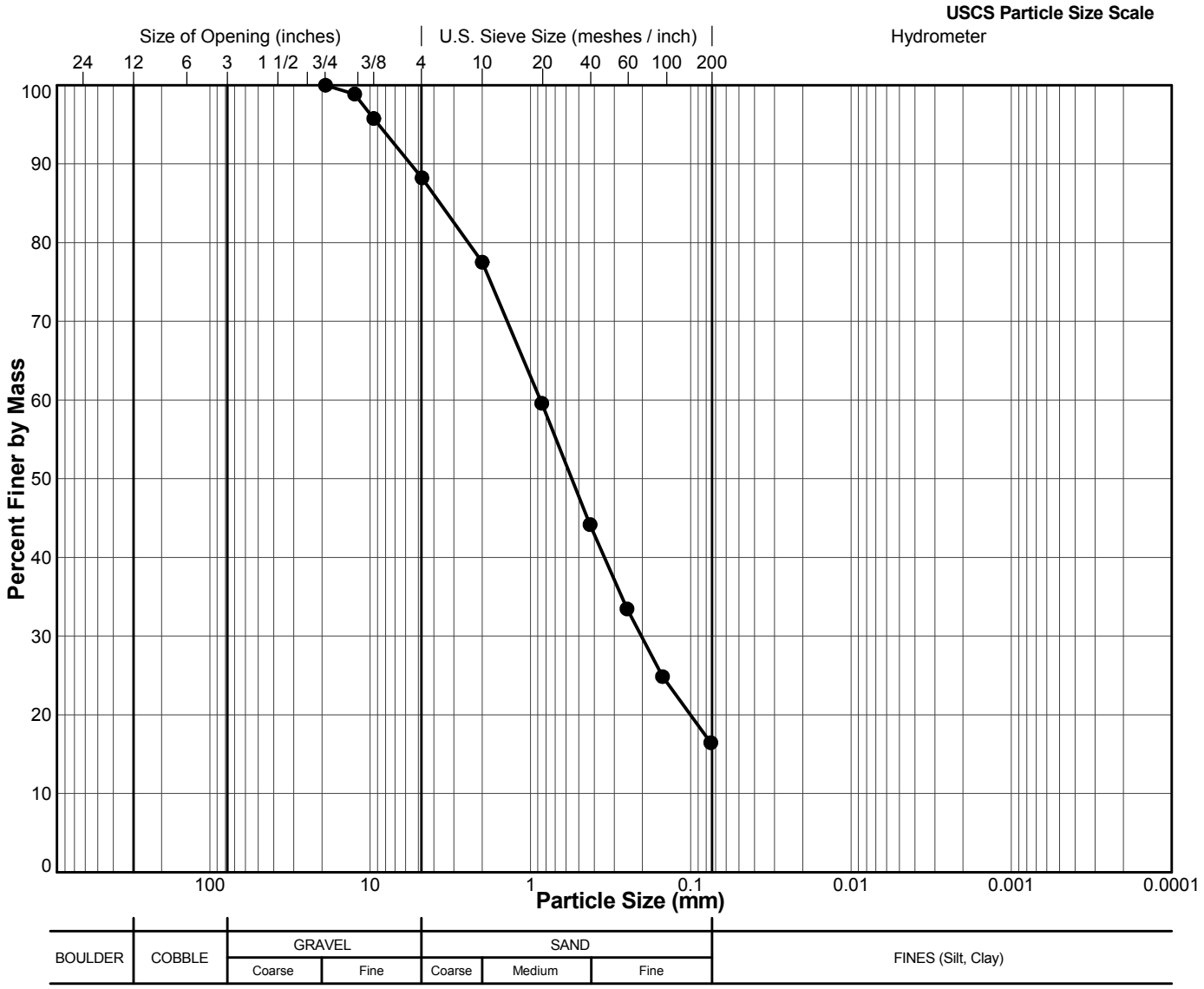
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-04
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	3
Location:	Ladysmith, BC	**Depth Interval (m):**	3.00 to 3.70
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024882

Other Remarks: **N/A**

Specific Gravity (assumed): 2.76	**Shape: N/A**
Max. Particle Size Passing (mm): 19	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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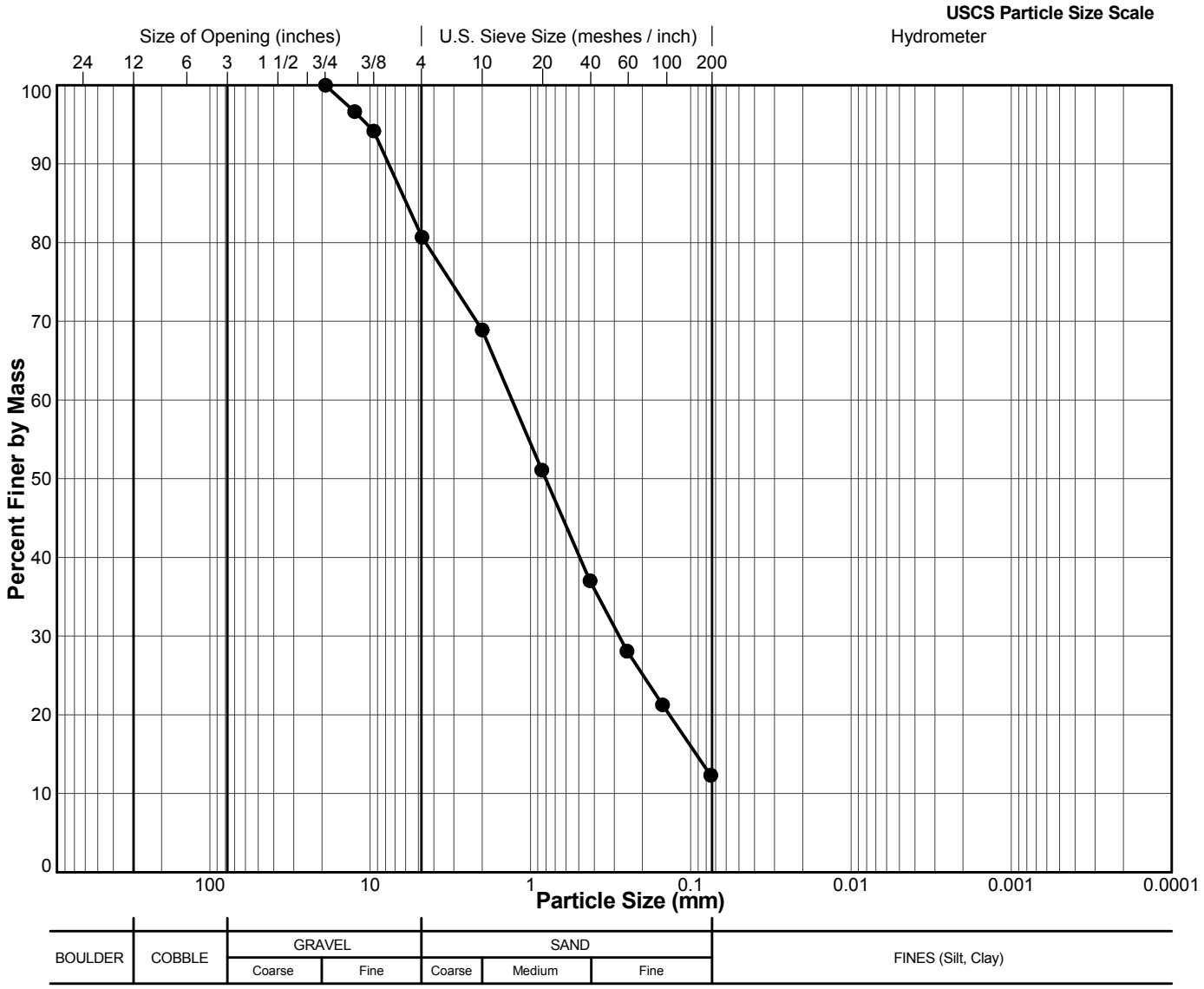
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-05
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	4
Location:	Ladysmith, BC	**Depth Interval (m):**	3.00 to 3.50
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024895

Other Remarks: **N/A**

Specific Gravity (assumed): 2.76	**Shape: N/A**
Max. Particle Size Passing (mm): 19	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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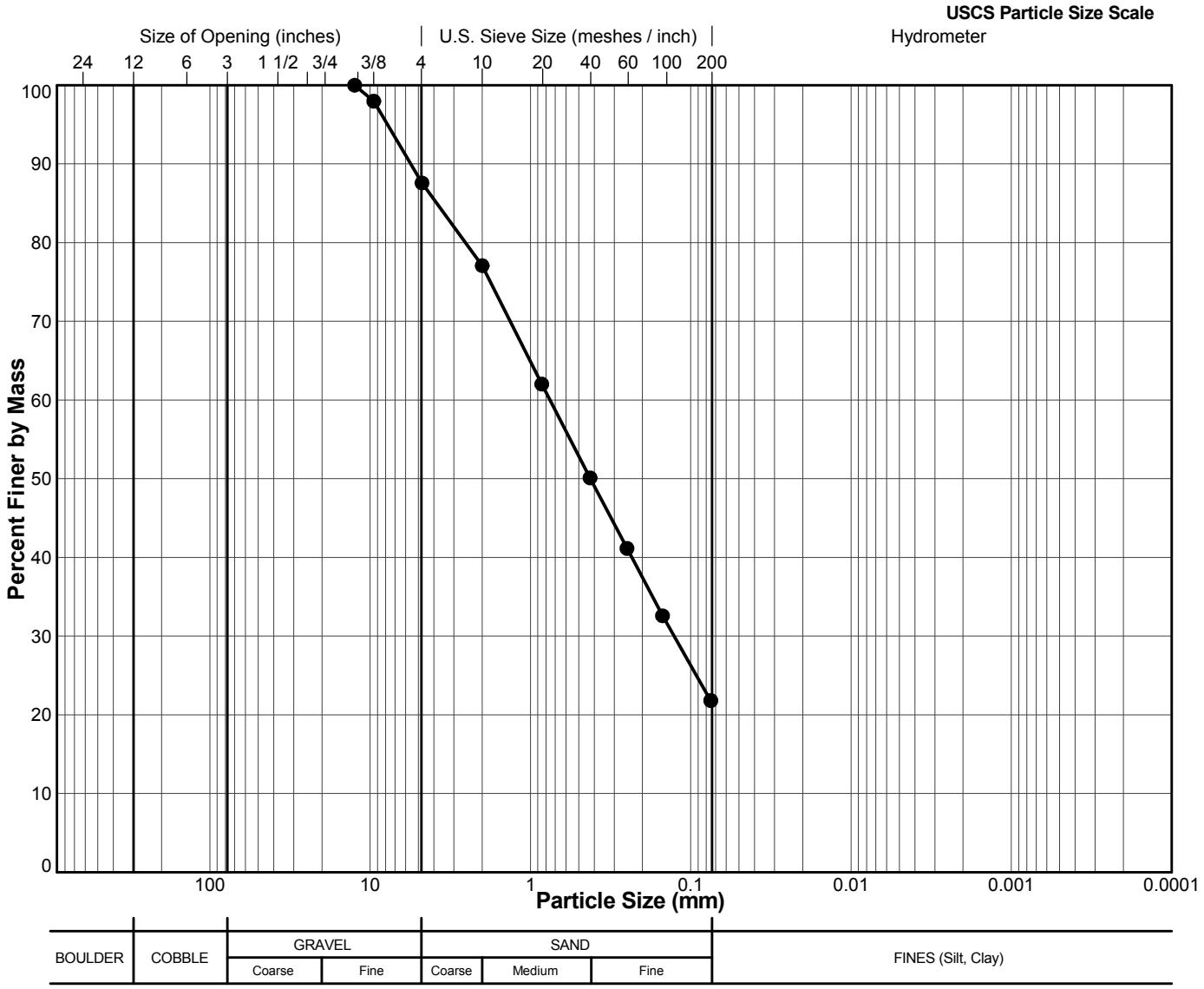
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-05
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	9
Location:	Ladysmith, BC	**Depth Interval (m):**	7.60 to 8.10
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:**	225 **Esis No.:** BURNAS0000024900

Other Remarks: **N/A**

Specific Gravity (assumed): 2.76	**Shape: N/A**
Max. Particle Size Passing (mm): 12.5	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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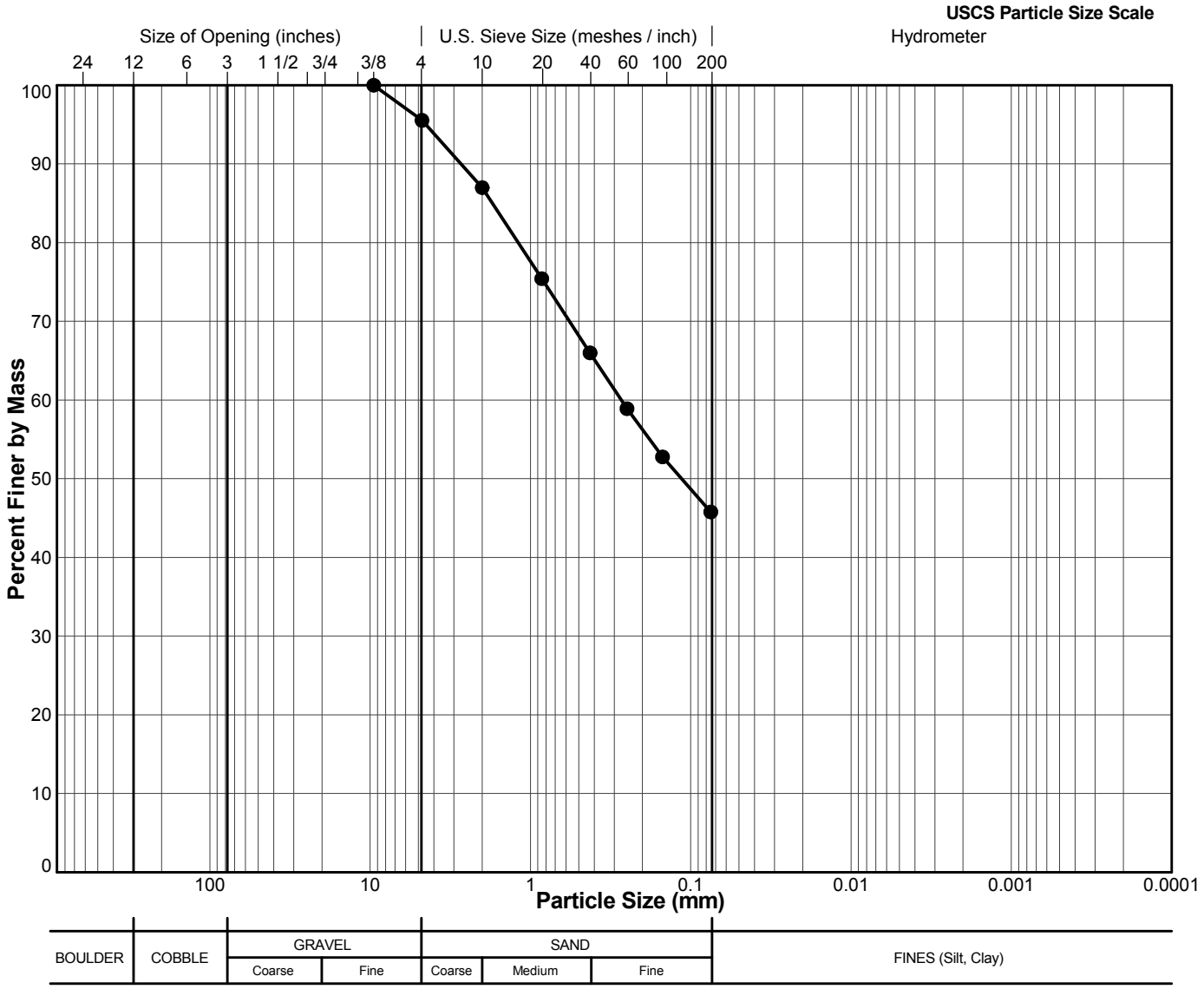
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-05
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	12
Location:	Ladysmith, BC	**Depth Interval (m):**	13.70 to 14.20
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024903

Other Remarks: **N/A**

Specific Gravity (assumed): 2.76	**Shape: N/A**
Max. Particle Size Passing (mm): 9.5	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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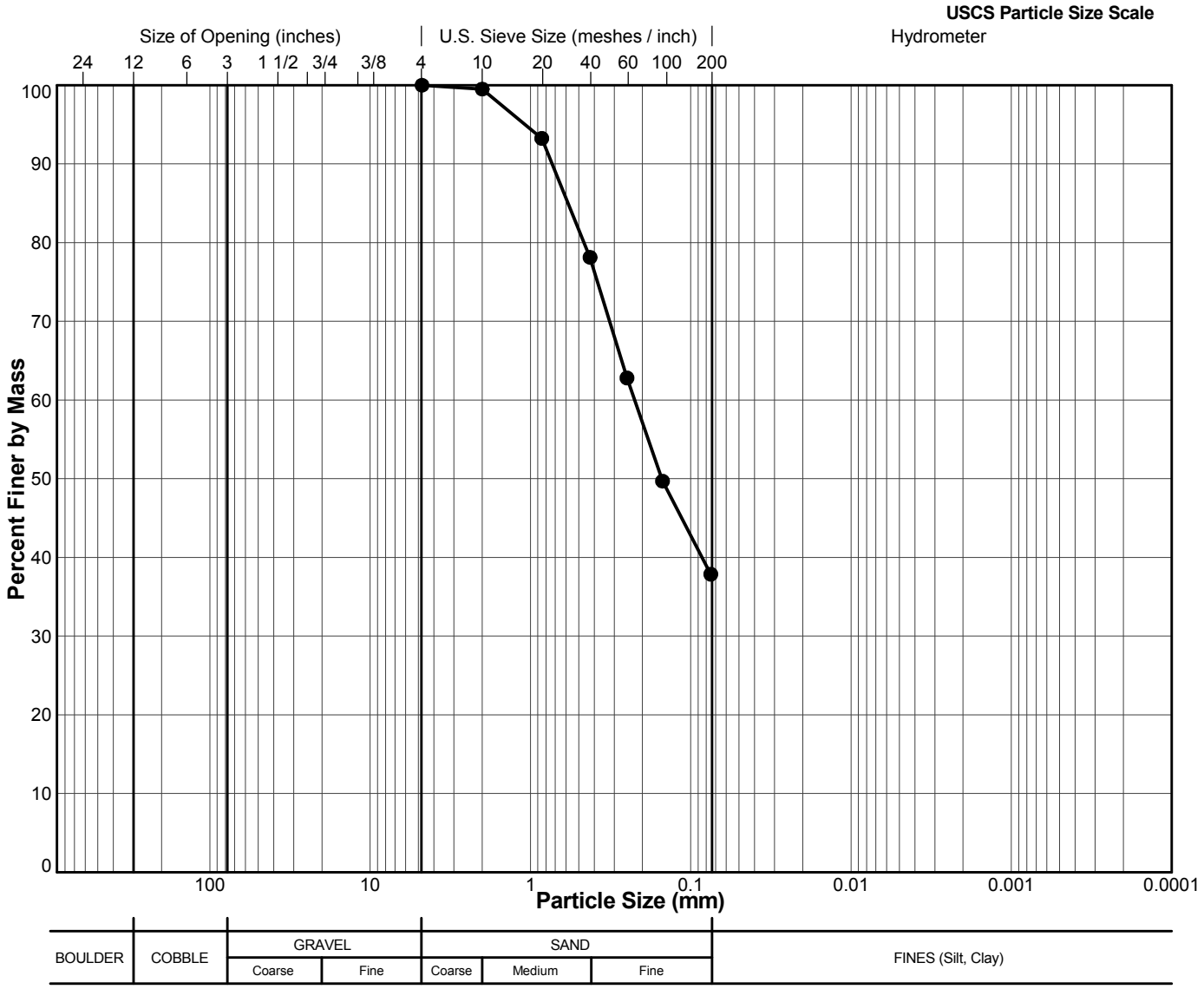
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-05
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	17
Location:	Ladysmith, BC	**Depth Interval (m):**	21.30 to 21.80
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024908

Other Remarks: **N/A**

Specific Gravity (assumed): 2.76	**Shape: N/A**
Max. Particle Size Passing (mm): 4.75	**Hardness: N/A**
Method: Split, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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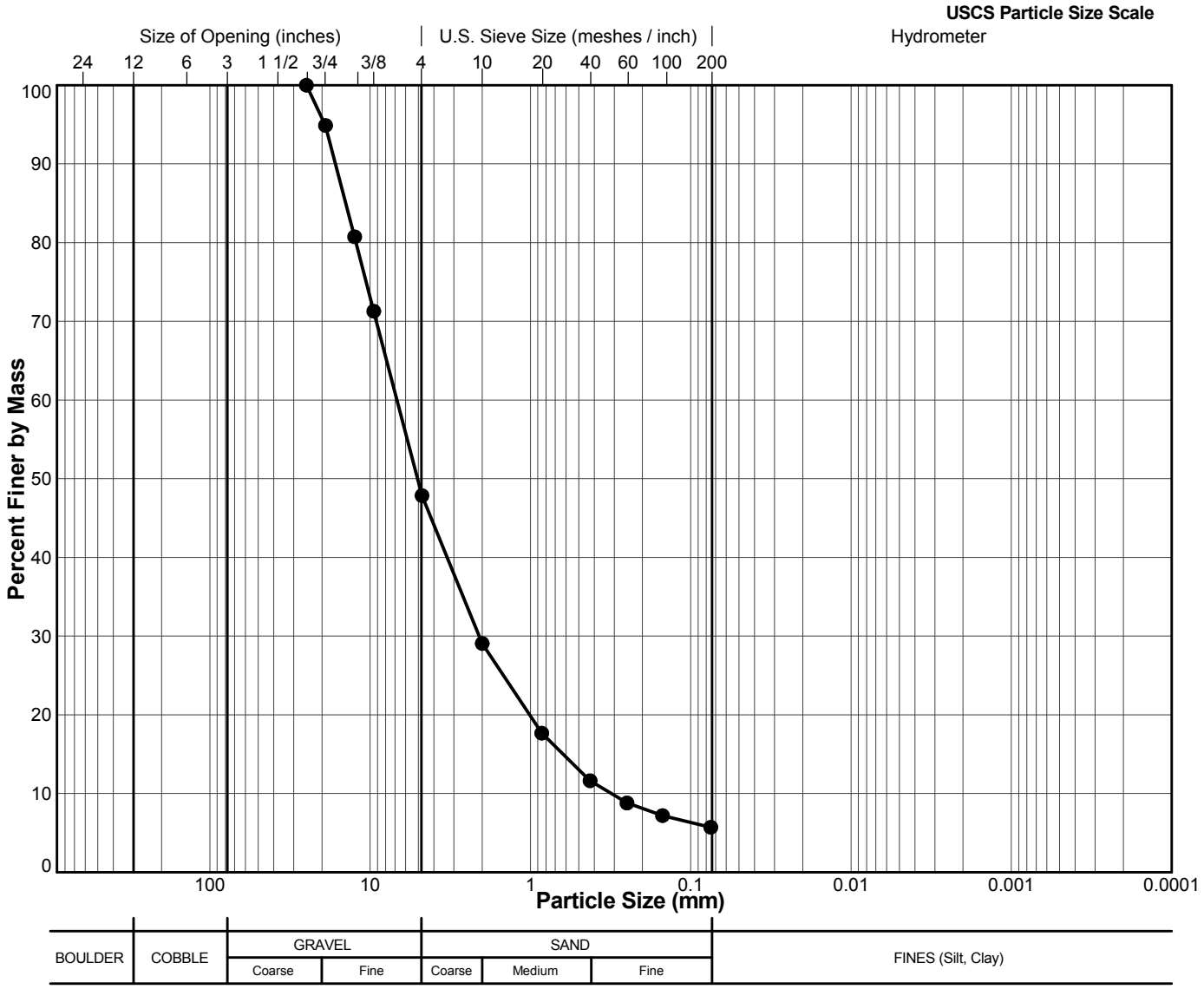
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-05
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	19
Location:	Ladysmith, BC	**Depth Interval (m):**	24.40 to 24.80
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024910

Other Remarks: **N/A**

Specific Gravity (assumed): 2.76	**Shape: N/A**
Max. Particle Size Passing (mm): 25	**Hardness: N/A**
Method: Combined, Washed	



EB/PC	**09/12/2009**	**LP**	**10/12/2009**
Tech	Date	Checked	Date

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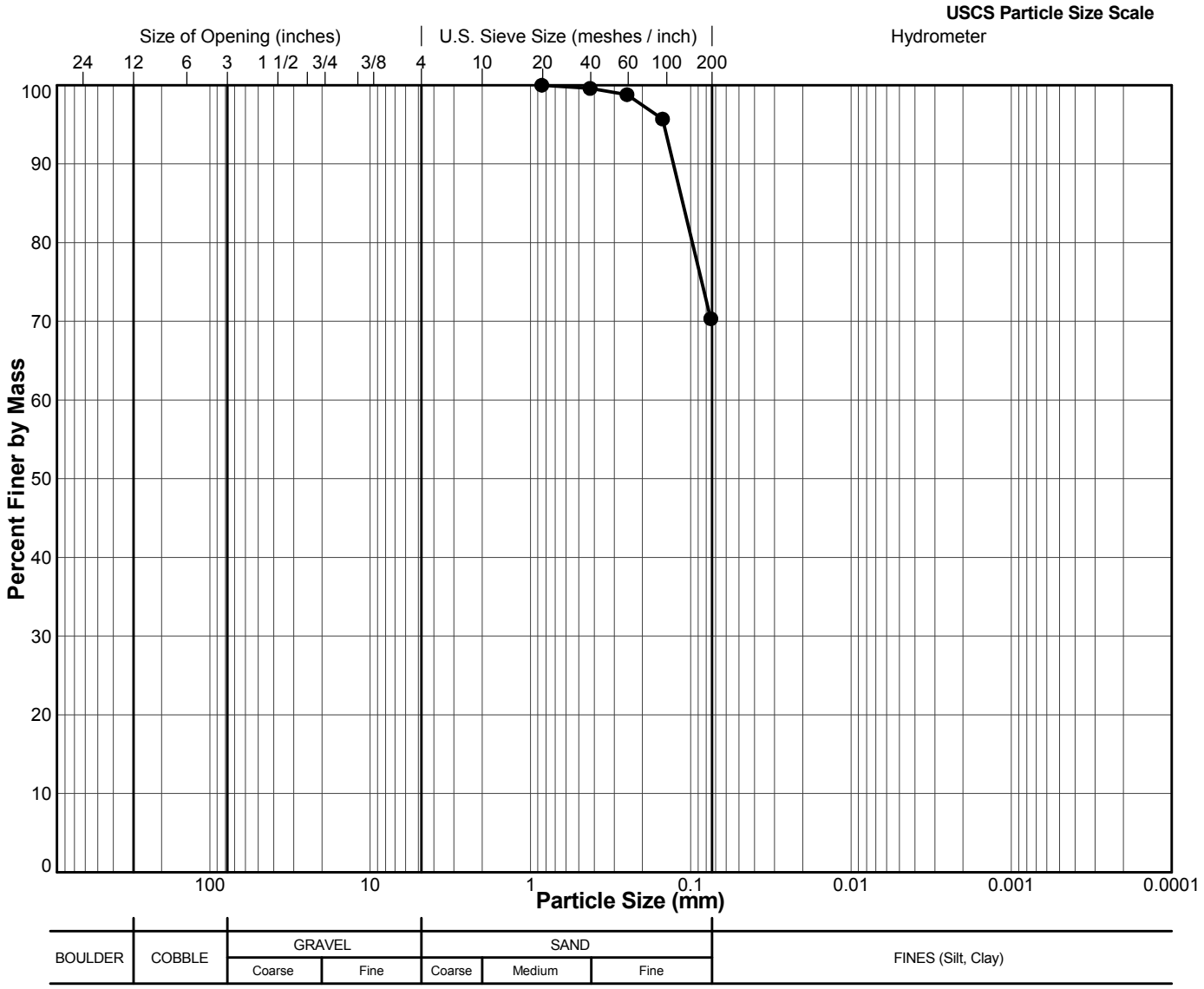
PARTICLE SIZE ANALYSIS OF SOILS

Reference(s)
ASTM D 422-63 (2007)

Client:	Ministry of Agriculture and Lands	**Sample Location:**	BH09-06
Project:	Ladysmith Harbour - Site Investigation	**Sample No.:**	4
Location:	Ladysmith, BC	**Depth Interval (m):**	4.00 to 4.40
Project No.:	09-1436-5008 **Phase:** 6000	**Lab Schedule No.:** 225	**Esis No.:** BURNAS0000024917

Other Remarks: **N/A**

Specific Gravity (assumed): 2.76	**Shape: N/A**
Max. Particle Size Passing (mm): 0.85	**Hardness: N/A**
Method: Split, Washed	



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Tech	Date	Checked	Date

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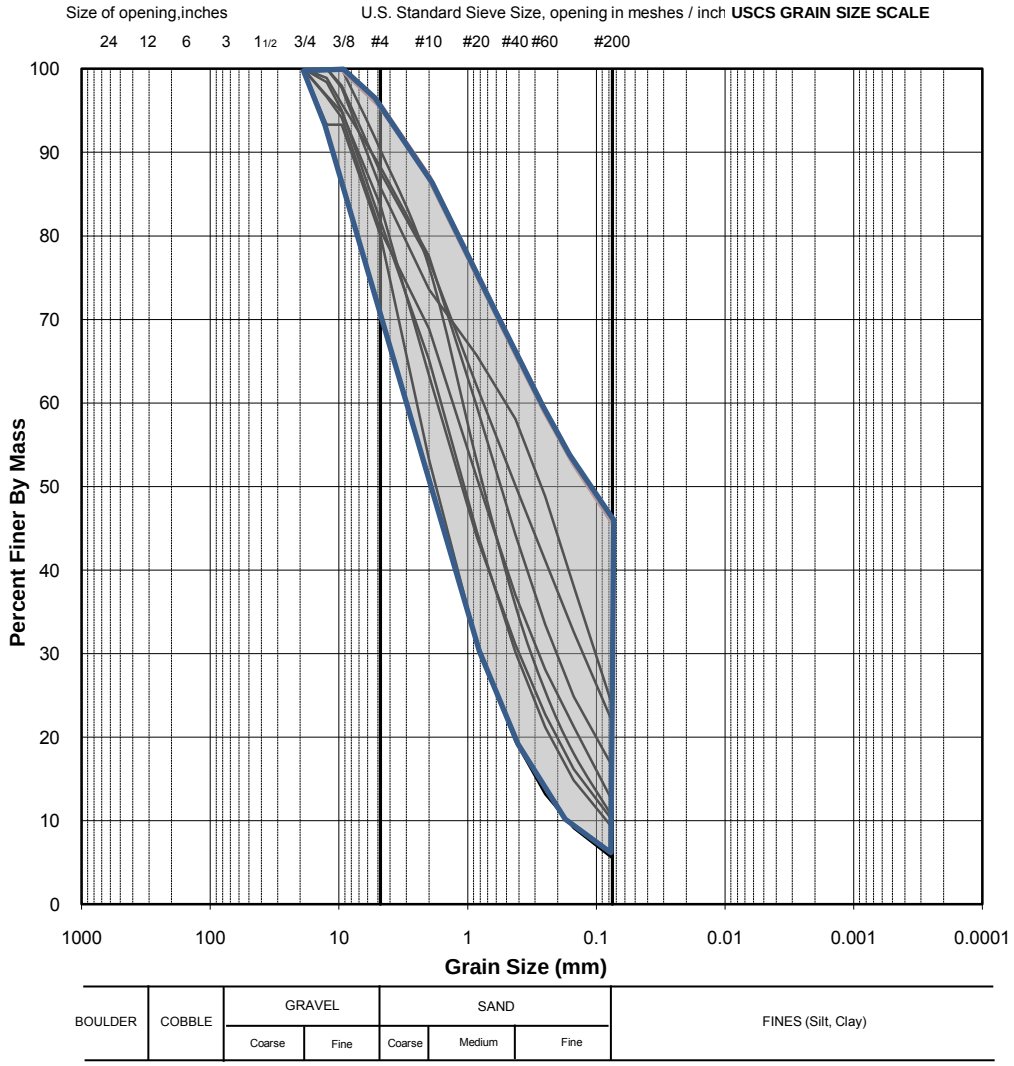
PARTICLE SIZE ANALYSIS OF SOILS

Reference
ASTM C136-06 & C117-04

Project No.: 09-1436-5008/6000
Client: Ministry of Agriculture and Lands - Crown Land Restoration Bra
Project: Ladysmith Harbour - Stage 1 Preliminary Site Investigation
Location: Ladysmith, BC

Figure C-1

Material Specification: Coal
Method: SPLIT, WASHED



NOTES

EB/PC	December 9, 2009	LP	December 10, 2009
TESTED BY	DATE	CHECKED BY	DATE

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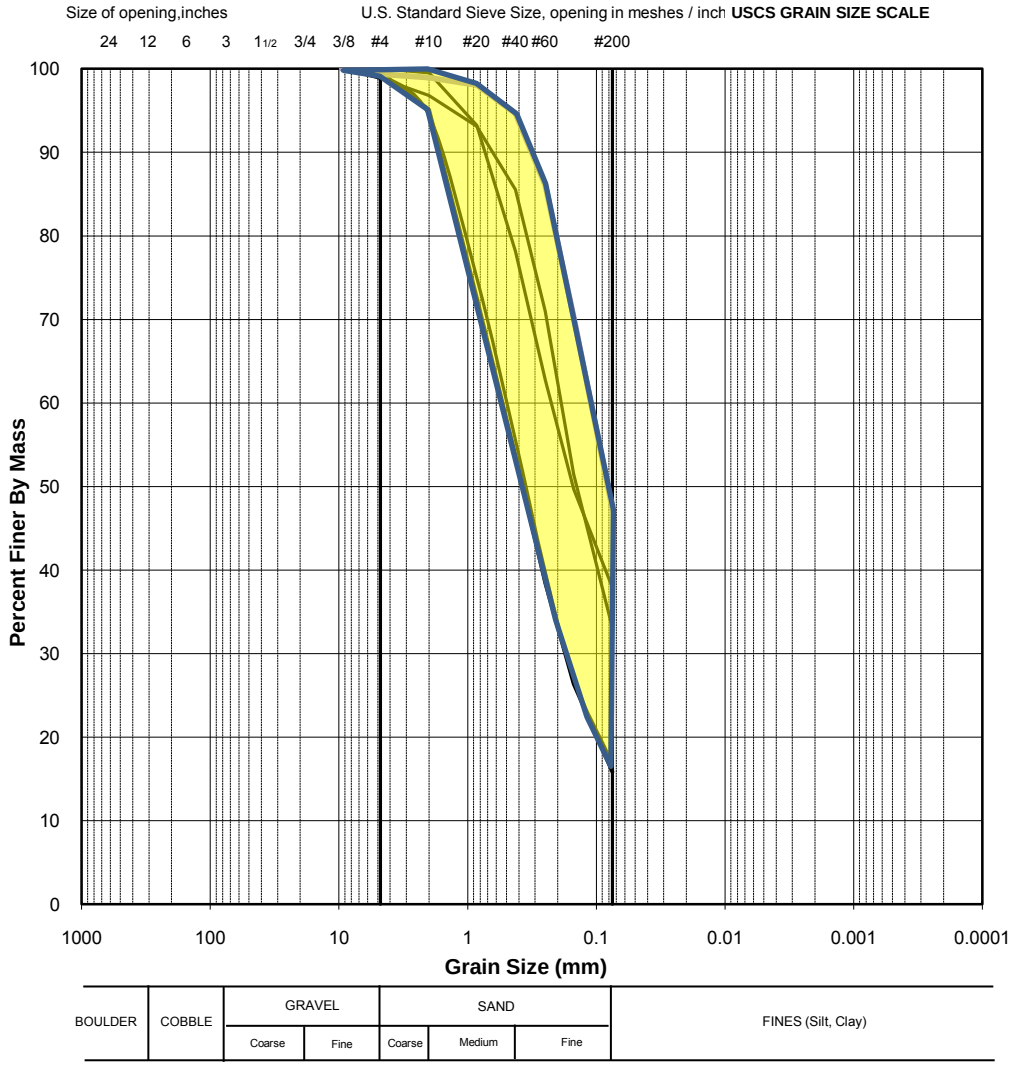
PARTICLE SIZE ANALYSIS OF SOILS

Reference
ASTM C136-06 & C117-04

Project No.: 09-1436-5008/6000
Client: Ministry of Agriculture and Lands - Crown Land Restoration Bra
Project: Ladysmith Harbour - Stage 1 Preliminary Site Investigation
Location: Ladysmith, BC

Figure C-2

Material Specification: Silty Sand & Sand
Method: SPLIT, WASHED



NOTES

EB/PC	December 9, 2009	LP	December 10, 2009
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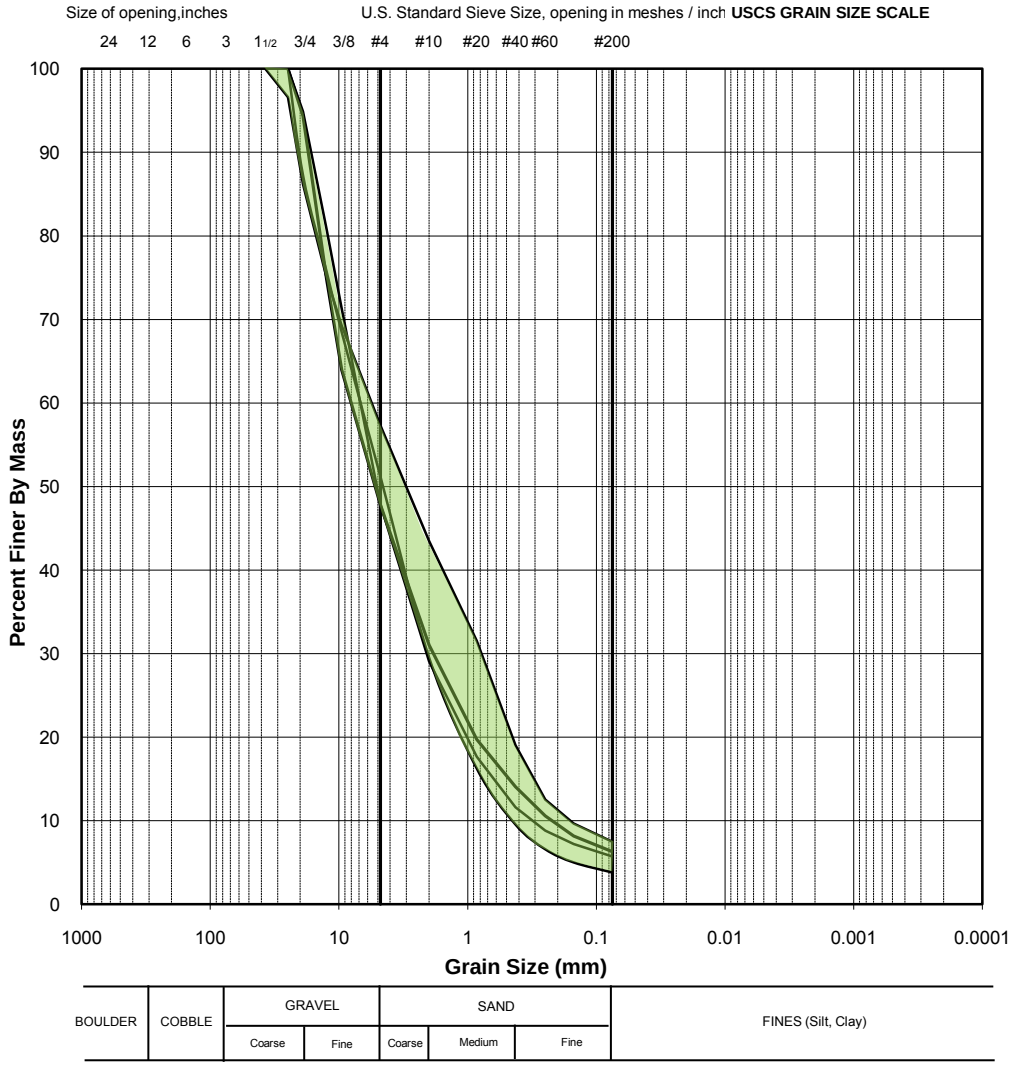
PARTICLE SIZE ANALYSIS OF SOILS

Reference
ASTM C136-06 & C117-04

Project No.: 09-1436-5008/6000
Client: Ministry of Agriculture and Lands - Crown Land Restoration Bra
Project: Ladysmith Harbour - Stage 1 Preliminary Site Investigation
Location: Ladysmith, BC

Figure C-3

Material Specification: SAND & GRAVEL
Method: SPLIT, WASHED



NOTES

EB/PC	December 9, 2009	LP	December 10, 2009
TESTED BY	DATE	CHECKED BY	DATE

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Unconfined Compressive Strength of Intact Rock Core Specimens

Reference
ASTM D7012-07 Method C

Project No.:	09-1436-5008/6000	**Borehole:**	**BH09-6**
Project:	Ladysmith Harbour	**Sample Number:**	1
Location:	0	**Depth (m):**	21"1"-21'11"
Client:	0	**Lab ID No:**	230

Testing Results

Max Load (kN)	**297.70**
Stress σ (MPa)	**103.32**
Pace Rate (kN/s)	0.50
Lithology	-

Sample Measurements

Diameter (mm)	60.57
Height (mm)	122.40
Area (cm^2)	28.81
Volume (cm^3)	352.68
Mass (g)	880.60
Moisture Content (%)	0.06
Wet Density (Kg/m^3)	2496.85
Dry Density (Kg/m^3)	2495.29

Failure Mode

Type: **3**

Degrees:*

* Degrees measured with respect to core axis.

Notes

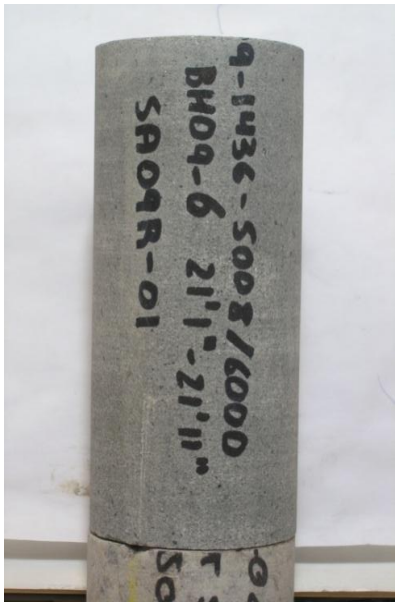
- Water content as received

Mode:

(1) Single diagonal shear plane
(2) Vertical fracture(s)
(3) Vertical splitting
(4) Shear along foliation /discontinuity
(5) Conical
(6) Spalling
(7) Other

Comments

** The test data given herein pertain to the sample provided only. This report constitutes a testing service only. Interpretation of the data given here may be provided upon request.*



BEFORE TEST

AFTER TEST

LP	December 8,2009		
TESTED BY	DATE	CHECKED BY	DATE

APPENDIX D

Geotechnical Rock Core Photographs

BH09-04 – Box 1 of 1: 12.3 m to 15.7 m (40’6” to 51’4”)

BH10-06 – Box 1 of 1: 5.6 m to 9.1 m (18’5” to 29’11”)

PROJECT	Geotechnical Investigation Ladysmith Harbour Ladysmith, BC
TITLE	Rock Core Photographs

Golder Associates

PROJECT No. 09-1436-5008			PHASE No. 6000	
DESIGN	ALF	20MAR11	SCALE -NTS-	REV.
REVIEW	MY	20MAR11		

FIGURE D-1

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