APPENDIX "D"

Preliminary Geotechnical Assessment

LEVELTON
Engineering Solutions

October 30, 2002
File Ref: 602-0236

Earth Tech Consulting Ltd.
Suite 203
4430 Chatterton Way
Victoria, BC
V8X 5J2

Levelton Engineering Ltd.
1935 Bollinger Road
Nanaimo, B.C.
Canada V9S 5W9
Tel: 250 753-1077
Fax: 250 753-1203
E-Mail: nanaimo@levelton.com
Web Site: www.levelton.com

Construction Materials
Building Science
Geotechnical
Metallurgy and Corrosion
Environmental
Analytical Chemistry
Physical Testing

Attn: Mr. Bruce Kenning, P.Eng.

Dear Sir,

Re: Preliminary Geotechnical Overview
Town of Ladysmith Water Supply and Distribution
Pre-Design Study

Introduction

As requested by Earth Tech, Levelton Engineering Ltd. has completed a preliminary geotechnical overview study for the Town of Ladysmith Water Supply and Distribution Pre-Design Study. The study was conducted in general accordance with our proposal of February 11, 2002 (File Ref. 602-P21). Authorization to proceed with the study was received on October 18, 2002.

The purpose of the preliminary geotechnical overview at this pre-design stage of the project is to identify the presence and nature of significant geotechnical constraints or geo-hazards that could impact the feasibility and siting of the proposed reservoir. In particular, we would seek to identify adverse surficial geological conditions, published locations of major bedrock faulting and landslide potential.

Project Description

The Town of Ladysmith presently supplies its customers with drinking water from two upland watersheds situated above the Town, namely; the Holland Lake and Stocking Lake watersheds. The community of Saltair presently supplies water directly from Stocking Lake in a separate system. Raw water from these sources is understood to be chlorinated but not filtered.

Upgrading the Town of Ladysmith water supply infrastructure has been the subject of several reports. However, the concept of providing a dual supply to both Ladysmith and Saltair is a relatively new one and is the subject of this pre-design study and conceptual feasibility engineering evaluation. Once the most feasible design method of water supply has been established, it is understood that the study will progress under separate terms of reference to preliminary design, including the supply lines, treatment plant, storage reservoir and distribution system.

Five potential reservoir sites were identified by Earth Tech. The five sites are located in two general areas identified in this report as the north and south study areas as shown on the attached Figure 1. The approximate locations of the individual proposed reservoir locations are shown on the aerial photograph in Figure 2 and are identified on portions of the topographic plan provided by Earth Tech appended as Figures 3 and 4.

We understand that the proposed reservoir would be an above grade, possibly bolted steel tank structure with a storage capacity in the order of 4 to 9 megalitres (1 to 2 million gallons).

Background and Geotechnical Setting

A review of published geological maps [1, 2] indicated that the surficial geology of the slope upon which the Town of Ladysmith is located consists largely of a thick blanket of glacial till with a thin veneer of granular marine deposits. To the west of the Town, between an elevation of approximately 75 m and 175 m, is a large physiographic plain. Available geological mapping indicates this plain to be underlain by hummocky till, interspersed with swamps and islands of culluvial covered bedrock. The origin of these swamps is reportedly associated with ice stagnation towards the end of the last glacial period.

The geological mapping shows the northern study area potential reservoir sites 1 and 2 to be located in an area of hummocky morainal till eastward of the relatively deeply incised Holland Creek channel. Site 3 in the northern study area is shown near the boundary between glacial till and colluvial deposits. Both potential reservoir sites in the southern study area are shown within a colluvial blanket area. Geologically, a blanket is referred to as being at least 1.5m thick.

Colluvial deposits are weathered materials transported by gravity and are commonly the result of mass wastage, such as talus (fallen rock fragments) and landslides. Dependant on the amount of movement, colluvial deposits may be poorly compacted with variable foundation and drainage characteristics. Morainal glacial till is typically a well compacted and over-consolidated material of variable proportions of silt, clay sand and gravel. Morainal glacial till is typically a good foundation material, with poor drainage properties.

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[1] Surficial Geology of the Duncan Area, Open File 1993-27. Geological Survey Branch, Ministry of Energy, Mines and Petroleum Resources.

[2] Surficial Geology Nanaimo British Columbia Map 27-1963, Geological Survey of Canada.

Major bedrock faults in the area[3] are typically aligned northwest to southeast and southwest to northeast. A thrust fault generally follows the northwest alignment along the centre of Ladysmith Harbour, with other less defined bedrock faults located just westward of the Town of Ladysmith. Local bedrock jointing and discontinuities often mirror the orthogonal arrangement described above.

Aerial photographs of the study area, taken in 1986, were obtained. The photographs showed the potential reservoir sites to be primarily forested. Local bedrock exposures were visible in the immediate vicinity of Site 2 in the north study area. Existing roads are visible within close proximity to all of the sites, except Site 3 in the north study area.

Site Reconnaissance

A site reconnaissance of the potential reservoir areas was conducted on October 25, 2002. Our observations at each of the sites are summarized below.

Northern Study Area, Site 1

This potential reservoir location was located within a relatively level area between the existing Arbutus Reservoir and a natural gas transmission right-of-way. The area was moderately treed primarily with conifers having trunks typically about 200mm in diameter and occasionally up to approximately 400mm in diameter. Frequent angular rock fragments were visible on the ground surface, possibly remnants from the construction of the excavated Arbutus reservoir that is located a short distance to the northeast. Several bedrock exposures were also observed in the general area.

Town of Ladysmith staff noted that observations of the adjacent Arbutus reservoir during a recent cleaning suggested that the reservoir appeared to be excavated into till-like material.

Northern Study Area, Site 2

The Northern Site 2 site was located near the crest of a hill northeastward of the Arbutus reservoir. The hill was estimated to be approximately 45m high and was vegetated primarily with scotch broom on the lower slope, and primarily arbutus trees in the higher elevations.

Granitic bedrock, interpreted from published mapping as the early to middle Jurassic Island Plutonic Suite, was exposed in large areas on the hillside. The exposed rock was generally strong with widely spaced, irregular discontinuities. The hillside sloped down to the southwest at approximately 20 to 25° from horizontal. No evidence of recent slope instability was observed in the area, with the exception of occasional loose rock pieces on the slope surface.

[3] Geological Composition, Vancouver Island, BC, Open File 1994-6, Ministry of Energy, Mines and Petroleum Resources.

Northern Study Area, Site 3

The general vicinity of the Northern Site 3 was heavily forested predominantly with conifers with trunks generally about 200mm to 250mm in diameter. The general area sloped northward at approximately 15° from horizontal.

The heavy forest and distance from the nearest road (approximately 150m) made for difficult access to the site and time restrictions limited our review of the slope area. Soil exposures observed at the road northward of the site comprised silty sand with some gravel and angular cobble size particles. Town of Ladysmith staff noted that this general area had been considered as a reservoir site in a previous study.

Contact Tank Reservoir Area

The potential reservoir site in the area of the existing contact tank was an area heavily forested with predominantly conifers having trunk diameters in the order of 300 to 400mm with a fern understorey. The general area sloped gently down towards the north at approximately 10 to 15° from horizontal. Frequent angular rock pieces were noted on the ground surface.

An exposure of compact sand and gravel with subangular to angular particles was noted in the immediate area. A soil exposure in a nearby road cut slope showed approximately 1m thickness of sand and gravel overlying clean, fine to medium grained sand.

Balancing Reservoir Area

The potential reservoir site in the vicinity of the existing balancing reservoir was in an area of moderately dense conifer forest. The topography of the general area was variable, ranging from relatively flat in the immediate area of the existing balancing reservoir, with local slopes in adjacent areas up to approximately 20° from horizontal.

A soil exposure observed on the eastern side of the access road in the immediate area comprised silty/clayey sand with some angular gravel, cobbles and small boulders.

Geotechnical Considerations

Surficial observations made during the site reconnaissance were in general agreement with the published geological mapping that was obtained. Based on the information reviewed and our site observations, the potential reservoir sites 1 and 2 in the northern study area are most likely to have favorable near surface foundation conditions comprised of glacial till or bedrock at relatively shallow depth. The other sites are also considered geotechnically suitable but may require greater site preparation.

Surficial soils at the other three potential sites (northern area Site 3, Contact Tank Area and Balancing Reservoir Area) appear to be comprised of variable colluvial materials that can have variable performance as foundation materials. Accordingly, some overexcavation of the colluvial material with possible construction of a structural fill pad should be anticipated. The

amount of foundation preparation will be dependant upon the nature and thickness of the colluvium and the design tolerances and expectations of the reservoir. If the reservoirs are to be considered as post disaster structures, then the amount of foundation preparation work may increase.

The potential reservoir sites 2 and 3 at the northern study area would require extensive cutting to provide a level foundation area. The naturally occurring colluvial materials are unlikely to be suitable for reuse as structural fill in a cut and fill arrangement for leveling a foundation area. Blasted rock may be suitable for reuse as structural fill, if appropriately graded. In general, it would be geotechnically preferable to found the reservoir entirely on native ground or on a uniform thickness of structural fill, rather than on a cut/fill scenario.

No observations were made to suggest that the rock slopes observed below Site 2 in the Northern Area were unstable. However, rock discontinuity mapping of the proposed reservoir site should be conducted if this site is selected for detailed design. Further slope stability assessment of the Northern Area Site 3 should be conducted if that site is selected.

Construction equipment access to the potential sites 2 and 3 in the northern study area may also be problematic, due to their distance from existing roads and relatively steep local grades.

The Ladysmith area is located within one of the most seismically active areas of Canada. Predicted peak ground acceleration values (PGA) established by the Pacific Geoscience Centre are expected to be in the order of 0.25g for the 1:475 year earthquake. In the event that the structure is designed as "post disaster", PGA design values may be closer to 0.4g (1 in 1000 year design earthquake). A site specific value should be determined once the site has been selected. However, based on observations, liquefaction or particularly adverse ground response is not expected at any of the sites in the north or south areas.

In light of the above, we consider the potential reservoir site at Northern Study Area Site 1 to be the geotechnically simplest site to develop. However, it should be possible to locate the proposed reservoir at any of other observed sites with increased subgrade preparation effort and construction access issues, provided slope stability assessment results are favourable. Detailed geotechnical recommendations for site preparation and foundation design could be provided once the preferred site is selected and site specific subsurface investigation has been conducted. Levelton would be pleased to provide a proposal for site specific subsurface investigation on request.

Summary

The geotechnical considerations discussed above are summarized in the following table:

Summary of Geotechnical Considerations	
Potential Reservoir Area	Geotechnical Considerations
Northern Area 1	• Probable good foundation materials and shallow depth
Northern Area 2	• Relatively steep rock slopes may make difficult construction access • Large cut may be required to develop level subgrade • Rock discontinuity mapping should be conducted to fine tune siting
Northern Area 3	• Potentially variable colluvial foundation materials may require improvement and/or removal • Slope stability assessment should be conducted • Greater distance from existing roads than the other potential sites
Southern Contact Tank Area	• Potentially variable colluvial foundation materials may require improvement and/or removal
Southern Balancing Reservoir Area	• Potentially variable colluvial foundation materials may require improvement and/or removal

Closure

This report has been prepared by Levelton Engineering Ltd. exclusively for Earth Tech Consulting Ltd. in accordance with standard geotechnical engineering practices. No other warrantee, expressed or implied, is made.

Any use of this report by a non-authorized third party, or any reliance on, decisions made, or actions taken based on it by third parties are the responsibility of such third parties. Levelton does not accept responsibility for damages suffered, if any, by a non-authorized third party as a result of their use of this report.

The recommendations contained in this report are based on review of existing information and surficial observations of the project area. Levelton did not conduct any subsurface investigation for this project. Actual subsurface conditions may vary across the site. The results of the assessment are based on inferred conditions and may be modified with site specific information collected from the site.

LEVELTON
Engineering Solutions

We appreciate the opportunity to conduct this geotechnical assessment and trust this information meets your immediate requirements. If you have any questions or require further information, please contact our office at your convenience.

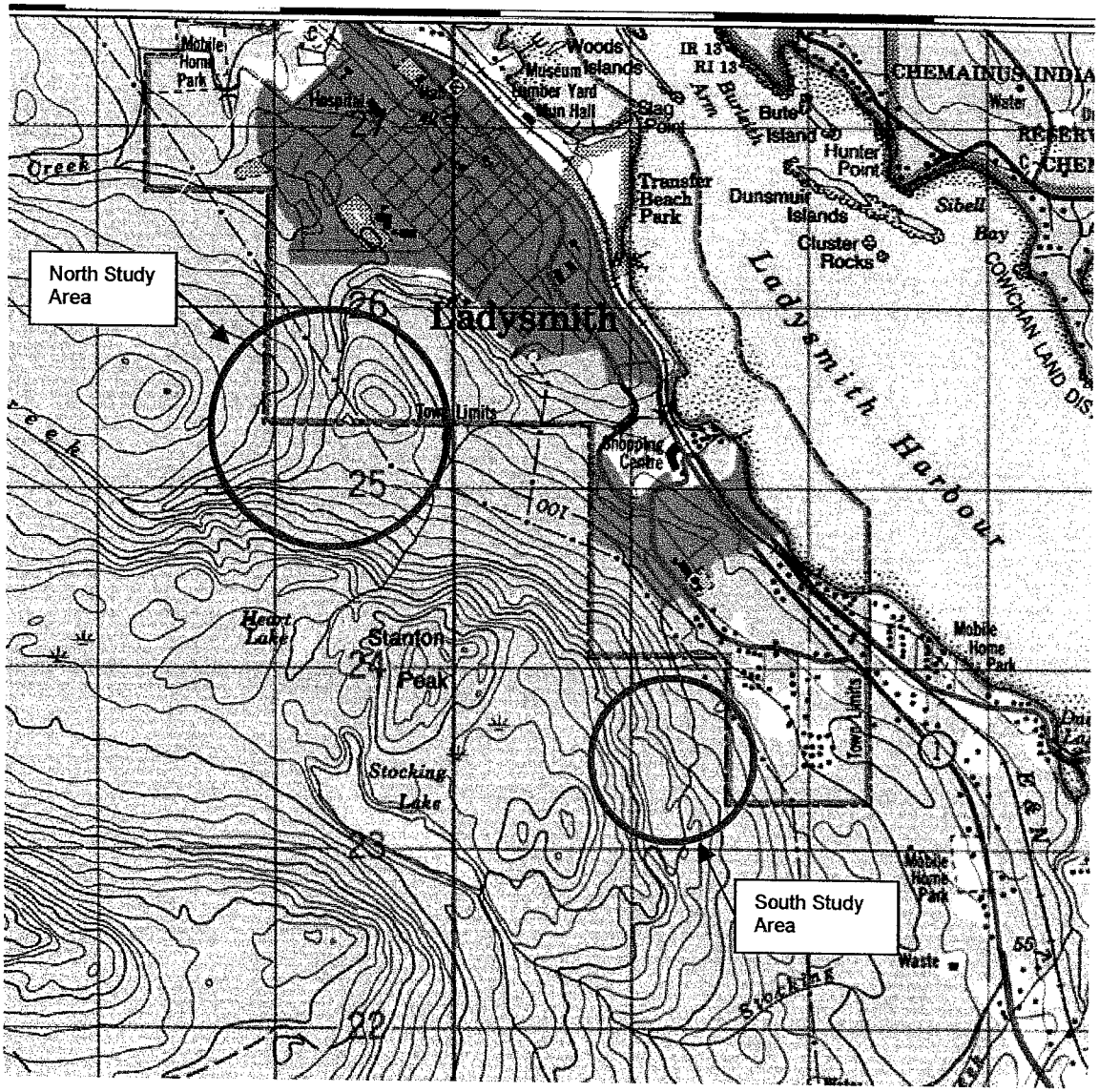
Yours truly,
LEVELTON ENGINEERING LTD.

PROFESSIONAL ENGINEER
PROVINCE OF BRITISH COLUMBIA
R.R. SIMPSON

Richard Simpson, P.Eng.
Geotechnical Engineer

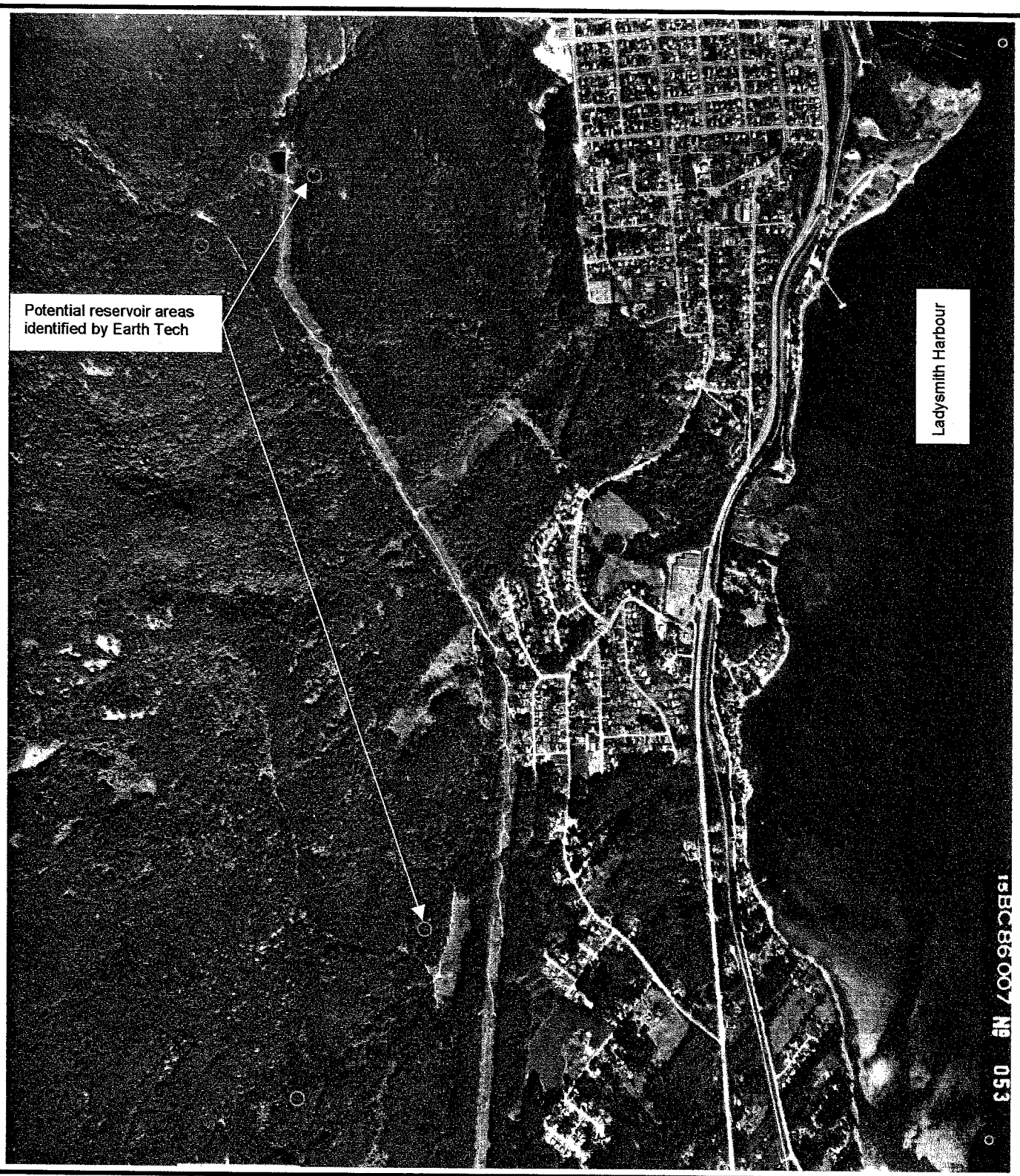
Reviewed by: Carl Miller, M.Sc., P.Eng.
Senior Geotechnical Engineer

Attachments: Figure 1 – Study Area Location Plan
Figure 2 – 1986 Aerial Photograph
Figure 3 – Topographic Plan of North Study Area
Figure 4 – Topographic Plan of South Study Area



LEVELTON Engineering Solutions	PROJECT: Preliminary Geotechnical Overview				
	TITLE: Town of Ladysmith Water Supply and Distribution Predesign Study Study Area Location Plan				
	CLIENT: Earth Tech Consulting Ltd.				
DRAWING NO.: Figure 1	DATE: Oct 2002	FILE NO.: 602-0236	SCALE: NTS	DRAWN BY:	REV NO.:

Levelton Engineering Ltd., 1935 Bollinger Road, Nanaimo, B.C., V9S 5W9 Phone: 250/753-1077 Fax: 250/753-1203 Email: nanaimo@levelton.com



LEVELTON Engineering Solutions	PROJECT: Preliminary Geotechnical Overview				
	TITLE: Town of Ladysmith Water Supply and Distribution Predesign Study Aerial photograph - 1986				
	CLIENT: Earth Tech Consulting Ltd.				
DRAWING NO.: Figure 2	DATE: Oct 2002	FILE NO.: 602-0236	SCALE: NTS	DRAWN BY:	REV NO.:

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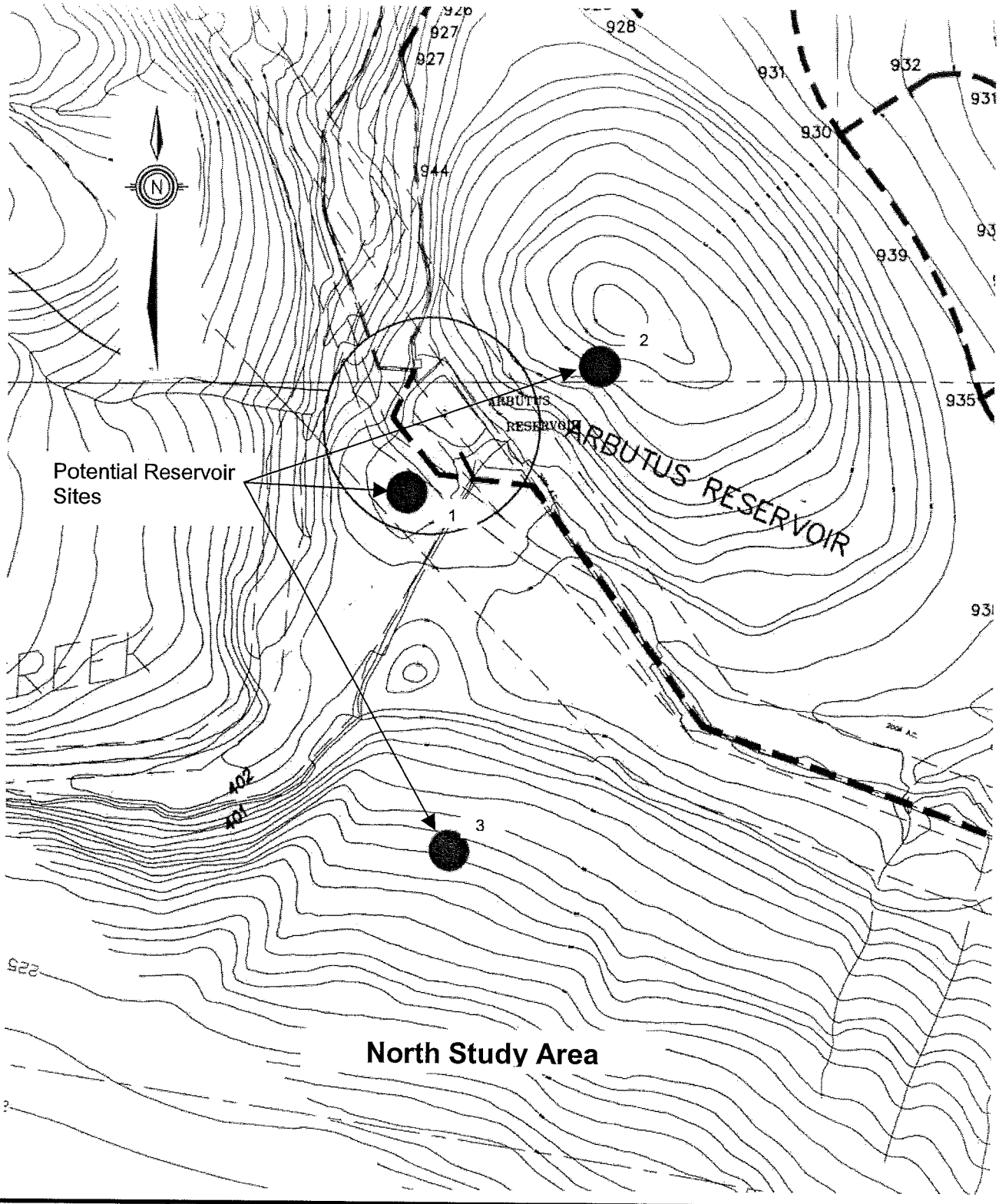

LEVELTON Engineering Solutions	PROJECT: Preliminary Geotechnical Overview				
	TITLE: Town of Ladysmith Water Supply and Distribution Predesign Study North Study Area				
	CLIENT: Earth Tech Consulting Ltd.				
DRAWING NO.: Figure 3	DATE: Oct 2002	FILE NO.: 602-0236	SCALE: NTS	DRAWN BY:	REV NO.:

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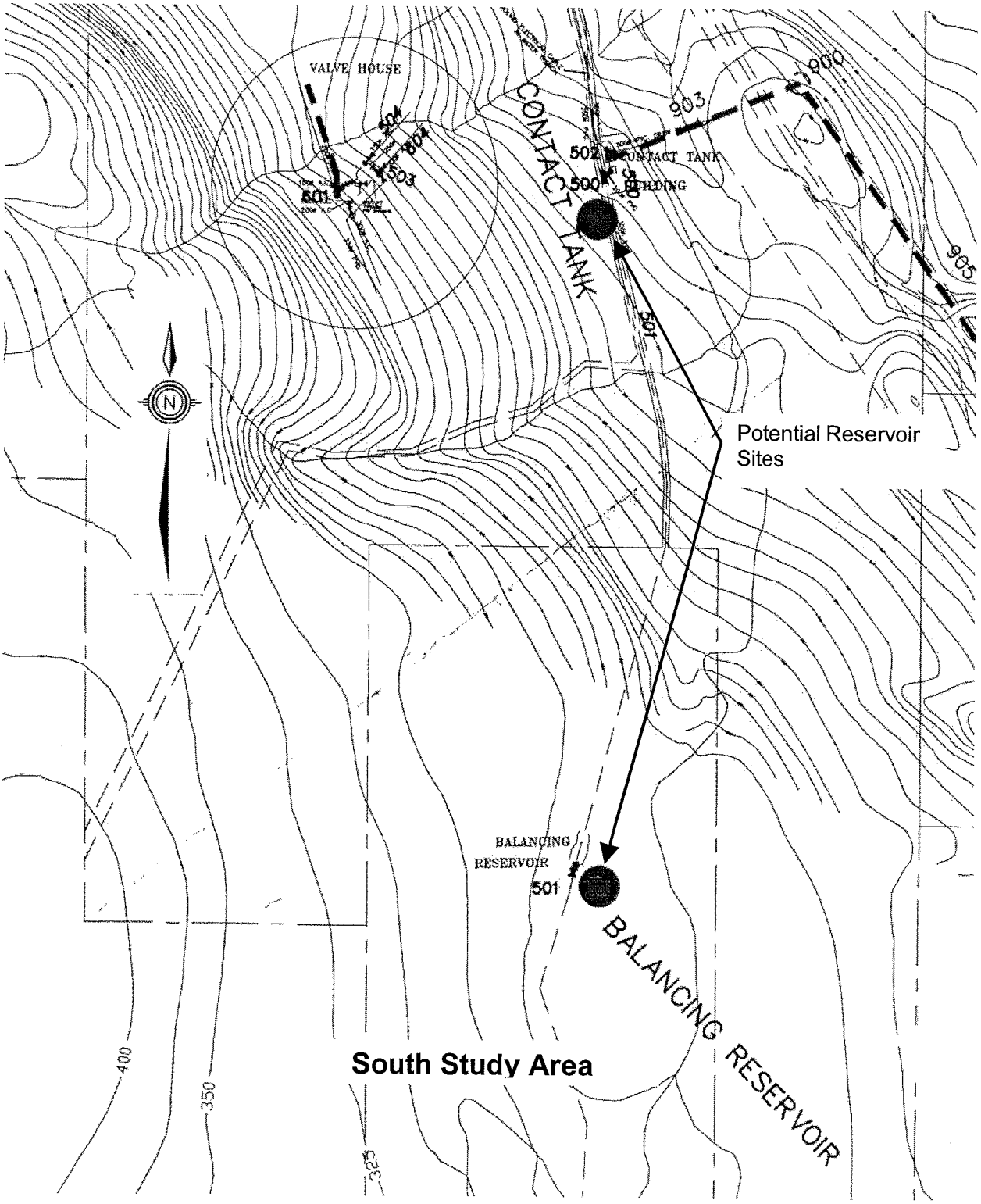

LEVELTON Engineering Solutions	PROJECT: Preliminary Geotechnical Overview				
	TITLE: Town of Ladysmith Water Supply and Distribution Predesign Study North Study Area				
	CLIENT: Earth Tech Consulting Ltd.				
DRAWING NO.: Figure 4	DATE: Oct 2002	FILE NO.: 602-0236	SCALE: NTS	DRAWN BY:	REV NO.:

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