MERIT ENGINEERING INC.

GEOTECHNICAL FEASIBILITY STUDY

Samish Way Urban Village
Vicinity of Samish Way
Bellingham, Washington 98225

Prepared For:

Darby Galligan
City of Bellingham:
Planning and Community Development
210 Lottie Street
Bellingham, WA 98225

October 10th, 2008
Project No. PH0112614

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2004 ACEC Washington Gold Award Recipient Engineering Excellence

Darby Galligan
City of Bellingham: Planning and Community Development
210 Lottie Street
Bellingham, WA 98225

Re: Feasibility Study - Urban Planning
Samish Way Urban Village
Vicinity of Samish Way
Bellingham, Washington 98225

Dear Darby:

At your request, we have conducted a feasibility study for the above referenced project. The following report represents the results of our literature review and field study and derives conclusions on the feasibility of development on the site.

Thank you for this opportunity to work with you on this project. Please contact us if you have any questions about this report.

Sincerely,

Austin X. Huang, Ph.D., P.E., L.G., F.ASCE
Principal

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1. INTRODUCTION

Darby Galligan of the City of Bellingham Planning and Community Development Department in Bellingham, Washington requested Merit Engineering, Inc. to conduct a preliminary geotechnical feasibility study for the proposed Samish Way Urban Village. The proposed project is intended to change the zoning and development regulations to allow redevelopment of the area along Samish Way between Byron Ave and East Maple Street, with a revised transportation layout as well as new residential and commercial structures design standards. We are informed that the current proposal considers construction of new up to seven-story buildings with possible two-story underground parking structures. We also understand development may include multiple large stormwater ponds, as well as shallow infiltration gardens incorporated into proposed reconstruction of Samish Way. We have been requested to evaluate general project feasibility along with special attention to these several key elements. In the Appendix, the project location and vicinity is shown in Figure 1 and a proposed site development map is shown in Figure 2.

The purpose of this study was to conduct an in depth literature review and interpretation of available documents pertaining to past and existing soil, bedrock, and groundwater conditions in the project area. The primary objective of this study was to address the feasibility of development components including underground parking and stormwater infiltration capability based on soils, bedrock depth, and depth to groundwater information acquired during our literature review. The secondary objective was to provide recommendations for further work based on our preliminary interpretations of feasibility for the proposed Samish Way Urban Village.

2. SCOPE

The scope of work for this study has included:

- Reviewing available documents regarding soil, bedrock and groundwater conditions;
- Conducting 5 hand-auger test pits to a maximum depth of 3.25´, logging subsurface soil and groundwater conditions;
- Addressing the following topics in this geotechnical engineering feasibility report:

  (1) Surface conditions,

(2) Subsurface soil conditions,
(3) Bedrock conditions,
(4) Surface and groundwater conditions,
(5) Critical area concerns, and
(6) Feasibility of the site for proposed development with the following topics:
- ◇ engineering and construction properties of site soils,
- ◇ depth to bedrock and groundwater in relation to proposed infiltration and underground parking facilities, and,
- ◇ recommendations for further work.

3. SITE INVESTIGATION

3.1 General Site Conditions

The proposed area of development is located in Bellingham, Washington within Section 31 of Township 38 North, Range 3 East. It encompasses an area along the west side of I-5 from Byron Avenue/Bill McDonald Parkway in the south, continuing to Edwards Street/Ellis Street in the north. The area is flanked by the I-5 corridor to the east and extends west to approximately 34th street. It is located just east of the Sehome Hill Arboretum and neighboring residential zone. Currently, the area contains abundant commercial and residential developments and the vast majority of the site is covered by impervious surface. Along Samish Way, businesses include gas stations, hotels, restaurants, and retail establishments. To the west and north/northwest within the study area are primarily residential areas with single-family homes and small apartment buildings. The vast majority of the subject area is developed and currently in use. Most residential and commercial structures are surrounded by roads and/or parking lots, so the total area of exposed vegetated ground near Samish Way is relatively low. A schematic site overview including major project area components overlaying local streets is provided in Figure 2. This general layout as illustrated in the attached site plan was provided by the City of Bellingham at the time of this investigation.

Topographically speaking, in general the site slopes gently to the south from Edwards Street at its north end and to the east from 34th Street at an overall low grade, with some areas of rolling surface. Along Samish Way itself, the road consistently loses elevation from north to south at an estimated average grade of less than 5%. South of the intersection with Byron Avenue/Bill McDonald Parkway, the Samish Way corridor undergoes an approximately 30´ elevation gain

over about 400´ to accommodate the freeway undercrossing. From the same intersection, Byron Avenue slopes down gently to the east then levels out.

3.2 Literature Review - Subsurface Conditions

Near-surface soil and bedrock conditions in the project area are referenced from the *Soil Survey of Whatcom County Area* (1992) issued by the U.S. Department of Agriculture's (USDA) Soil Conservation Service. The Survey indicates five (5) soil groups present as mapped across and nearby the site: Chuckanut - Urban Land Complex, Nati Loam, Squalicum Gravelly Loam, Squalicum-Urban Land Complex, and Urban Land-Whatcom-Labounty Complex. A map showing boundaries of each soil group is portrayed in Figure 3. Generalized soil and engineering properties per group are presented as tabled data in Figure 4 in the Appendix. Each profile outlines soil and/or bedrock conditions to a maximum depth of 5´.

Additional sources of documented soil and bedrock conditions were researched by reviewing resource protection well logs from the Washington State Department of Ecology (WA DoE), geotechnical test borings from the Washington State Department of Transportation (WSDOT), geotechnical reports from past developments in the project area, and environmental cleanup reports from sites with leaking underground storage tanks in the project area.

Within the project area, native soils in the *Soil Survey* (SCS, 1992) are described as primarily loam to gravelly loam, consisting of a mixture of gravel-sand-silt material, variably coherent or cemented. Prominent soil types identified by other sources (well logs, geotechnical borings, past reports) in turn generally classify a local abundance of gravelly sand to sand-silt mixture soils. Some documents also suggest sporadic occurrences of stiff brown to gray clay lenses or localized units near the surface. Well logs and test borings characterize the gravelly sand and sand-silt mix as dense or stiff to very dense/stiff. From this review of existing data, we expect shallow soils to be dominantly loam throughout the subject property.

Based on *Soil Survey* (SCS, 1992) data, soil groups present beneath the vast majority of the project area may be underlain at shallow depths by dense-compacted glacial till or sandstone bedrock (Figure 4). The most dominant soil group (Chuckanut - Urban Land Complex, #29) is recorded to reach sandstone bedrock at a likely depth of 4´ beneath the gravelly loam cover.

This group is mapped covering the northern 2/3 of the study area. The southern 1/3 is dominated by Squalicum - Urban Land Complex (#159), reportedly underlain by dense glacial till by ~4´ depth on average. Of course, the large majority of developed land in the project area (and thus covered conditions) may hinder a more detailed understanding of basal conditions as given in the *Soil Survey* (SCS, 1992).

We again consulted multiple additional sources as described above to better delineate actual bedrock occurrence in the project area. Bedrock in the area consists of Chuckanut Sandstone (TKc), according to the Geologic Map of Western Whatcom County, Washington (Easterbrook, 1976). Locations and known bedrock depths from our compiled research of existing documentation are shown in Figure 5. A large-scale schematic cross-section along Samish Way through the project area is given in Figure 6 in the Appendix; the cross-section was extrapolated based on gathered existing data shown in Figure 5. Considering *Soil Survey* (1992) information and supplemental data, it is apparent that depth to sandstone bedrock varies from near-surface to (greater than 25´) >25´ within the project area. It is expected that the sandstone surface is variable on a local level, as is common for this region. The zone with greatest density of bedrock data (between Byron and Consolidation Avenues) shows large local variation ranging from 1´-26´ depth within a single block. Further north along Samish Way existing data is scarce with only two points available. In the specific area of proposed underground parking one well log documents bedrock depth >18´; a depth of >15´ is recorded to the north by Abbot Street. Bedrock may in general be deeper in this middle to northern part of the study area versus the southern 1/3, but a lack of existing data hinders further interpretation. It is possible that bedrock varies to shallow depths in this portion as well. According to past testing by Merit Engineering, bedrock appears to reside at a relatively shallow 3´-6´ below ground surface in the residential area bordering the site to the northwest.

3.3 Literature Review - Groundwater Conditions

Existing literature and data logs were consulted for information on groundwater occurrence within the project vicinity. According to the *Soil Survey* (SCS, 1992), some portions of the study area may experience high winter groundwater levels (Figure 4). The southern 1/3 (Squalicum - Urban Land Complex #159) is anticipated to have seasonal high groundwater

levels between 3´-5´. Note that this unit is underlain by glacial till of very slow permeability. At the southern edge of the site area in the Whatcom-Labounty Complex (#172) water levels may be as shallow as 1´-3´ in winter months. The laterally expansive unit of Chuckanut Complex in the northern 2/3 of the site is not listed to have consistently high winter groundwater within 5´ depth, and is expected to drain well according to the *Soil Survey* (SCS, 1992). However, shallow bedrock may lead to localized perched water or areas of seepage within this unit especially in low-lying areas.

Past well logs and geotechnical test borings within the project area were consulted to complement soil data. Figure 7 displays the existing data by location and designates wet season (November - May) versus dry season (June - October) recordings. Most of the data, including all southern and central locations, were collected in summer months; depth to water ranges from 5´-10´ to 20´ or greater. But as stated in the *Soil Survey* (SCS, 1992), water levels may be within 5´ of the surface in the winter. One north-central test location near Abbot Street records water at 6´ depth in the wet season, which may be indicative of overall winter conditions in much of the project site. Previous investigations by Merit Engineering just northwest of the site in the Laurel Street neighborhood recorded shallow perched seasonal groundwater at a consistent 1´-3´ depth. In the project area, local water table depths may be dependent on depth to bedrock or dense till, amount of seasonal precipitation and time of year, and permeability/percolation rates of the site soils.

3.4 Results of Field Testing

We performed field hand-auger tests on September 10, 2008 to observe subsurface conditions for soil infiltration estimation. The amount and locations of test pits were chosen by the City of Bellingham for accessibility and regional coverage in conference with Merit Engineering prior to testing. In total, five (5) test pits were conducted spread around the main site area as shown in the site plan (Figure 2). Procedure for test pit excavation included soil sample collection, pocket penetrometer readings, and logging of soil and groundwater conditions. Due to the specific limitations of hand-augering, test pits were attempted to a maximum depth of ~3´ or until refusal on hard soil/bedrock. Test pit results are presented as soil logs in the Appendix (Figures 9 through 13) of this report. Descriptions of soil symbols and classifications used in

this report also are presented in the Appendix (Figure 8).

The preliminary field investigation generally confirms soil conditions as detailed in the *Soil Survey* (SCS, 1992) with some local variation noted. Soil was observed to vary from a loose sand-silt mixture to a dense, cemented gravel-sand-silt. At the southwest end of the site, TP-6 located on a forested hillside was the deepest augered pit, extending past 3´ through loose to moderately dense silt-sand soils. TP-5, TP-4, and TP-2 were spaced throughout the site but were all located on the main plateau level that encompasses the Samish Way corridor. In these test locations, we encountered early refusal by 1´-1.25´ depth due to a dense, cemented silt loam to gravelly loam subsoil beneath thin topsoil. In TP-5 soils appeared to become more of a silt-sand mixture beneath the hard upper horizon, similar to soils seen in TP-6. Within TP-3 on the eastern downslope edge of the project area adjacent to I-5, moderately dense gravel-sand-silt mixture soils were also observed within a sloped forest setting (like in TP-6). Refusal was encountered by ~1.5´ depth in TP-3 on what appeared to be weathered sandstone bedrock. This eastern slope may be defined by shallow bedrock below thin cover soil.

Our field tests were completed in early September at the end of the summer season when conditions were comparatively very dry. We observed no groundwater in the test holes or surface water near the test sites. Mottling was documented where observed to give an indication of winter conditions. In TP-3 we observed light mottling and rust coloration at ~1´ depth just above the weathered bedrock contact. Because the location is moderately sloped, this feature is likely from shallow transient temporary groundwater flow atop bedrock during storm events. In TP-5 we documented light rust spotting at less than 1´ depth in the cemented silt horizon; mottling was not present in the underlying layer so this may be a local perched water/slow infiltration feature. Evidence of groundwater and mottling was absent from the shallow cemented silt soils in TP-2 and TP-4. Mottling was also absent from the relatively permeable TP-6 soils to >3´ depth. Our test pits, along with literature information, indicate shallow groundwater is present at least in places within the study area. Local topography and development varies enough across the area that water presence and depth is difficult to predict on a smaller scale without more detailed information or testing.

3.5 Critical Areas

Various sources are referenced in order to determine possible critical areas associated with the subject property. Geologic hazards such as landslide potential, erosion potential, seismic hazards, volcanic hazards, mining hazards and potential flooded areas are investigated. The **2005 Whatcom County Critical Areas Ordinance (CAO), Articles III and IV** are referenced to determine landslide potential (moderate 15-35% and steep >35%), seismic/geologic, seismic/manmade, alluvial fan, mine hazards, and frequently flooded (FEMA 100-year base flood) critical areas at the subject property.

According to CAO articles III and IV, the site is not located within a landslide or volcanic hazard area. Referencing the CAO Geologically Hazardous Areas Map, the Liquefaction Susceptibility for this area is considered 'very low to low' and the area is located within Site Class C-D on the Potential for Enhanced Ground Shaking map. Referencing the Department of Natural Resources "Site Class Map of Whatcom County", with increased amplification of ground shaking, site classes are rated from B (low) to F (high). Site class maps provide a general guide to areas where shaking will be the strongest and where potential damage to buildings and other structures may be elevated because of soil effects. Site Class C represents shear wave velocities in the upper 100 feet ranging from 2500 ft/sec to 1200 ft/sec. This represents a rock-soil category of very dense soil and soft rock. Site class D represents a stiff soil profile with shear wave velocities ranging from 1200 ft/sec to 600 ft/sec.

According to the Geologic Hazard Areas Map Folio of Bellingham, Washington (De Chant, Fox, 1991), the project area is not located within a volcanically hazardous area. The nearest mining hazard area identified is from the Sehome mine and is located approximately one-half mile northwest of the northern proposed project area boundary. No other documents identified mining hazards any closer to the subject area.

4. DISCUSSION ON SUBSURFACE CONDITIONS

4.1 Engineering Significant Properties of Soils

A breakdown of pertinent engineering and hydrologic properties for each soil formation

described in the *Soil Survey* (SCS, 1992) is portrayed below in Table 4-1.

Table 4-1. Engineering Properties of Soil - from various tables in *Soil Survey* (SCS, 1992)

Soil Type	*Construction Feasibility*		*Hydrologic Parameters*		
	Limiting Degree	**Limiting Factors**	**Hydrologic Group**	**Permeability (in/hr)**	**Limiting Degree: Limitations**
Chuckanut - Urban Land (#29)	Moderate to Severe	Slope	**B**	0-48": 0.6-2.0 48+": ---	**Moderate - Severe:** Percs slowly, shallow depth to bedrock
Nati Loam (#110)	Severe	Slope	**C**	0-38": 0.6-2.0 38+": ---	**Moderate - Severe:** Percs slowly, shallow depth to bedrock
Squalicum Soils (#156 & 159)	Moderate to Severe	Wetness, slope	**B**	0-44": 0.6-2.0 44+": ---	**Moderate - Severe:** High water table, wetness, percs slowly, shallow depth to restricting layer
Urban Land -Whatcom-Labounty (#172)	Moderate to Severe	Wetness, shrink-swell, slope	**C**-(What) **D**-(Lab)	0-16": 0.6-2.0 16-60": 0.2-0.6	**Moderate - Severe:** High water table, wetness, percs slowly

A complete summary of soil conditions and engineering specific soil properties are presented in table form as Figure 4 in the Appendix of this report.

4.2 Impact of Subsurface Conditions on Structures

We understand development plans for the Samish Way Urban Village call for up to seven-story complexes within the core mixed-use and commercial transition areas. Proposed development plans also call for two-story underground parking beneath buildings in all of the core mixed-use and commercial transition areas, depending on feasibility. Based on the limited amount of data available from well logs and test borings within the northernmost commercial transition zone and the core mixed use area, the most basic interpretation is that the development of underground parking structures may be feasible in these area. In contrast, the southernmost commercial transition area features an abundant amount of bedrock data west of Samish Way. However, because of the almost complete lack of data elsewhere we cannot accurately portray the bedrock profile within the northern 2/3 of the site at this time. The one datum point available in the core mixed-use area documents no bedrock encountered by 18´ depth; a second point in the commercial transition area to the north shows a similar trend with

bedrock absent to 15´+ depth (Figure 6). This data, although sparse, is encouraging for feasibility of the structure in general, but is much too limited to provide even preliminary conclusions regarding depth to bedrock in the section.

In contrast, other available information raises concern for the possibility of shallow bedrock which could hinder underground parking development. Bedrock in all commercial transition and core mixed-use areas may exhibit similar behavior to the section of the site west of Samish Way between Byron Avenue and Consolidation Avenue (Figure 5). We see from a cluster of borings in the southern area that bedrock depth varies from greater than 20´ to no more than 1´ below ground surface within a relatively small area. This particular area, classified as Squalicum soil by the *Soil Survey* (SCS, 1992) is described as having a "typical" soil profile which does not encounter bedrock to a depth of 5´, yet bedrock is known to vary more widely. In the vicinity of proposed underground parking, Chuckanut soils are said to be underlain by bedrock at an average of 4´ depth (SCS, 1992), which is inconsistent with the sparse field data.

As evidenced by this discussion and contradictions, further field work is necessary to ascertain an accurate interpretation of bedrock conditions in order to address the feasibility of this development. Please see the below Section 5.2 regarding recommendations for future work.

4.3 Impact of Subsurface Conditions on Stormwater Ponds & Infiltration

We also understand at this time that stormwater retention ponds are proposed to be installed within the development. Currently the schematic drawing of proposed plans provided to us by the City of Bellingham show two (2) locations for stormwater ponds, both along the eastern edge of the proposed core mixed-use area near I-5. We were informed these locations are tentative, however, and subject to change based in part upon the results of this study. Also proposed at this time are shallow infiltration facilities, rain gardens or similar system, along or within the Samish Way corridor. Both of these stormwater-related facilities will be impacted by native subsurface conditions identified in this study.

For the stormwater ponds, we currently focus on constructability concerns because design and operation information is not available to our knowledge. The primary concern with development of the ponds from a geotechnical standpoint is the possible shallow depth to bedrock in the

proposed locations. Echoing the above discussion on bedrock for underground parking feasibility, it is not possible at this time to reliably evaluate where bedrock is present shallowly and at what depth it can be found beneath proposed pond areas. We found no existing field data present in the vicinity of proposed ponds. The two boring locations with confirmed deeper bedrock are separated far enough from the ponds as to not be reliably correlatable in our opinion (Figure 5). The only spatially applicable literature data is from the *Soil Survey* (SCS, 1992) which documents bedrock at an average of 4´ depth below Chuckanut soils, but our previous section calls into question the consistency of bedrock presence given the variability in field data. In our hand-auger test pit survey we conducted one shallow field test in the pond area (TP-3 in Figure 10). We encountered what looked to be weathered sandstone bedrock by ~1.5´ depth on the moderate slopeside just east of the northern proposed pond area. Uphill from the test location at the edge of the plateau where the pond is likely to be placed bedrock may or may not deepen, but from our single test it appears the eastern slope is defined by shallow bedrock so it is likely still relatively shallow uphill. As far as pond area soils are concerned, we anticipate gravelly loam to loam will reside above bedrock. This material may be suitable for infiltration depending on design needs, and conversely is not expected to be suitable for water retainment purposes. If detention is planned, a clay liner and/or impermeable manufactured lining will most likely be needed.

Shallow infiltration facilities such as rain gardens, trenches, or wells are mostly affected by low infiltration rate of native soils, shallow depth to impermeable formations, and shallow groundwater conditions. The typical soil descriptions outlined by the *Soil Survey* (SCS, 1992) and substantiated by our field tests suggest that all three mitigating features exist throughout the project area in each significant soil formation. Concentrating on the Samish Way corridor, the two soil groups most present are the Chuckanut and Squalicum complexes. Both soils are composed generally of gravelly loam, expected to display moderate to moderately slow permeability with areas of lower permeability due to local cementation. Basal features of sandstone (Chuckanut, north area) or glacial till (Squalicum, south end) if present near the proposed infiltration depth can greatly reduce infiltration capability by direct interference or by causing local mounding in flat areas. Both features are documented at the average depth of ~4´ in the *Soil Survey* (SCS, 1992) although field data shows more variation and areas of deeper

soils. The Squalicum complex is also recorded to exhibit shallow wet season groundwater conditions, with the water table up to 3.5´ depth. Chuckanut soils are not documented to display seasonal groundwater within 5´ of the surface, but our past local test experience suggests at least local perched groundwater can occur above shallow sandstone near the study area (Figure 7). Ultimately the feasibility and functionality of shallow infiltration will depend on all these factors, which tend to vary locally especially across a study area of this size.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Comments on Project Feasibility

We conclude, based on this investigation, that the site may be feasible for the proposed project from the point of view of geotechnical engineering, although, more information is needed for full interpretation specific to certain development components.

In regards to the possibility of installing 2-story underground parking complexes, it is our opinion that the areas proposed for this development may be feasible depending mostly on actual depth-to-bedrock in the building area. The sparse data available for the proposed locations, with the exception of data west of Samish Way between Consolidation and Byron Avenue, suggests bedrock may be deep enough (greater than 15´-20´ depth) to allow for 1 to 2 stories of underground development without great excavation difficulty, but data is too limited to provide actual interpretation at this time. Seasonal groundwater presence at relatively shallow levels may also present issues for underground parking design and should therefore be considered along with soil and bedrock factors.

Stormwater ponds may also be feasible under the current proposed plan depending mostly on actual subsurface conditions that at this time are largely unknown due to the lack of literature and field data. Again, the largest limiting factor for pond construction appears to be the possibility of shallow or variable depth to bedrock. Secondary limiting factors include possible shallow seasonal groundwater, and the applicability of native soil conditions to pond construction. These criteria should be evaluated in conjunction with pond design.

Concerning on-site infiltration, feasibility for a given proposed location will depend greatly on

actual local conditions. The literature data and our substantiating field testing provide an average overview of anticipated soil conditions and limiting factors. But we find very often that local variations can outweigh average interpretations of conditions for infiltration, and thus can result in either better or more limited effectiveness for infiltrating stormwater. Our initial interpretation is that rain gardens or similar infiltration facilities may be feasible for the project area, but limiting factors discussed herein may be problematic. Design of such structures should be mindful of the limiting issues and possibility of local variation; field testing and resulting revisions should be anticipated.

5.2 Recommendations for Further Study

As discussed above, the existing literature data we have acquired during this preliminary study is limited in many portions and virtually absent in other portions of the project area. Additional field data and analysis is greatly needed to fully address the feasibility of underground parking and stormwater facilities specifically. Given the necessity to ascertain accurate depth to bedrock in the proposed areas for underground parking and ponds, as well as specific hydrologic characteristics of soils and subsurface conditions in areas proposed for stormwater ponds or infiltration gardens, we recommend that a full-scale geotechnical investigation or multiple investigations be conducted for chosen areas of the site. Further study should be directed specifically towards evaluating the feasibility and limitations of these components of the Samish Urban Village for the proposal and design phase of the project.

The underground parking facilities as currently proposed will reside up to two stories, or approximately 20´, below ground surface after construction. Therefore, we recommend that geotechnical test borings should be included in the scope of a detailed subsurface site investigation, and should be drilled to a minimum depth of 30´, or at least 10´ coring into bedrock. Test boring locations and amount should be determined to adequately cover the sites of the underground parking facilities, and should be organized in multiple transects as permitted to create an accurate depth to bedrock profile. Such investigation will also be helpful by allowing analysis of deeper soil and groundwater conditions (if present) at and below footing grade for the large proposed structures, and in turn will contribute to preliminary recommendations for appropriate foundations to support the seven story building.

A more thorough geotechnical investigation is also needed for reliable evaluation of proposed pond areas for similar reasons. We anticipate, depending on pond design, that initial study may be accomplished by backhoe or excavator to observe soils at and past the pond base depth. In this study, adequate separation from bedrock can also be verified on the local level. Seasonal high groundwater conditions should be documented, preferably directly by performing tests during the wet season. Properties of soils crucial to pond design must be verified by field and laboratory testing.

We recommend thorough testing be completed to ensure the applicability and performance of infiltration facilities. Field tests should include test pits past proposed infiltration depth by backhoe or hand-auger as necessary to categorize soils, local variations, and depth to limiting layers or groundwater, as well as shallow and/or deeper percolation tests to observe and verify field infiltration capabilities of native soils. Significant soils should be laboratory tested by gradation analysis to determine/verify long-term infiltration rates according to Washington State Department of Ecology requirements. These methods are crucial to identifying any issues with design standards versus general field conditions or local variations within areas proposed for infiltration use. Thorough testing also provides a level of quality assurance for operation of the facility not otherwise attained.

6. GENERAL CONDITIONS

This report is based on our understanding of the project at this time through literature review as well as a site investigation that included 5 hand-augered tests pits on September 10th, 2008.

We recommend that further comprehensive geotechnical investigation(s) be completed for design and construction of specific site improvements and for site earthwork. Geotechnical investigations should address concerns discussed herein.

This report has been prepared for Darby Galligan at the City of Bellingham Planning and Community Development Department for the specific application of the Proposed Samish Way Urban Village. The property is located in Section 31, Township 38 North, Range 3 East, in the city of Bellingham, Whatcom County, Washington. In the Appendix, the project location and vicinity is shown in Figure 1 and the site plan is shown in Figure 2. This report has been

completed in accordance with generally accepted geological engineering practices in this area. No other warranty, expressed or implied, is made.

Neither Merit Engineering, Inc. nor anyone in Merit Engineering, Inc. has any financial interest in this project, or the client's organization, or the other parties involved in this case, except for this study.

This report is an instrument of our professional service, and we (Merit Engineering, Inc.) shall retain an ownership and property interest therein. We grant Darby Galligan and the City of Bellingham Planning and Community Development Department a license to use the report for the purpose of determining the feasibility of the Samish Way Urban Village project. We do not permit reuse or modification of this document for application to a different site or to another property because soil and subsurface conditions are unique and site specific for different locations.

REFERENCES

Easterbrook, D.J., Geologic Map of Western Whatcom County, Washington, *United States Geological Survey,* 1976.

Environmental Resolutions, Inc., 2007. *Confirmation Boring and Soil Sampling, Former Mobil Gas Station 99-BWA, 140 South Samish Way, Bellingham, Washington.*

GN Northern, Inc., 2001, *Geotechnical Engineering Report - McDonald's Restaurant Site, 112 Samish Way, Bellingham, Washington,* Project No.: 201-896.

United States Department of Agriculture - Soil Conservation Service, *Soil Survey of Whatcom County Area, Washington,* 1992.

Washington State Department of Ecology 2003 - 2008 Well Logs from Section 31, Township 38 North, Range 3 East.

Washington State Deparment of Transportation, 1959, *Log of Test Boring - Byron St. Undercrossing,* Job No. L-1804, Hole No. H-1, H-2.

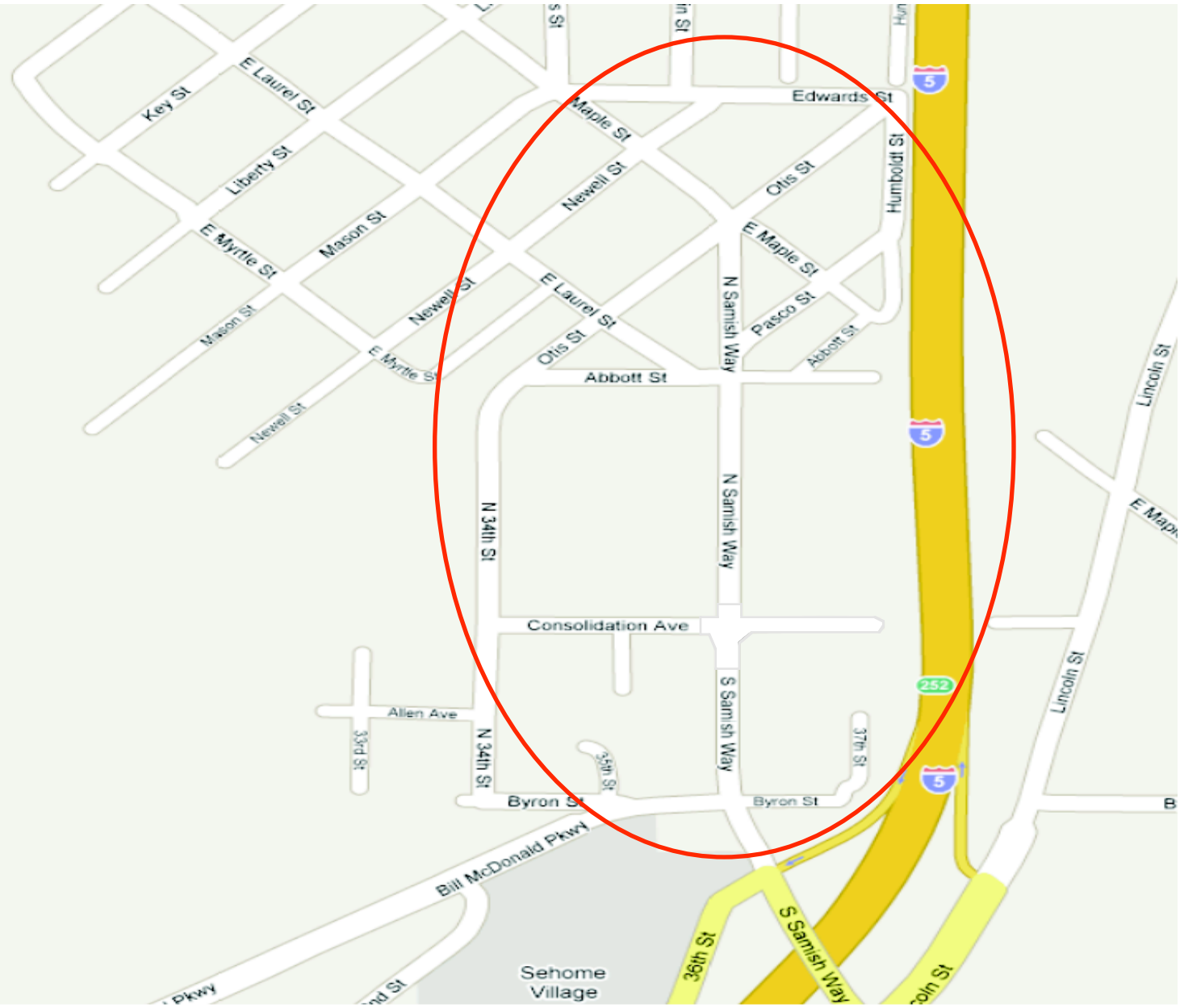
APPENDIX

Subsurface conditions at the site were investigated by reviewing available literature and by conducting 5 hand augered test pits to a maximum depth of 3.25´ on September 10th, 2008.

The descriptions of subsurface conditions at the site are based on water well logs obtained from the Washington State Department of Ecology, geotechnical test borings reviewed from the Washington State Department of Transportation soils testing database, various geotechnical reports for prior developments within the project area, and confirmation boring reports in coordinance with leaking underground storage tank cleanup obtained during an extensive literature review pertaining to the project area. General near-surface soil and bedrock conditions in the project area were referenced from the *Soil Survey of Whatcom County Area* (1992) issued by the U.S. Department of Agriculture's (USDA) Soil Conservation Service, and are presented as a soil map in Figure 3, with a table of general engineering properties in Figure 4.

Test pit locations were determined by Darby Galligan of the City of Bellingham Planning and Community Development Department in conference with a representative of Merit Engineering Inc., as shown approximately on the Site Plan (Figure 2) presented in the Appendix of this report. Depths referred to in this report are relative to the existing ground surface at the time of the field investigation. Field test results are presented in the Appendix as Figures 9 through 13, with the corresponding USCS Soils Classification Chart provided in Figure 8.

Bellingham, Washington



Referenced from maps.google.com

Project No. PH0112614	**PROJECT LOCATION & VICINITY MAP**	Date: 9/30/2008	*Figure 1*

Feasibility Study - Urban Planning
Samish Urban Village
Bellingham, Washington

For: City of Bellingham, Planning Department

MERIT ENGINEERING INC.
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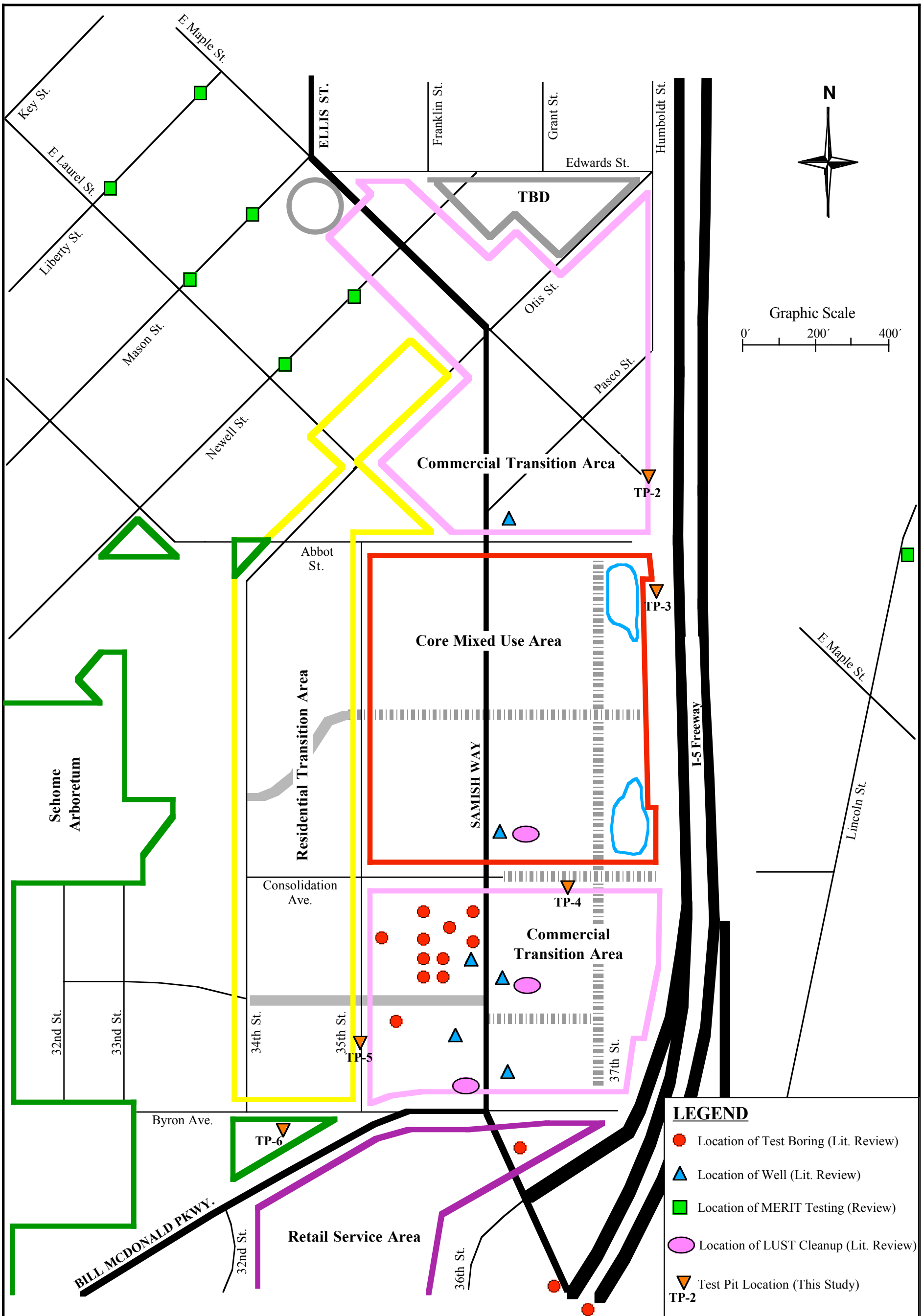

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Samish Urban Village
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For: City of Bellingham - Planning Department

Figure 2 | Scale: Graphic

SITE OVERVIEW

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PH0112614	9/30/08	A.X.H.

Note: Map adapted from preliminary conceptual draft of Samish Way Urban Village Design.

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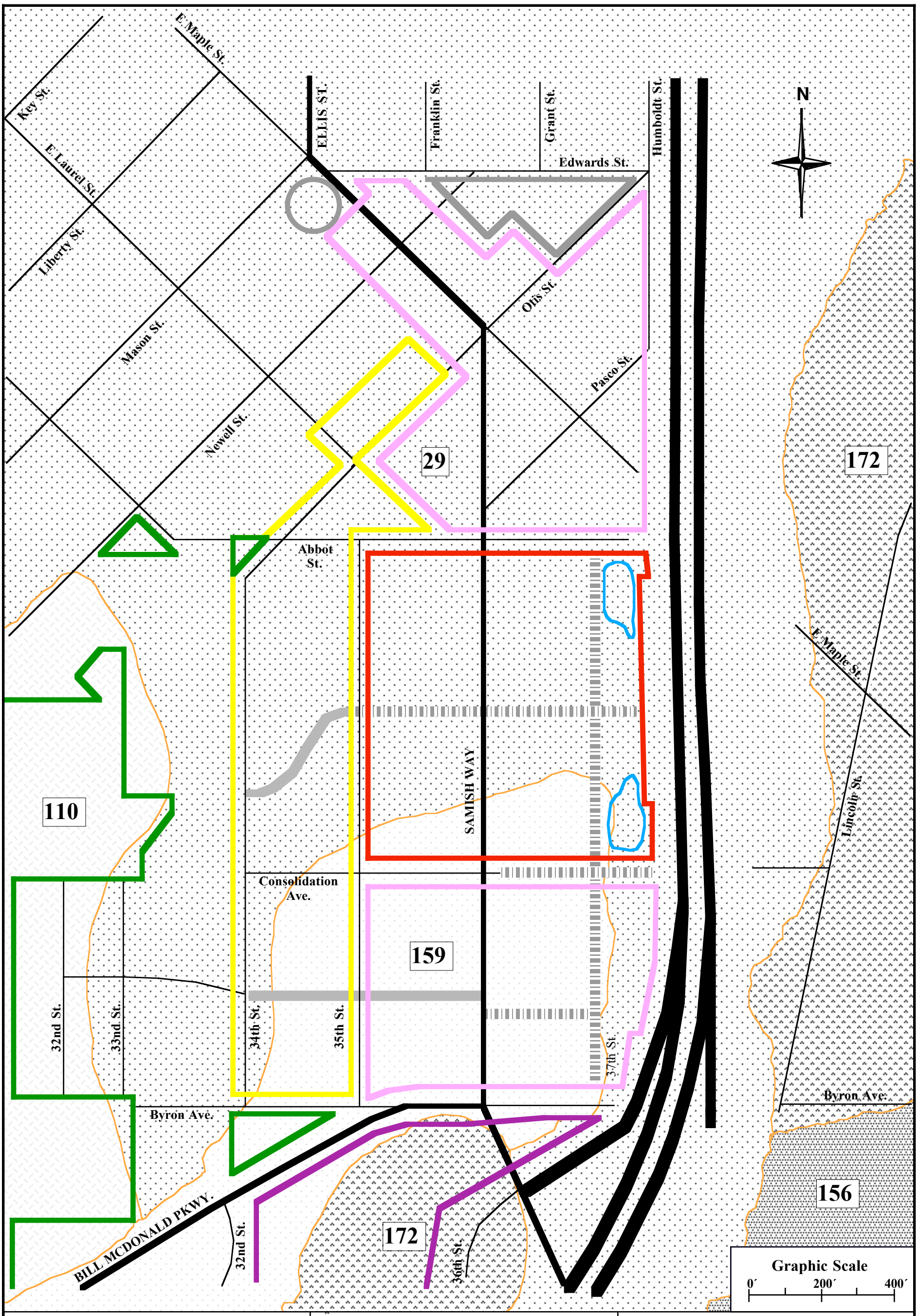

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Figure 3 | Scale: Graphic

SOIL GROUP MAP

PROJECT NO.	DATE	APPROVED BY
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Note: Data from Soil Survey (SCS, 1992). See Figure 4 for legend & descriptions.

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Map Symbol (soil #)	Soil Name	Percentage of Study Area	Typical Profile	Depth to Water (seasonal high)	Drainage	Permeability	Runoff	Water Erosion Hazard	Construction Concerns/Notes
(29)	Chuckanut - Urban Land Complex	~64%	0-48″ - Gravelly Loam **Sandstone at 48″**	N/A	Well Drained	Moderate	Medium	Moderate	Highly erodible during construction and on cut and fill slopes
(110)	Nati Loam	~7%	0-28″ - Loam **Sandstone at 28″**	N/A	Well Drained	Moderate	Medium	Moderate	Cut and fill slopes slump when wet. Soil creep common in this unit.
(156)	Squalicum Gravelly Loam	~5%	0-44″ - Gravelly Loam **Dense Glacial Till at 44″**	3.5 - 5′	Well Drained	Moderate in Loam; Very slow in Till	Slow	Slight	Rock for construction not readily available. Dense glacial till is rippable and therefore is not a serious limitation for most engineering uses.
(159)	Squalicum - Urban Land Complex	~11%	0-44″ - Gravelly Loam **Dense Glacial Till at 44″**	3.5 - 5′	Moderately Well Drained	Moderate in Loam; Very slow in Till	Slow	Moderate	Highly erodible during construction and on cut and fill slopes. Excavation limited by dense glacial till, but rippable so not a serious limitation.
(172)	Urban Land - Whatcom - Labounty Complex	~13%	WHATCOM 0-60″ - Loam	1.5 - 3′	Moderately Well Drained	Moderate in upper part; Slow in lower part	Slow	Slight	Main limitation affecting development is high water table.
			LABOUNTY 0-60″ - Loam	1 - 3′	Poorly Drained	Moderately Slow	Very Slow	None	Main limitation affecting development is high water table.

Note - According to the Whatcom County Soil Survey, the designation of Urban Land Complex represents areas covered by streets, buildings, parking lots, and other structures that so obscure the soils that identification of the soil series is not feasible. The majority of the subject area is Urban Land Complex.

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Figure 4

DETAIL SOIL INFORMATION

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Note: Referenced from Soil Survey of Whatcom County area, Washington (SCS, 1992).

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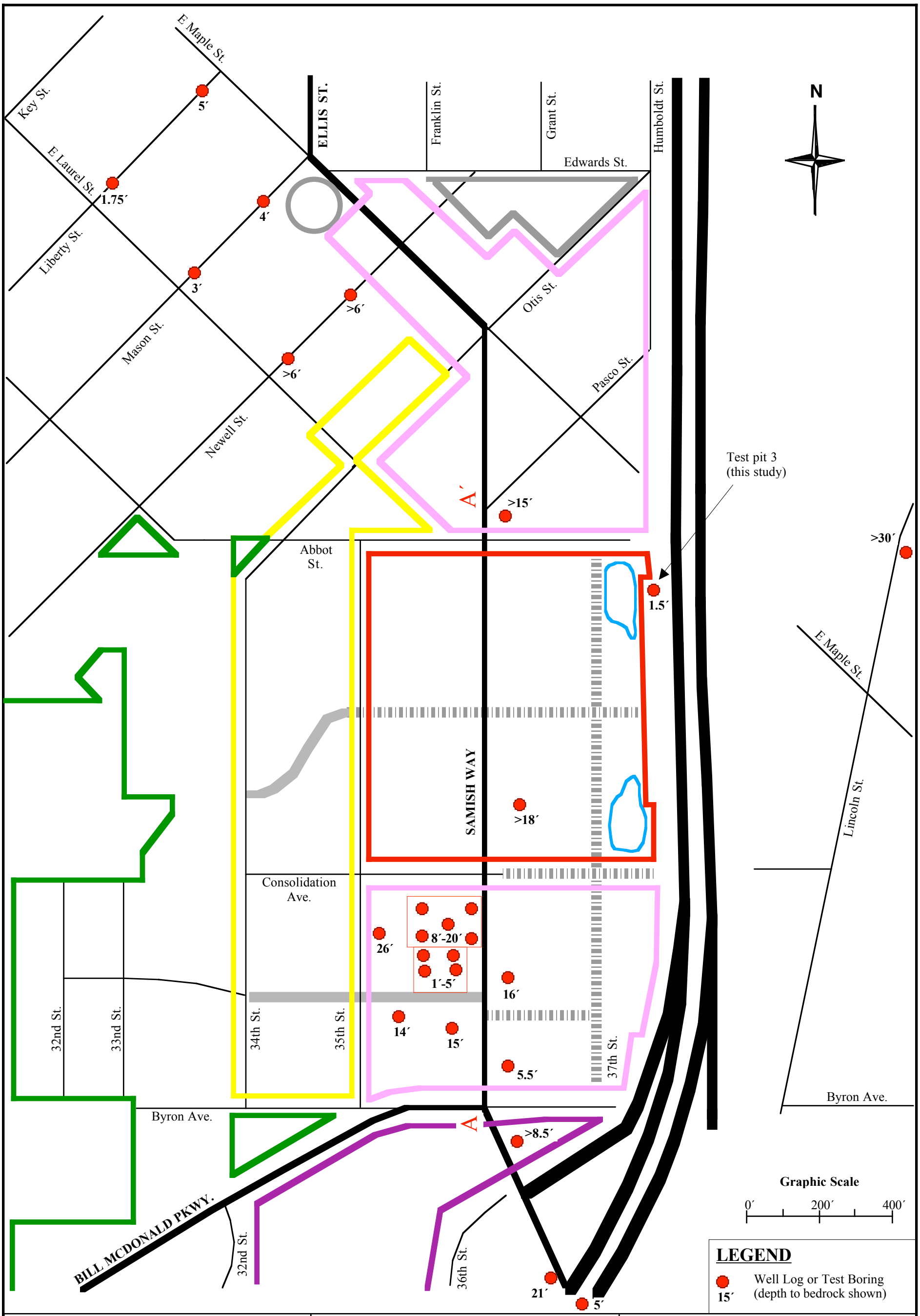

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Figure 5 | Scale: Approx.

BEDROCK DEPTH MAP

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Note: Locations of well logs and test boring are approximated from site address.

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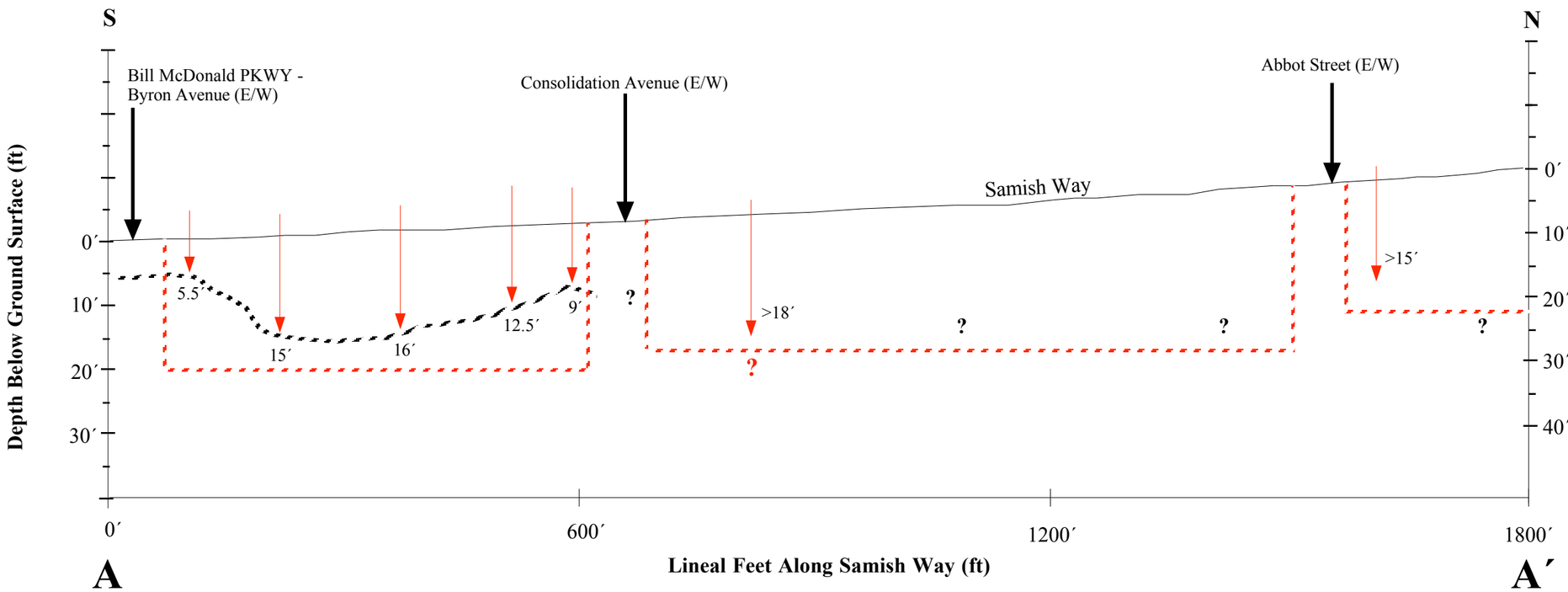
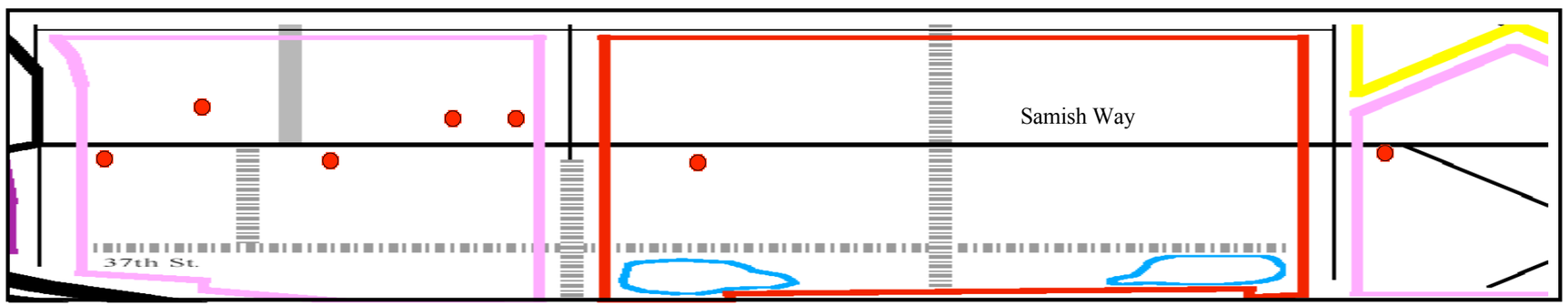
Vertical Exaggeration: 8x





Topographic Profile

Proposed Underground Parking Areas

Bedrock Profile (Inferred)

? ? ? Bedrock Profile (Unknown)

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Figure 6

SITE CROSS SECTION

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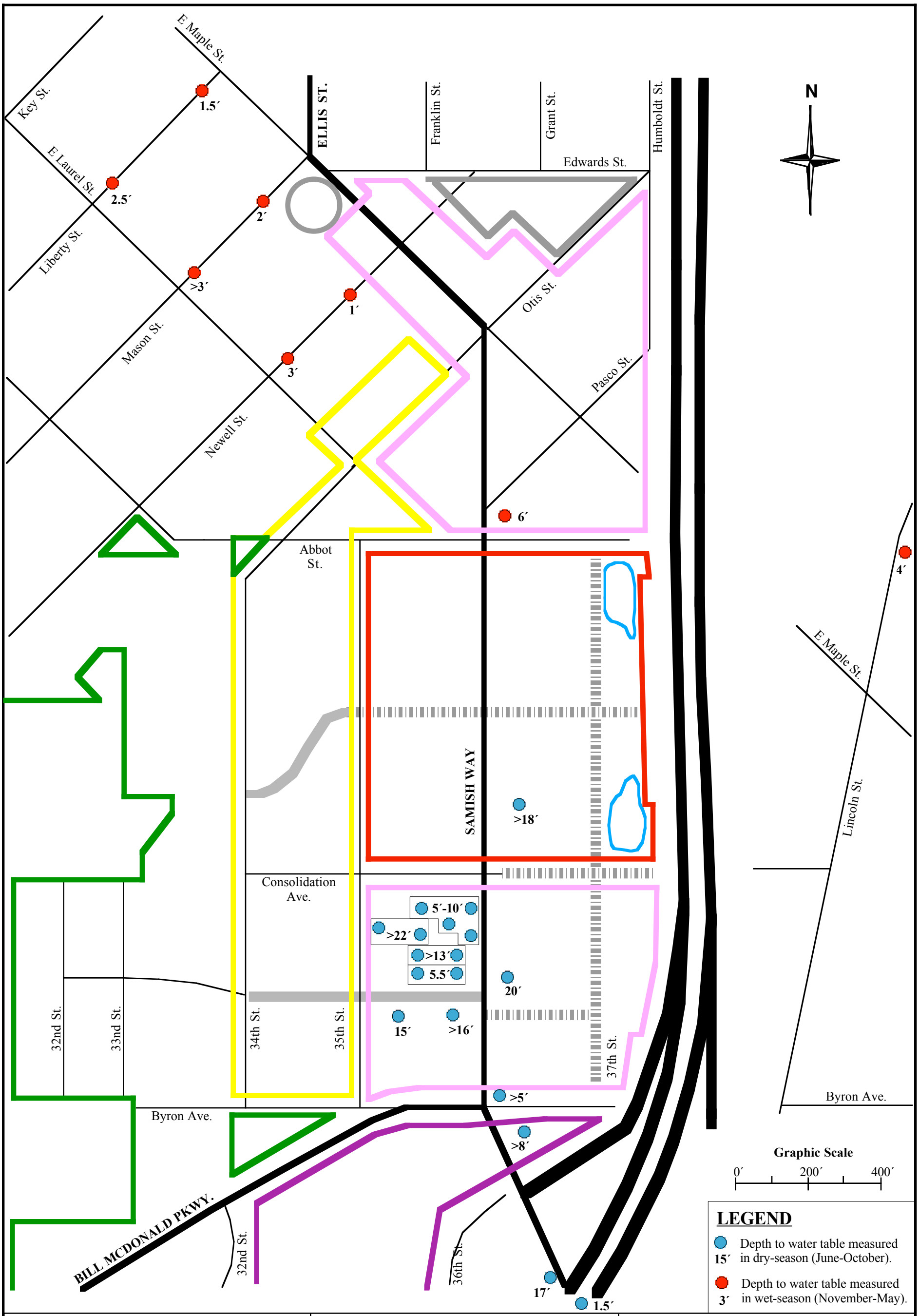

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Figure 7 | Scale: Approx.

WATER LEVEL MAP

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Note: Water level measurements may not reflect seasonal high levels. Data extracted from well logs and borings.

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UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS				DESCRIPTION	
COARSE GRAINED SOILS more than 50% retained on #200 sieve	GRAVELS more than 50% coarse fraction is larger than No. 4 sieve size	Gravels with less than 5% fines		GW	Well graded gravels, gravel-sand mixtures
				GP	Poorly graded gravels, gravel-sand mixtures
		Gravels with more than 12% fines		GM	Silty gravels, gravel-sand-silt mixtures
				GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS more than 50% coarse fraction is smaller than No. 4 sieve size	Sands with less than 5% fines		SW	Well graded sands, gravelly sands
				SP	Poorly graded sands, gravelly sands
		Sands with more than 12% fines		SM	Silty sands, sand-silt mixtures
				SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS more than 50% passing #200 sieve	SILTS AND CLAYS Liquid Limit less than 50			ML	Inorganic silts & very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity
				CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, or lean clays
				OL	Organic clays and organic silty clays of low plasticity
	SILTS AND CLAYS Liquid Limits greater than 50			MH	Inorganic silts, micaceous or diatomacious fine, sandy or silty soils, elastic silts
				CH	Inorganic clays of high plasticity, fat clays
				OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS				PT	Peat and other highly organic soils
UNCONTROLLED FILL					Uncontrolled, with highly variable constituents

LEGEND

SAMPLE	SYMBOL
SPLIT SPOON SAMPLER	GROUNDWATER TABLE
SHELBY TUBE SAMPLER	q_u PENETROMETER READING TSF (*tons per square foot*)

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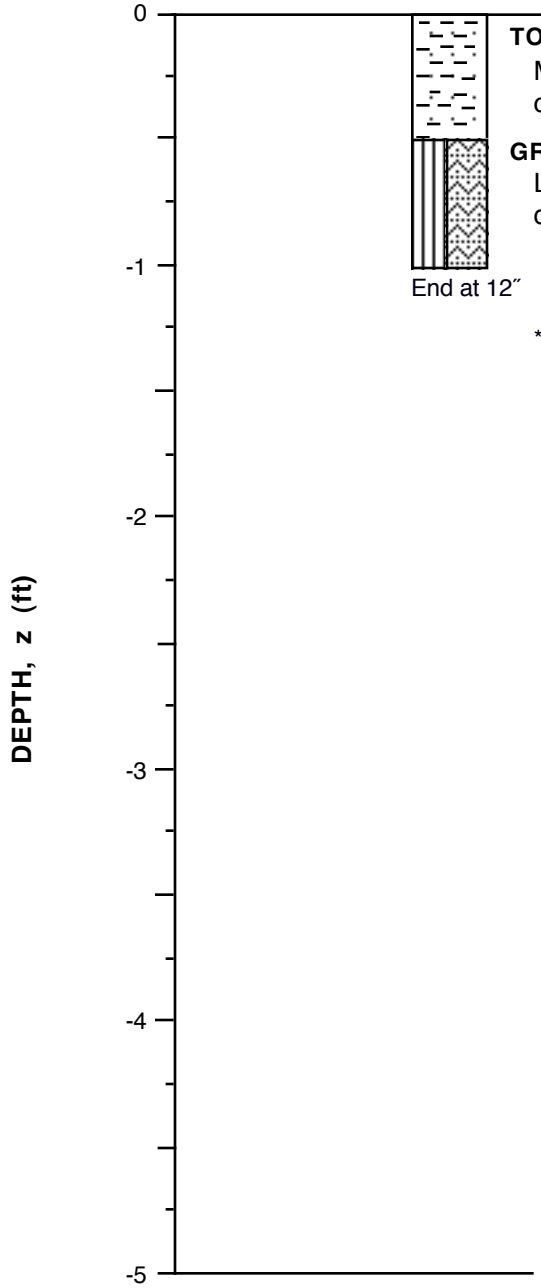
SOIL CLASSIFICATION & LEGEND

Figure 8

TP-2	Surface Elevation ≈ X = Y=	SOIL DESCRIPTION AND CLASSIFICATION



TOPSOIL: SANDY SILT (OL/ML)
Med. brown gravelly silt topsoil. Mod. dense, dry and crumbly, some roots.

GRAVELLY SAND-SILT MIXTURE (ML/GM)
Light brown-tan gravelly sand-silt, some cementation. Very dense, well graded, dry. Hand-augering very difficult.

*Shallow hand-auger refusal due to rocks and hard soil conditions.

Notes: No groundwater or seepage observed during hand-augering.

Project No. PH0112614	Date: 9/10/08	Approved by A.X.H.	*Figure 9*

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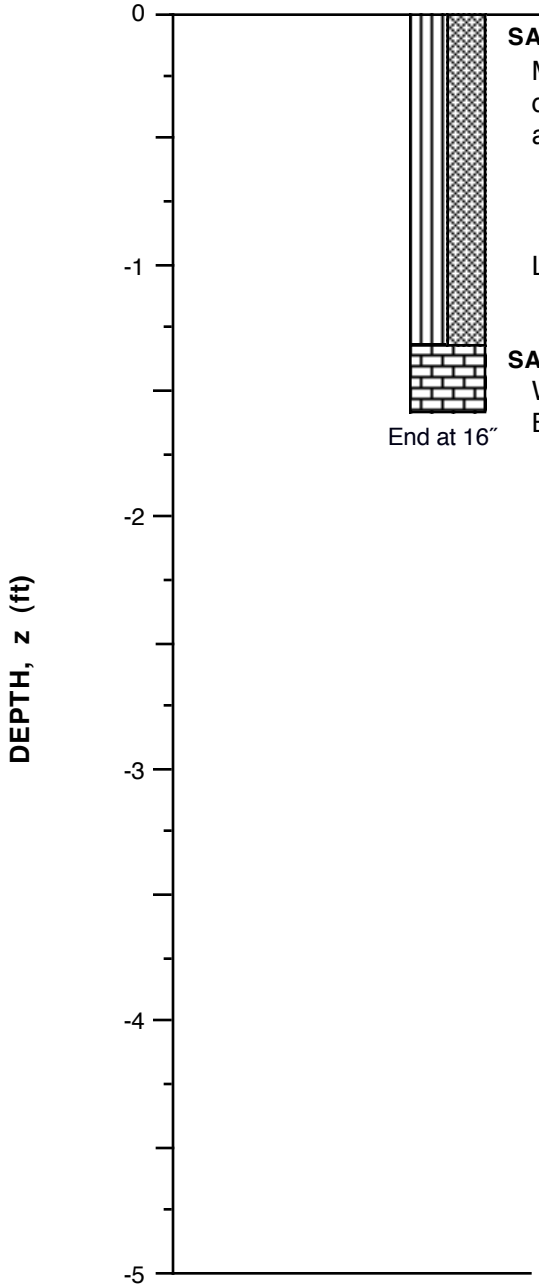
TP-3	Surface Elevation ≈ X = Y=	SOIL DESCRIPTION AND CLASSIFICATION



SAND-SILT MIXTURE (ML/SM)

Med. brown sand-silt mixture to silty sand, minor gravel. Mod. dense, mod. coherent in pockets, sl. damp to damp, abundant roots.

Light mottling and rust coloration begins.

SANDSTONE (TKc) - Weathered

Weathered sandstone encountered, uneven surface. Bedrock surface or possibly large rock obstruction.

Notes: No groundwater or seepage observed during hand-augering. Light rust mottling seen above refusal horizon.

Project No. PH0112614	Date: 9/10/08	Approved by A.X.H.	*Figure 10*

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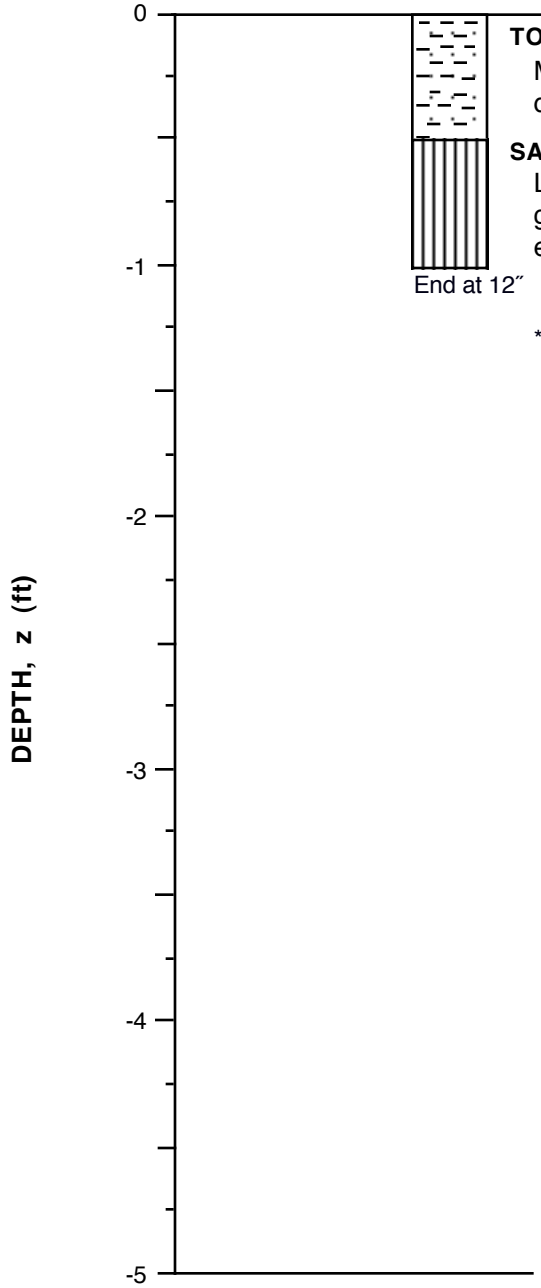
TP-4	Surface Elevation ≈ X = Y=	SOIL DESCRIPTION AND CLASSIFICATION



TOPSOIL: SANDY SILT (OL/ML)
Med. brown sandy silt topsoil, rock pieces intermixed. Dense, dry, some roots. Possibly reworked.

SANDY SILT - Cemented (ML)
Light brown-tan sandy silt, cemented hardpan, with gravel/rocks. Dry and very hard in place - crumbly when extracted. Hand-augering very difficult into layer.

*Shallow hand-auger refusal due to hard soil conditions.

Notes: No groundwater or seepage observed during hand-augering.

Project No. PH0112614	Date: 9/10/08	Approved by A.X.H.	*Figure 11*

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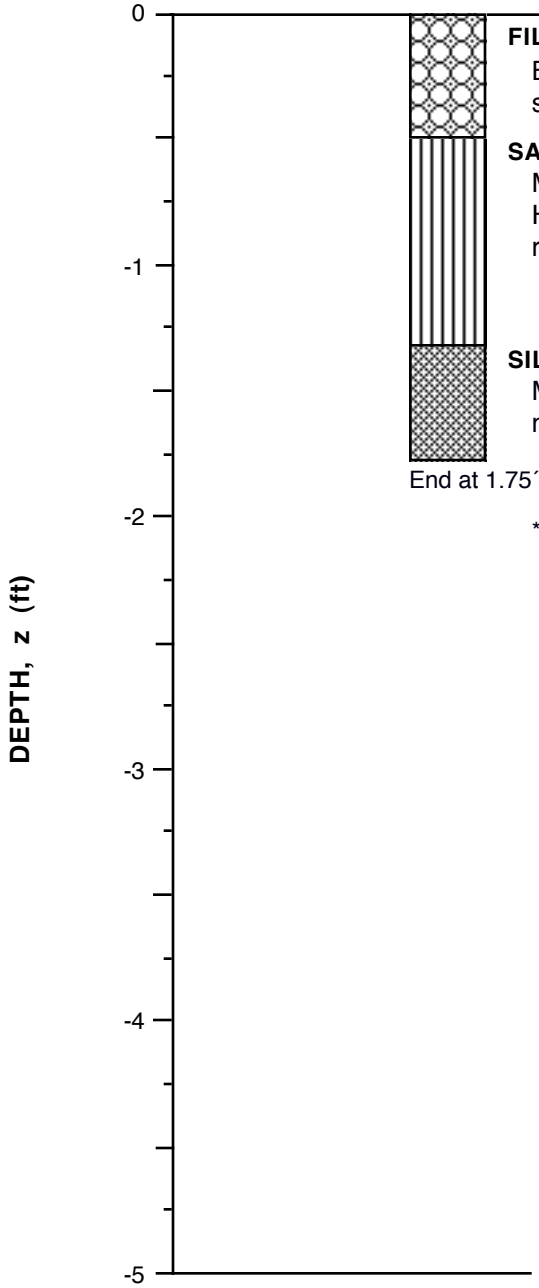
TP-5	Surface Elevation ≈ X = Y=	SOIL DESCRIPTION AND CLASSIFICATION



FILL: GRAVEL-SAND MIXTURE (GP)
Brown gravel-sand fill from roadway installation. Very dense, sl. cemented fines, sl. damp.

SANDY SILT - Cemented (ML)
Medium brown sandy silt, cemented/structured, some gravel. Hard and dry in place - crumbly when extracted, dry. Local rust mottling observed. Hand-augering difficult through layer.

SILTY SAND (SM)
Medium-light brown silt-sand mixture, some gravel. Dense, non-coherent, damp.

End at 1.75´

*Shallow hand-auger refusal due to hard condition of cemented silt.

Notes: No groundwater or seepage observed during hand-augering. Light patchy mottling noted at shallow depths.

Project No. PH0112614	Date: 9/10/08	Approved by A.X.H.	*Figure 12*

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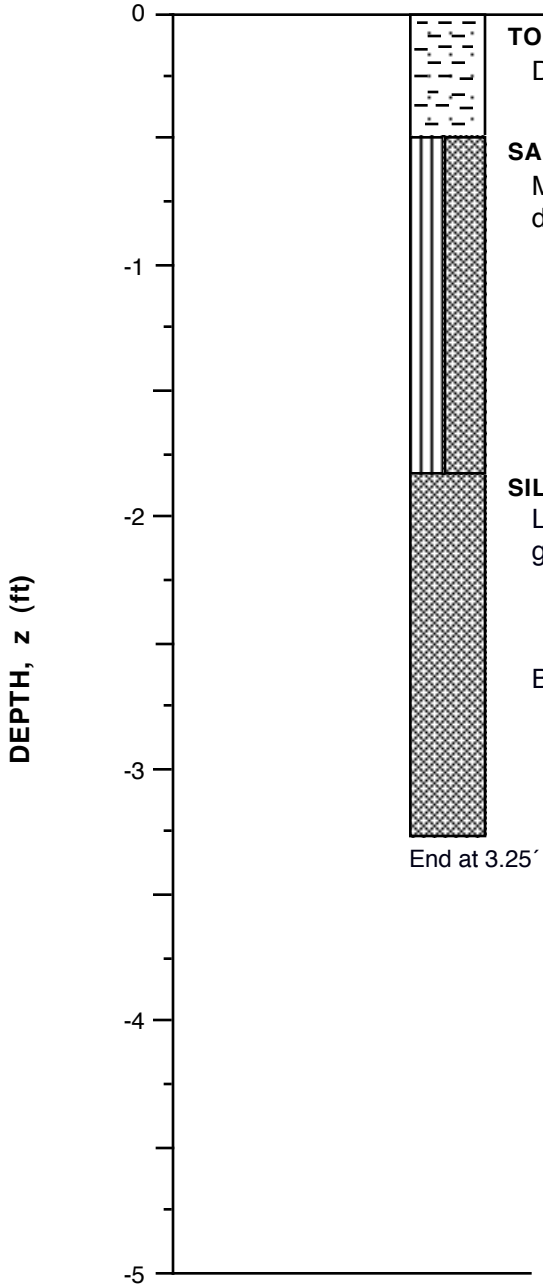
TP-6	Surface Elevation ≈ X = Y=	SOIL DESCRIPTION AND CLASSIFICATION



TOPSOIL: SANDY SILT (OL)
Dark brown sandy silt topsoil. Soft and loose, dry, roots.

SANDY SILT TO SAND-SILT MIXTURE (ML)
Medium brown sand-silt mixture with some gravel. Mod. dense in place - loose when extracted, non-coherent, dry.

SILTY SAND (SM)
Light brown-tan sand-silt to silty sand with common small gravel. Dense in place, non-coherent, dry to sl. damp.

Becomes more sandy and higher gravel content at depth.

Notes: No groundwater, seepage, or mottling observed.

Project No. PH0112614	Date: 9/10/08	Approved by A.X.H.	*Figure 13*

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