Associated Earth Sciences, Inc.

Technical Memorandum

FOR INTERNAL DISCUSSION PURPOSES DURING DESIGN DEVELOPMENT

Date:	June 12, 2012		**Page 1 of 5**
To:	Steve Burke, SvR Design Company	**Project Name:**	Barton Basin CSO Control
From:	Curtis J. Koger, L.G., L.E.G., L.Hg. Jennifer H. Saltonstall, L.G., L.Hg.	**Project No:**	KH110220A
Subject:	Task 230.3 Geotechnical Design Report Executive Summary, Barton Basin CSO Control Project with GSI		

Introduction and Project Background

In 2008, King County Wastewater Treatment Division (KCWTD) reported that the Barton Combined Sewer Basin facility had four overflows per year on average that discharge a total of four million gallons into Puget Sound near the Fauntleroy Ferry Terminal in West Seattle. A combined sewer overflow (CSO) event occurs when flow exceeds system capacity resulting in a mixture of raw sewage and stormwater discharging into local water bodies. In order to provide CSO control of no more than one overflow per year for compliance with Washington State Department of Ecology (Ecology) requirements, the project proposes to utilize Green Stormwater Infrastructure (GSI) to filter, attenuate, divert, and infiltrate stormwater runoff in the Barton Basin. The GSI approach will capture and subsequently remove a portion of stormwater runoff from entering from the combined sewer conveyance system. The reduction in stormwater runoff will reduce the number of CSO events.

For this project, bioretention swales with an underdrain and deep infiltration systems (Ecology's Underground Injection Control [UIC] wells/Pit Drain) make up the basic components of the proposed GSI system in order to provide CSO control for the Basin. The bioretention swales will be located in existing planting strips in "city-owned" parking strips along multiple streets within the project area in order to intercept, treat, and reduce the amount of stormwater discharging into the combined sewer pipes. Stormwater runoff that flows into the curbside bioretention swales will filter downward through the bioretention soil and flow into a perforated underdrain pipe below the swales. The underdrain will then convey the flow to a UIC well that is located inside a maintenance hole at the end of each street. The flow will then discharge into the deep Vashon advance outwash receptor horizon via a pipe drilled vertically into the ground with perforations at the end of the pipe (UIC well). Stormwater runoff that bypasses the curbside bioretention swales will overflow into the street's gutter and drain into a storm drain collection structure that conveys the bypass flow to the combined sewer system. Only stormwater that enters into the underdrain after it has been treated by the bioretention swale will flow into the UIC well.

Project Area Description

The project study area (approximately 200 acres) for implementing GSI for Barton's CSO control is an area within Barton's 416 Subbasin located in the West Seattle neighborhood of the city of Seattle, Washington bounded by SW Othello Street on the north to about SW Barton Street to the south, and from an alley just west of 34th Avenue SW on the west to approximately 30th Avenue SW on the west. The topography in the project area consists of a rolling glaciated upland that gradually slopes from north to south. The ground surface elevations within the project area boundaries range from about 500 feet at the northwest corner to about 300 feet at the southeast corner. Outside the project area to the west of 34th Avenue SW, the ground slopes generally southwestward, eventually draining to the Fauntleroy Creek drainage system and Puget Sound. Steep slopes and incised drainages are present in the headwater area of Fauntleroy Creek and in an unnamed drainage northwest of the project area. Outside the project area to the east of 30th Avenue SW, the ground slopes generally easterly downward to Longfellow Creek and the Westwood Village Shopping Complex. Grading operations from past developments have created steep slopes in some locations. See Figures 1 and 2 in the GDR for a map of the project area, drainages, and other topographic features.

Geotechnical Design Report (GDR)

The attached geotechnical design report was prepared by Associated Earth Sciences, Inc. (AESI) in support of King County's Barton Basin CSO Control Project with GSI. The purpose of this study was to obtain and evaluate geologic, hydrogeologic, and soils data needed to assess the existing conditions in the project area, including the permeability of subsurface units, capacity of the subsurface to accept infiltrated stormwater, and depth to ground water, and to interpret those conditions with respect to the potential for probable significant adverse impacts. The information contained within is applicable to the part of GSI under design to remove a portion of stormwater flows from the combined sanitary sewer and storm drainage system. The attached report describes the exploration and testing program, expected soils and ground water conditions within the project area, technical modeling demonstrating lack of adverse impacts to water quality, regional aquifer/ground water and slope stability, and provides geotechnical design criteria and recommendations for developing the design and proposed improvements. Information contained in AESI's previously and concurrently completed reports and memoranda for the project has also been reviewed and included as appendices in the geotechnical design report for ease of reference.

Key Results of GDR

- Shallow infiltration is limited due to the presence of low-permeability Vashon lodgement till and shallow ground water within thin Vashon recessional age deposits.
- Based on our field explorations and review of previous explorations completed by others, a thick sequence of unsaturated regionally extensive permeable Vashon advance outwash is present beneath the low-permeability lodgement till and underlies the entire Barton Basin project area. The thick unsaturated Vashon advance outwash has the capacity to infiltrate treated stormwater runoff via UIC wells, allowing the water to slowly infiltrate downward to the regional Vashon advance aquifer. On a few streets where the depth to the Vashon advance outwash is less than 20 feet, pit drains (approximately 3-foot-wide by 15-foot-long trench backfilled with clean gravel) could be utilized, whereas UIC wells could be utilized on all the streets.
- The treated stormwater that is discharged into the UIC well provides supplemental ground water recharge to the regional Vashon advance aquifer. The increased ground water recharge will enhance year-round baseflows to the Fauntleroy Creek and Longfellow Creek drainage basins.
- Modeling demonstrated that the proposed infiltration system with UIC wells would not increase off-site landslide hazards.

- Based on Ecology and City of Seattle criteria, the proposed GSI design will provide water quality treatment to prevent degradation of ground water quality and will be protective of all beneficial uses of ground water resources.
- The UIC wells, including the pretreatment facility upstream (bioretention swales), would be registered and permitted by Ecology.

Subsurface Exploration and Testing

AESI's technical studies to evaluate site conditions and to assess geologic and water resource impacts included subsurface exploration, laboratory testing, monitoring, and analytical modeling. See Figure 2 in the GDR for the "Site and Exploration Plan." AESI's field investigation included review of soil and ground water data from seventeen existing shallow wells completed by others, completing twelve deeper exploration borings completed as monitoring wells, excavating and testing six infiltration test pits and two infiltration pit drains, advancing and testing three 6-inch-diameter infiltration borings completed as test UIC wells, completing aquifer tests including both slug tests and aquifer pumping tests, and conducting geologic reconnaissance of selected portions of Fauntleroy Creek basin and Longfellow Creek basin. The field study also included completing laboratory testing of soils, monitoring ground water levels, baseline ground water quality sampling, and aquifer testing.

Project Area Geologic Conditions

Geologic conditions at the site were evaluated using data obtained from AESI fieldwork, as well as review of selected regional geologic maps, well logs, and other documents. The explorations generally encountered a grass-covered fill overlying native glacial sediments interpreted as Vashon recessional outwash, Vashon ice-contact deposits, Vashon lodgement till, Vashon advance outwash, and pre-Fraser sediments in the areas explored. Low-permeability deposits consisting primarily of Vashon lodgement till cover most of the project basin to depths of about 20 to 25 feet below ground surface, although the unit thickness varies in some locations. Beneath the relatively thin surficial geologic deposits (Fill, Vashon recessional outwash, Vashon ice-contact deposits, and Vashon till), subsurface exploratory wells encountered a thick sequence of Vashon advance outwash underlain by coarse- and fine-grained pre-Fraser sediments. The Vashon advance outwash can be a suitable receptor horizon for dispersed or concentrated infiltration facilities beneath the project basin since there is a sufficient thickness of unsaturated sediments above a deep aquifer interval. See Figures 4 and 5 in the GDR for a map of the project area and a cross section of the geologic condition through the site based on the findings from the field exploration.

Project Area Ground Water Conditions

Ground water in the project area is contained within unconsolidated sediments of glacial and non-glacial origin. Four natural ground water intervals and two intervening aquitard units were encountered during our exploration activities. The ground water intervals include one relatively deep regional Vashon advance outwash aquifer (including granular Olympia non-glacial deposits) and three relatively shallow water-bearing intervals consisting of: 1) a shallow interflow zone, 2) perched water within the till and uppermost silty Vashon advance outwash, and 3) a perched "aquifer" system contained within Vashon recessional outwash/Vashon ice-contact deposits. The aquitards include Vashon lodgement till and a pre-Fraser, likely Olympia non-glacial, lower fine-grained unit. The uppermost water-bearing units include Vashon recessional outwash and Vashon ice-contact deposits, and the weathered soils above Vashon lodgement till. The Vashon advance outwash aquifer is interpreted to underlie the entire project area at an approximate elevation of 260 feet corresponding to a depth range of approximately 240 to 40 feet, respectively. The unsaturated coarse-grained Vashon

advance outwash deposits above the Vashon advance aquifer will serve as the receptor soils for the proposed deep infiltration facilities.

Water Quality and Regulatory Guidance

Stormwater that flows into the UIC wells will flow through pretreatment facilities (bioretention swales) designed to meet Ecology's water quality requirements presented in *Guidance for UIC Wells That Manage Stormwater Runoff,* Publication Number 05-10-067 (Ecology UIC Manual) (Ecology, 2006). Treated stormwater flows that enter the UIC well will be conveyed via an underdrain pipe below the bioretention swales. The bioretention swales will be designed in accordance with City of Seattle's *Volume III: Stormwater Flow Control and Water Quality Treatment Technical Requirements Manual, Directors Rule 2009-005 SPU* (Seattle Stormwater Manual) (City of Seattle, 2009b) which has been accepted by Ecology as equivalently stringent as Ecology's 2005 *Stormwater Management Manual for Western Washington* (Ecology 2005 SWMM) (Ecology, 2005) requirements.

In accordance with the Seattle Stormwater Manual (City of Seattle, 2009b) and the Ecology 2005 SWMM (Ecology, 2005), bioretention swales which are constructed in accordance with manual can provide both "Enhanced" and "Basic" water quality treatment. As noted in the Seattle Stormwater Manual, Ecology 2005 SWMM, and Curtis Hinman's 2009 report to Ecology (Hinman, 2009), stormwater that filters downward through 18 inches of bioretention soil meets Ecology's "Enhanced Treatment" standard which is a higher treatment standard than "Basic." The bioretention for Barton GSI will have 18-inch minimum bioretention soil mix per City of Seattle Standard Specifications, Section 7.21; providing both "Enhanced" water quality treatment and satisfying the requirements for the "presumptive approach" and non-endangerment standard (Ecology, 2006). Therefore, the proposed GSI design will provide treatment to prevent degradation of ground water quality and will be protective of ground water resources.

Ground Water Modeling and Slope Stability Modeling

The treated stormwater that is discharged into the UIC well provides supplemental ground water recharge to the regional Vashon advance aquifer. The increased ground water recharge will enhance baseflows to the Fauntleroy Creek and Longfellow Creek drainage basins. Technical ground water and slope stability modeling demonstrates that the proposed infiltration system does not increase off-site landslide hazards.

A numerical ground water flow model MODFLOW was developed in order to evaluate the effect on ground water conditions in the project area and vicinity due to infiltration via UIC wells, including flow direction and magnitude of increase in ground water elevations, and changes to seepage volumes at the drain cells representing discharge zones for the Vashon advance outwash aquifer in the Fauntleroy Creek and Longfellow Creek drainage basins. The MODFLOW analysis of UIC stormwater inflow in the project area showed no effect on regional ground water flow directions and modeled a small increase to water levels and spring/seepage flow rates in the Fauntleroy and Longfellow Creek drainages and on the slopes west of the project area.

A slope stability model was developed to evaluate the modeled increase in water levels and spring/seep discharge rates and potential impacts to off-site steep slope hazard areas. The modeling consisted of a finite element numerical modeling analysis SEEP/W and SLOPE/W. The model specifically evaluated the factors of safety for potential slip surfaces within the Fauntleroy Creek drainage, located southwest of the site, selected because it is the closest steep slope with aquifer discharge, and represents a "worst-case" scenario for potential impacts. Based on the results of the slope stability simulations, the modeled increase in water levels and spring/seep discharge rates are considered insignificant with respect to slope stability, and no significant adverse impacts to off-site slopes have been identified.

30% Design Recommendations

Preliminary UIC Design Flow Rate Recommendations

Based on the results of UIC well testing, the site was divided into areas, referred to as Areas A1, B2, C1, C2, and C3, which represent areas of similar infiltration capabilities (see Figure 10 in the GDR). Based on the flow test results for wells constructed with 20 feet of 6-inch-diameter telescoping stainless steel well screen, it is AESI's opinion that the proposed UIC wells would be capable of infiltrating approximate design flow rates of 100 gallons per minute (gpm) of treated stormwater into the deep unsaturated Vashon advance outwash in Area A1, 50 gpm in Area B2, and 25 gpm in Areas C1, C2, and C3. The infiltration receptor horizon (Vashon advance outwash) is not homogeneous. Deeper portions of the Vashon advance outwash may have a lower infiltration rate because the grain size consists of finer sand than the upper tested portions. Extrapolating the results for the 20-foot screen tests may not be applicable to a longer screen interval. The preliminary design assumes up to 75 feet of screen can be used in Areas A1 and B1. Subareas C1 and C2 are expected to have maximum screen lengths of 50 feet. Subarea C3 is likely limited to 20 feet of screen length since the unsaturated zone thickness is constrained by the regional water table. The maximum screen length is also limited by Ecology requirements to remain a minimum distance of 5 feet above the seasonal high water table. The maximum preliminary design depth of UIC wells is limited to approximately 100 feet (base of screen) based on maintenance limitations related to vactoring. For well screen lengths in excess of 20 feet, we recommend additional testing as part of Barton CSO Phase 2 services.

Preliminary Infrastructure and Site Improvement-Related Recommendations

The GSI design captures stormwater runoff from the project area by strategically locating bioretention swales along the residential streets. Installation of the GSI system includes excavations for the swales, catch basins, maintenance holes, UIC wells, and associated underdrains along with minor street restoration. In general, all work occurring within the City of Seattle public right-of-way shall be done in accordance with the 2011 edition of the *City of Seattle Standard Specifications for Road, Bridge, and Municipal Construction*, *City of Seattle Standard Plans for Municipal Construction* (2011 edition), and the *Seattle Department of Transportation Directors Rule 5-2009 for Street and Sidewalk Pavement Opening and Restoration* (current edition).

As the design progresses to Phase 2, we will continue to review the plans and specifications at 60%, 90%, and 100% and provide recommendations.

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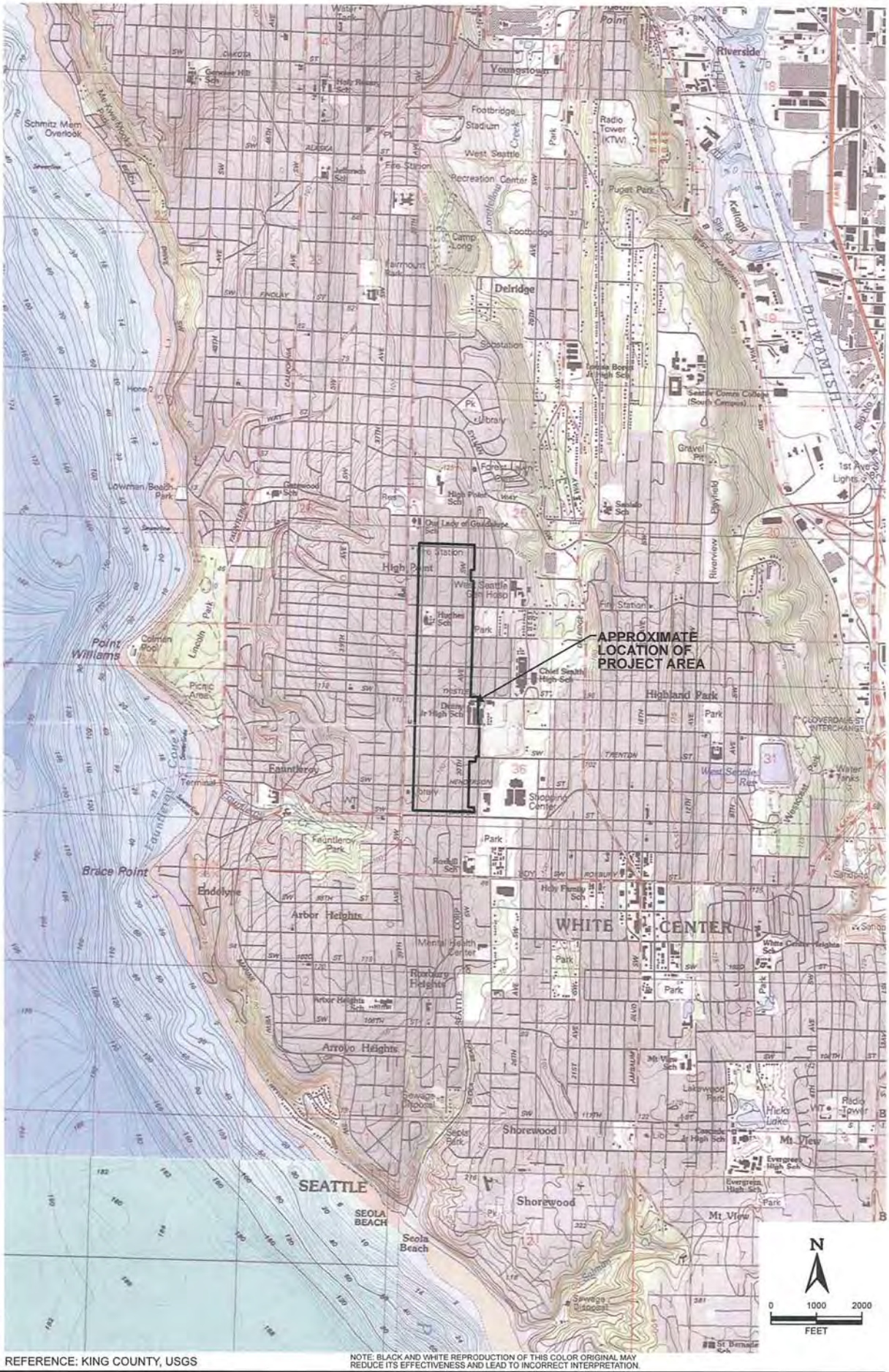

REFERENCE: KING COUNTY, USGS

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VICINITY MAP
BARTON BASIN CSO CONTROL PROJECT
SEATTLE, WASHINGTON

FIGURE 1
DATE 03/12/12
PROJ. NO. KH110220A

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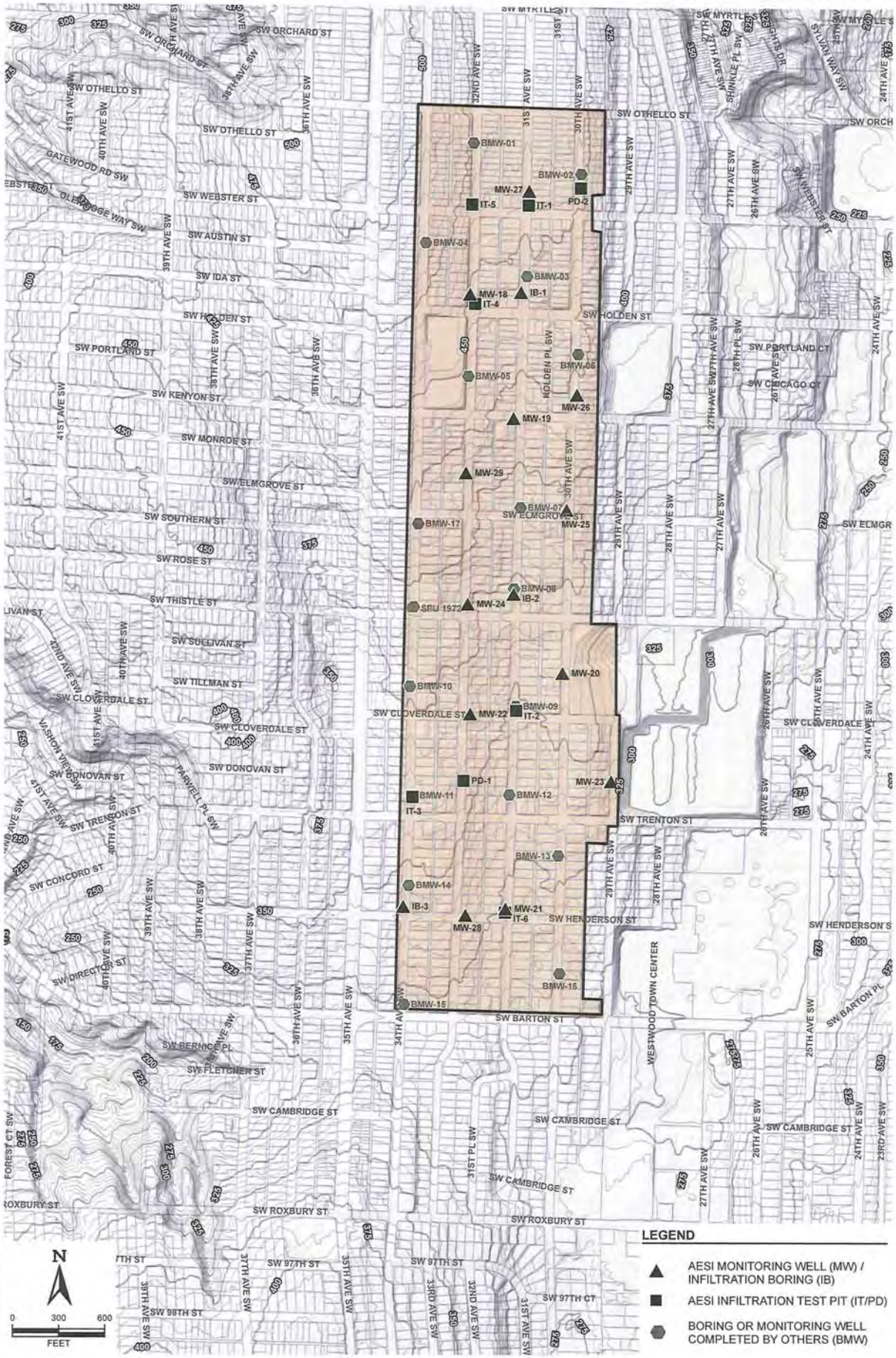

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SITE AND EXPLORATION PLAN

BARTON BASIN CSO CONTROL PROJECT
SEATTLE, WASHINGTON

FIGURE 2

DATE 03/12/12

PROJ. NO. KH110220A

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LEGEND

- ▲ AESI MONITORING WELL (MW)/ INFILTRATION BORING (IB)
- ■ AESI INFILTRATION TEST PIT
- ⬢ BORING OR MONITORING WELL COMPLETED BY OTHERS
- ● GEOMAPNW EXPLORATION 0-40 FEET
- ● GEOMAPNW EXPLORATION >40 FEET
- 16892 MW-3 — GEOMAP NW DOCUMENT ID AND EXPLORATION NAME, WELL LOG INCLUDED IN APPENDIX B

REFERENCE: KING COUNTY, GEOMAPNW

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SELECTED NEARBY OFFSITE EXPLORATIONS

BARTON BASIN CSO CONTROL PROJECT
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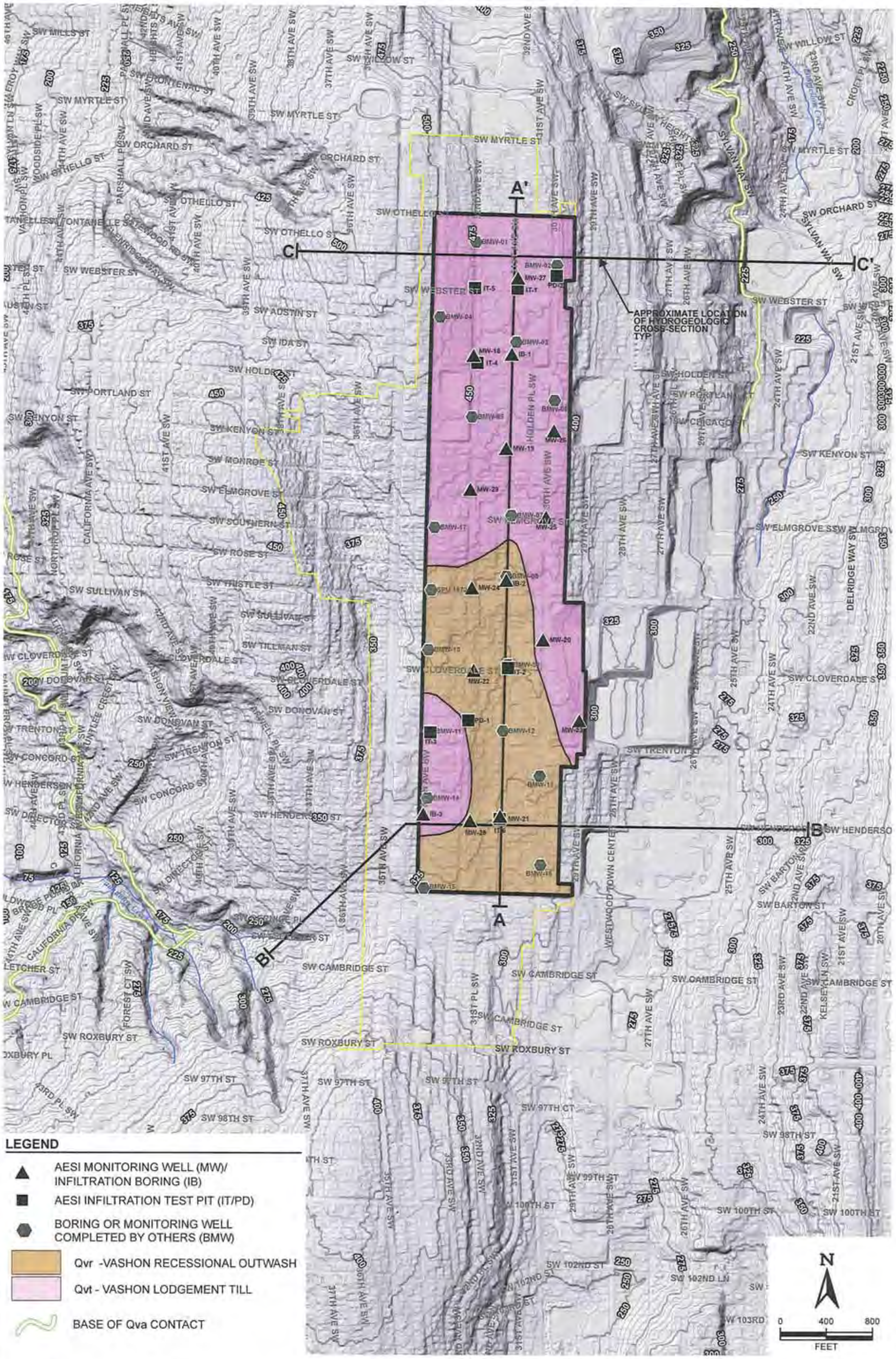
FIGURE 3

DATE 03/12/12

PROJ. NO. KH110220A



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PROJECT SURFICIAL GEOLOGY MAP
BARTON BASIN CSO CONTROL PROJECT
SEATTLE, WASHINGTON

FIGURE 4

DATE 02/22/12

PROJ. NO. KH110220A

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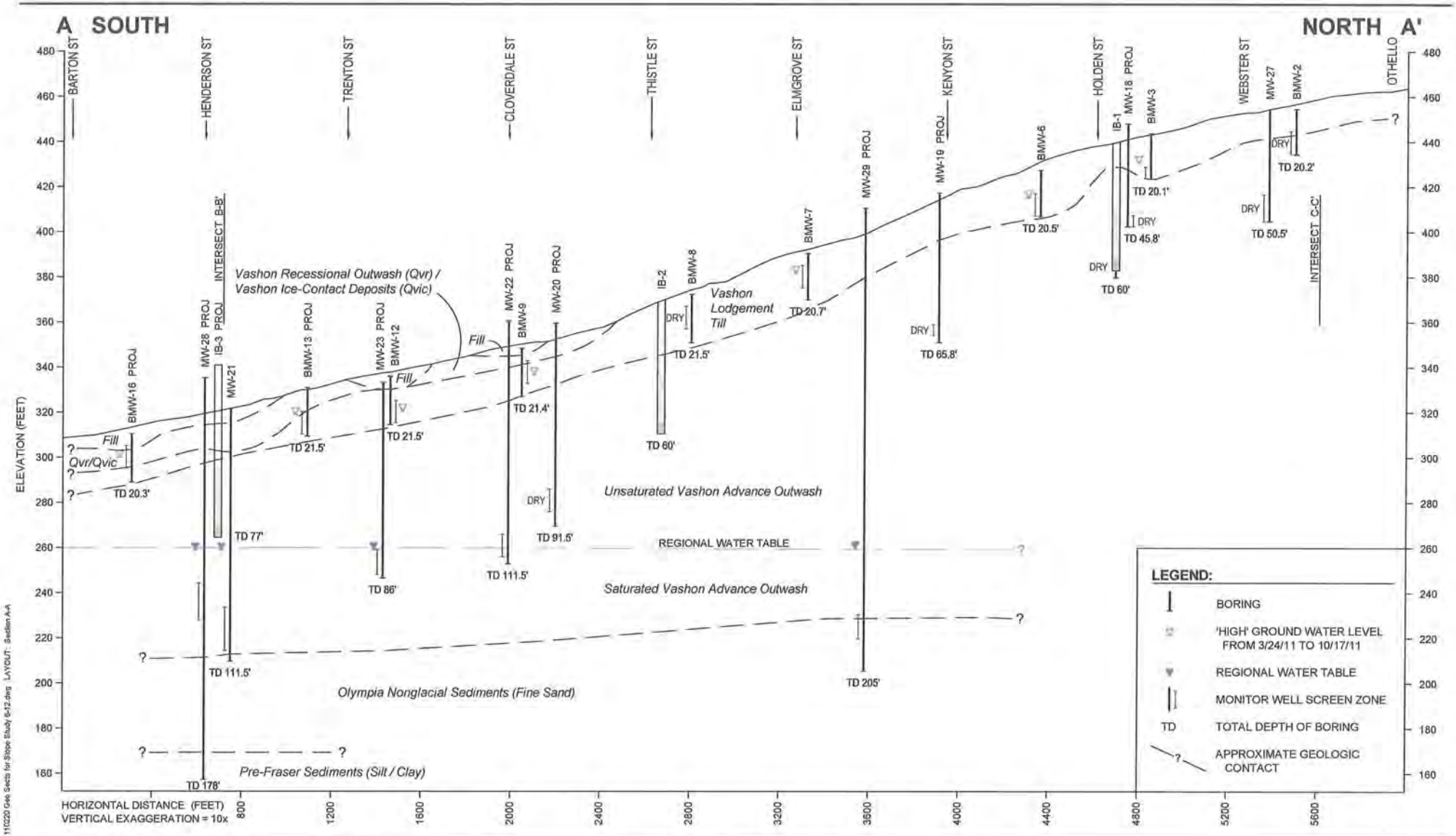

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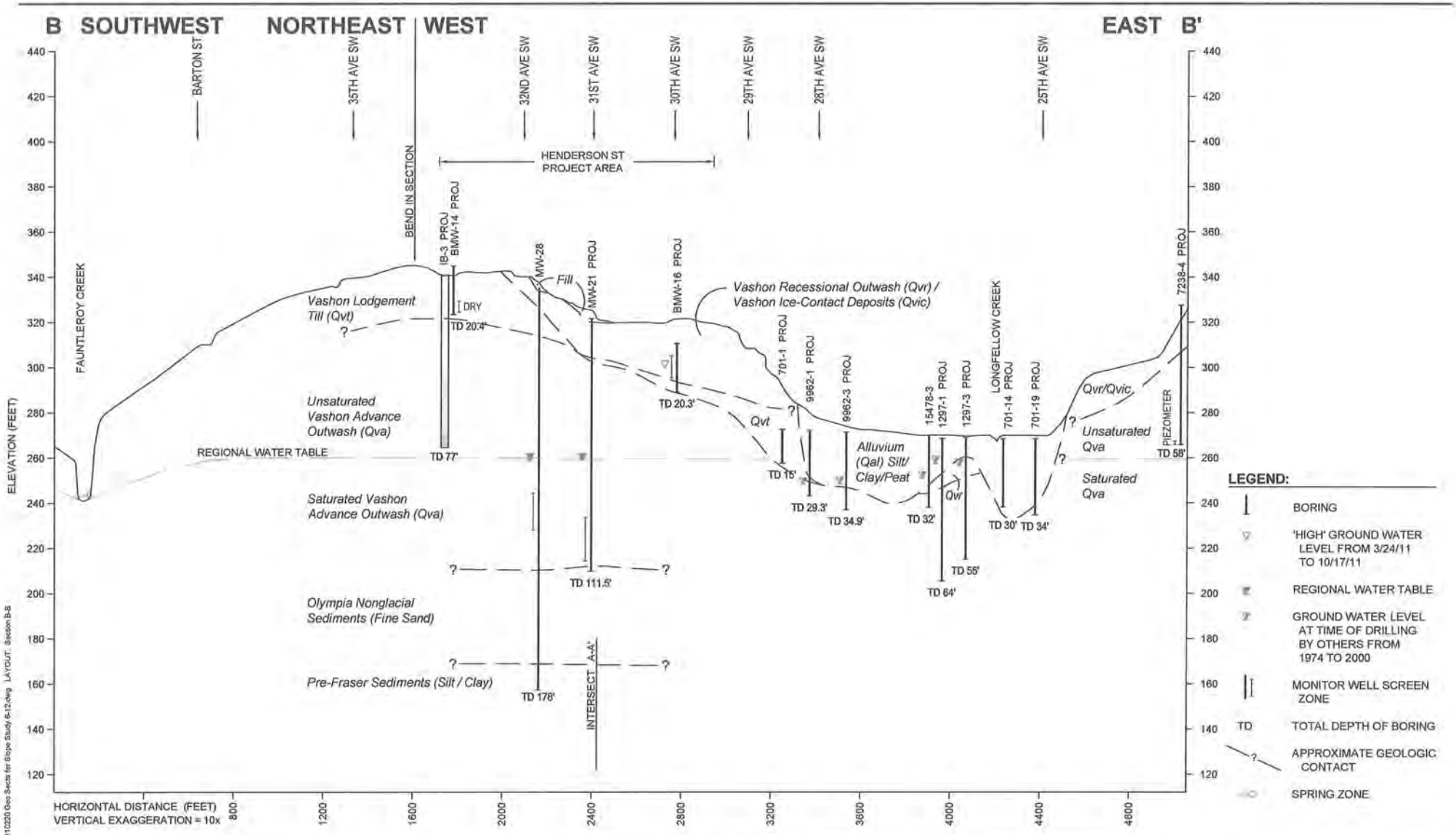
SCHEMATIC HYDROGEOLOGIC CROSS-SECTION A - A'

BARTON BASIN - CSO CONTROL PROJECT
SEATTLE, WASHINGTON

FIGURE 5
DATE 6/12
PROJECT NO. KH110220A

110220 Barton Basin \ 110220 Geo Sects for Slope Study 6-12.dwg LAYOUT: Section A-A



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SCHEMATIC HYDROGEOLOGIC CROSS-SECTION B - B'

BARTON BASIN - CSO CONTROL PROJECT

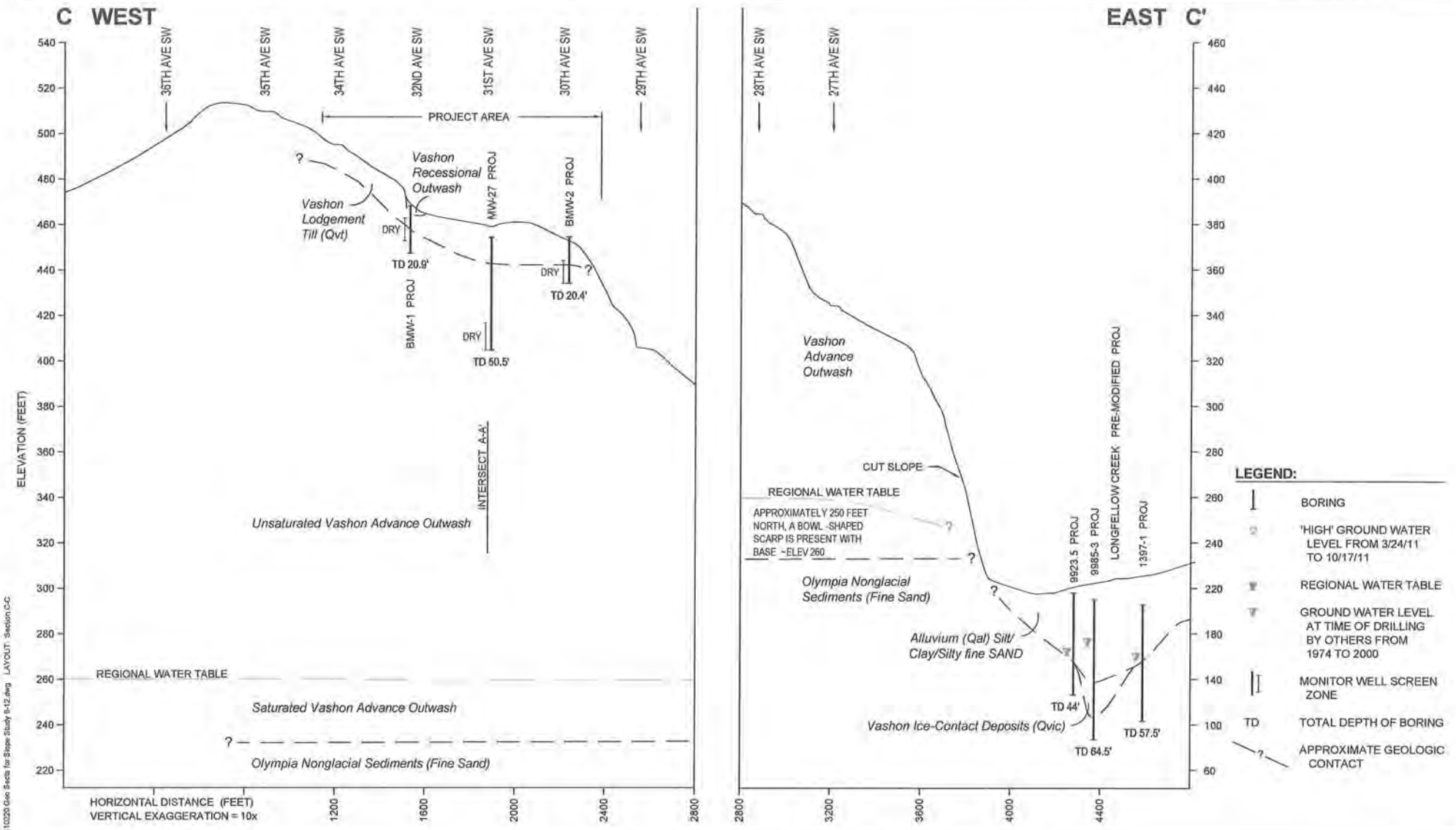
SEATTLE, WASHINGTON

FIGURE 6

DATE 6/12

PROJECT NO. KH110220A

110220 Barton Basin \ 110220 Geo Sects for Slope Study 6-12.dwg LAYOUT: Section B-B



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SCHEMATIC HYDROGEOLOGIC CROSS-SECTION C - C'

BARTON BASIN - CSO CONTROL PROJECT

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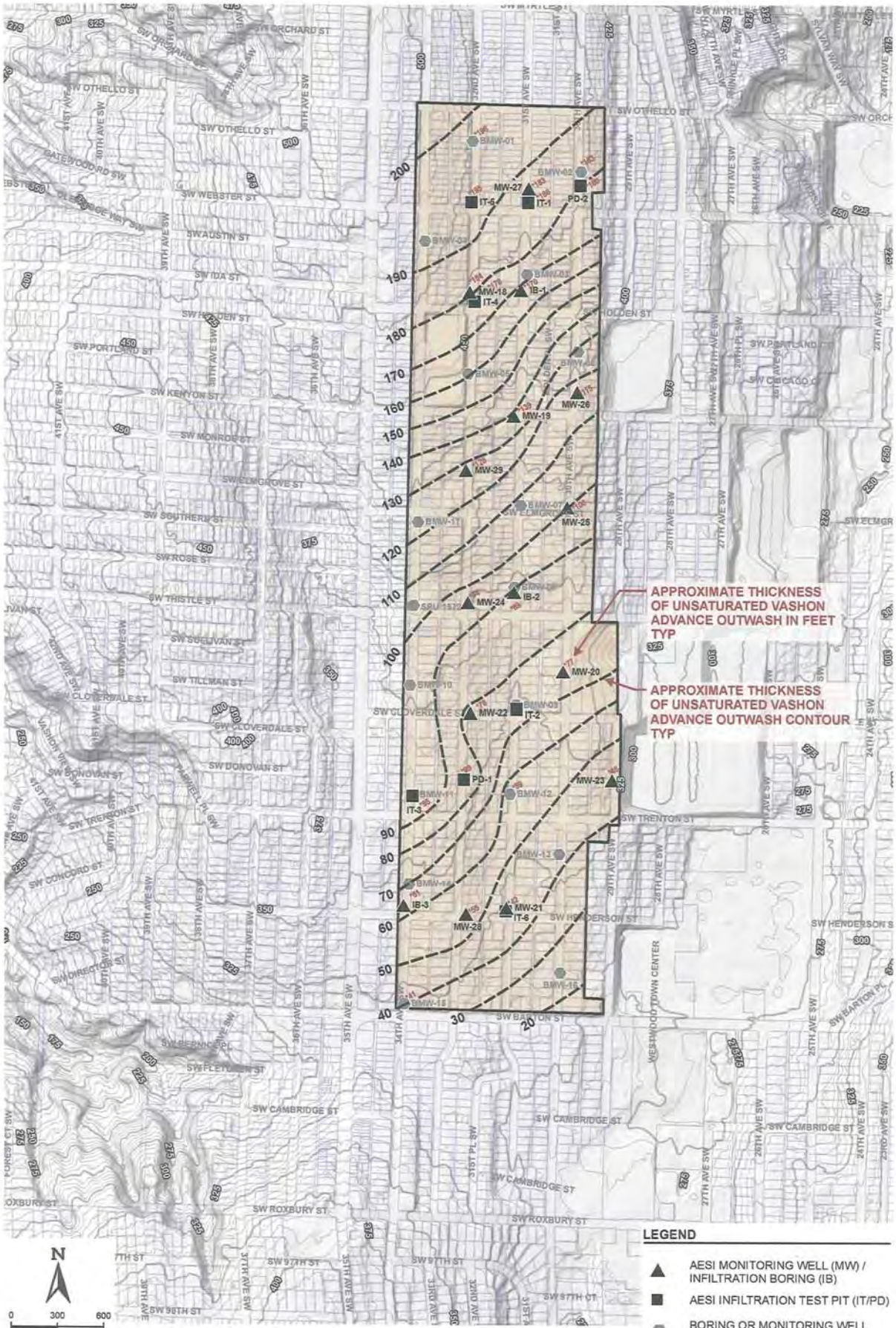
FIGURE 7

DATE 6/12

PROJECT NO. KH110220A

110220 Barton Basin \ 110220 Geo Sects for Slope Study 8-12.dwg LAYOUT: Section C-C'



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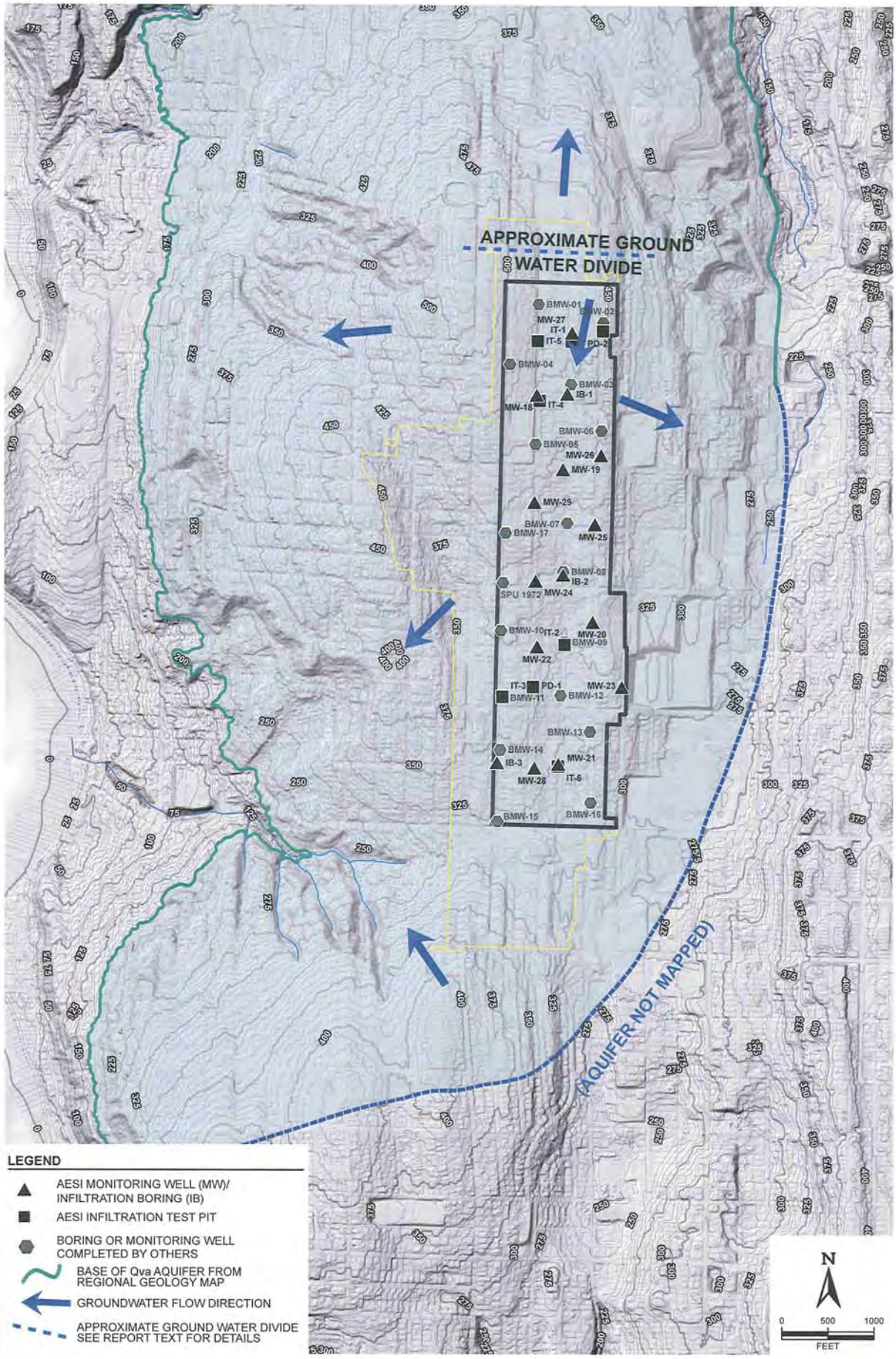
UNSATURATED VASHON ADVANCE OUTWASH THICKNESS

BARTON BASIN CSO CONTROL PROJECT
SEATTLE, WASHINGTON

FIGURE 8
DATE 3/12
PROJ. NO. KH110220A



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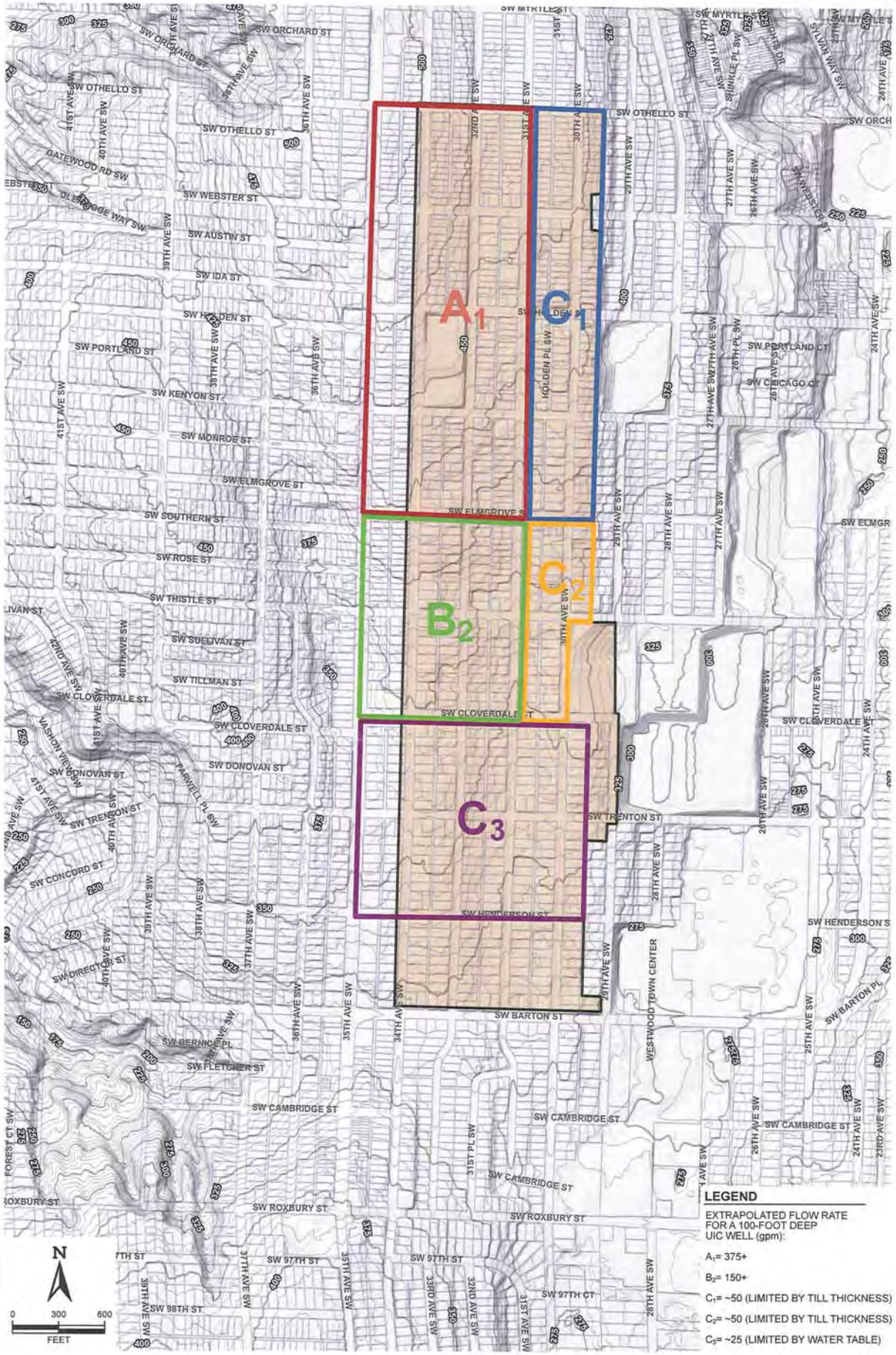
GENERALIZED DISTRIBUTION OF VASHON ADVANCE AQUIFER

BARTON BASIN CSO CONTROL PROJECT
SEATTLE, WASHINGTON

FIGURE 9
DATE 04/03/12
PROJ. NO. KH110220A



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PRELIMINARY FLOW RATE DISTRIBUTION MAP

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FIGURE 10

DATE 04/03/12

PROJ. NO. KH110220A

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