



## ***Preliminary Stormwater Site Plan***

### *PREPARED FOR:*

City of Fircrest  
115 Ramsdell Street  
Fircrest, WA 98466

### *PROJECT:*

Fircrest Pool and Community Center  
2170774.10

### *PREPARED BY:*

William Thompson, EIT  
Project Engineer

### *REVIEWED BY:*

Lucas Johnson, PE, LEED AP  
Project Manager

### *DATE:*

February 2019

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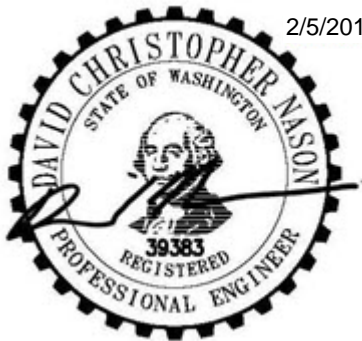
William Thompson, EIT  
Project Engineer

*REVIEWED BY:*

Lucas Johnson, PE, LEED AP  
Project Manager

*DATE:*

February 2019



I hereby state that this [Stormwater Site Plan](#) for the [Fircrest Pool and Community Center](#) project has been prepared by me or under my supervision, and meets the standard of care and expertise that is usual and customary in this community for professional engineers. I understand that [the City of Fircrest](#) does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities prepared by me.

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## 1.0 Project Overview

The Fircrest Pool and Community Center project includes the demolition of the existing community center, pool, parking lots and adjacent paved areas, and includes the construction of a new community center, bathhouse, and pool area. The scope of the project includes site grading, utility and stormwater improvements; and hardscape improvements such as drive aisles, parking spaces, and pedestrian walkways.

The project will consist of three phases; the first phase being the north half of the on-site project, the second phase being the south half of the on-site project, and the third phase being the on-street parking and sidewalk. Phase 1 will consist of the demolition of the paved play area to the north, pool area, and a portion of the community center; and the construction of the bathhouse, pool area, ADA parking stalls, and pedestrian walkways. Phase 2 will consist of the demolition of the community center, parking lot, paved play area, and drop-off area; and the construction of the new community center, parking lot, and pedestrian walkways. Phase 3 will consist of the demolition of the sidewalk and asphalt; and the construction of the new sidewalk, angle parking, and associated curb. Refer to Appendix C for Civil Engineering Plans.

The project site address is 555 Contra Costa Avenue, Fircrest, Washington. The site is located on Parcel No. 7160201251, which totals 7.35 acres. The project site is located in the Northwest Quarter of the Southeast Quarter of Section 11, Township 20 North, Range 2 East of the Willamette Meridian in Fircrest, Washington. Refer to Appendix A for a Vicinity Map. The site is roughly "L" shaped and has frontage along two public streets, Electron Way and Contra Cost Avenue.

The site generally drains from northwest to southeast. Stormwater from the project is collected using a series of catch basins, located in the field, parking lots, and drive aisles, and then conveyed via a pipe network to the City of Fircrest stormwater network on the south end of the site. The City network conveys stormwater south across Electron Way, ultimately discharging into Puget Sound. Offsite stormwater does not drain onto the project site.

## 2.0 Existing Conditions Summary

The existing site consists of one parcel that totals 7.35 acres. Existing site development features include a community center, pool area, paved play areas, parking lots, drive aisles, and pedestrian walkways on the southwest corner of the site. A majority of the remainder of the site is grass and used as a park, including play areas, baseball diamonds, and soccer fields. A survey of the site was completed by AHBL.

Existing utilities serving the project site include sanitary sewer, domestic water, irrigation water, natural gas, power, and communications. These utility services extend from mains or primary lines located in the Electron Way right-of-way and the Contra Costa Avenue right-of-way. Existing utility services for the site will be used, replaced, or decommissioned.

Site soils consist of recessional outwash. A geotechnical engineering services report was prepared by GeoEngineers, Inc. (March 18, 2016) and is included in Appendix E. Stormwater infiltration is presumed to be infeasible. Groundwater was determined to be around 3 feet deep during the onsite testing, which took place from January to March in 2016.

The project site is generally sloped from the northwest to the southeast with an elevation difference of approximately 6 feet across the site. Stormwater drains to a few low points, a couple in the nearby field and the remainder in the parking areas, and is conveyed south to the City of Fircrest stormwater system. This system directs stormwater south across Electron Way and ultimately discharges into Puget Sound.

There are no known streams, wetlands, or other water bodies located on or within the vicinity of the project site. There are also no known area-specific requirements established in local plans, ordinances, regulations, or in Water Clean-Up Plans approved by the Department of Ecology. The project site is not located within a flood zone. Refer to Appendix A for a Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM).

### **3.0 Offsite Analysis Report**

#### **3.1 Qualitative Analysis**

##### **3.1.1 Study Area Definition and Mapping**

This project is located within the City of Fircrest stormwater service area. Stormwater from the project is collected using a series of catch basins, located in the field, parking lots, and drive aisles, and then conveyed via a pipe network to the City of Fircrest stormwater network on the south end of the site. The City network conveys stormwater south across Electron Way, ultimately discharging into Puget Sound. Refer to Appendix C for Civil Engineering Plans, which show the project site and general stormwater flow patterns.

##### **3.1.2 Study Area Information Review**

The following resources were reviewed to determine the stormwater path downstream of the project site and to identify any existing or potential problems in the study area:

1. Soils Information: GeoEngineers, Inc. prepared a Geotechnical Engineering Services Report (March 18, 2016), which is included in Appendix E.
2. Permit and record drawings for the Community Center were consulted to verify locations of existing onsite utilities.
3. The topographic survey for the project site serves as the background for the design of the project.
4. Field investigations performed by AHBL staff.

##### **3.1.3 Study Area Field Inspection**

The drainage system downstream from the project site was field inspected to determine the path and condition. No issues with the onsite stormwater system were observed.

##### **3.1.4 Drainage System Description**

Based on site observations, site survey, and information provided by City of Fircrest, there are no indications of onsite problems such as erosion, ponding water, or insufficient conveyance capacity.

#### **3.2 Upstream Qualitative Analysis**

Stormwater does not flow onto the project site from other adjacent parcels.

## 4.0 Permanent Stormwater Control Plan

### 4.1 Existing Site Hydrology

The project is broken up into three phases, but they are all located in a common basin. The basin is 2.64 acres and is located entirely in the City of Fircrest stormwater services area. The basin is currently developed with a building, parking lots, paved play areas, and pool area. The pre-developed site basin was modeled using WWHM2012 (Western Washington Hydrology Model). Impervious surfaces were modeled as *DRIVEWAYS/FLAT* or *ROOF TOPS/FLAT* and pervious surfaces were modeled as *C, Lawn, Flat*.

**Table 1. Pre-Developed Basin Summary**

Sub-Basin Name	A <sub>imp</sub> (ac)	A <sub>perv</sub> (ac)	Total (ac)
Phase 1	0.47	0.22	<b>0.69</b>
Phase 2	0.76	0.64	<b>1.40</b>
Phase 3	0.40	0.15	<b>0.55</b>

### 4.2 Developed Site Hydrology

The proposed site consists of a single stormwater basin, with three sub-basins. One sub-basin consists of the runoff generated by the parking lot and surrounding sidewalk. The second sub-basin consists of the remainder of the onsite runoff (roofs, lawn, and other paved areas). The third sub basin consists of offsite runoff (runoff generated in the right-of-way) including on-street parking and sidewalk. The basin is 2.64 acres and is located entirely in the City of Fircrest stormwater services area. Improvements in the site basin include construction of a new community center, bathhouse, and pool area, as well as new parking areas, sidewalks, and courtyards. Offsite improvements include sidewalk replacement, angled on-street parking, new driveway approaches, and utility patches.

Included in Appendix A is a Basin Map for the developed condition. A summary of the project basin is provided in Table 2 below. The site was modeled using WWHM2012. Impervious surfaces were modeled as *DRIVEWAYS/FLAT* or *ROOF TOPS/FLAT* and pervious surfaces were modeled as *C, Lawn, Flat*.

**Table 2. Developed Basin Summary**

Sub-Basin Name	A <sub>imp</sub> (ac)	A <sub>perv</sub> (ac)	Total (ac)
Phase 1	0.56	0.13	<b>0.69</b>
Phase 2	0.94	0.46	<b>1.40</b>
Phase 3	0.53	0.02	<b>0.55</b>

#### 4.2.1 Performance Standards and Goals

All Minimum Requirements from the Department of Ecology 2012 *Stormwater Management Manual for Western Washington (SMMWW)* apply to the new and replaced hard surfaces and converted vegetation areas. This is based on Figure I-2.4.2 – Flow Chart for Determining Requirements for Redevelopment from the *SMMWW*, which is included in Appendix A of this report. Each phase of the project is exempt from some of the Minimum Requirements, however. This is discussed below in more detail.

#### **4.2.2 Low Impact Development Features**

Project improvements will include low impact development (LID) features such as a bioretention cell and perforated stub-out connections. A bioretention cell will provide treatment for stormwater generated by the drive aisle and off-street parking area.

#### **4.2.3 Flow Control System**

This project is exempt from flow control because none of the three phases meet any of the thresholds listed in Section I-2.5.7 of the *SMMWW*. There will be less than 10,000 square feet of new impervious surface, there is no conversion of vegetation areas, and the 100-year flow rate will increase by less than 0.1 cfs. Of the three phases, phase 2 will have the biggest increase in impervious surface. That increase will be approximately 0.18 acre (0.94 acre in the developed condition, compared to 0.76 acre in the existing condition) or 7,850 square feet of new impervious surface. Refer to the Basin Maps included in Appendix A for more details.

#### **4.2.4 Water Quality System**

Project improvements include creating and replacing pollutant generating surfaces. Examples of such surfaces include a drive aisle and parking areas. Stormwater generated by these surfaces will be treated such that 80 percent of the total suspended solids will be removed from 91 percent of the total stormwater volume, as estimated by WWHM2012.

Stormwater generated by the off-street parking area and drive aisle will be treated in a bioretention cell. Stormwater generated by the on-street parking will likely be treated using proprietary media filters, but this will be evaluated more in the final design. Refer to Appendix C for Civil Engineering Plans, which shows the proposed location of the parking lot treatment facility. Detailed water quality calculations will be provided in Appendix B of the final Stormwater Site Plan.

#### **4.2.5 Conveyance System**

Each phase of this project will have its own conveyance system that will consist of an enclosed network of catch basins and pipes. Phase 1 will collect runoff from the roof and other paved areas and convey the water to the City of Fircrest stormwater network. Phase 2 will collect runoff from onsite pollution generating impervious surfaces (PGIS) and non-PGIS separately, treat the runoff from the PGIS in a bioretention cell, and discharge all the runoff into the City of Fircrest stormwater network. Phase 3 will collect the stormwater generated by the offsite PGIS, treat the runoff, and discharge it into the City of Fircrest stormwater network.

The conveyance systems will be designed with the following parameters:

Analysis Methodology:	Santa Barbara Urban Hydrograph (SBUH) method using StormSHED2G software, Type 1A rainfall distribution Manning's equation for uniform flow
Curve Numbers:	Per <i>SMMWW</i> , Volume III, Table 2.3.2 Hydrologic Soil Group (HSG) C Pavement and other impervious surfaces = 98 Grass and other landscaping = 86
Design Storm:	25-year, 24-hour (3.5 inches)
Pipe Material:	Polyvinyl chloride (n=0.011) Ductile iron (n=0.011)

Corrugated polyethylene (n=0.011)

Detailed conveyance calculations will be provided in the final Stormwater Site Plan and will be included in Appendix B.

## **5.0 Discussion of Minimum Requirements**

### **5.1 Minimum Requirements**

#### **5.1.1 MR 1 – Preparation of Stormwater Site Plans**

This report provides the Stormwater Site Plan narrative, exhibits, figures, and calculations. Civil engineering plans will be provided in the form of temporary erosion and sedimentation control plans, grading plans, and drainage plans.

#### **5.1.2 MR 2 – Construction Stormwater Pollution Prevention**

The proposed project is required to provide a Construction Stormwater Pollution Prevention Plan (SWPPP), including a narrative and Erosion Control Plans. The Construction SWPPP will comply with the 13 Elements identified in the *SMMWW*. The Construction SWPPP is discussed in Section 6.0 and will be included in the final Stormwater Site Plan.

#### **5.1.3 MR 3 – Source Control of Pollution**

All applicable source control Best Management Practices (BMPs) will be identified in the final Stormwater Site Plan. The Construction SWPPP to be included in the final Stormwater Site Plan will provide details on the control of pollution during construction.

#### **5.1.4 MR 4 – Preservation of Natural Drainage Systems and Outfalls**

The project site currently directs stormwater to the south end of the site, where it discharges into the City of Fircrest stormwater system. Following project improvements, stormwater will discharge to the same location. Stormwater discharges from the project site will not cause an adverse impact to downstream receiving waters or downgradient properties.

#### **5.1.5 MR 5 – Onsite Stormwater Management**

Phase 1 of this project is required to address Minimum Requirements 1 through 9, which includes Minimum Requirement 5, Onsite Stormwater Management. This phase of the project will incorporate BMPs from List 2. These BMPs will be evaluated further as the design progresses.

Below is a preliminary summary of how each BMP in the list will be addressed or why it is infeasible.

Lawn and Landscaped Areas:

- BMP T5.13: Post-Construction Soil Quality and Depth will be applied to all landscaped areas. No other BMPs are required for lawn and landscape areas.

Roofs:

- Full Dispersion or Downspout Full Infiltration Systems – There is not sufficient room on the project site for Full Dispersion. The Geotechnical Report prepared by GeoEngineers

indicates that the site has high groundwater levels; therefore, this BMP is considered infeasible.

- Bioretention – Bioretention will be considered and its feasibility will be evaluated as the project progresses to meet this requirement. There is limited space available for Phase 1, which may make this BMP infeasible.
- Downspout Dispersion – Downspout dispersion is infeasible due to the lack of 25 feet for the vegetated flow path.
- Perforated Stub-Out Connections – A perforated stub-out connection is likely feasible and will be implemented if applicable. No other BMPs required consideration for roofs.

#### Other Hard Surfaces:

- Full Dispersion – There is insufficient room to preserve 65 percent of the site in a forest or native condition; therefore, this BMP is infeasible.
- Permeable Pavement – Permeable pavement is infeasible due to poor infiltration rates of the underlying soils.
- Bioretention – Bioretention is likely infeasible due to lack of useable space onsite.
- Sheet Flow Dispersion or Concentrated Flow Dispersion – Sheet flow dispersion is infeasible for most of this site due to the lack of room for a vegetated buffer.

Phase 2 of this project is required to address Minimum Requirements 1 through 9, which include Minimum Requirement 5, Onsite Stormwater Management. This phase of the project will incorporate BMPs from List 2. These BMPs will be evaluated further as the design progresses and further geotechnical investigations are performed.

Below is a preliminary summary of how each BMP in the list will be addressed or why it is infeasible.

#### Lawn and Landscaped Areas:

- BMP T5.13: Post-Construction Soil Quality and Depth will be applied to all landscaped areas. No other BMPs are required for lawn and landscape areas.

#### Roofs:

- Full Dispersion or Downspout Full Infiltration Systems – There is not sufficient room on the project site for Full Dispersion. The Geotechnical Report prepared by GeoEngineers indicates that the site has high groundwater levels; therefore, this BMP is considered infeasible.
- Bioretention – Bioretention is currently proposed to treat the runoff from the parking lot. It may be possible to expand the footprint to manage runoff from some of the building roof, but there is limited space available.
- Downspout Dispersion – Downspout dispersion is infeasible due to the lack of 25 feet for the vegetated flow path.

- Perforated Stub-Out Connections – A perforated stub-out connection is likely feasible and will be implemented if applicable. No other BMPs required consideration for roofs.

Other Hard Surfaces:

- Full Dispersion – There is insufficient room to preserve 65 percent of the site in a forest or native condition; therefore, this BMP is infeasible.
- Permeable Pavement – Permeable pavement is infeasible due to poor infiltration rates of the underlying soils.
- Bioretention – Bioretention appears to be feasible and will be implemented. No other BMPs required consideration for other hard surfaces.

Phase 3 of this project is required to address Minimum Requirements 1 through 9, which include Minimum Requirement 5, Onsite Stormwater Management. This phase of the project will incorporate BMPs from List 2. These BMPs will be evaluated further as the design progresses and further geotechnical investigations are performed.

Below is a preliminary summary of how each BMP in the list will be addressed or why it is infeasible.

Lawn and Landscaped Areas:

- BMP T5.13: Post-Construction Soil Quality and Depth will be applied to all landscaped areas. No other BMPs are required for lawn and landscape areas.

Roofs:

- There are no roof areas in phase 3 of this project.

Other Hard Surfaces:

- Full Dispersion – Phase three of this project does not include any forest or native conditions to preserve; therefore, this BMP is infeasible.
- Permeable Pavement – Permeable pavement is infeasible due to poor infiltration rates of the underlying soils.
- Bioretention – Bioretention is infeasible due to lack of useable space.
- Sheet Flow Dispersion or Concentrated Flow Dispersion – Sheet flow dispersion is infeasible for phase 3 due to the lack of room for a vegetated buffer. No other BMPs required consideration for other hard surfaces.

#### **5.1.6 MR 6 – Runoff Treatment**

This project meets the thresholds for Minimum Requirement 6: Runoff Treatment. This requirement will be met by routing stormwater that is generated from pollutant generating surfaces through either a bioretention cell or a proprietary media filter (e.g. StormFilter structures). Preliminary water quality calculations are provided in Appendix B.

#### **5.1.7 MR 7 – Flow Control**

This project is exempt from flow control because, as discussed previously in Section 4.2.3, neither phases one, two, or three meets the thresholds listed in Section I-2.5.7 of the *SMMWW*.

#### **5.1.8 MR 8 – Wetlands Protection**

There are no known wetlands on the project site or within the vicinity of the project. Therefore, wetland protection measures are not required.

#### **5.1.9 MR 9 – Operations and Maintenance**

The operations and maintenance requirements are discussed in Section 9.0.

### **6.0 Construction Stormwater Pollution Prevention Plan**

A Construction SWPPP will be prepared for the final Stormwater Site Plan and will be included in Appendix D. The Construction SWPPP will address the 13 Elements outlined by Minimum Requirement 2 of the *SMMWW*. The intent of the Construction SWPPP is to minimize erosion and prevent sediment-laden runoff from discharging off the project site. BMPs outlined in Volume II of the *SMMWW* will be used to prevent or reduce the release of pollutants to the waters of Washington State.

### **7.0 Special Reports and Studies**

A Geotechnical Engineering Services Report was prepared by GeoEngineers, Inc. (March 18, 2016) and is included in Appendix E.

### **8.0 Other Permits**

Permits required for the project include the following City of Fircrest permits:

- Base Land Use Permit
- Site Development Permit
- Commercial Building Permit
- Administrative Design Review
- SEPA Checklist
- Demolition Permit

### **9.0 Operation and Maintenance Manual**

The City of Fircrest will own all onsite stormwater facilities. An Operation and Maintenance Manual will not be required because the City of Fircrest will be responsible for operation and maintenance of onsite stormwater facilities.

### **10.0 Declaration of Covenant for Privately Maintained Flow Control and Treatment Facilities**

A declaration of covenant will not be required because the City of Fircrest will own and maintain the onsite treatment facility.



### **11.0 Declaration of Covenant for Privately Maintained Onsite Stormwater Management BMPs**

A declaration of covenant will not be required because the City of Fircrest will own and maintain all onsite stormwater management BMPs.

### **12.0 Bond Quantities Worksheet**

A bond is not anticipated because the City of Fircrest will be the owner of the proposed project, and thus a bond quantity worksheet was not prepared. If required, documentation will be provided in the final Stormwater Site Plan to establish the appropriate project bond (or other financial guarantee) amount.

### **13.0 Conclusion**

This project has been designed to meet the requirements of the Department of Ecology 2012 *Stormwater Management Manual for Western Washington*, as adopted by the City of Fircrest. This analysis is based on data and records either supplied to or obtained by AHBL. The analysis has been prepared using procedures and practices within the standard accepted practices of the industry.

AHBL, Inc.



William Thompson, EIT  
Project Engineer

WAT/lsk

February 2019

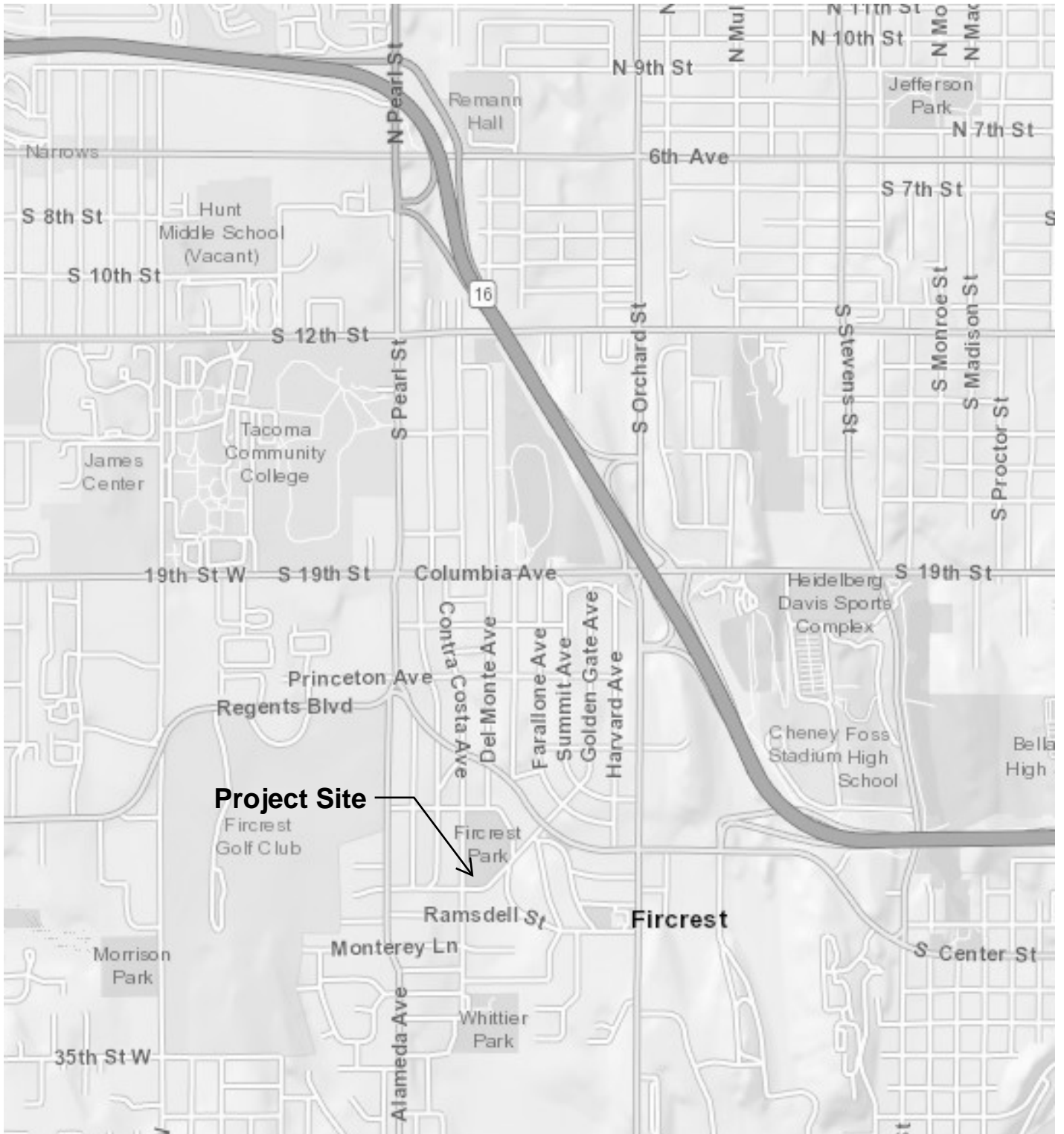
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# ***Appendix A***

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## **Exhibits**

- Vicinity Map
- FEMA FIRM
- Flow Chart for Determining Requirements for Redevelopment
- Existing Condition Basin Map
- Developed Condition Basin Map



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**Fircrest Pool & Community Center**

**Vicinity Map**

**A-1**

## NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The community map repository should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations (BFEs)** and/or **footprint elevations** have been determined, users are encouraged to consult the Flood Profiles and Footprint Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

**Coastal Base Flood Elevations** shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **footways** were computed at cross sections and interpolated between cross sections. The footways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Footway widths and other pertinent footway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 Flood Protection Measures of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 10. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at <http://www.ngs.noaa.gov> or contact the National Geodetic Survey at the following address:

NGS Information Services  
NOAA, NGS12  
National Geodetic Survey  
SSMC-3, #5202  
1315 East-West Highway  
Silver Spring, Maryland 20910-3282  
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at (301) 713-3242, or visit its website at <http://www.ngs.noaa.gov>.

**Base map** information shown on this FIRM was derived from multiple sources. Base map files were provided in digital format by Pierce County GIS, WA DNR, WSDOT, USFWS, Washington State Department of Ecology, and Puget Sound Regional Council. This information was compiled at scales of 1:1,200 to 1:24,000 during the time period 1996-2012.

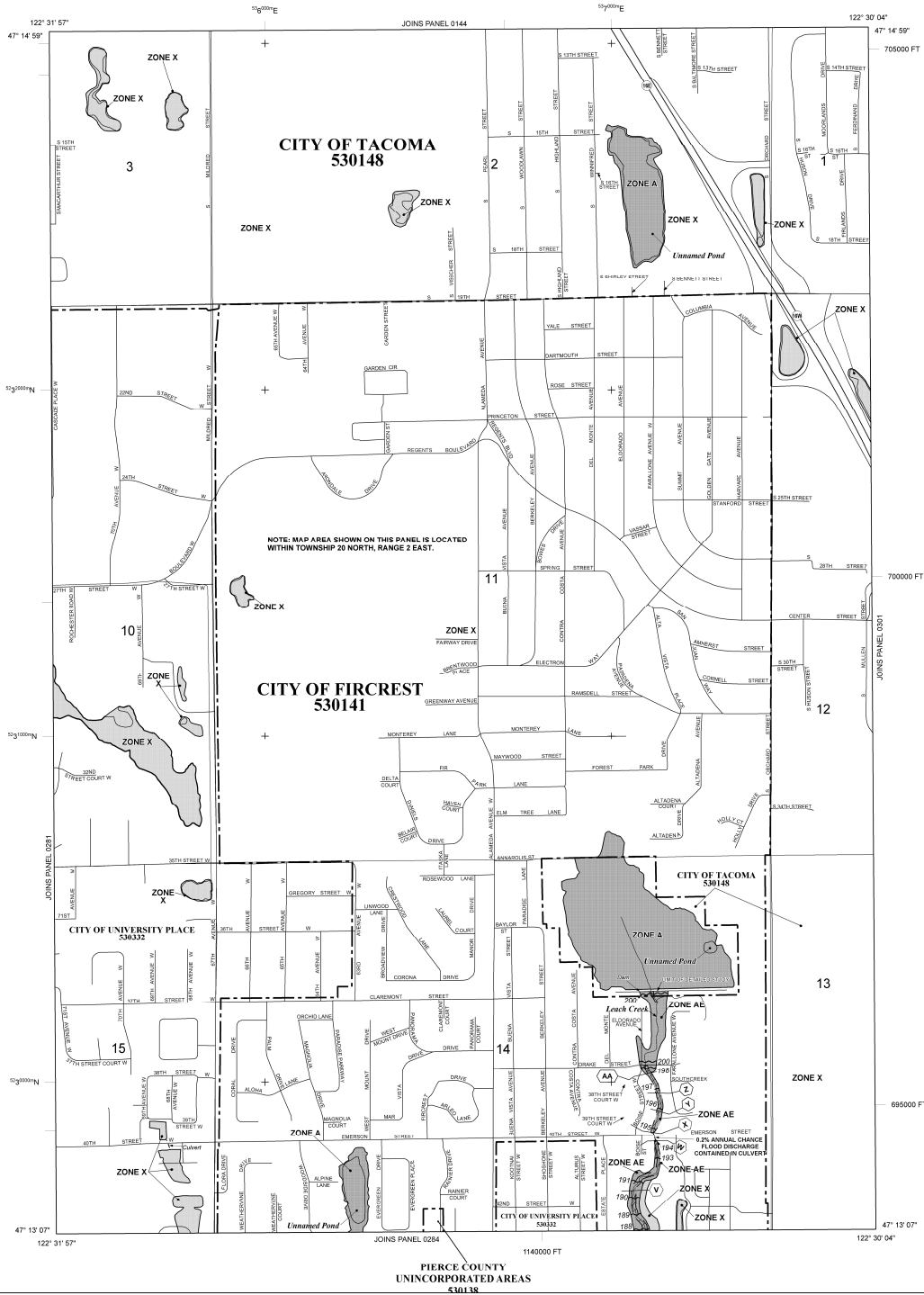
The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

**Corporate limits** shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels, community map repository addresses, and a listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

For information on available products associated with this FIRM visit the **Map Service Center (MSC)** website at <http://msc.fema.gov>. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. Many of these products can be ordered or obtained directly from the MSC website.

If you have questions about this map, how to order products, or the National Flood Insurance Program in general, please call the **FEMA Map Information eXchange (FMIX)** at 1-877-FEMA-MAP (1-877-336-2627) or visit the FEMA website at <http://www.fema.gov/business/fm>.



## LEGEND

**SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD.**  
The 1% annual chance flood (100-year flood), also known as the **base flood**, is the flood that has a 1% chance of being equaled or exceeded in any given year. The flood shown on this map is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, AV, and VE. The **Base Flood Elevation** is the water-surface elevation of the 1% annual chance flood.

- ZONE A** No Base Flood Elevations determined.
- ZONE AE** Base Flood Elevations determined.
- ZONE AH** Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
- ZONE AO** Flood depths of 1 to 3 feet (usually shear flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
- ZONE AR** Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being removed to provide protection from the 1% annual chance or greater flood.
- ZONE AV** Area to be protected from the 1% annual chance flood by a federal flood protection system under construction; no Base Flood Elevations determined.
- ZONE V** Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
- ZONE VE** Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

**FLOODWAY AREAS IN ZONE AE**

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

**OTHER FLOOD AREAS**

- ZONE X** Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from the 1% annual chance flood.
- OTHER AREAS**
- ZONE X** Areas determined to be outside the 0.2% annual chance floodplain. Areas in which flood hazards are undetermined, but possible.
- ZONE D** Areas determined to be outside the 0.2% annual chance floodplain. Areas in which flood hazards are undetermined, but possible.
- COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS**
- OTHERWISE PROTECTED AREAS (OPAs)**

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

- 1% Annual Chance Floodplain Boundary
- Floodway boundary
- Zone D boundary
- CBRS and OPA boundary
- Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths, or flood velocities
- Base Flood Elevation line and value, elevation in feet\*
- Base Flood Elevation value where uniform within zone; elevation in feet\*

\*Referenced to the North American Vertical Datum of 1988

- Cross section line
- Traverse line
- Bridge
- Clutter
- Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere
- Map 1000-meter Universal Transverse Mercator grid values, zone 10
- Bench mark (see explanation in Notes to Users section of this FIRM panel)
- River mile
- MAP REPOSITORIES
- Refer to Map Repositories list on Map Index
- EFFECTIVE DATE OF COUNTRYWIDE FLOOD INSURANCE RATE MAP
- March 7, 2017
- EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study Report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-435-6820.

**NFIP**

**PANEL 0282E**

**FIRM**

**FLOOD INSURANCE RATE MAP**

**PIERCE COUNTY,**

**WASHINGTON**

**AND INCORPORATED AREAS**

**PANEL 282 OF 1375**

**(SEE MAP INDEX FOR FIRM PANEL LAYOUT)**

**CONTAINS:**

COMMUNITY	NUMBER	PANEL	SUFFIX
FIRCREST CITY OF	530141	0282	E
PIERCE COUNTY	030134	0282	E
TACOMA CITY OF	530148	0282	E
UNIVERSITY PLACE, CITY OF	530332	0282	E

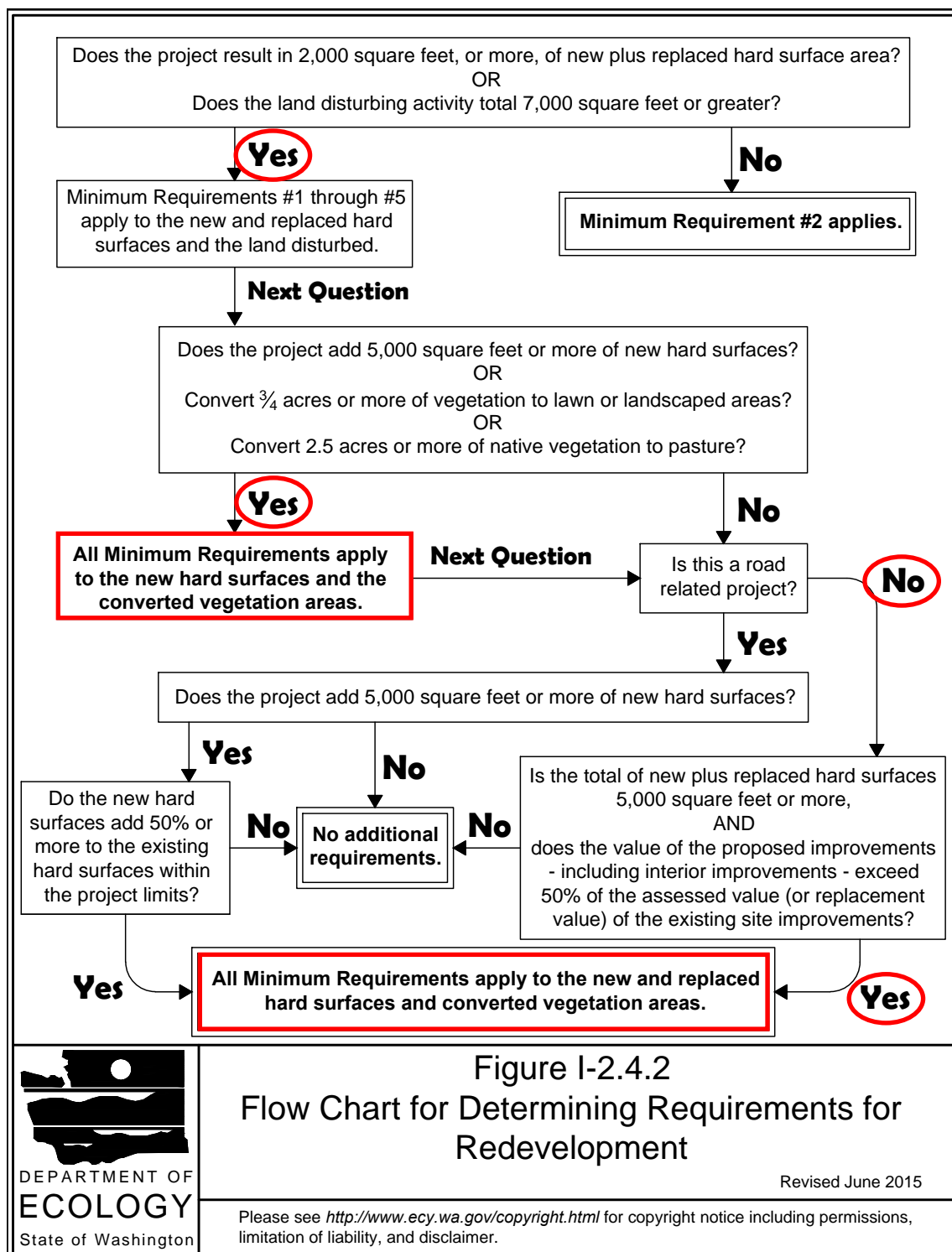
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for this subject community.

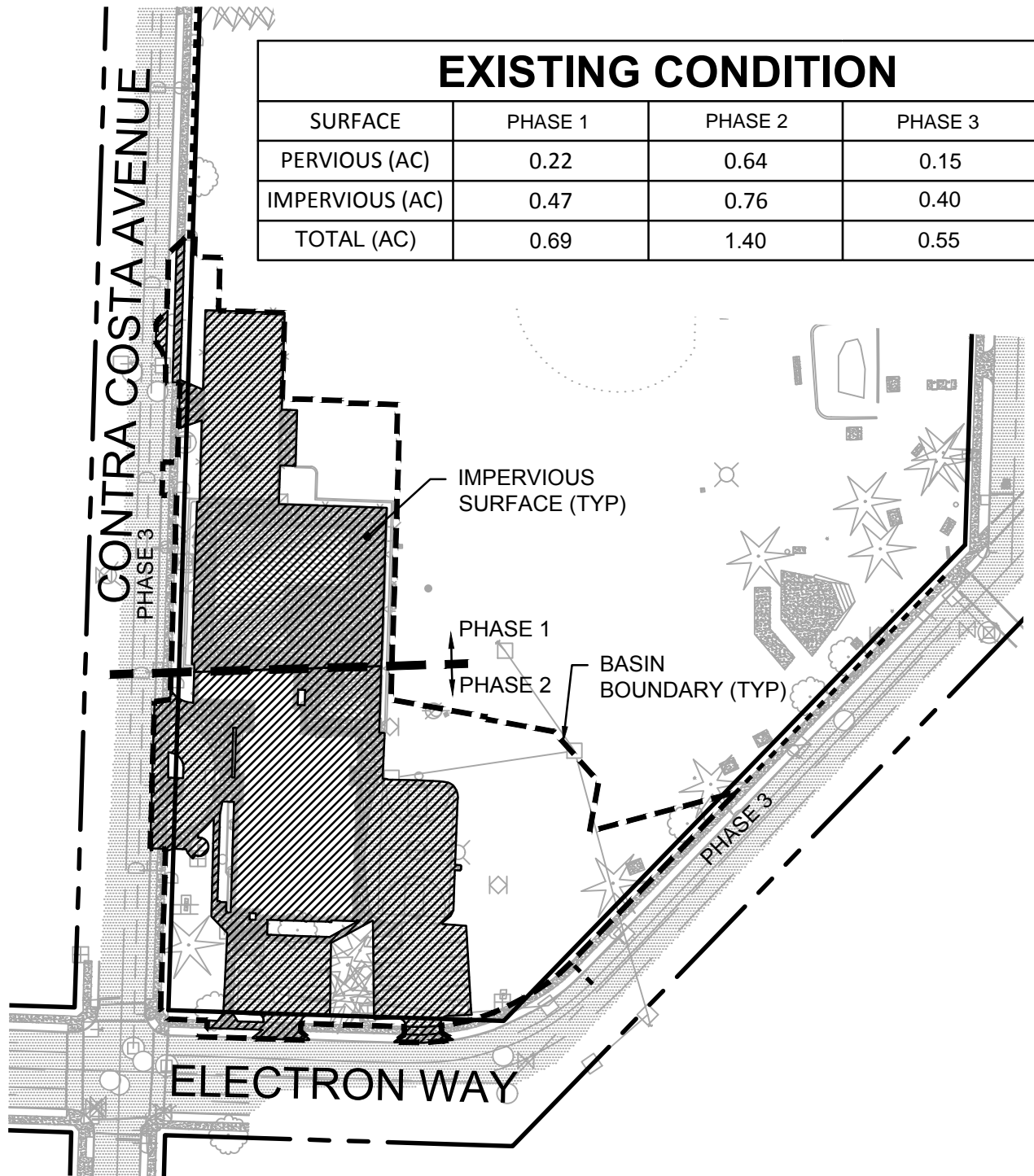
**MAP NUMBER**  
**53053C0282E**

**EFFECTIVE DATE**  
**MARCH 7, 2017**

Federal Emergency Management Agency

**Figure I-2.4.2 Flow Chart for Determining Requirements for Redevelopment**





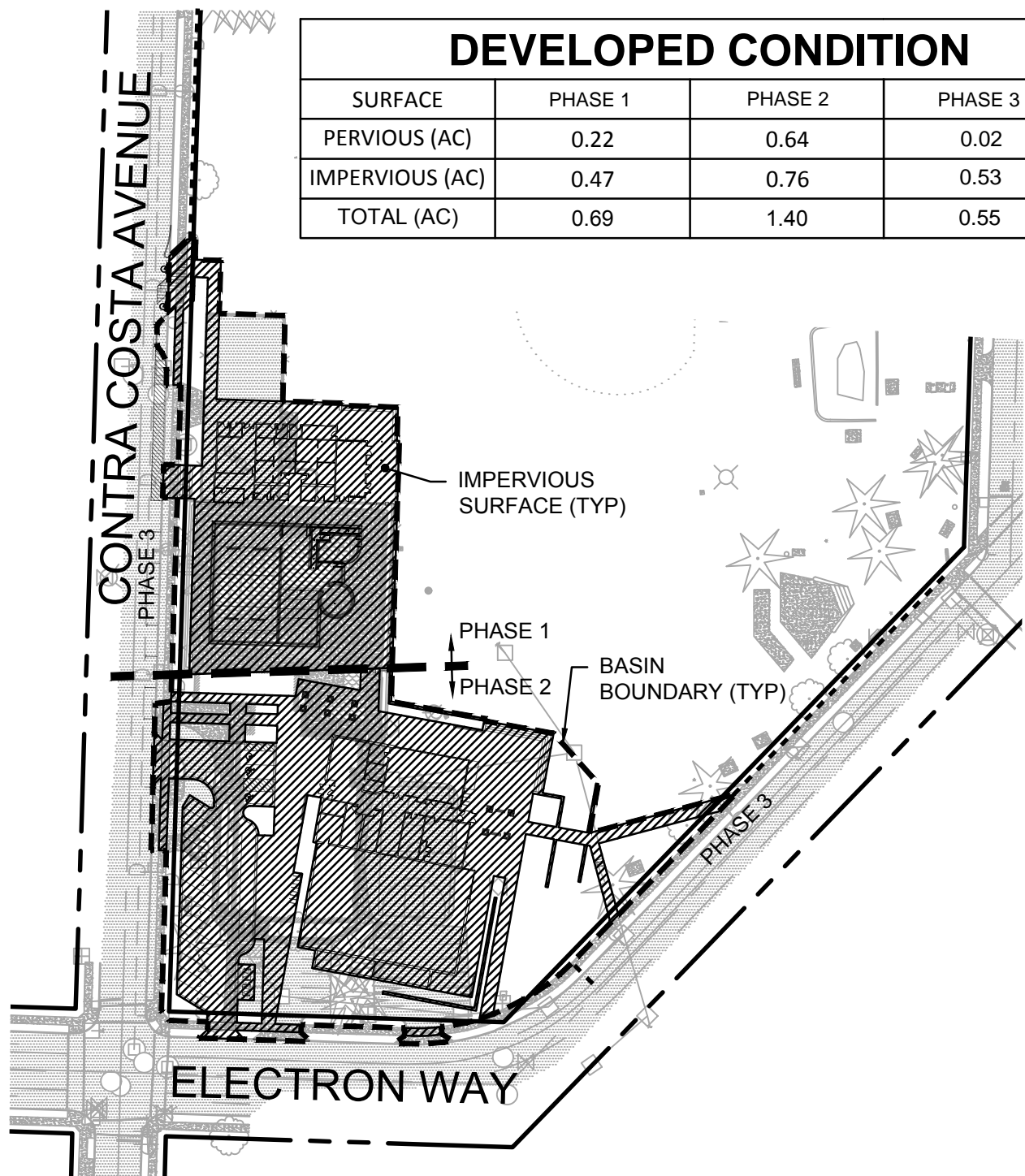
2215 North 30th Street  
Suite 300  
Tacoma, WA 98403  
253.383.2422 TEL  
253.383.2572 FAX

**Fircrest Pool & Community Center**

**Existing Condition Basin Map**

**A-4**





DEVELOPED CONDITION			
SURFACE	PHASE 1	PHASE 2	PHASE 3
PERVIOUS (AC)	0.22	0.64	0.02
IMPERVIOUS (AC)	0.47	0.76	0.53
TOTAL (AC)	0.69	1.40	0.55



2215 North 30th Street  
Suite 300  
Tacoma, WA 98403  
253.383.2422 TEL  
253.383.2572 FAX

**Fircrest Pool & Community Center**

**Developed Conditions Basin Map**

**A-5**

# ***Appendix B***

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## **Stormwater Calculations**

- Water Quality



**WWHM2012**  
**PROJECT REPORT**

## *General Model Information*

Project Name: FCC (Phase 2 Water Quality)  
Site Name:  
Site Address:  
City:  
Report Date: 1/30/2019  
Gage:  
Data Start: 10/01/1901  
Data End: 09/30/2059  
Timestep: 15 Minute  
Precip Scale: 1.000  
Version Date: 2018/07/12  
Version: 4.2.15

## *POC Thresholds*

---

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

---

## *Landuse Basin Data*

### *Predeveloped Land Use*

#### Existing - PH2

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.13
Pervious Total	0.13
Impervious Land Use	acre
DRIVEWAYS FLAT	0.19
SIDEWALKS FLAT	0.11
Impervious Total	0.3
Basin Total	0.43

Element Flows To:		
Surface	Interflow	Groundwater

## *Mitigated Land Use*

### PROPOSED - PH2

Bypass: No

GroundWater: No

Pervious Land Use      acre  
C, Lawn, Flat      0.13

Pervious Total      0.13

Impervious Land Use      acre  
DRIVEWAYS FLAT      0.19  
SIDEWALKS FLAT      0.11

Impervious Total      0.3

Basin Total      0.43

#### Element Flows To:

Surface	Interflow	Groundwater
Surface retention 1	Surface retention 1	

## *Routing Elements*

### *Predeveloped Routing*

## Mitigated Routing

### Bioretention 1

Bottom Length: 7.00 ft.  
 Bottom Width: 7.00 ft.  
 Material thickness of first layer: 1.5  
 Material type for first layer: SMMWW 12 in/hr  
 Material thickness of second layer: 1  
 Material type for second layer: GRAVEL  
 Material thickness of third layer: 0  
 Material type for third layer: GRAVEL  
 Underdrain used  
 Underdrain Diameter (feet): 0.5  
 Orifice Diameter (in.): 6  
 Offset (in.): 3  
 Flow Through Underdrain (ac-ft.): 135.02  
 Total Outflow (ac-ft.): 145.102  
 Percent Through Underdrain: 93.05  
 Discharge Structure  
 Riser Height: 0.5 ft.  
 Riser Diameter: 12 in.  
 Element Flows To:  
 Outlet 1                      Outlet 2

Bioretention Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.0111	0.0000	0.0000	0.0000
0.0385	0.0111	0.0000	0.0000	0.0000
0.0769	0.0109	0.0000	0.0000	0.0000
0.1154	0.0106	0.0001	0.0000	0.0000
0.1538	0.0104	0.0001	0.0000	0.0000
0.1923	0.0102	0.0001	0.0000	0.0000
0.2308	0.0100	0.0001	0.0000	0.0000
0.2692	0.0098	0.0002	0.0000	0.0000
0.3077	0.0095	0.0002	0.0000	0.0000
0.3462	0.0093	0.0002	0.0000	0.0000
0.3846	0.0091	0.0003	0.0000	0.0000
0.4231	0.0089	0.0003	0.0000	0.0000
0.4615	0.0087	0.0003	0.0000	0.0000
0.5000	0.0085	0.0004	0.0000	0.0000
0.5385	0.0083	0.0004	0.0000	0.0000
0.5769	0.0081	0.0005	0.0000	0.0000
0.6154	0.0079	0.0005	0.0003	0.0000
0.6538	0.0077	0.0006	0.0004	0.0000
0.6923	0.0075	0.0006	0.0005	0.0000
0.7308	0.0073	0.0007	0.0006	0.0000
0.7692	0.0071	0.0007	0.0007	0.0000
0.8077	0.0069	0.0008	0.0009	0.0000
0.8462	0.0068	0.0008	0.0011	0.0000
0.8846	0.0066	0.0009	0.0013	0.0000
0.9231	0.0064	0.0009	0.0015	0.0000
0.9615	0.0062	0.0010	0.0017	0.0000
1.0000	0.0060	0.0011	0.0020	0.0000
1.0385	0.0059	0.0012	0.0023	0.0000
1.0769	0.0057	0.0012	0.0026	0.0000

1.1154	0.0055	0.0013	0.0029	0.0000
1.1538	0.0054	0.0014	0.0033	0.0000
1.1923	0.0052	0.0015	0.0037	0.0000
1.2308	0.0051	0.0015	0.0041	0.0000
1.2692	0.0049	0.0016	0.0045	0.0000
1.3077	0.0048	0.0017	0.0050	0.0000
1.3462	0.0046	0.0018	0.0055	0.0000
1.3846	0.0045	0.0019	0.0060	0.0000
1.4231	0.0043	0.0020	0.0065	0.0000
1.4615	0.0042	0.0021	0.0071	0.0000
1.5000	0.0040	0.0022	0.0077	0.0000
1.5385	0.0039	0.0023	0.0083	0.0000
1.5769	0.0037	0.0024	0.0090	0.0000
1.6154	0.0036	0.0025	0.0097	0.0000
1.6538	0.0035	0.0026	0.0104	0.0000
1.6923	0.0033	0.0027	0.0112	0.0000
1.7308	0.0032	0.0028	0.0120	0.0000
1.7692	0.0031	0.0029	0.0128	0.0000
1.8077	0.0030	0.0030	0.0136	0.0000
1.8462	0.0029	0.0031	0.0136	0.0000
1.8846	0.0027	0.0033	0.0136	0.0000
1.9231	0.0026	0.0034	0.0136	0.0000
1.9615	0.0025	0.0035	0.0136	0.0000
2.0000	0.0024	0.0036	0.0136	0.0000
2.0385	0.0023	0.0038	0.0136	0.0000
2.0769	0.0022	0.0039	0.0136	0.0000
2.1154	0.0021	0.0041	0.0136	0.0000
2.1538	0.0020	0.0042	0.0136	0.0000
2.1923	0.0019	0.0043	0.0136	0.0000
2.2308	0.0018	0.0045	0.0136	0.0000
2.2692	0.0017	0.0046	0.0136	0.0000
2.3077	0.0016	0.0048	0.0136	0.0000
2.3462	0.0015	0.0050	0.0136	0.0000
2.3846	0.0014	0.0051	0.0136	0.0000
2.4231	0.0014	0.0053	0.0136	0.0000
2.4615	0.0013	0.0055	0.0136	0.0000
2.5000	0.0012	0.0056	0.0136	0.0000
2.5000	0.0011	0.0056	0.0136	0.0000

Bioretention Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Infiltr(cfs)
2.5000	0.011111	0.005648	0.0000	0.0140	0.0000
2.5385	0.011345	0.006079	0.0000	0.0140	0.0000
2.5769	0.011582	0.006520	0.0000	0.0143	0.0000
2.6154	0.011821	0.006970	0.0000	0.0147	0.0000
2.6538	0.012063	0.007430	0.0000	0.0150	0.0000
2.6923	0.012307	0.007898	0.0000	0.0154	0.0000
2.7308	0.012554	0.008376	0.0000	0.0157	0.0000
2.7692	0.012803	0.008864	0.0000	0.0161	0.0000
2.8077	0.013054	0.009361	0.0000	0.0164	0.0000
2.8462	0.013308	0.009868	0.0000	0.0168	0.0000
2.8846	0.013564	0.010385	0.0000	0.0171	0.0000
2.9231	0.013823	0.010912	0.0000	0.0175	0.0000
2.9615	0.014084	0.011448	0.0000	0.0178	0.0000
3.0000	0.014348	0.011995	0.0000	0.0181	0.0000
3.0385	0.014614	0.012552	0.0800	0.0185	0.0000
3.0769	0.014883	0.013119	0.2257	0.0188	0.0000
3.1154	0.015154	0.013697	0.4122	0.0192	0.0000

3.1538	0.015427	0.014285	0.6273	0.0195	0.0000
3.1923	0.015703	0.014884	0.8600	0.0199	0.0000
3.2308	0.015981	0.015493	1.0991	0.0202	0.0000
3.2692	0.016262	0.016113	1.3333	0.0206	0.0000
3.3077	0.016545	0.016744	1.5516	0.0209	0.0000
3.3462	0.016831	0.017386	1.7445	0.0213	0.0000
3.3846	0.017119	0.018039	1.9054	0.0216	0.0000
3.4231	0.017410	0.018703	2.0318	0.0220	0.0000
3.4615	0.017703	0.019378	2.1274	0.0223	0.0000
3.5000	0.017998	0.020065	2.2033	0.0227	0.0000



## Surface retention 1

Element Flows To:

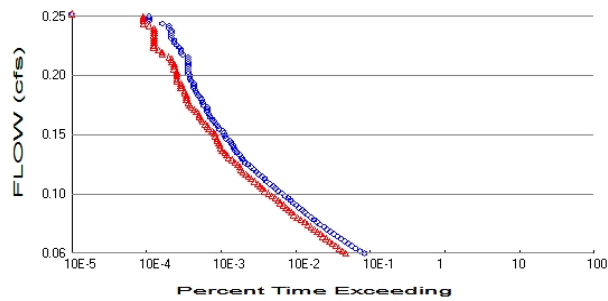
Outlet 1

Outlet 2

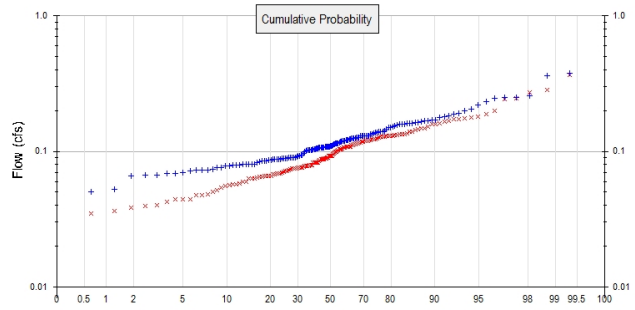
Bioretention 1

# Analysis Results

## POC 1



+ Predeveloped x Mitigated



### Predeveloped Landuse Totals for POC #1

Total Pervious Area: 0.13  
Total Impervious Area: 0.3

### Mitigated Landuse Totals for POC #1

Total Pervious Area: 0.13  
Total Impervious Area: 0.3

Flow Frequency Method: Log Pearson Type III 17B

### Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.110339
5 year	0.150249
10 year	0.179579
25 year	0.220079
50 year	0.252839
100 year	0.287898

### Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.092562
5 year	0.13409
10 year	0.163428
25 year	0.202454
50 year	0.232892
100 year	0.264469

## Annual Peaks

### Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1902	0.125	0.092
1903	0.138	0.136
1904	0.178	0.173
1905	0.072	0.063
1906	0.079	0.069
1907	0.116	0.118
1908	0.090	0.079
1909	0.106	0.088
1910	0.110	0.116
1911	0.122	0.071

1912	0.234	0.246
1913	0.083	0.057
1914	0.376	0.282
1915	0.074	0.057
1916	0.133	0.141
1917	0.050	0.044
1918	0.106	0.100
1919	0.068	0.047
1920	0.094	0.076
1921	0.080	0.066
1922	0.131	0.083
1923	0.087	0.074
1924	0.154	0.083
1925	0.067	0.068
1926	0.125	0.105
1927	0.102	0.075
1928	0.079	0.078
1929	0.161	0.158
1930	0.159	0.158
1931	0.079	0.076
1932	0.086	0.092
1933	0.084	0.082
1934	0.150	0.149
1935	0.070	0.065
1936	0.103	0.075
1937	0.146	0.131
1938	0.073	0.073
1939	0.091	0.085
1940	0.159	0.128
1941	0.156	0.087
1942	0.129	0.133
1943	0.122	0.119
1944	0.182	0.189
1945	0.130	0.130
1946	0.108	0.078
1947	0.078	0.076
1948	0.109	0.100
1949	0.164	0.147
1950	0.092	0.054
1951	0.139	0.048
1952	0.191	0.198
1953	0.171	0.175
1954	0.090	0.089
1955	0.080	0.044
1956	0.078	0.031
1957	0.088	0.072
1958	0.118	0.122
1959	0.120	0.123
1960	0.085	0.063
1961	0.256	0.273
1962	0.106	0.088
1963	0.076	0.055
1964	0.245	0.178
1965	0.107	0.106
1966	0.086	0.044
1967	0.129	0.075
1968	0.102	0.068
1969	0.093	0.092

1970	0.111	0.107
1971	0.109	0.108
1972	0.359	0.364
1973	0.187	0.145
1974	0.143	0.133
1975	0.168	0.168
1976	0.168	0.140
1977	0.066	0.060
1978	0.125	0.131
1979	0.120	0.058
1980	0.123	0.090
1981	0.108	0.104
1982	0.089	0.092
1983	0.126	0.130
1984	0.125	0.112
1985	0.149	0.075
1986	0.071	0.065
1987	0.117	0.114
1988	0.073	0.069
1989	0.067	0.066
1990	0.090	0.083
1991	0.136	0.112
1992	0.120	0.108
1993	0.138	0.135
1994	0.104	0.107
1995	0.076	0.042
1996	0.107	0.097
1997	0.092	0.052
1998	0.114	0.112
1999	0.113	0.064
2000	0.105	0.104
2001	0.080	0.069
2002	0.172	0.174
2003	0.089	0.090
2004	0.130	0.125
2005	0.248	0.182
2006	0.115	0.050
2007	0.134	0.132
2008	0.108	0.078
2009	0.080	0.078
2010	0.106	0.108
2011	0.108	0.035
2012	0.105	0.102
2013	0.103	0.065
2014	0.092	0.059
2015	0.180	0.143
2016	0.096	0.040
2017	0.158	0.165
2018	0.108	0.117
2019	0.160	0.161
2020	0.123	0.104
2021	0.101	0.099
2022	0.165	0.122
2023	0.199	0.129
2024	0.248	0.243
2025	0.103	0.056
2026	0.114	0.087
2027	0.127	0.098

2028	0.050	0.036
2029	0.087	0.083
2030	0.163	0.114
2031	0.053	0.048
2032	0.087	0.039
2033	0.109	0.038
2034	0.085	0.079
2035	0.119	0.120
2036	0.085	0.075
2037	0.115	0.071
2038	0.122	0.123
2039	0.219	0.129
2040	0.089	0.088
2041	0.113	0.109
2042	0.127	0.129
2043	0.139	0.112
2044	0.099	0.095
2045	0.081	0.068
2046	0.089	0.077
2047	0.105	0.108
2048	0.087	0.086
2049	0.129	0.120
2050	0.102	0.079
2051	0.152	0.152
2052	0.103	0.063
2053	0.088	0.089
2054	0.204	0.124
2055	0.107	0.083
2056	0.139	0.116
2057	0.069	0.066
2058	0.130	0.093
2059	0.162	0.126

### Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.3761	0.3643
2	0.3593	0.2824
3	0.2563	0.2730
4	0.2482	0.2457
5	0.2482	0.2431
6	0.2449	0.1984
7	0.2340	0.1886
8	0.2192	0.1815
9	0.2041	0.1776
10	0.1986	0.1751
11	0.1909	0.1736
12	0.1873	0.1734
13	0.1821	0.1678
14	0.1800	0.1649
15	0.1785	0.1608
16	0.1716	0.1584
17	0.1712	0.1579
18	0.1682	0.1524
19	0.1679	0.1489
20	0.1652	0.1475
21	0.1635	0.1451
22	0.1635	0.1430

23	0.1618	0.1406
24	0.1607	0.1402
25	0.1605	0.1360
26	0.1589	0.1345
27	0.1587	0.1331
28	0.1582	0.1330
29	0.1564	0.1317
30	0.1540	0.1314
31	0.1518	0.1305
32	0.1504	0.1298
33	0.1491	0.1295
34	0.1456	0.1293
35	0.1426	0.1292
36	0.1394	0.1285
37	0.1389	0.1282
38	0.1388	0.1257
39	0.1384	0.1247
40	0.1377	0.1236
41	0.1360	0.1234
42	0.1342	0.1226
43	0.1330	0.1219
44	0.1308	0.1216
45	0.1304	0.1200
46	0.1297	0.1200
47	0.1296	0.1192
48	0.1294	0.1179
49	0.1294	0.1171
50	0.1293	0.1164
51	0.1270	0.1160
52	0.1268	0.1140
53	0.1257	0.1138
54	0.1254	0.1125
55	0.1251	0.1124
56	0.1248	0.1119
57	0.1246	0.1116
58	0.1233	0.1088
59	0.1228	0.1077
60	0.1220	0.1077
61	0.1219	0.1076
62	0.1217	0.1076
63	0.1201	0.1072
64	0.1196	0.1068
65	0.1195	0.1060
66	0.1187	0.1047
67	0.1177	0.1043
68	0.1174	0.1037
69	0.1159	0.1035
70	0.1146	0.1021
71	0.1146	0.1005
72	0.1143	0.0999
73	0.1143	0.0991
74	0.1134	0.0977
75	0.1133	0.0966
76	0.1108	0.0952
77	0.1096	0.0926
78	0.1094	0.0923
79	0.1092	0.0921
80	0.1089	0.0920

81	0.1082	0.0919
82	0.1081	0.0897
83	0.1079	0.0896
84	0.1076	0.0892
85	0.1075	0.0891
86	0.1069	0.0882
87	0.1068	0.0879
88	0.1067	0.0878
89	0.1062	0.0873
90	0.1062	0.0870
91	0.1061	0.0857
92	0.1060	0.0853
93	0.1055	0.0831
94	0.1050	0.0831
95	0.1048	0.0828
96	0.1039	0.0828
97	0.1034	0.0827
98	0.1032	0.0822
99	0.1028	0.0795
100	0.1028	0.0792
101	0.1024	0.0788
102	0.1023	0.0783
103	0.1020	0.0782
104	0.1010	0.0778
105	0.0990	0.0777
106	0.0961	0.0768
107	0.0942	0.0761
108	0.0933	0.0759
109	0.0921	0.0757
110	0.0920	0.0754
111	0.0915	0.0752
112	0.0906	0.0749
113	0.0904	0.0747
114	0.0903	0.0746
115	0.0899	0.0742
116	0.0894	0.0730
117	0.0891	0.0715
118	0.0890	0.0712
119	0.0886	0.0706
120	0.0882	0.0692
121	0.0877	0.0688
122	0.0873	0.0687
123	0.0870	0.0683
124	0.0869	0.0679
125	0.0868	0.0676
126	0.0863	0.0661
127	0.0861	0.0659
128	0.0854	0.0657
129	0.0853	0.0655
130	0.0852	0.0650
131	0.0839	0.0649
132	0.0827	0.0641
133	0.0808	0.0634
134	0.0801	0.0627
135	0.0799	0.0627
136	0.0799	0.0597
137	0.0797	0.0594
138	0.0795	0.0583

139	0.0794	0.0574
140	0.0787	0.0569
141	0.0785	0.0561
142	0.0781	0.0552
143	0.0764	0.0539
144	0.0760	0.0520
145	0.0739	0.0503
146	0.0730	0.0484
147	0.0726	0.0478
148	0.0722	0.0472
149	0.0714	0.0444
150	0.0700	0.0444
151	0.0687	0.0442
152	0.0684	0.0422
153	0.0671	0.0401
154	0.0668	0.0394
155	0.0656	0.0383
156	0.0528	0.0363
157	0.0500	0.0346
158	0.0496	0.0307



## Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0552	4589	2599	56	Pass
0.0572	4016	2326	57	Pass
0.0592	3505	2107	60	Pass
0.0612	3133	1908	60	Pass
0.0632	2791	1718	61	Pass
0.0652	2495	1560	62	Pass
0.0671	2237	1407	62	Pass
0.0691	2004	1291	64	Pass
0.0711	1799	1191	66	Pass
0.0731	1624	1073	66	Pass
0.0751	1443	975	67	Pass
0.0771	1324	891	67	Pass
0.0791	1189	802	67	Pass
0.0811	1072	729	68	Pass
0.0831	974	649	66	Pass
0.0851	888	580	65	Pass
0.0871	803	524	65	Pass
0.0891	730	484	66	Pass
0.0911	675	443	65	Pass
0.0931	617	410	66	Pass
0.0951	564	378	67	Pass
0.0971	520	342	65	Pass
0.0991	471	319	67	Pass
0.1011	439	293	66	Pass
0.1031	397	266	67	Pass
0.1051	363	238	65	Pass
0.1071	324	214	66	Pass
0.1091	297	197	66	Pass
0.1111	274	184	67	Pass
0.1131	249	171	68	Pass
0.1151	226	155	68	Pass
0.1171	212	139	65	Pass
0.1191	195	129	66	Pass
0.1211	177	119	67	Pass
0.1231	164	108	65	Pass
0.1251	154	102	66	Pass
0.1270	139	98	70	Pass
0.1290	127	92	72	Pass
0.1310	114	85	74	Pass
0.1330	108	77	71	Pass
0.1350	105	69	65	Pass
0.1370	99	66	66	Pass
0.1390	90	62	68	Pass
0.1410	86	57	66	Pass
0.1430	82	54	65	Pass
0.1450	79	53	67	Pass
0.1470	76	52	68	Pass
0.1490	72	49	68	Pass
0.1510	65	49	75	Pass
0.1530	62	46	74	Pass
0.1550	60	45	75	Pass
0.1570	58	42	72	Pass
0.1590	52	38	73	Pass

0.1610	50	36	72	Pass
0.1630	47	34	72	Pass
0.1650	44	31	70	Pass
0.1670	42	30	71	Pass
0.1690	39	28	71	Pass
0.1710	38	28	73	Pass
0.1730	36	26	72	Pass
0.1750	36	24	66	Pass
0.1770	36	22	61	Pass
0.1790	32	21	65	Pass
0.1810	31	20	64	Pass
0.1830	30	19	63	Pass
0.1850	29	19	65	Pass
0.1869	27	19	70	Pass
0.1889	26	18	69	Pass
0.1909	25	18	72	Pass
0.1929	24	16	66	Pass
0.1949	24	16	66	Pass
0.1969	24	16	66	Pass
0.1989	22	14	63	Pass
0.2009	21	14	66	Pass
0.2029	21	14	66	Pass
0.2049	20	14	70	Pass
0.2069	20	14	70	Pass
0.2089	20	13	65	Pass
0.2109	20	13	65	Pass
0.2129	20	13	65	Pass
0.2149	20	12	60	Pass
0.2169	20	12	60	Pass
0.2189	20	11	55	Pass
0.2209	17	9	52	Pass
0.2229	16	9	56	Pass
0.2249	16	8	50	Pass
0.2269	15	7	46	Pass
0.2289	14	7	50	Pass
0.2309	13	7	53	Pass
0.2329	13	7	53	Pass
0.2349	12	7	58	Pass
0.2369	12	7	58	Pass
0.2389	12	7	58	Pass
0.2409	12	7	58	Pass
0.2429	11	7	63	Pass
0.2449	11	6	54	Pass
0.2468	9	5	55	Pass
0.2488	6	5	83	Pass
0.2508	6	5	83	Pass
0.2528	6	5	83	Pass

## Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume: 0 acre-feet

On-line facility target flow: 0 cfs.

Adjusted for 15 min: 0 cfs.

Off-line facility target flow: 0 cfs.

Adjusted for 15 min: 0 cfs.

## LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
retention 1 POC	<input type="checkbox"/>	132.04			<input type="checkbox"/>	0.00			
Total Volume Infiltrated		132.04	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

## POC 2

POC #2 was not reported because POC must exist in both scenarios and both scenarios must have been run.

## *Model Default Modifications*

Total of 0 changes have been made.

### *PERLND Changes*

No PERLND changes have been made.

### *IMPLND Changes*

No IMPLND changes have been made.

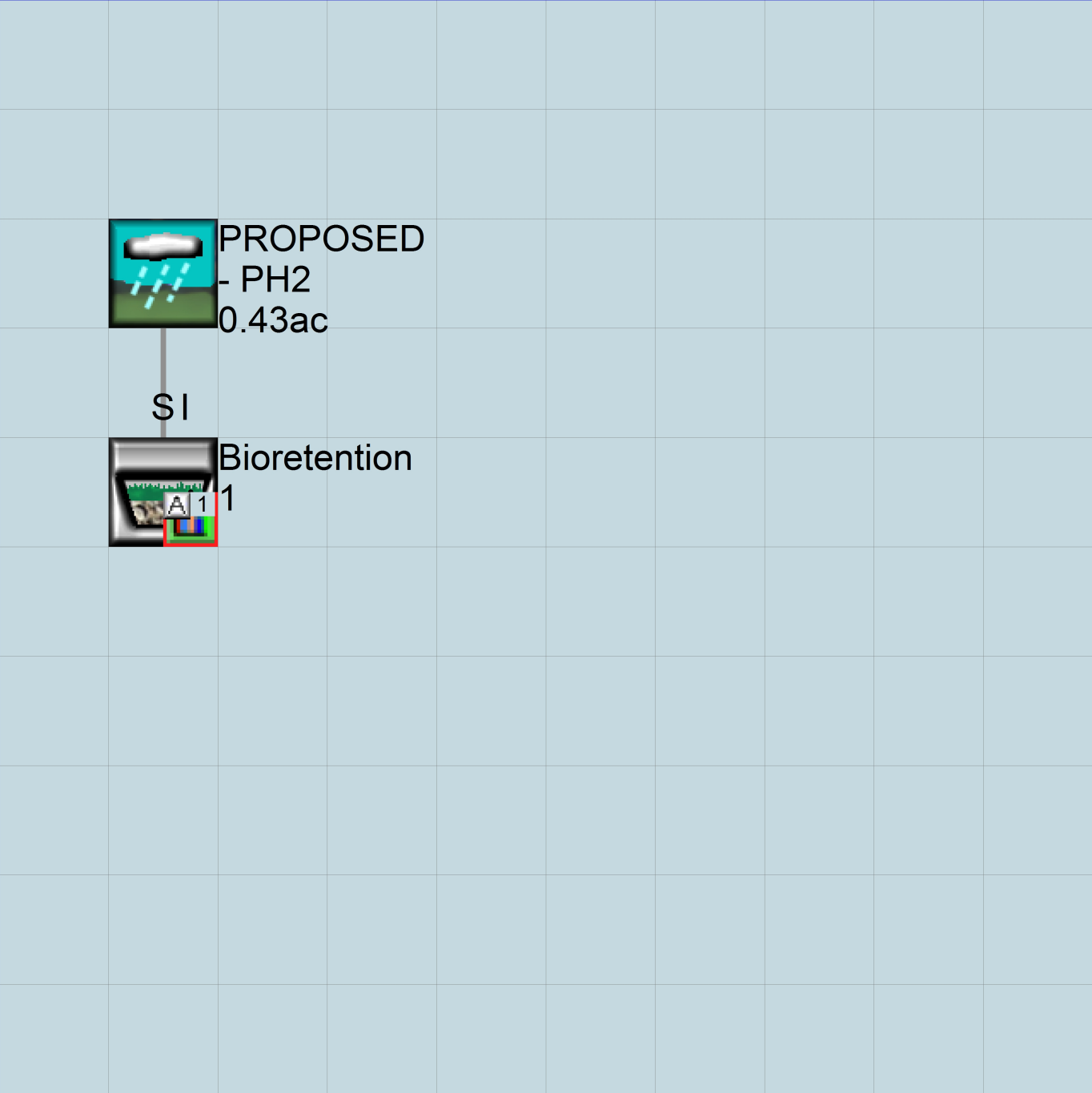
## Appendix

### Predeveloped Schematic



Existing -  
PH2  
0.43ac

Mitigated Schematic





## Predeveloped UCI File

RUN

GLOBAL

```
WWMH4 model simulation
START      1901 10 01      END      2059 09 30
RUN INTERP OUTPUT LEVEL    3      0
RESUME     0 RUN          1
UNIT SYSTEM      1
END GLOBAL
```

FILES

```
<File>  <Un#>  <-----File Name----->***
<-ID->                                     ***
WDM      26     FCC (Phase 2 Water Quality).wdm
MESSU    25     PreFCC (Phase 2 Water Quality).MES
          27     PreFCC (Phase 2 Water Quality).L61
          28     PreFCC (Phase 2 Water Quality).L62
          30     POCFCC (Phase 2 Water Quality)1.dat
```

END FILES

OPN SEQUENCE

INGRP INDELT 00:15

```
PERLND    16
IMPLND     5
IMPLND     8
COPY      501
DISPLY     1
```

END INGRP

END OPN SEQUENCE

DISPLY

DISPLY-INFO1

```
# - #<-----Title----->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
1      Existing - PH2              MAX              1      2      30      9
```

END DISPLY-INFO1

END DISPLY

COPY

TIMESERIES

```
# - # NPT NMN ***
1      1      1
501    1      1
```

END TIMESERIES

END COPY

GENER

OPCODE

```
#      # OPCODE ***
```

END OPCODE

PARM

```
#      #          K ***
```

END PARM

END GENER

PERLND

GEN-INFO

```
<PLS ><-----Name----->NBLKS      Unit-systems      Printer ***
# - #      User      t-series      Engl Metr ***
          in      out          ***
```

```
16      C, Lawn, Flat      1      1      1      1      27      0
```

END GEN-INFO

\*\*\* Section PWATER\*\*\*

ACTIVITY

```
<PLS > ***** Active Sections *****
# - # ATMP SNOW PWAT  SED  PST  PWG  PQAL MSTL PEST  NITR  PHOS  TRAC ***
16      0      0      1      0      0      0      0      0      0      0      0
```

END ACTIVITY

PRINT-INFO

```
<PLS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW PWAT  SED  PST  PWG  PQAL MSTL PEST  NITR  PHOS  TRAC  *****
16      0      0      4      0      0      0      0      0      0      0      0      1      9
```

END PRINT-INFO

PWAT-PARM1

```
<PLS > PWATER variable monthly parameter value flags ***
# - # CSNO RTOP UZFG VCS VUZ VNN VIFW VIRC VLE INFC HWT ***
16      0      0      0      0      0      0      0      0      0      0      0
```

END PWAT-PARM1

PWAT-PARM2

```
<PLS > PWATER input info: Part 2 ***
# - # ***FOREST LZSN INFILT LSUR SLSUR KVARV AGWRC
16      0      4.5      0.03      400      0.05      0.5      0.996
```

END PWAT-PARM2

PWAT-PARM3

```
<PLS > PWATER input info: Part 3 ***
# - # ***PETMAX PETMIN INFEXP INFILD DEEPFR BASETP AGWETP
16      0      0      2      2      0      0      0
```

END PWAT-PARM3

PWAT-PARM4

```
<PLS > PWATER input info: Part 4 ***
# - # CEPSC UZSN NSUR INTFW IRC LZETP ***
16      0.1      0.25      0.25      6      0.5      0.25
```

END PWAT-PARM4

PWAT-STATE1

```
<PLS > *** Initial conditions at start of simulation
ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
# - # *** CEPS SURS UZS IFWS LZS AGWS GWVS
16      0      0      0      0      2.5      1      0
```

END PWAT-STATE1

END PERLND

IMPLND

GEN-INFO

```
<PLS ><-----Name-----> Unit-systems Printer ***
# - # User t-series Engr Metr ***
in out ***
5 DRIVEWAYS/FLAT 1 1 1 27 0
8 SIDEWALKS/FLAT 1 1 1 27 0
```

END GEN-INFO

\*\*\* Section IWATER\*\*\*

ACTIVITY

```
<PLS > ***** Active Sections *****
# - # ATMP SNOW IWAT SLD IWG IQAL ***
5      0      0      1      0      0      0
8      0      0      1      0      0      0
```

END ACTIVITY

PRINT-INFO

```
<ILS > ***** Print-flags ***** PIVL PYR
# - # ATMP SNOW IWAT SLD IWG IQAL *****
5      0      0      4      0      0      0      1      9
8      0      0      4      0      0      0      1      9
```

END PRINT-INFO

IWAT-PARM1

```
<PLS > IWATER variable monthly parameter value flags ***
# - # CSNO RTOP VRS VNN RTLI ***
5      0      0      0      0      0
8      0      0      0      0      0
```

END IWAT-PARM1

IWAT-PARM2

```
<PLS > IWATER input info: Part 2 ***
# - # *** LSUR SLSUR NSUR RETSC
5      400      0.01      0.1      0.1
8      400      0.01      0.1      0.1
```

```

END IWAT-PARM2

IWAT-PARM3
  <PLS >          IWATER input info: Part 3          ***
  # - # ***PETMAX    PETMIN
  5          0          0
  8          0          0
END IWAT-PARM3

IWAT-STATE1
  <PLS > *** Initial conditions at start of simulation
  # - # *** RETS      SURS
  5          0          0
  8          0          0
END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->          <--Area-->          <-Target->      MBLK      ***
<Name> #          <-factor->          <Name> #      Tbl#      ***
Existing - PH2***
PERLND 16          0.13      COPY      501      12
PERLND 16          0.13      COPY      501      13
IMPLND 5           0.19      COPY      501      15
IMPLND 8           0.11      COPY      501      15

*****Routing*****
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name> #          <Name> # #<-factor->strg <Name> # #          <Name> # #          ***
COPY      501 OUTPUT MEAN      1 1      48.4      DISPLY      1      INPUT TIMSER 1

<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name> #          <Name> # #<-factor->strg <Name> # #          <Name> # #          ***
END NETWORK

RCHRES
GEN-INFO
  RCHRES          Name          Nexits      Unit Systems      Printer          ***
  # - #<-----><-----> User T-series Engl Metr LKFG          ***
                                in out          ***
END GEN-INFO
*** Section RCHRES***

ACTIVITY
  <PLS > ***** Active Sections *****
  # - # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
END ACTIVITY

PRINT-INFO
  <PLS > ***** Print-flags ***** PIVL      PYR
  # - # HYDR ADCA CONS HEAT SED      GQL OXRX NUTR PLNK PHCB PIVL      PYR *****
END PRINT-INFO

HYDR-PARM1
  RCHRES      Flags for each HYDR Section          ***
  # - #      VC A1 A2 A3      ODFVFG for each *** ODGTFG for each      FUNCT for each
                FG FG FG FG      possible exit *** possible exit      possible exit
                * * * *      * * * *      * * * *      * * * *
END HYDR-PARM1

HYDR-PARM2
  # - #      FTABNO          LEN          DELTH          STCOR          KS          DB50          ***
<-----><-----><-----><-----><-----><-----><----->          ***
END HYDR-PARM2

```

```

HYDR-INIT
  RCHRES Initial conditions for each HYDR section ***
  # - # *** VOL Initial value of COLIND Initial value of OUTDGT
  *** ac-ft for each possible exit for each possible exit
  <-----><-----> <----><----><----><----><----> *** <----><----><----><----><---->
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name> # <Name> # tem strg<-factor->strg <Name> # # <Name> # # ***
WDM 2 PREC ENGL 1 PERLND 1 999 EXTNL PREC
WDM 2 PREC ENGL 1 IMPLND 1 999 EXTNL PREC
WDM 1 EVAP ENGL 1 PERLND 1 999 EXTNL PETINP
WDM 1 EVAP ENGL 1 IMPLND 1 999 EXTNL PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name> # <Name> # #<-factor->strg <Name> # <Name> tem strg strg***
COPY 501 OUTPUT MEAN 1 1 48.4 WDM 501 FLOW ENGL REPL
END EXT TARGETS

MASS-LINK
<Volume> <-Grp> <-Member-><--Mult--> <Target> <-Grp> <-Member->***
<Name> <Name> # #<-factor-> <Name> <Name> # #***
MASS-LINK 12
PERLND PWATER SURO 0.083333 COPY INPUT MEAN
END MASS-LINK 12

MASS-LINK 13
PERLND PWATER IFWO 0.083333 COPY INPUT MEAN
END MASS-LINK 13

MASS-LINK 15
IMPLND IWATER SURO 0.083333 COPY INPUT MEAN
END MASS-LINK 15

END MASS-LINK

END RUN

```

## Mitigated UCI File

RUN

GLOBAL

```
WWM4 model simulation
START      1901 10 01      END      2059 09 30
RUN INTERP OUTPUT LEVEL    3      0
RESUME     0 RUN          1          UNIT SYSTEM      1
END GLOBAL
```

FILES

```
<File>  <Un#>  <-----File Name----->***
<-ID->                                     ***
WDM      26     FCC (Phase 2 Water Quality).wdm
MESSU    25     MitFCC (Phase 2 Water Quality).MES
          27     MitFCC (Phase 2 Water Quality).L61
          28     MitFCC (Phase 2 Water Quality).L62
          30     POCFCC (Phase 2 Water Quality)1.dat
```

END FILES

OPN SEQUENCE

INGRP INDELT 00:15

```
PERLND    16
IMPLND     5
IMPLND     8
GENER      2
RCHRES     1
RCHRES     2
COPY       1
COPY      501
DISPLY     1
```

END INGRP

END OPN SEQUENCE

DISPLY

DISPLY-INFO1

```
# - #<-----Title----->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
1      Surface retention 1      MAX      1      2      30      9
```

END DISPLY-INFO1

END DISPLY

COPY

TIMESERIES

```
# - #  NPT  NMN ***
1      1      1
501    1      1
```

END TIMESERIES

END COPY

GENER

OPCODE

```
#      # OPCD ***
2      24
```

END OPCODE

PARM

```
#      #      K ***
2      0.
```

END PARM

END GENER

PERLND

GEN-INFO

```
<PLS ><-----Name----->NBLKS      Unit-systems      Printer ***
# - #      User      t-series      Engl Metr ***
          in      out      ***
```

```
16      C, Lawn, Flat      1      1      1      1      27      0
```

END GEN-INFO

\*\*\* Section PWATER\*\*\*

ACTIVITY

```
<PLS > ***** Active Sections *****
# - #  ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
16      0      0      1      0      0      0      0      0      0      0      0
```

END ACTIVITY

PRINT-INFO

```
<PLS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW PWAT  SED  PST  PWG  PQAL MSTL PEST NITR PHOS TRAC  *****
16      0      0      4      0      0      0      0      0      0      0      0      0      1      9
END PRINT-INFO
```

PWAT-PARM1

```
<PLS >  PWATER variable monthly parameter value flags  ***
# - # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT  ***
16      0      0      0      0      0      0      0      0      0      0      0
END PWAT-PARM1
```

PWAT-PARM2

```
<PLS >          PWATER input info: Part 2          ***
# - # ***FOREST      LZSN      INFILT      LSUR      SLSUR      KVARV      AGWRC
16      0      4.5      0.03      400      0.05      0.5      0.996
END PWAT-PARM2
```

PWAT-PARM3

```
<PLS >          PWATER input info: Part 3          ***
# - # ***PETMAX      PETMIN      INFEXP      INFILD      DEEPFR      BASETP      AGWETP
16      0      0      2      2      0      0      0
END PWAT-PARM3
```

PWAT-PARM4

```
<PLS >          PWATER input info: Part 4          ***
# - #      CEPSC      UZSN      NSUR      INTFW      IRC      LZETP  ***
16      0.1      0.25      0.25      6      0.5      0.25
END PWAT-PARM4
```

PWAT-STATE1

```
<PLS > *** Initial conditions at start of simulation
          ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
# - # ***  CEPS      SURS      UZS      IFWS      LZS      AGWS      GWVS
16      0      0      0      0      2.5      1      0
END PWAT-STATE1
```

END PERLND

IMPLND

GEN-INFO

```
<PLS ><-----Name----->  Unit-systems  Printer ***
# - #                        User  t-series  Engr Metr ***
                        in  out  ***
5      DRIVEWAYS/FLAT      1      1      1      27      0
8      SIDEWALKS/FLAT      1      1      1      27      0
END GEN-INFO
*** Section IWATER***
```

ACTIVITY

```
<PLS > ***** Active Sections *****
# - # ATMP SNOW IWAT  SLD  IWG IQAL  ***
5      0      0      1      0      0      0
8      0      0      1      0      0      0
END ACTIVITY
```

PRINT-INFO

```
<ILS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW IWAT  SLD  IWG IQAL  *****
5      0      0      4      0      0      0      1      9
8      0      0      4      0      0      0      1      9
END PRINT-INFO
```

IWAT-PARM1

```
<PLS >  IWATER variable monthly parameter value flags  ***
# - # CSNO RTOP VRS  VNN RTLI  ***
5      0      0      0      0      0
8      0      0      0      0      0
END IWAT-PARM1
```

```

IWAT-PARM2
<PLS >          IWATER input info: Part 2          ***
# - # ***  LSUR      SLSUR      NSUR      RETSC
5          400      0.01      0.1      0.1
8          400      0.01      0.1      0.1
END IWAT-PARM2

IWAT-PARM3
<PLS >          IWATER input info: Part 3          ***
# - # ***PETMAX      PETMIN
5          0          0
8          0          0
END IWAT-PARM3

IWAT-STATE1
<PLS > *** Initial conditions at start of simulation
# - # ***  RETS      SURS
5          0          0
8          0          0
END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->          <--Area-->          <-Target->          MBLK          ***
<Name> #          <-factor->          <Name> #          Tbl#          ***
PROPOSED - PH2***
PERLND 16          0.13          RCHRES 1          2
PERLND 16          0.13          RCHRES 1          3
IMPLND 5          0.19          RCHRES 1          5
IMPLND 8          0.11          RCHRES 1          5

*****Routing*****
PERLND 16          0.13          COPY 1          12
IMPLND 5          0.19          COPY 1          15
IMPLND 8          0.11          COPY 1          15
PERLND 16          0.13          COPY 1          13
RCHRES 1          1          RCHRES 2          8
RCHRES 2          1          COPY 501          16
RCHRES 1          1          COPY 501          17
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name> #          <Name> # #<-factor->strg <Name> # #          <Name> # #          ***
COPY 501 OUTPUT MEAN 1 1 48.4          DISPLY 1          INPUT TIMSER 1
GENER 2 OUTPUT TIMSER .0011111          RCHRES 1          EXTNL OUTDGT 1

<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member-> ***
<Name> #          <Name> # #<-factor->strg <Name> # #          <Name> # #          ***
END NETWORK

RCHRES
GEN-INFO
RCHRES          Name          Nexits          Unit Systems          Printer          ***
# - #<-----><----> User T-series Engl Metr LKFG          ***
in out
1          Surface retentio-014          3          1          1          1          28          0          1
2          Bioretention 1          1          1          1          1          28          0          1
END GEN-INFO
*** Section RCHRES***

ACTIVITY
<PLS > ***** Active Sections *****
# - # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUGF PKFG PHFG ***
1          1          0          0          0          0          0          0          0          0
2          1          0          0          0          0          0          0          0          0

```

```

END ACTIVITY

PRINT-INFO
<PLS > ***** Print-flags ***** PIVL  PYR
# - # HYDR ADCA CONS HEAT SED GQL OXRX NUTR PLNK PHCB PIVL  PYR  *****
1      4      0      0      0      0      0      0      0      0      0      1      9
2      4      0      0      0      0      0      0      0      0      0      1      9
END PRINT-INFO

HYDR-PARM1
RCHRES  Flags for each HYDR Section                                     ***
# - # VC A1 A2 A3 ODFVFG for each *** ODGTFG for each  FUNCT for each
      FG FG FG FG possible exit *** possible exit  possible exit
      * * * * * * * * * * * * * * * * * * * * * * *
1      0  1  0  0      4  5  6  0  0      0  1  0  0  0      2  1  2  2  2
2      0  1  0  0      4  0  0  0  0      0  0  0  0  0      2  2  2  2  2
END HYDR-PARM1

HYDR-PARM2
# - # FTABNO      LEN      DELTH      STCOR      KS      DB50      ***
<-----><-----><-----><-----><-----><-----><----->      ***
1      1      0.01      0.0      0.0      0.5      0.0
2      2      0.01      0.0      0.0      0.5      0.0
END HYDR-PARM2

HYDR-INIT
RCHRES  Initial conditions for each HYDR section                                     ***
# - # *** VOL      Initial value of COLIND      Initial value of OUTDGT
      *** ac-ft      for each possible exit      for each possible exit
<-----><----->      <-----><-----><-----><-----><-----> *** <-----><-----><-----><-----><----->
1      0      4.0  5.0  6.0  0.0  0.0      0.0  0.0  0.0  0.0  0.0
2      0      4.0  0.0  0.0  0.0  0.0      0.0  0.0  0.0  0.0  0.0
END HYDR-INIT
END RCHRES

SPEC-ACTIONS
*** User-Defined Variable Quantity Lines
***
***      addr
***      <----->
*** kwd  varnam optyp  opn  vari  s1 s2 s3 tp multiply  lc ls ac as agfn ***
<****> <-----> <-----> <-> <-----><-><-><-><-><-----> <-><-> <-><-> <---> ***
UVQUAN vol2  RCHRES  2 VOL      4
UVQUAN v2m2  GLOBAL  WORKSP  1      3
UVQUAN vpo2  GLOBAL  WORKSP  2      3
UVQUAN v2d2  GENER  2 K      1      3
*** User-Defined Target Variable Names
***      addr or      addr or
***      <----->      <----->
*** kwd  varnam ct  vari  s1 s2 s3  frac oper      vari  s1 s2 s3  frac oper
<****> <-----><-> <-----><-><-><-> <-----> <---> <-----><-><-><-> <-----> <---> <--->
UVNAME v2m2  1 WORKSP  1      1.0 QUAN
UVNAME vpo2  1 WORKSP  2      1.0 QUAN
UVNAME v2d2  1 K      1      1.0 QUAN
*** opt foplop dcdts  yr mo dy hr mn d t  vnam  s1 s2 s3 ac quantity  tc  ts rp
<****><-><-----><-><-><-> <-> <-> <-> <-><-> <-----><-><-><-><-><-----> <-> <-><->
GENER  2      v2m2      = 234.
*** Compute remaining available pore space
GENER  2      vpo2      = v2m2
GENER  2      vpo2      -= vol2
*** Check to see if VPORA goes negative; if so set VPORA = 0.0
IF (vpo2 < 0.0) THEN
GENER  2      vpo2      = 0.0
END IF
*** Infiltration volume
GENER  2      v2d2      = vpo2
END SPEC-ACTIONS

FTABLES
FTABLE  2
67      4
Depth      Area      Volume      Outflow1 Velocity      Travel Time***
(ft)      (acres) (acre-ft) (cfs) (ft/sec) (Minutes)***

```



0.000000	0.011111	0.000000	0.000000
0.038462	0.011111	0.000020	0.000000
0.076923	0.010879	0.000042	0.000000
0.115385	0.010650	0.000065	0.000000
0.153846	0.010423	0.000090	0.000000
0.192308	0.010198	0.000116	0.000000
0.230769	0.009976	0.000144	0.000000
0.269231	0.009757	0.000173	0.000000
0.307692	0.009539	0.000204	0.000000
0.346154	0.009325	0.000236	0.000000
0.384615	0.009112	0.000270	0.000000
0.423077	0.008902	0.000306	0.000000
0.461538	0.008695	0.000344	0.000000
0.500000	0.008490	0.000383	0.000000
0.538462	0.008287	0.000425	0.000000
0.576923	0.008087	0.000468	0.000000
0.615385	0.007890	0.000513	0.000313
0.653846	0.007694	0.000560	0.000360
0.692308	0.007502	0.000609	0.000466
0.730769	0.007311	0.000661	0.000589
0.769231	0.007124	0.000714	0.000730
0.807692	0.006938	0.000770	0.000889
0.846154	0.006755	0.000827	0.001068
0.884615	0.006575	0.000887	0.001266
0.923077	0.006397	0.000950	0.001486
0.961538	0.006221	0.001014	0.001727
1.000000	0.006048	0.001081	0.001990
1.038462	0.005877	0.001151	0.002276
1.076923	0.005709	0.001223	0.002585
1.115385	0.005543	0.001297	0.002918
1.153846	0.005379	0.001374	0.003276
1.192308	0.005218	0.001454	0.003659
1.230769	0.005060	0.001536	0.004067
1.269231	0.004904	0.001621	0.004502
1.307692	0.004750	0.001709	0.004964
1.346154	0.004599	0.001799	0.005453
1.384615	0.004450	0.001892	0.005969
1.423077	0.004304	0.001988	0.006515
1.461538	0.004160	0.002087	0.007089
1.500000	0.004019	0.002180	0.007692
1.538462	0.003880	0.002275	0.008325
1.576923	0.003743	0.002373	0.008988
1.615385	0.003609	0.002473	0.009682
1.653846	0.003477	0.002577	0.010406
1.692308	0.003348	0.002683	0.011163
1.730769	0.003222	0.002793	0.011950
1.769231	0.003097	0.002905	0.012770
1.807692	0.002975	0.003020	0.013611
1.846154	0.002856	0.003138	0.013611
1.884615	0.002739	0.003259	0.013611
1.923077	0.002625	0.003384	0.013611
1.961538	0.002512	0.003511	0.013611
2.000000	0.002403	0.003642	0.013611
2.038462	0.002296	0.003776	0.013611
2.076923	0.002191	0.003913	0.013611
2.115385	0.002089	0.004054	0.013611
2.153846	0.001989	0.004197	0.013611
2.192308	0.001891	0.004344	0.013611
2.230769	0.001796	0.004495	0.013611
2.269231	0.001704	0.004649	0.013611
2.307692	0.001614	0.004806	0.013611
2.346154	0.001526	0.004967	0.013611
2.384615	0.001441	0.005132	0.013611
2.423077	0.001358	0.005300	0.013611
2.461538	0.001278	0.005472	0.013611
2.500000	0.001200	0.005648	0.013611
2.500000	0.001125	0.011860	0.013611

END FTABLE 2

FTABLE 1

27 6

Time***	Depth (ft) (Minutes)***	Area (acres)	Volume (acre-ft)	Outflow1 (cfs)	Outflow2 (cfs)	outflow 3 (cfs)	Velocity (ft/sec)	Travel
	0.000000	0.001125	0.000000	0.000000	0.000000	0.000000		
	0.038462	0.011345	0.000432	0.000000	0.013960	0.000000		
	0.076923	0.011582	0.000873	0.000000	0.014309	0.000000		
	0.115385	0.011821	0.001323	0.000000	0.014658	0.000000		
	0.153846	0.012063	0.001782	0.000000	0.015007	0.000000		
	0.192308	0.012307	0.002251	0.000000	0.015356	0.000000		
	0.230769	0.012554	0.002729	0.000000	0.015705	0.000000		
	0.269231	0.012803	0.003217	0.000000	0.016054	0.000000		
	0.307692	0.013054	0.003714	0.000000	0.016403	0.000000		
	0.346154	0.013308	0.004221	0.000000	0.016752	0.000000		
	0.384615	0.013564	0.004738	0.000000	0.017101	0.000000		
	0.423077	0.013823	0.005264	0.000000	0.017450	0.000000		
	0.461538	0.014084	0.005801	0.000000	0.017799	0.000000		
	0.500000	0.014348	0.006348	0.000000	0.018148	0.000000		
	0.538462	0.014614	0.006905	0.079976	0.018497	0.000000		
	0.576923	0.014883	0.007472	0.225672	0.018846	0.000000		
	0.615385	0.015154	0.008050	0.412175	0.019195	0.000000		
	0.653846	0.015427	0.008638	0.627270	0.019544	0.000000		
	0.692308	0.015703	0.009236	0.859995	0.019893	0.000000		
	0.730769	0.015981	0.009846	1.099144	0.020242	0.000000		
	0.769231	0.016262	0.010466	1.333311	0.020591	0.000000		
	0.807692	0.016545	0.011097	1.551565	0.020940	0.000000		
	0.846154	0.016831	0.011738	1.744468	0.021289	0.000000		
	0.884615	0.017119	0.012391	1.905359	0.021638	0.000000		
	0.923077	0.017410	0.013055	2.031838	0.021987	0.000000		
	0.961538	0.017703	0.013731	2.127417	0.022336	0.000000		
	1.000000	0.017998	0.014417	2.203335	0.022685	0.000000		

END FTABLE 1  
END FTABLES

#### EXT SOURCES

<-Volume->	<Member>	SsysSgap<--Mult-->	Tran	<-Target	vols>	<-Grp>	<-Member-->	***	
<Name>	#	<Name>	#	tem strg<-factor-->	strg	<Name>	#	#	
WDM	2	PREC	ENGL	1	PERLND	1	999	EXTNL	PREC
WDM	2	PREC	ENGL	1	IMPLND	1	999	EXTNL	PREC
WDM	1	EVAP	ENGL	1	PERLND	1	999	EXTNL	PETINP
WDM	1	EVAP	ENGL	1	IMPLND	1	999	EXTNL	PETINP
WDM	2	PREC	ENGL	1	RCHRES	1		EXTNL	PREC
WDM	1	EVAP	ENGL	0.5	RCHRES	1		EXTNL	POTEV
WDM	1	EVAP	ENGL	1	RCHRES	2		EXTNL	POTEV

END EXT SOURCES

#### EXT TARGETS

<-Volume->	<-Grp>	<-Member-->	<--Mult-->	Tran	<-Volume->	<Member>	Tsys	Tgap	Amd	***
<Name>	#	<Name>	#	#<-factor-->	strg	<Name>	#	<Name>	tem	strg
RCHRES	2	HYDR	RO	1	1	WDM	1008	FLOW	ENGL	REPL
RCHRES	2	HYDR	STAGE	1	1	WDM	1009	STAG	ENGL	REPL
RCHRES	1	HYDR	STAGE	1	1	WDM	1010	STAG	ENGL	REPL
RCHRES	1	HYDR	O	1	1	WDM	1011	FLOW	ENGL	REPL
COPY	1	OUTPUT	MEAN	1	1	WDM	701	FLOW	ENGL	REPL
COPY	501	OUTPUT	MEAN	1	1	WDM	801	FLOW	ENGL	REPL

END EXT TARGETS

#### MASS-LINK

<Volume>	<-Grp>	<-Member-->	<--Mult-->	<Target>	<-Grp>	<-Member-->	***
<Name>	#	<Name>	#	<Name>	#	<Name>	#
MASS-LINK	2						
PERLND	PWATER	SURO	0.083333	RCHRES	INFLOW	IVOL	
END MASS-LINK	2						
MASS-LINK	3						
PERLND	PWATER	IFWO	0.083333	RCHRES	INFLOW	IVOL	
END MASS-LINK	3						
MASS-LINK	5						

IMPLND	IWATER	SURO		0.083333	RCHRES	INFLOW	IVOL
END MASS-LINK		5					
MASS-LINK		8					
RCHRES	OFLOW	OVOL	2		RCHRES	INFLOW	IVOL
END MASS-LINK		8					
MASS-LINK		12					
PERLND	PWATER	SURO		0.083333	COPY	INPUT	MEAN
END MASS-LINK		12					
MASS-LINK		13					
PERLND	PWATER	IFWO		0.083333	COPY	INPUT	MEAN
END MASS-LINK		13					
MASS-LINK		15					
IMPLND	IWATER	SURO		0.083333	COPY	INPUT	MEAN
END MASS-LINK		15					
MASS-LINK		16					
RCHRES	ROFLOW				COPY	INPUT	MEAN
END MASS-LINK		16					
MASS-LINK		17					
RCHRES	OFLOW	OVOL	1		COPY	INPUT	MEAN
END MASS-LINK		17					
END MASS-LINK							
END RUN							



## *Mitigated HSPF Message File*

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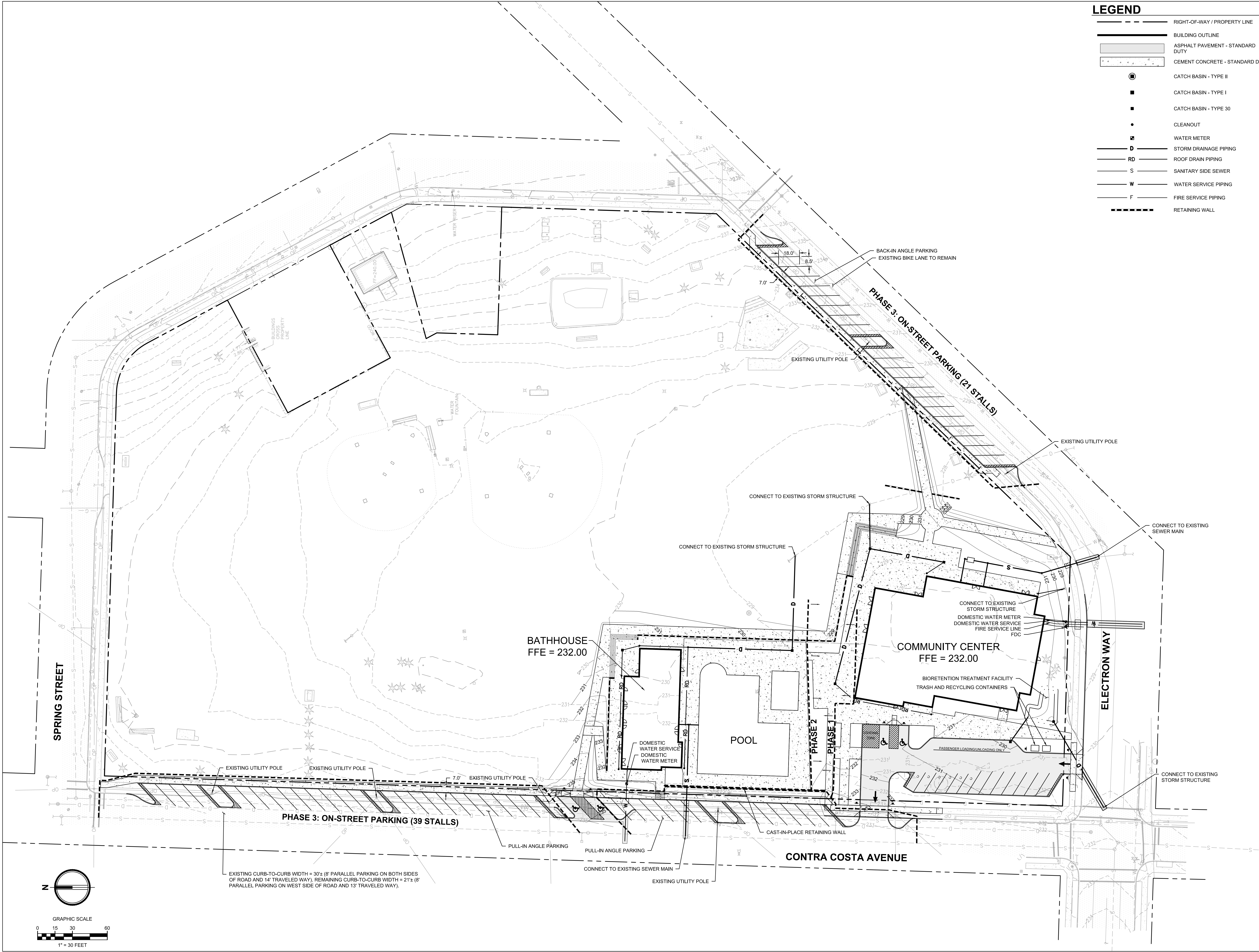
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# ***Appendix C***

---

## **Civil Engineering Plans**





LEGEND	
	RIGHT-OF-WAY / PROPERTY LINE
	BUILDING OUTLINE
	ASPHALT PAVEMENT - STANDARD DUTY
	CEMENT CONCRETE - STANDARD DUTY
	CATCH BASIN - TYPE II
	CATCH BASIN - TYPE I
	CATCH BASIN - TYPE 30
	CLEANOUT
	WATER METER
	STORM DRAINAGE PIPING
	ROOF DRAIN PIPING
	SANITARY SIDE SEWER
	WATER SERVICE PIPING
	FIRE SERVICE PIPING
	RETAINING WALL

**FIRCREST COMMUNITY  
CENTER AND POOL**  
555 CONTRA COSTA AVENUE    FIRCREST, WA    98466

**MAJOR SITE  
PLAN REVIEW  
SUBMITTAL**

ISSUE DATE: FEBRUARY 5, 2019  
REVISION SCHEDULE - NO PERMIT  
CLOUDS SHOWN IN BID SET

Rev #	Date	Description
-------	------	-------------

CONTENTS  
**SITE PLAN**

SCALE:  
DRAWN:  
CHECKED:  
PROJECT NO: 2018008.00

SHEET:  
**C1.0**



# ***Appendix D***

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## **Construction Stormwater Pollution Prevention Plan** (To be included in final Stormwater Site Plan)

# ***Appendix E***

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## **Geotechnical Engineering Report**

## **Geotechnical Engineering Services Report**

Fircrest Community Center and Pool  
Fircrest, Washington

*for*  
**ARC Architects**

March 18, 2016



**GEOENGINEERS**   
Earth Science + Technology

## **Geotechnical Engineering Services Report**

Fircrest Community Center and Pool  
Fircrest, Washington

*for*  
**ARC Architects**

March 18, 2016



1101 South Fawcett Avenue, Suite 200  
Tacoma, Washington 98402  
253.383.4940

# Geotechnical Engineering Services Report

## Fircrest Community Center and Pool Fircrest, Washington

File No. 4639-005-00

March 18, 2016

Prepared for:

ARC Architects  
1101 East Pike Street  
Seattle, Washington 98122

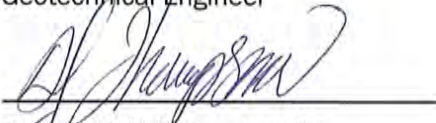
Attention: Stan Lokting, LEED, AP BD+C

Prepared by:

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## LIST OF FIGURES

Figure 1. Vicinity Map

Figure 2. Site Plan

Figure 3. Historic Site Photo (1931)

## APPENDICES

Appendix A. Subsurface Explorations and Laboratory Testing

    Figure A-1 – Key to Exploration Logs

    Figures A-2 through A-4 – Logs of Borings and Monitoring Well

    Figure A-5 – Sieve Analysis Results

Appendix B. Report Limitations and Guidelines for Use

## INTRODUCTION AND PROJECT UNDERSTANDING

This report presents a summary of our findings, conclusions, and recommendations addressing geotechnical aspects of a feasibility study for proposed improvements to the existing Fircrest Community Center and Pool. The community center is located at 555 Contra Costa Avenue, Fircrest, Washington as indicated on the Vicinity Map, Figure 1. Our current services are provided in general accordance with the agreement between GeoEngineers and ARC Architects, authorized on December 12, 2015.

Our understanding of the proposed project is based on information provided by you and discussions with you. We understand the project is still in conceptual design stage with the City of Fircrest Department of Parks and Recreation (Fircrest Parks). Three alternatives are under consideration by Fircrest Parks: 1) renovation of the existing facility, 2) renovation and expansion of the existing facility, and 3) demolition of the existing facility and construction of a new facility. Existing site features and the project site are shown on the Site Plan, Figure 2.

The community center is located within Fircrest Park. We understand that a former lake, which has been filled, is located within the limits of the park. Figure 3, Historic Site Photo (1931), shows the extent of the lake in 1931 relative to existing features. Based on our experience lakes such as these (referred to as kettle lakes) often have soft sediments susceptible to settlement under building loads. The thickness of these sediments can vary, but are generally between about 10 to 30 feet thick. Additionally, shallow groundwater is typically present. We understand that when the pool was drained several years ago it began to rise out of the ground. This was likely due to the presence of shallow groundwater and the pool becoming buoyant.

## PURPOSE AND SCOPE OF SERVICES

Because this project is in the feasibility stage, our services are intended to provide general geotechnical design recommendations and discussion of potential construction difficulties for each of the three proposed alternatives. Our proposed scope of services includes:

1. Reviewing readily available published geologic data in the project vicinity and available nearby geotechnical information from our in-house files.
2. Performing a site reconnaissance to visually evaluate existing surface conditions and mark out potential exploration locations.
3. Preparing an exploration plan based on our understanding of the proposed building and pool location(s) and our experience in the project vicinity.
4. Locating and coordinating clearance of existing utilities. We contacted the "One-Call Underground Utility Locate Service" prior to beginning explorations.
5. Retaining a private locating service to identify utilities not located by the One-Call.
6. Exploring soil and groundwater conditions at the project site by advancing three borings to depths between 11½ feet and 21½ feet below existing site grades. One of the borings was completed as a monitoring well.



7. Performing laboratory tests on selected soil samples obtained from the explorations to evaluate pertinent engineering characteristics. The laboratory testing program consisted of moisture content determinations, organic content determinations, percent fines determinations, and sieve analysis tests.
8. Providing a discussion of the subsurface conditions encountered, including the depth and composition of soil, and depth to groundwater. We also provide a discussion of the potential impacts that the soil and groundwater conditions could have on design and construction.
9. Discussing seismic considerations including International Building Code (IBC) seismic design parameters, an assessment of potential risks associated with liquefaction- and landslide-related hazards, and an assessment of the potential risks associated with surface fault rupture, where applicable.
10. Providing recommendations for shallow foundations, including foundation bearing surface preparation, allowable soil bearing pressures, settlement (total and differential) estimates, lateral earth pressures and coefficient of friction for evaluating sliding resistance.
11. Discussing preliminary pile options for up to two types of deep foundations. Our discussion includes our opinion of applicable foundation types and constructability.
12. Providing recommendations for support of on-grade floor slabs, including capillary break, vapor retarder, underslab drainage, and modulus of subgrade reaction.
13. Providing recommendations for site preparation and earthwork, including clearing and stripping, temporary and permanent cut slopes, suitability of on-site soils for use as structural fill including constraints for wet weather construction, specifications for imported soil for use as structural fill, and fill placement and compaction requirements.
14. Providing recommendations for site drainage and control of groundwater that may be encountered, including subsurface drains and buoyancy considerations for design of the swimming pool.

## **SITE CONDITIONS**

### **Vertical Datum**

In this report we reference vertical elevation to the National Geodetic Vertical Datum of 1929 (NGVD29). Elevations provided from other sources may use another vertical datum for referencing elevations. When possible the reference datum is identified and converted to an approximate elevation relative to the NGVD29.

### **Geology and Groundwater Review**

The geologic information we reviewed for the project vicinity includes the *Geologic Map of the Steilacoom 7.5 Minute Quadrangle, Pierce County, Washington* (Troost, in review) and the *Geologic Map of the City of Tacoma, Pierce County, Washington* (Smith, 1977). Both maps identify the soil in the project vicinity as recessional outwash, which is shown to continue south generally following the alignment of Leach Creek. Recessional outwash is typically described as consisting of a stratified sand and gravel deposited by streams emanating from the face of a retreating glacier. Outwash deposits can also contain glaciolacustrine silt deposited in ponds or lakes from glacier melt water.

To gain an understanding of groundwater conditions near the project site we reviewed the “Water Resources of the Tacoma Area” (Griffin, et al., 1962), the Washington State Department of Ecology (Ecology) well log database, and select boring and monitoring well logs from our in-house files. The Griffin report includes a figure showing “water-table contours” with a 25-foot contour interval. Based on our review, we interpret the regional water table in the project vicinity at approximately Elevation 225 feet (NGVD29).

## **Surface Conditions**

### **Existing Conditions**

The existing community center is located within Fircrest Park. The areas surrounding the park is developed as single family residential. Fircrest Park is bound on the west by Contra Costa Avenue. Electron Way forms the south/southeast boundary of the park. The east and north sides of the park are bounded by Spring Street. For the purposes of this report we define the project area as the southwest portion of the park where the community center is located, as shown on Figure 2.

The existing community center facility faces Contra Costa Avenue and consists of a complex that is aligned north-south. Structures within the complex include an in-ground swimming pool, the community center building, parking areas and drive lanes, and an outdoor basketball court.

The swimming pool is located at the north end of the complex. Around the pool is a concrete patio area, which is raised about 2 feet above the surrounding ground surface of the park. South of the pool is the community center building, which appears to be of wood-frame construction. Existing foundation support of the building was not readily apparent. However, we did not observe indications of stress that would be expected to result from settlement of foundation elements. An asphalt concrete pavement (ACP) parking area is located south of the building, which is accessed from Electron Way. An outdoor basketball court is located east of the building and north of the parking area.

Open park space is located east of the community center complex. The ground surface is approximately level and surfaced with grass. Large coniferous trees are located along Electron Way near the south end of the project site.

### **Site History**

We reviewed historic aerial photographs available on City of Tacoma GovME website and Google Earth historical imagery. The GovME website provides three aerial photographs that include the project sites taken in 1931, 1950 and 1973. The dates (month/day) of the photos presented on the GovME website are not provided.

In the 1931 photograph, Contra Costa Avenue, Electron Way, and Spring Street are present, but the project site surrounding areas are largely undeveloped. A small lake is visible near the center of the park, in the northeast portion of project site as shown on Figure 3. What appears to be dense areas of trees are visible along the west and south boundaries of the project site near Contra Costa Avenue and Electron Way.

In the 1950 photograph, the project site remains largely undeveloped. The lake is noticeably smaller, the trees along Contra Costa Avenue have been removed, and a structure is present within the park north of the project site. Because the timing of the photograph is not known, it is difficult to interpret if the cause of the smaller lake size is due to seasonal effects or some other cause.

In the 1973 photograph, the existing buildings appear in approximately their current configuration as does the remaining portion of the project site and park in general. The lake is no longer visible and only a few trees remain near the south end of the site near Electron Way.

The Google Earth historical imagery provides a series of aerial photographs taken between 1990 and 2015. No significant changes were noticed in the photos relative to current site conditions.

## **Subsurface Conditions**

### **Subsurface Explorations**

We explored subsurface conditions at the site by advancing three borings to depths between 11½ feet and 21½ feet below the ground surface (bgs) at the approximate locations indicated on Figure 2. The borings were advanced using a track-mounted drilling equipment. One of the borings was completed as a monitoring well (MW-2). Details of the exploration program including methodology, summary logs of the borings and monitoring well, laboratory testing methodologies, and results of the laboratory testing are included in Appendix A.

### **Soils**

At the exploration locations we encountered materials which we interpret as fill, native lake deposits, and native glacial deposits. Below we provide brief descriptions of each soil unit and approximate depths at which the soils were observed.

#### ***Fill***

Material we interpret to be fill was encountered at all three exploration locations. The fill extended from the ground surface to depths between about 2½ and 4 feet bgs. At the locations explored, the fill consisted of silt and silty sand. The silt was observed to be in a soft to medium stiff condition; the silty sand was observed to be in a loose to medium dense condition.

#### ***Lake Deposits***

Material we interpret to be derived from the former lake were encountered at the location of boring B-3 and extended from below the fill to a depth of about 14 feet bgs. At this location these deposits consisted of organic silt. The organic silt was observed to be in a very soft to soft condition.

#### ***Glacial Deposits***

Materials we interpret to be glacial in origin were encountered at all three exploration locations and extended from below the fill and lake deposits to the depths explored. At the locations explored, the glacial deposits predominantly consisted of silty sand in a medium dense to very dense condition. Dense gravel with silt was observed in boring B-1 at a depth of about 11 feet.

### **Groundwater**

Groundwater was observed at the time of drilling in all three explorations. The table below provides measured depth to groundwater at MW-2.

**TABLE 1: GROUNDWATER READINGS AT MW-2**

Date	Depth to Groundwater (feet) <sup>1</sup>
January 25, 2016	3.15
February 23, 2016	3.13
March 14, 2016	2.94

Note:

<sup>1</sup> Depth measured from top of PVC casing within well monument. Elevation is undetermined.

Based on the site history, conditions observed in our explorations, and our experience we anticipate shallow groundwater to be present year round. Although the magnitude of seasonal groundwater fluctuation is not known, we anticipate the groundwater to be lowest near the late summer and early fall months and the highest groundwater levels to occur near the late winter and early spring months.

### Summary and Discussion

Based on the conditions observed in our explorations, it appears that the center and north portions of the project site are underlain by native glacial deposits. The south portion of the project site appears to be underlain by soft lake deposits. Based on the lake visible in Figure 3, lake deposits could be anticipated in the vicinity of MW-2. However, the aerial photographs only show a particular moment in time and the previous location, width, and depth of the lake is unknown. Because the lake deposits were only encountered in one of our explorations, the lateral extent and variation in depth of the soft sediments is not known. In our opinion, the presence of the lake deposits and shallow groundwater could potentially be a factor to consider during design and construction of the proposed improvements particularly if option 3, new construction, is selected.

## SEISMIC DESIGN CRITERIA

### General

The site is located in western Washington, which is seismically active. Seismicity in this region is attributed primarily to the interaction between the Pacific, Juan de Fuca and North American tectonic plates. As the Juan de Fuca plate is subducted beneath the North American plate at the Cascadia Subduction Zone (CSZ) intercrustal (between plates) and intracrustal (within a plate) earthquakes are produced.

Ongoing research by geologists regarding large magnitude CSZ-related intercrustal earthquake activity along the Washington and Oregon coasts suggest as many as five large magnitude earthquakes (magnitude 8 to 9) have occurred along the CSZ in the last 1,500 years at intervals between about 250 and 450 years, the most recent of which occurred about 300 years ago. Five large subduction zone earthquakes have been observed globally since 1960: 1) in 1960, a magnitude 9.5 earthquake occurred in Chile; 2) in 1964, a magnitude 9.2 earthquake occurred in Alaska; 3) in 2006, a magnitude 9.2 earthquake occurred in Indonesia; 4) in 2010, a magnitude 8.8 occurred of the coast of Chile; and 5) in 2011, a magnitude 9.0 occurred in Japan. No documented earthquakes of this magnitude have occurred along the CSZ during the recorded history of the Pacific Northwest.

Hundreds of smaller intracrustal earthquakes have been recorded in western Washington. Four of the most recent earthquakes were: 1) in 1946, a magnitude 7.2 earthquake occurred in the Vancouver Island, British

Columbia area; 2) in 1949, a magnitude 7.1 earthquake occurred in the Olympia area; 3) in 1965, a magnitude 6.5 earthquake occurred between Seattle and Tacoma; and 4) on February 28, 2001, a magnitude 6.8 occurred in Nisqually near Olympia.

### Seismic Design Factors

Based on subsurface conditions encountered in our explorations and our understanding of the geologic conditions in the site vicinity, the site may be characterized as Class D in accordance with the 2012 IBC Design Manual. Seismic design parameters are provided in Table 2, below.

**TABLE 2: 2012 IBC SEISMIC DESIGN VALUES**

Site Coefficient	Site Factor	MCE <sup>1</sup> Spectral Response	Design Spectral Response
$S_s = 1.305g$	$F_a = 1.000$	$S_{MS} = 1.305g$	$S_{DS} = 0.870g$
$S_1 = 0.512g$	$F_v = 1.500$	$S_{M1} = 0.769g$	$S_{D1} = 0.512g$

Note:

<sup>1</sup> MCE = Maximum Considered Earthquake

### Peak Ground Acceleration

The peak ground acceleration (PGA) is used in seismic analyses such as liquefaction, lateral spreading, and seismic slope stability as well as assessing seismic surcharge loads for retaining walls. Based on our understanding of site conditions, we recommend using a PGA of 0.536g as determined in accordance with Section 11.8.3 of American Society of Civil Engineers (ASCE) Standard 7-10.

### Liquefaction Potential

Liquefaction refers to a condition where vibration or shaking of the ground, usually from earthquake forces, results in development of excess pore pressures in loose, saturated soils and subsequent loss of strength in the deposit of soil so affected. In general, soils that are susceptible to liquefaction include loose to medium dense sands to silty sands that are below the water table. The *Liquefaction Susceptibility Map of Pierce County* (Palmer, et al., 2004) indicates the soils along Leach Creek where the site is located have a “low to moderate” liquefaction potential. Based on our review, observations, and experience, it is accordingly our opinion that the potential for liquefaction at this site is moderate.

Organic-rich soils such as peat or organic silt, are described by Palmer, et al. (2004) as “not susceptible to liquefaction but may undergo permanent displacement or loss of strength as a result of earthquake shaking.” If structures are to be located in the area near boring B-3 further investigations should be performed to better understand the potential impacts.

### Lateral Spreading Potential

Lateral spreading related to seismic activity typically involves lateral displacement of large, surficial blocks of non-liquefied soil when a layer of underlying soil loses strength during seismic shaking. Lateral spreading usually develops in areas where sloping ground or large grade changes (including retaining walls) are present. Based on our understanding of the subsurface conditions and current site topography, it is our opinion that the risk of lateral spreading is low.

## Surface Rupture Potential

According to the Washington Department of Geology and Earth Sciences map *Faults and Earthquakes in Washington State* (Czajkowski and Bowman, 2014), the closest mapped fault is the Tacoma fault approximately 3½ miles east of the project site. The location of the fault has been inferred from geophysical studies, there are no known surface expressions of the Tacoma fault. Paleoseismologic studies indicate the last event occurred approximately 1,000 years ago. Information regarding recurrence interval potential magnitude are not available. Based on this, it is our opinion that the risk for seismic surface rupture at the site is low.

## CONCLUSIONS AND RECOMMENDATIONS

### Summary

Based on the results of our geology review, subsurface exploration program, and experience, it is our opinion the portions of the project site are more conducive to development than others. In general, conditions favorable to shallow foundation support of buildings are present in the central and north portions of the project site. The final location of the proposed improvements will have an influence on which soil conditions will need to be addressed during design.

The following list provides a summary of our conclusions and recommendations. The specific sections must be reviewed for our complete recommendations.

- Subsurface conditions across the project site vary. Shallow foundation support of structures is unlikely to be feasible in the south portion of the project site near Electron Way.
- Shallow foundation support of buildings in the central and north portions of the project site, in our opinion, is feasible. Footings founded on the native glacial deposits, or structural fill extending to these soils may be designed using an allowable soil bearing pressure of 3,000 pounds per square foot (psf).
- Dewatering will be necessary for excavation of a new in-ground pool. Depending on the time of year dewatering may also be required for shallower excavations.
- The existing soils on site contain a significant percentage of fines (material passing the U.S. No. 200 sieve). This material may be difficult or impossible to work when wet or if earthwork is performed during wet conditions.

### Design Alternatives

Below we provide a preliminary overview of the potential geotechnical issues associated with each alternative. Additional recommendations are provided in the sections following this overview.

#### Alternative 1 - Renovation

Based on our review, the existing community center was constructed in the mid-20<sup>th</sup> Century. As-built plans were not readily available during the time of this study, but based on the location and condition of surface soil, we anticipate that the existing community center was constructed with shallow spread footings. Additional geotechnical recommendations will not be required for renovation unless column or wall loads are increased, in which case we should evaluate the footings to determine if they are adequately designed to handle the increase loads.

## **Alternative 2 – Renovation and Expansion**

If this alternative is selected, the primary geotechnical concern is the potential for differential settlement between the existing structure and new addition structures. The estimated magnitude of differential settlement and potential solutions are presented in the “Shallow Foundation” section, below. The foundation system selected and structural connection of the addition to the existing building will be influenced by the soil conditions present, anticipated structural loads, and settlement tolerance of the structures.

## **Alternative 3 - New Construction**

If this alternative is selected, the primary geotechnical concern is the location of structures within the project site. The lake deposits observed in boring B-3 are susceptible to consolidation settlement under loads imposed by shallow foundations. Additionally, the full extent of the lake deposits is not known. If construction on these soils cannot be avoided, we provide preliminary recommendations for alternative foundations support.

## **Shallow Foundations**

It is our opinion that shallow foundations may be suitable in portions of the project site. In areas of the project site underlain by glacial deposits the recommendations provided in this section can be used for design and construction of shallow spread footings.

Areas that are underlain by silt or organic silt such as observed in boring B-3 could experience significant post-construction settlement. Buildings constructed in areas underlain by compressible soils may need to consider the use of deep foundations for support. Recommendations for alternative foundation support option are provided in the “Soft Soil Foundation Options” section of this report.

## **Depth and Size**

It is our opinion that shallow foundations can be used to support the proposed community center where medium dense to dense glacial deposits are located or in areas of unsuitable soil where ground improvement has been implemented.

Continuous wall or isolated column footings must bear directly on competent native glacial deposits or structural fill extending to native soils. Shallow footings may also be supported directly on improved ground. In either situation, we recommend a minimum width of 18 inches for continuous wall footings and 2 feet for isolated column footings. For frost protection, perimeter footing elements must be embedded at least 18 inches below the lowest adjacent external grade; internal footing elements must be embedded a minimum of 12 inches.

## **Foundation Bearing Surface Preparation**

Foundation bearing surfaces must be uniformly firm and in an unyielding condition. Excavation for foundations should be performed using a smooth-edged bucket to limit bearing surface disturbance. Loose or disturbed materials present at the base of footing excavations must be removed or compacted. Voids created by the removal of cobbles, boulders or tree roots must be backfilled with structural fill. Foundation bearing surfaces must not be exposed to standing water. Should water collect in an excavation, the water must be removed and the bearing surface re-evaluated before placing structural fill, formwork or reinforcing steel.



If footings are to be located where existing fill is present, the fill should be overexcavated. The overexcavation should extend to competent glacial soils. The overexcavation must extend beyond each edge of a footing a horizontal distance equal to the depth of overexcavation or 2 feet, whichever is less. The footings may be founded directly on the competent native material or the overexcavation can be backfilled with structural fill to the design foundation bearing surface. We recommend we provide additional assistance in determining depth of overexcavation once building location and footing elevations are determined.

If the overexcavation extends below the groundwater table then the water should be pumped out to allow placement and compaction of structural fill in dry conditions. If this is not feasible, then quarry spalls can be placed to raise the working surface above the water level.

### **Allowable Soil Bearing Pressure**

For the purposes of design we have assumed groundwater may be present at or below the bearing surface elevation and that drainage will be provided to prevent the foundation elements from becoming submerged. Footings founded as described may be designed using an allowable soil bearing pressure of 3,000 psf. The allowable soil bearing pressure value applies to long-term dead and live loads exclusive of the weight of the footing and any overlying backfill. When considering total loads, including transient loads such as those induced by wind and seismic forces the allowable bearing pressure may be increased by one-third.

### **Lateral Load Resistance**

Lateral loads on foundation elements may be resisted by passive pressure on the sides of footings and other below-grade structural elements and by friction on the base of footings. Passive resistance may be estimated using an equivalent fluid density of 300 pounds per cubic foot (pcf). This value may be used provided undisturbed native soil or compacted structural fill extends from the edge of footing a horizontal distance equal to or greater than  $2\frac{1}{2}$  times the depth of the footing. Frictional resistance may be estimated using 0.35 for the coefficient of base friction. The above values include a factor of safety of about 1.5.

The passive earth pressure and friction components may be combined provided that the passive component does not exceed two-thirds of the total resistance. The passive earth pressure value is based on the assumptions that the adjacent grade is level and that groundwater remains below the base of the footing throughout the year. The top foot of soil must be neglected when calculating passive lateral earth pressure unless the area adjacent to the foundation is covered with ACP or a slab-on-grade.

### **Settlement**

Our settlement analyses are based on assumed loading conditions of up to 50 kips for columns and 5 kips per linear foot (klf) for strip footings. For footings bearing on material constructed as recommended we estimate settlement to be less than 1 inch. Differential settlements between comparably loaded isolated column footings bearing on similar material or along 50 feet of continuous footing are estimated to be less than  $\frac{1}{2}$  inch. Settlement is expected to occur rapidly as loads are applied. Settlements could be larger than estimated if footings are placed on loose or disturbed soil, including the existing fill.

Shallow spread footings founded on silt or organic silt will experience significantly greater post-construction settlement.



### **Footing Drains**

We recommend that footing drains be installed around the foundation elements of the proposed building. The drains should be designed to collect and direct water away from the perimeter and interior footings of the building. We recommend that the drainpipe consist of 4-inch-diameter heavy-wall solid pipe (SDR-35 PVC, or equal) or rigid corrugated smooth interior polyethylene pipe (ADS N-12, or equal). We recommend against using flexible tubing for footing drainpipes. The drainpipe must be placed on a 3-inch bed of, and surrounded by, 6 inches of drainage material consisting of pea gravel or "Gravel Backfill for Drains." A non-woven geotextile fabric such as Mirafi 140N (or approved equivalent) must be placed between the drain rock and native soils to prevent fine soil from migrating into the drain material.

The perimeter drains must be sloped to drain by gravity to a suitable discharge point at or below the bearing surface elevation. Water collected in roof downspout lines must not be routed to the perimeter footing or wall drain lines. Cleanout access must be provided periodically along the length of the drains.

### **Soft Soil Foundation Options**

In this section we discuss some of the potential options for foundation support of the proposed community center improvements on soft soil. The options presented here do not represent a full list of potential solutions. Other solutions may be better suited to the project if additional information on subsurface conditions is obtained.

### **Surcharge Fill**

For this report we define a surcharge fill as temporary fill placed above planned final grades to cause additional consolidation settlement. The surcharge fill is subsequently removed before continuing with the next phase of construction; typically building construction.

Based on the assumed loading conditions of 50 kips for columns and 5 klf for walls, our preliminary analysis indicates a surcharge thickness of about 5 feet. We anticipate that the majority of primary consolidation under a surcharge load should occur within about 6 to 8 weeks. If larger loads are anticipated, the thickness of the surcharge load should be reevaluated. The lateral extent of the lake deposits should be determined to evaluate where a surcharge would be most effective. If significant organic material or peat is present in other portions of the lake deposits, the surcharge could be less effective due to the long term decay of plant material and secondary consolidation.

The use of a surcharge near existing structures, such as for a building addition, will require additional analysis. A minimum setback of the surcharge from the building should be established to reduce the potential of the surcharge inducing settlement of the existing building.

### **Ground Improvement**

Ground improvement techniques, such as stone columns or rammed aggregate piers can be used to reduce the potential magnitude of both consolidation and liquefaction-induced settlement. Stone columns are a ground improvement method that can be constructed by several local contractors. Rammed aggregate piers are a ground improvement method proprietary to Geopier NW. The stone column technique uses a large vibrator to advance a probe to the design depth. Crushed aggregate is injected through the inside of the vibrator as it is removed. Compaction is achieved using vibration to create a stone column of crushed aggregate. For rammed aggregate piers a mandrel is driven into the soil to the design depth. As the mandrel

is withdrawn crushed aggregate is placed into the hole in thin lifts and compacted using a hydraulic ram to densify the crushed aggregate and create the rammed aggregate pier.

One benefit of ground improvement is that the consolidation settlement period associated with a surcharge load is not required, which typically takes 6- to 8-weeks. Once installed, the spread footings and floor slab can typically be supported directly on the piers/columns without the need for subgrade or bearing surface improvements. Additionally, a higher allowable bearing pressure can be achieved through proper design and construction. Both of these methods involve displacing rather than replacing the natural soil, which can limit the amount of soil exported from the site.

### **Augercast Piles**

Augercast piles are a structural foundation element that extend from the building structure to a bearing layer at depth. Augercast concrete piles are typically constructed using a crane-mounted continuous-flight, hollow-stem auger. Construction of a typical pile consists of augering a hole through the fill to a minimum depth. Pile grout is pumped under pressure through the hollow-stem as the auger is withdrawn from the hole. A cage of reinforcing steel for bending and uplift is placed in the fresh grout column immediately after withdrawal of the auger. The depth and diameter of the piles are design based on the soil conditions and axial and lateral structural loads.

Because augercast piles are a structural foundation element they can be designed for relatively large axial loads. They can also be designed to resist lateral loading conditions such as those imposed by seismic forces. Augercast piles replace existing soil which results in spoils that must be removed from the site.

### **Floor Slabs**

A modulus of subgrade reaction of 300 pounds per cubic inch (pci) may be used for designing the building floor slab provided that the subgrade consists of undisturbed native glacial deposits, or proof compacted existing fill and prepared as described in this report. Settlement for a floor slab designed and constructed as recommended is estimated to be less than 1 inch. We estimate that differential settlement of the floor slab will be ½ inch or less over a span of 50 feet provided materials below the slab are prepared as recommended.

We recommend that on-grade slabs be underlain by a minimum 4-inch-thick capillary break layer to reduce the potential for moisture migration into the slab. If dry slabs are required (e.g., where adhesives are used to anchor carpet or tile to the slab), a waterproof liner may be placed as a vapor barrier below the slab.

### **Pool Considerations**

We understand an in-ground pool is planned as part of the proposed community center project. Geotechnical considerations associated with pools include lateral earth pressures on the side walls and the potential for buoyant conditions in the presence of groundwater.

### **Drainage and Buoyancy**

Because of the high groundwater table in the project vicinity, positive drainage around and below the pool will likely not be possible. We recommend the pool walls be designed to include hydrostatic pressure. Additionally, buoyancy of the pool will need to be evaluated for this condition. For the purposes of evaluating

the potential for pool buoyancy, we recommend using a groundwater level about 2 feet below the existing site grades.

It may be possible to install an optional vertical drain/clean out in the backfill zone around the pool. A sump pump can be placed in the vertical drain to temporarily lower the groundwater level around the pool to facilitate emptying of the pool. The drainage zone should extend horizontally at least 18 inches from the back of the pool walls. A non-woven geotextile fabric such as Mirafi 140N (or approved equivalent) should be placed between the drain rock and native soils to prevent fine soil from migrating into the drain material. We recommend that the drainpipe consist of 4-inch-diameter heavy-wall solid pipe (SDR-35 PVC, or equal) or rigid corrugated smooth interior polyethylene pipe (ADS N-12, or equal). The vertical drainpipe should be surrounded by 6 inches of drainage material consisting of pea gravel or "Gravel Backfill for Drains." This concept should be tested with drawdown pump tests in wells installed near the proposed pool location to determine if the groundwater can be drawn down sufficiently to reduce the potential for buoyancy. If dewatering wells are installed during construction they could be used to perform the pump tests. Another option to reduce the potential buoyant effects is to increase the weight of the pool. This could be achieved by thickening the walls or bottom slab, or by extending the bottom slab beyond the pool perimeter and backfilling with structural fill.

#### Lateral Earth Pressures

The lateral earth pressures presented assume that backfill placed within 2 feet of the wall is compacted by hand-operated equipment to a density of 90 percent of the maximum dry density (MDD) and that wall drainage measures discussed below are implemented. We assume that the tops of the walls are not structurally restrained and are free to rotate. Because of the high groundwater table, the design of the pool walls must include hydrostatic pressures.

**TABLE 3: RECOMMENDED ACTIVE EARTH PRESSURES**

Soil Type	Soil Pressure	Hydrostatic Pressure	Total Active Earth Pressure	Seismic Earth Pressure
Glacial Deposits	16 pcf	62.4 pcf	78.4 pcf	7H
Lake Deposits	20 pcf	62.4 pcf	82.4 pcf	7H

Lateral earth pressures can be influenced by other structural elements or loading conditions located near the pool walls. We recommend shallow spread footing elements be set back from the pool a minimum horizontal distance equal to the height of the pool wall. If surcharge loads such as those imposed by traffic, parked cars, or delivery trucks, etc. are anticipated these could induce additional lateral loading on the pool walls. We should be consulted to evaluate the potential impact to the pool and provide recommended lateral earth pressures for surcharge loading conditions.

#### Site Development and Earthwork

##### General

We anticipate that site development work will include removing existing vegetation, stripping sod and topsoil, excavating for footings and utility trenches, general site grading, and placing and compacting fill and backfill materials. We expect that the majority of site grading can be accomplished with conventional earthmoving equipment in proper working order. Special considerations will be required for excavations

extending below the water table, such as for the pool. The following sections provide recommendations for earthwork, site development and fill materials.

### **Stripping and Clearing**

We estimate that stripping depths in structural areas will be on the order of 6 to 12 inches. Overexcavation may be required where tree root zones or obstacles have been removed. Overexcavated areas must be backfilled with properly placed and compacted structural fill. If excessive disturbance of the existing soil occurs during demolition of existing structures or clearing and stripping activities, removal of the disturbed soil may be required. Material generated during stripping operations must be disposed of off site or used in non-structural areas.

### **Obstacles**

Obstacles may potentially be encountered while excavating in native fill soils. Although not encountered in our explorations, boulders can occasionally be found in glacial soils. Wood debris consisting of large roots, or branches, or tree trunks can occasionally be found in organic-rich soils such as the lake deposits. The contractor should have a plan for removal of obstacles and backfilling voids created.

### **Subgrade Preparation**

Slabs-on-grade and pavements must be supported on subgrades consisting of native glacial deposits or proof-compacted existing fill. If competent native soils or existing fill is not present, then we recommend overexcavation and replacement. For preliminary planning, we recommend overexcavation extend to a depth of 2 feet or to competent native soil, whichever occurs first. Upon completion of clearing and stripping the exposed soil should be proof-compacted to a firm and unyielding condition prior to placement of structural fill, capillary break material for slabs-on-grade, or pavement subbase material.

We recommend the exposed soil surface be observed by a member of our firm prior to placement of fill material to establish subgrades, capillary break material for slabs-on-grade, or pavement subbase material. The exposed soil must be evaluated by proof rolling with heavy rubber tired equipment and/or by probing with a steel rod. Our representative will evaluate the suitability of the prepared subgrade and identify areas of yielding, which is indicative of soft or loose soil. Soft or otherwise unsuitable areas disclosed during proof rolling or probing that cannot be compacted to a firm and unyielding condition must be treated as follows:

- The subgrade soil must be scarified, aerated and recompacted, or
- The unsuitable soils must be removed and replaced with compacted structural fill as previously described.

Structural fill must be properly placed and compacted to establish design subgrade surfaces. Additional recommendations are provided in the “Fill Materials” and “Fill Placement and Compaction” sections of this report.

### **Temporary Excavation Support**

Regardless of the soil type, excavations deeper than 4 feet must be shored or laid back at a stable slope if workers are required to enter. Shoring and temporary slope inclinations must conform to the provisions of Title 296 Washington Administrative Code (WAC), Part N, “Excavation, Trenching and Shoring.” Regardless of the soil type encountered in the excavation, shoring, trench boxes or sloped sidewalls will be required

under Washington Industrial Safety and Health Act (WISHA). The contract documents should specify that the contractor is responsible for selecting excavation and dewatering methods, monitoring the excavations for safety and providing shoring, as required, to protect personnel and structures.

In general, temporary cut slopes must be inclined no steeper than about 1½H:1V (horizontal:vertical). This guideline assumes that all surface loads are kept at a minimum distance of at least one-half the depth of the cut away from the top of the slope and that significant seepage is not present on the slope face. Flatter cut slopes will be necessary where significant seepage occurs or if large voids are created during excavation. Some sloughing and raveling of the temporary slopes should be expected. Temporary covering with heavy plastic sheeting must be used to protect slopes during periods of wet weather. Where 1½H:1V temporary slopes are not feasible temporary shoring should be considered.

### **Groundwater Handling**

Depending on the time of year construction occurs, groundwater could be encountered as shallow as 2 feet below existing grades. We anticipate that excavations deeper than about 4 feet will require an engineered dewatering plan. Handling of groundwater in shallower excavations may be feasible without dewatering, but careful planning and staging by the contractor will be required. Ultimately, we recommend that the contractor performing the work be responsible for controlling and collecting the groundwater if encountered.

Dewatering of larger excavations, such as for the pool, should be approached with caution. Removal of large amounts of water over a short period of time can potentially induce settlement in the soils surrounding a dewatered excavation. We recommend GeoEngineers review dewatering plans developed by the contractor.

### **Surface Drainage**

Surface water from roofs, driveways, parking areas, play fields and landscape areas must be collected and controlled. Curbs or other appropriate measures such as sloping pavements, sidewalks and landscape areas should be used to direct surface flow away from buildings and erosion sensitive areas. Roof and catchment drains must discharge to an appropriate collection system. The surface drainage collection and discharge system must be kept separate from footing drains.

### **Erosion Control**

Based on existing site grades and the proposed development, we anticipate that temporary measures such as silt fences, straw bales and sand bags will generally be adequate for erosion control during construction. Temporary erosion control must be provided during construction activities and until permanent erosion control measures are functional. The existing slopes and temporary slopes resulting from staging of construction activities could be susceptible to surface water erosion. Surface water runoff must be properly contained and channeled using drainage ditches, berms, swales and tightlines and must not discharge onto slopes or to the wetlands. Any disturbed sloped areas must be protected with a temporary covering until final design grades are established or parking areas are paved. Jute or coconut fiber matting, excelsior matting or clear plastic sheeting is suitable for this purpose.

## **Wet Weather Considerations**

The wet weather season in western Washington generally begins in October and continues through May; however, periods of wet weather can occur during any month of the year. Additionally, the presence of shallow groundwater can potentially keep soils continually moist regardless of the season or weather. The majority of the soils encountered in our explorations contain a significant amount of fines (material passing the U.S. Standard No. 200 sieve) and will be susceptible to disturbance from construction traffic during extended periods of wet weather. If wet weather earthwork is unavoidable, we recommend that the following steps be taken.

- Earthwork activities must not take place during periods of heavy precipitation.
- Temporary or existing slopes with exposed soils must be covered with plastic sheeting.
- The ground surface in and around the work area must be sloped so that surface water is directed away from the work area to prevent pooling and collection of water in excavations.
- The contractor must take necessary measures to prevent on-site soils and stockpiled soils from becoming wet and potentially unsuitable for use as structural fill. These measures may include the use of plastic sheeting, sumps with pumps and grading.
- Construction traffic must be restricted to specific areas of the site, preferably areas that are surfaced with working pad materials not susceptible to wet weather disturbance.
- Construction activities must be scheduled so that the length of time that soils are left exposed to moisture is reduced to the extent practical.
- During periods of wet weather, concrete must be placed as soon as practical after preparation of the footing excavations. If timely concrete placement is not possible, prepared bearing surfaces must be protected. Protection consisting of crushed rock or a lean concrete mat should be considered if footing excavations are exposed to extended wet weather conditions.
- Foundation bearing surfaces must not be exposed to standing water. Water that pools in prepared footing excavations must be removed and the bearing surface re-evaluated before placing structural fill, formwork or reinforcing steel.

## **Fill Materials**

### **General**

Material used for fill must be free of debris, organic contaminants and rock fragments larger than 6 inches. The workability of material for use as fill will depend on the gradation and moisture content of the soil. Generally, soil with a higher fines content is more sensitive to changes in moisture. Below we provide recommendations for fill materials we anticipate will be used for this project. We recommend GeoEngineers review contractor submittals for alternate fill materials.

We provide recommendations for fill materials to be used in dry and wet weather conditions. Dry weather conditions assumes that groundwater is controlled and no standing water is present. If standing water is present wet weather fill material may not be appropriate, alternatives such as quarry spall placement should be considered.

### **Structural Fill**

We recommend that structural fill placed during wet weather consist of material of approximately the same quality as “Gravel Backfill for Walls,” as described in Section 9-03.12(2) of the Washington State Department of Transportation (WSDOT) Standard Specifications.

Structural fill placed during dry weather may consist of material of approximately the same quality as “Gravel Borrow,” as described in Section 9-03.14(1) of the WSDOT Standard Specifications.

### **Capillary Break**

Capillary break material should consist of a well-graded sand and gravel or crushed rock with a maximum particle size of  $\frac{3}{4}$  inch and less than 5 percent fines, such as “AASHTO Grading No 7” as described in Section 9-03.1(4)C of the WSDOT Standard Specifications. Alternatively, crushed rock having a maximum particle size of  $\frac{3}{4}$  inch and less than 5 percent fines may be considered for use as capillary break material. We recommend GeoEngineers review contractor submittals for alternate capillary break materials.

### **Pipe Bedding**

We recommend trench backfill for the bedding and pipe zone consist of material of approximately the same quality as “Gravel Backfill for Pipe Zone Bedding,” as described in Section 9-03.12(3) of the WSDOT Standard Specifications. The pipe manufacturer and local jurisdictions may have additional requirements that must be followed.

### **Trench Backfill**

We recommend that all trench backfill consist of material of approximately the same quality as “gravel borrow” described in Section 9-03.14(1) of the WSDOT Standard Specifications. We recommend that trench backfill placed during wet weather conditions or if seepage is present in trench excavations consist of material of approximately the same quality as “Gravel Backfill for Walls,” as described in Section 9-03.12(2) of the WSDOT Standard Specifications. Depending on the amount of water present, the extent of dewatering, and the soil conditions, backfill materials requiring less compactive effort may be required, such as quarry spalls.

### **Footing Drains**

We recommend material used for footing drains and in the wall drainage zone be of approximately the same quality as “gravel backfill for drains” described in Section 9-03.12(4) of the WSDOT Standard Specifications.

### **Crushed Rock**

We recommend that crushed rock used as structural fill consist of material of approximately the same quality as “crushed surfacing base course” described in Section 9-03.9(3) of the WSDOT Standard Specifications. For pavement sections crushed surfacing top course may be used where fine grading or grade control is desired.

### **Quarry Spalls**

We recommend that quarry spalls consist of clean, durable, angular rock material of approximately the same quality as described in Section 9-13.6 of the WSDOT Standard Specifications. This material is typically



ordered in 2- to 4-inch or 4- to 8-inch gradation. Rock spalls should be free of organic matter, debris and any material less than 2 inches in size.

### **On-Site Soil**

The native glacial deposits and portions of the existing fill may be considered for use as structural fill, provided that placement, moisture conditioning, and compaction can be adequately achieved as recommended. The native and fill soils observed in our explorations contain enough fines that they may not be suitable for use during extended periods of wet weather. The existing fill may be considered for use as structural fill provided any debris present is removed prior to placement and compaction. Additional drying of the existing fill and native materials will likely be required if the soils have a moisture content above optimum at the time of excavation.

It is our opinion that the native lake deposits observed in boring B-3 and fill soils consisting of silt observed in all three explorations should not be considered for use as structural fill.

### **Recycled Materials**

Crushed asphalt and Portland cement concrete (PCC) may be considered for use as structural fill provided it meets the gradation criteria described above and that the material can be compacted to a uniformly firm and unyielding condition. The maximum particle size must not exceed 6 inches. Gradation of the recycled asphalt and PCC is typically difficult to control and it may not be suitable where free-draining material is required, such as for capillary break material or footing drains. In addition, crushed asphalt has the potential to creep under large and sustained loads. Accordingly, we recommend that crushed/recycled asphalt not be used under foundation elements. Recycled glass may be considered for use as capillary break material or pipe bedding. In general, we recommend "Recycled Materials" conform to Section 9-03.21 of the WSDOT Standard Specifications. We further recommend that recycled material submittals be reviewed by the project civil or geotechnical engineer.

### **Fill Placement and Compaction**

#### **General**

Structural fill must be compacted at a moisture content near optimum. The optimum moisture content varies with the soil gradation and must be evaluated during construction. Fill and backfill material must be placed in uniform, horizontal lifts and uniformly densified with vibratory compaction equipment. The maximum lift thickness will vary depending on the material and compaction equipment used, but should generally not exceed 10 to 12 inches in loose thickness. Below we provide recommended compaction requirements for fill placement as a percentage of MDD determined by ASTM International (ASTM) Test Method D 1557 (modified Proctor).

#### **Area Fills and Bases**

Structural fill placed to raise site grades or establish subgrades for slabs-on-grade or pavements must be placed on a prepared surface that consists of uniformly firm and unyielding inorganic native soils or existing proof compacted fill. We recommend structural fill for area fills and bases be placed in appropriate lift thicknesses and be compacted to at least 95 percent of MDD.



### **Capillary Break Material**

We recommend capillary break material be placed and compacted to at least 95 percent of MDD. If capillary break materials consist of pea gravel, recycled glass, or similar material, we recommend these materials be compacted to a firm and unyielding condition and observed by a qualified geotechnical engineer.

### **Overexcavation**

We recommend the bottom of overexcavated areas be observed by a member of our firm prior to backfilling with structural fill. We recommend structural backfill be placed in uniform lift thicknesses and be compacted to at least 95 percent of MDD.

### **Quarry Spall Placement**

Quarry spalls can be used to stabilize soft/saturated soils or raise working surfaces above standing water in an excavation. The initial lift of quarry spalls must not exceed about 2 rocks in thickness and must be pressed (not tamped) into the soil. Depending on the soil conditions this may need to be repeated several times to establish a firm surface suitable for placement of structural fill.

A non-woven separation fabric may be placed over the quarry spalls to prevent downward migration of overlying materials.

### **Trench Backfill**

For utility excavations, we recommend that the initial lift of fill over the pipe be thick enough to reduce the potential for damage during compaction but generally should not be greater than about 18 inches. In addition, rock fragments greater than about 1 inch in maximum dimension must be excluded from this lift. Below we provide compaction requirements for trench backfill placed in:

- Building areas, 95 percent of MDD.
- Pavement areas, within 2 feet of the subbase, 95 percent of MDD.
- Pavement areas, more than 2 feet below the subbase, 90 percent of MDD.
- Nonstructural areas, compacted to a firm condition to allow mobilization of construction equipment.

## **ADDITIONAL INVESTIGATIONS**

Depending on the design alternative selected, additional explorations may be warranted. The lateral extent of the lake deposits is currently unknown. Additional explorations could better define the potential impact to proposed structures, as well as the depth of the soft soils. If the lake deposits are found to be relatively thin and shallow, removal and replacement could be feasible allowing the use of shallow foundations.

## **LIMITATIONS**

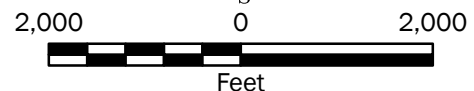
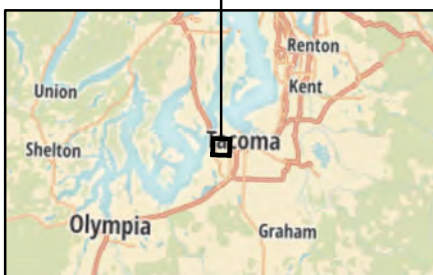
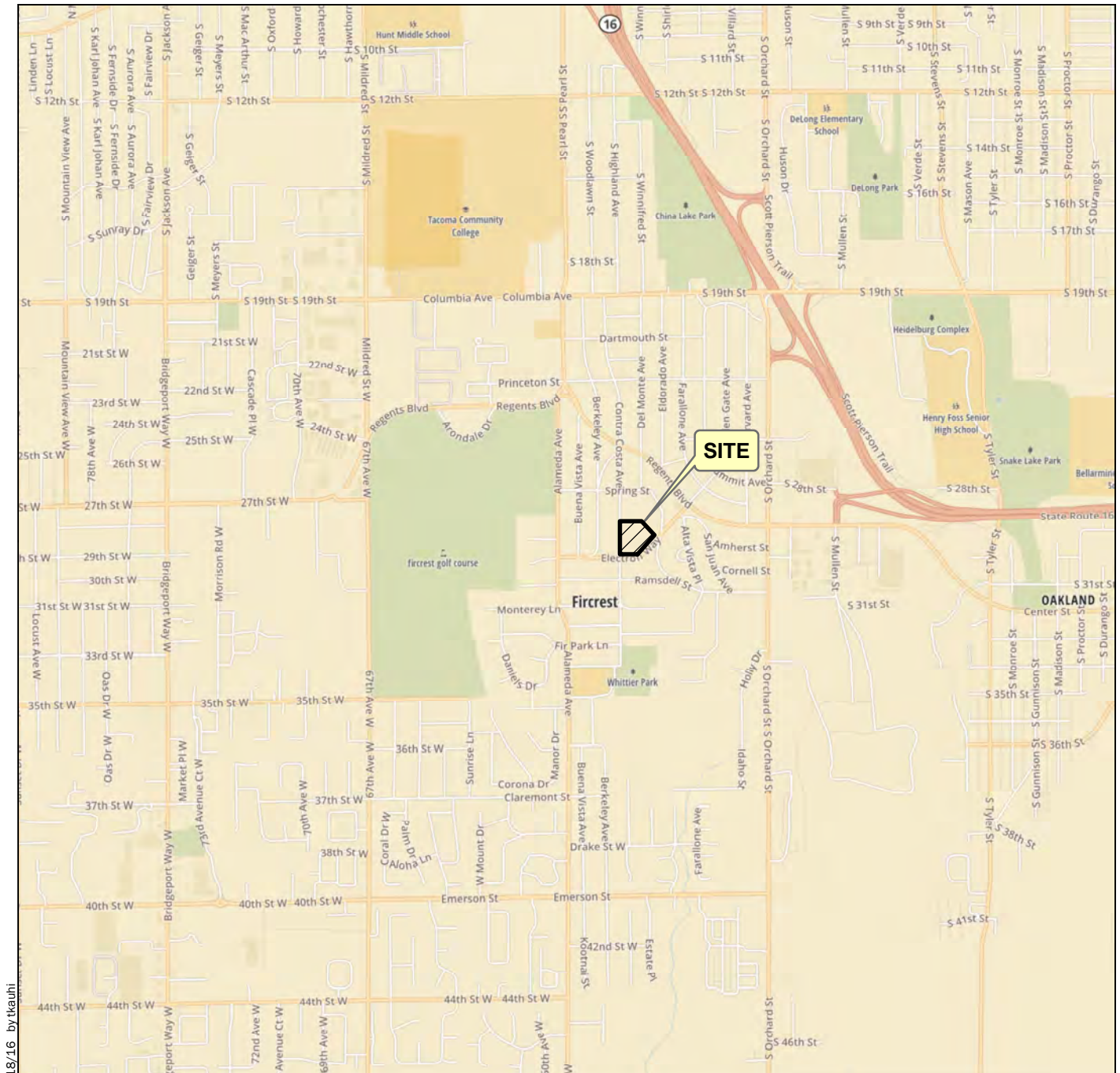
We have prepared this report for the exclusive use of the ARC Architects and their authorized agents for the Fircrest Community Center and Pool project, located in Fircrest, Washington.

Within the limitations of scope, schedule and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood.

Please refer to Appendix B “Report Limitations and Guidelines for Use” for additional information pertaining to use of this report.

## REFERENCES

- Brocher, T. M., and Sherrod, B. L., and Johnson, S. Y., and Blakely, R. J., and Lidke, D. J., compilers, 2004, Fault number 581, Tacoma fault, in Quaternary fault and fold database of the United States: U.S. Geological Survey website, <http://earthquakes.usgs.gov/hazards/qfaults>.
- Czajkowski, Jessica L., and Bowman, Jeffery D., “Faults and Earthquakes in Washington State,” 2014. Washington Department of Geology and Earth Sciences, Open File Report 2014-05. [http://wa-dnr.s3.amazonaws.com/publications/ger\\_ofr2014-05\\_fault\\_earthquake\\_map.pdf](http://wa-dnr.s3.amazonaws.com/publications/ger_ofr2014-05_fault_earthquake_map.pdf).
- City of Tacoma, govME web page, <http://www.govme.org/govME/Admin/Inter/StartPage/default.aspx>
- Griffin, W., J. Sceva, H. Swenson, and M. Mundorff, “Water Resources of the Tacoma Area, Washington,” State of Washington, Department of Conservation, Division of Water Resources, Water Supply Bulletin No. 19, 1962.
- International Code Council. “2012 International Building Code.” 2012.
- Palmer, S., S. Magsino, E. Bilderback, J. Poelstra, D. Folger and R. Niggemann, “Liquefaction Susceptibility and Site Class Maps of Washington State, By County,” Map 27A—Pierce County Liquefaction Susceptibility, Sheet 53 of 78. 2004. Washington Division of Geology and Earth Resources, Open File Report, 2004-20.
- Smith, M. “Geologic Map of the City of Tacoma, Pierce County, Washington” Washington Department of Natural Resources, Division of Geology and Earth Resources, Open File Report OF. 77-9. 1977.
- Troost, K. “Geologic Map of the Steilacoom 7.5’ Quadrangle, Pierce County, Washington” United States Geological Survey (in Review).
- U.S. Seismic Design Maps, United States Geological Survey - Earthquake Hazards Program, (<http://geohazards.usgs.gov/designmaps/us/application.php>).
- Washington State Department of Transportation, 2012, “Standard Specifications for Road, Bridge and Municipal Construction.”



### Vicinity Map

Fircrest Community Center and Pool  
Fircrest, Washington



Figure 1

### Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.




Data Source: Mapbox Open Street Map, 2016

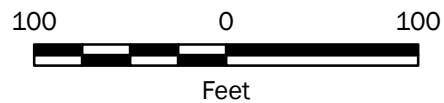
Projection: NAD 1983 UTM Zone 10N





### Legend

-  **B-1** Approximate Boring Location  
 **MW-2** Approximate Monitoring Well Location  
 Site Boundary



### Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Aerial from ESRI

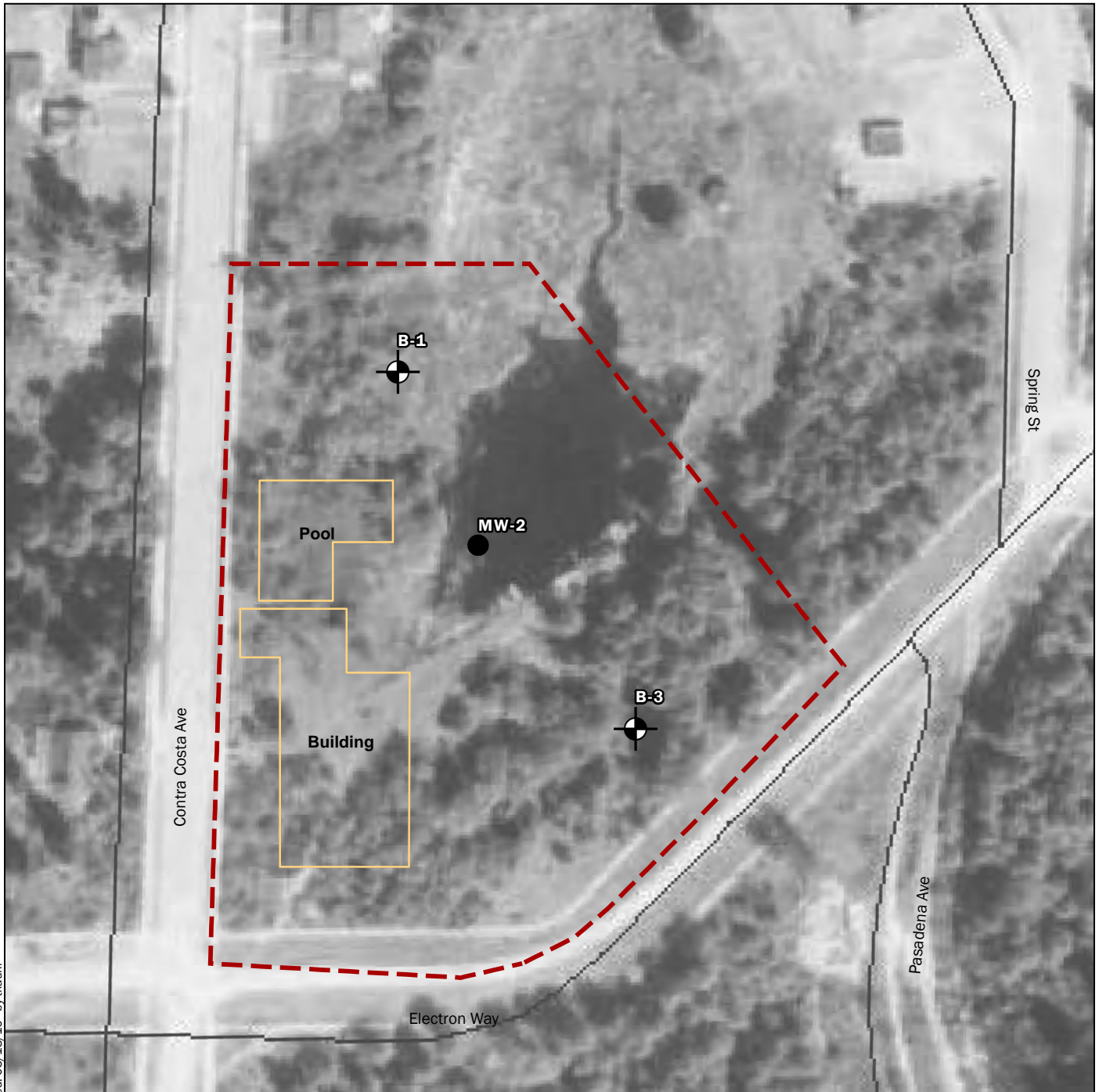
Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet

### Site Plan





Fircrest Community Center and Pool  
Fircrest, Washington



Figure 2



### Legend

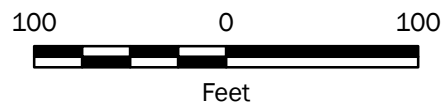
-  **B-1** Approximate Boring Location
-  **MW-2** Approximate Monitoring Well Location
-  Site Boundary
-  Current Site Features

### Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. cannot guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Data Source: Historic Aerial downloaded from GovMe City of Tacoma, 1931

Projection: NAD 1983 StatePlane Washington South FIPS 4602 Feet



### Historic Site Photo (1931)

Fircrest Community Center and Pool  
Fircrest, Washington



**Figure 3**

## **APPENDIX A**

### **Subsurface Explorations and Laboratory Testing**

## **APPENDIX A**

### **SUBSURFACE EXPLORATIONS AND LABORATORY TESTING**

#### **Subsurface Explorations**

Subsurface conditions for the proposed Fircrest Community Center & Pool project were explored by advancing three borings on January 15, 2016 at the approximate locations shown on Figure 2. The borings were performed using track-mounted drilling equipment and operator under subcontract to GeoEngineers. One of the borings was completed as a monitoring well, MW-2.

The borings were advanced using hollow-stem auger drilling methods and advanced to depths between approximately 11½ and 21 ½ feet below existing site grade (bgs). Soil samples were obtained from the borings using a 1.4-inch-inside-diameter split-barrel sampler driven into the soil using a 140-pound hammer free-falling a distance of 30 inches. The number of blows required to drive the sampler the last 12 inches or other indicated distance is recorded on the logs as the blow count. Our representative continuously monitored the borings, maintained a log of the subsurface conditions, and made sample attempts at 2.5- to 5-foot-depth intervals. The samples were retained in sealed plastic bags. The soils were classified visually in general accordance with the system described in Figure A-1. Summary logs of the borings are included as Figures A-2 through A-4.

The locations of the borings and monitoring well were determined by pacing from existing site features such as buildings, edge of pavement, and light poles. Recreation grade GPS equipment was also used to locate and record the exploration locations. The locations of the explorations should be considered approximate.

#### **Laboratory Test Results**

Soil samples obtained from the borings were transported to GeoEngineers laboratory. Representative soil samples were selected for laboratory tests to evaluate the pertinent geotechnical engineering characteristics of the site soils and to confirm our field classification. The following paragraphs provide a description of the tests performed.

##### **Sieve Analysis (SA)**

Sieve analyses were performed on selected samples in general accordance with ASTM International (ASTM) Test Method D 6913. This test method covers the quantitative determination of the distribution of particle sizes in soils. Typically, the distribution of particle sizes larger than 75 micrometers (µm) is determined by sieving. The results of the tests were used to verify field soil classifications. Figure A-5 presents the results of the sieve analyses.

##### **Percent Fines (%F)**

Minus 200 wash tests were performed on selected samples in general accordance with ASTM Test Method D 1140. This test method determines the percent of material passing the U.S. No. 200 sieve in soil. The results of the Minus 200 test assists in soil classification. Test results are indicated on the exploration logs, as appropriate.

**Moisture Content (MC)**

The moisture content of selected samples was determined in general accordance with ASTM Test Method D 2216. The test results are used to aid in soil classification and correlation with other pertinent engineering soil properties. The test results are presented on the exploration logs, as appropriate.

**Organic Content (OC)**

Organic content tests were performed on selected samples in general accordance with ASTM Test Method D 2974. This test method determines the percent organic matter in soil. The results of the organic content test are used to classify peat or other organic soil and assists in soil classification. Test results are indicated on the exploration logs, as appropriate.



## SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS	
			GRAPH	LETTER		
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS  (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES	
		GRAVELS WITH FINES  (APPRECIABLE AMOUNT OF FINES)		GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES	
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	SAND AND SANDY SOILS	CLEAN SANDS  (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS
					SP	POORLY-GRADED SANDS, GRAVELLY SAND
		MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	SANDS WITH FINES  (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
					SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS, ROCK FLOUR, CLAYEY SILTS WITH SLIGHT PLASTICITY	
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	
	MORE THAN 50% PASSING NO. 200 SIEVE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS SILTY SOILS
					CH	INORGANIC CLAYS OF HIGH PLASTICITY
					OH	ORGANIC CLAYS AND SILTS OF MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS	

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

### Sampler Symbol Descriptions

	2.4-inch I.D. split barrel
	Standard Penetration Test (SPT)
	Shelby tube
	Piston
	Direct-Push
	Bulk or grab
	Continuous Coring

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

A "WOH" indicates sampler pushed using the weight of the hammer.

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

## ADDITIONAL MATERIAL SYMBOLS

SYMBOLS		TYPICAL DESCRIPTIONS
GRAPH	LETTER	
	AC	Asphalt Concrete
	CC	Cement Concrete
	CR	Crushed Rock/Quarry Spalls
	TS	Topsoil/Forest Duff/Sod

### Groundwater Contact



Measured groundwater level in exploration, well, or piezometer



Measured free product in well or piezometer

### Graphic Log Contact



Distinct contact between soil strata



Approximate contact between soil strata

### Material Description Contact



Contact between geologic units



Contact between soil of the same geologic unit

### Laboratory / Field Tests

%F	Percent fines
%G	Percent gravel
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PI	Plasticity index
PP	Pocket penetrometer
PPM	Parts per million
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

### Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

## KEY TO EXPLORATION LOGS



FIGURE A-1

Start Drilled 1/15/2016	End 1/15/2016	Total Depth (ft) 11.5	Logged By Checked By BEL EWH	Driller Holocene Drilling, Inc.	Drilling Method Hollow Stem Auger
Surface Elevation (ft) Vertical Datum Undetermined			Hammer Data 140 (lbs) / 30 (in) Drop		Drilling Equipment Diedrich D50 Track Rig
Easting (X) Northing (Y)			System Datum		Groundwater Date Measured
Notes: 4-inch auger					Depth to Water (ft) Elevation (ft) See Remarks

Elevation (feet)	FIELD DATA					MATERIAL DESCRIPTION	Moisture Content, %	% Fines	REMARKS
	Interval	Recovered (in)	Blows/foot (N <sub>60</sub> )	Collected Sample	Sample Name Testing				
0						ML			
	18	12		1 MC			25		
				2 SA		SM	21	18	
5	18	15		3 MC			24		
									Groundwater observed at a depth of about 5.5 feet bgs at time of drilling
						SM			
10	18	46		4 MC			10		
				5 MC		GP-GM	7		Broken gravel in sample

Note: See Figure A-1 for explanation of symbols.

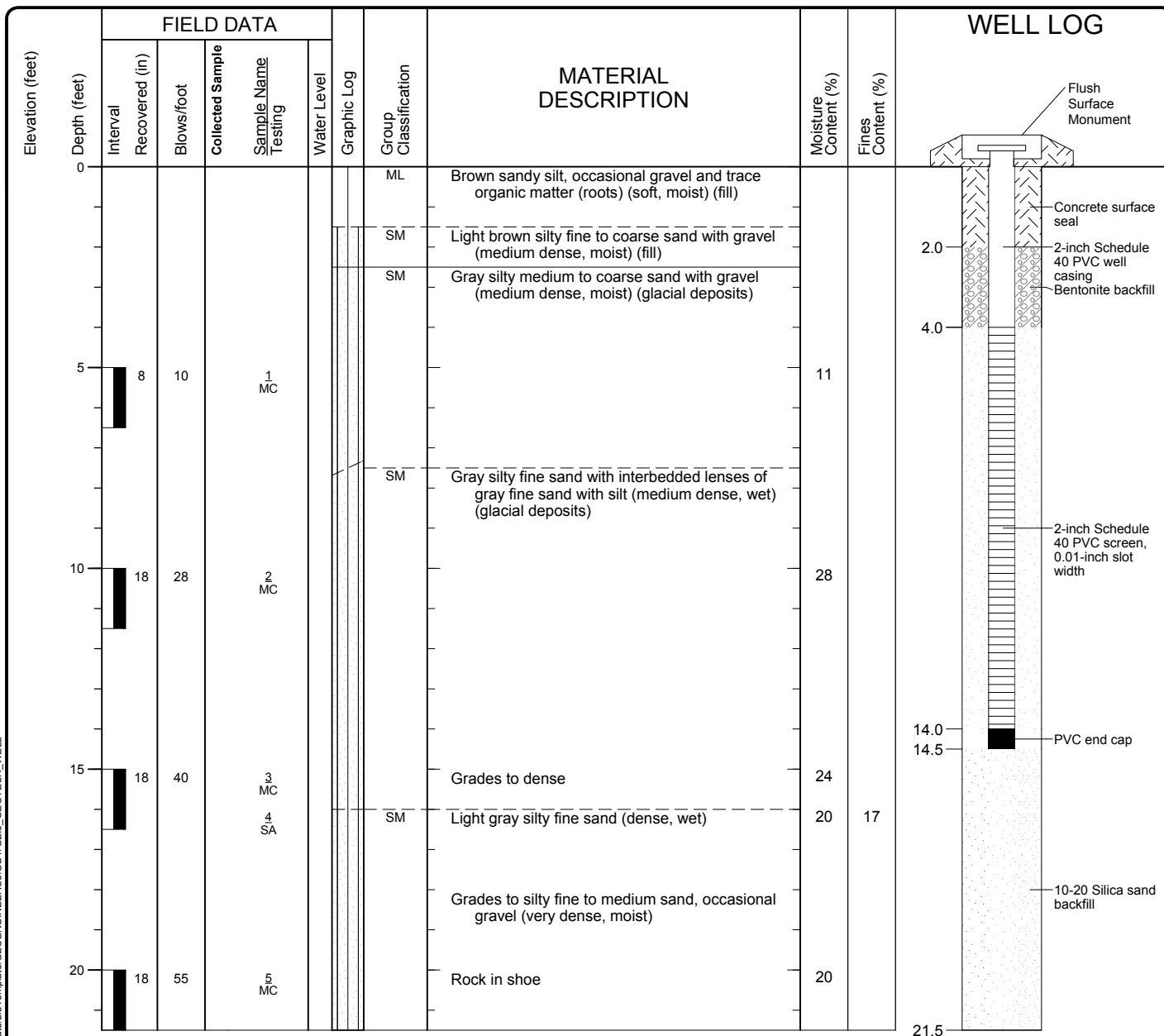
## Log of Boring B-1



Project: Fircrest Community Center and Pool  
 Project Location: Fircrest, Washington  
 Project Number: 4369-005-00

Figure A-2  
 Sheet 1 of 1

Start Drilled 1/15/2016	End 1/15/2016	Total Depth (ft) 21.5	Logged By Checked By BEL EWH	Driller Holocene Drilling, Inc.	Drilling Method Hollow Stem Auger
Hammer Data 140 (lbs) / 30 (in) Drop		Drilling Equipment Diedrich D50 Track Rig		A 2 (in) well was installed on 1/15/2016 to a depth of 21.5 (ft). Well was developed on 1/15/2016.	
Surface Elevation (ft) Vertical Datum Undetermined		Top of Casing Elevation (ft)		Groundwater Date Measured 2/23/2016	
Easting (X) Northing (Y)		Horizontal Datum		Depth to Water (ft) 2.1 Elevation (ft)	
Notes: 4-inch auger					



Note: See Figure A-1 for explanation of symbols.

### Log of Monitoring Well MW-2



Project: Fircrest Community Center and Pool  
 Project Location: Fircrest, Washington  
 Project Number: 4369-005-00

Figure A-3  
 Sheet 1 of 1

Start Drilled 1/15/2016	End 1/15/2016	Total Depth (ft) 16.5	Logged By Checked By BEL EWH	Driller Holocene Drilling, Inc.	Drilling Method Hollow Stem Auger
Surface Elevation (ft) Vertical Datum Undetermined			Hammer Data 140 (lbs) / 30 (in) Drop		Drilling Equipment Diedrich D50 Track Rig
Easting (X) Northing (Y)			System Datum		Groundwater Date Measured Depth to Water (ft) Elevation (ft)
Notes: 4-inch auger					See Remarks

Elevation (feet)	FIELD DATA					Group Classification	MATERIAL DESCRIPTION	Moisture Content, %	% Fines	REMARKS
	Interval Depth (feet)	Recovered (in)	Blows/foot (N <sub>60</sub> )	Collected Sample	Sample Name Testing					
0						ML	Dark brown sandy silt, occasional gravel, trace organic matter (roots) (medium stiff, moist) (fill)			
	18	7		1 MC 2 MC		SM	Light brown silty fine to coarse sand with gravel (loose, moist) (fill)	33 10		Sampler ran 12 inches on last blow
						OL	Dark brown organic silt, occasional sand (soft, wet) (lake deposits)			Groundwater observed at a depth of about 4 feet bgs at time of drilling
	18	2		3 MC				52		
	18	2		4 OC				68		Lenses of peat and organic matter (wood and leaves)
										OC=10
15	16	17		5 %F		SM	Gray silty fine sand (medium dense, wet) (glacial deposits)	22	17	

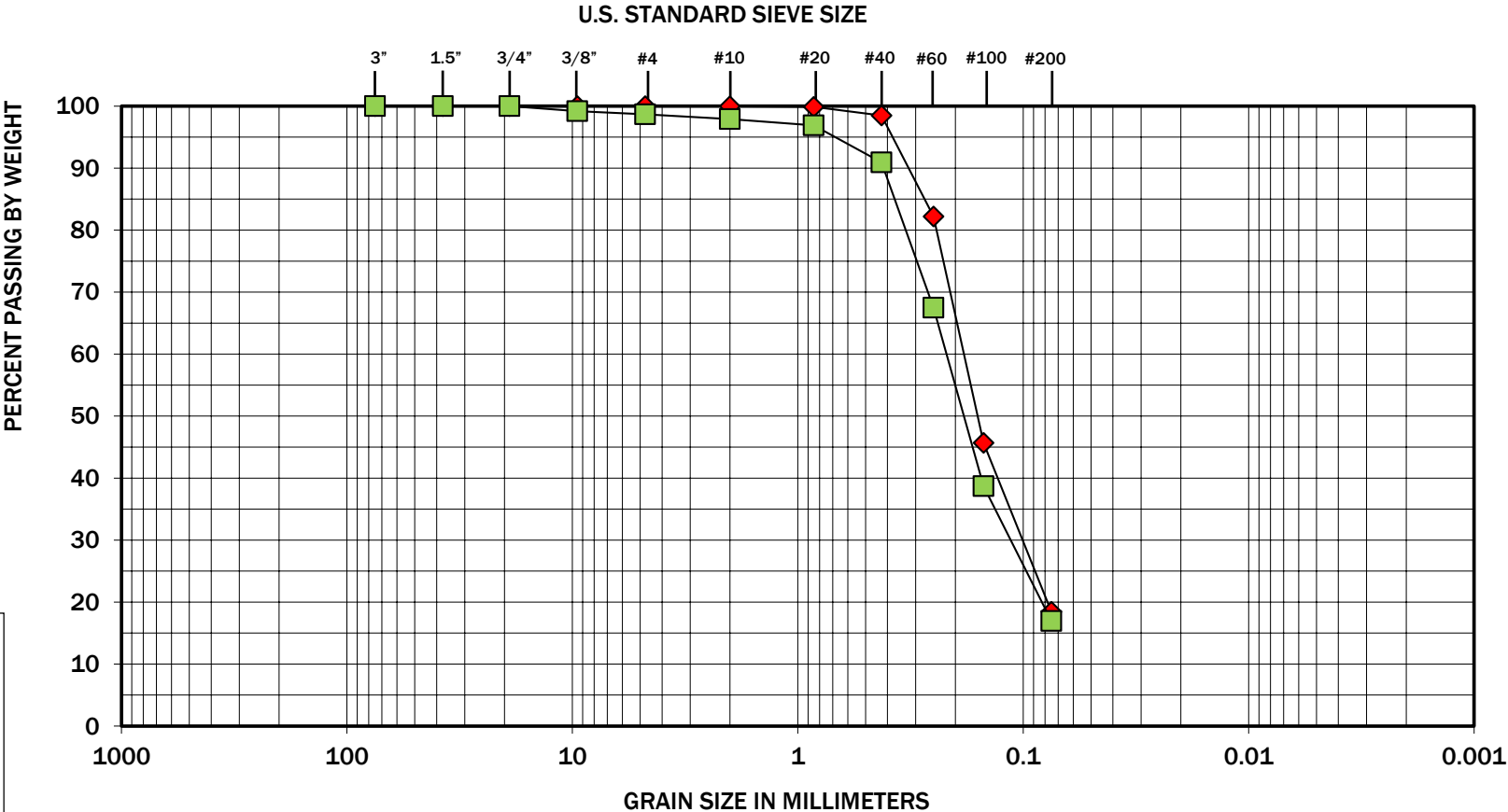
Note: See Figure A-1 for explanation of symbols.

### Log of Boring B-3



Project: Fircrest Community Center and Pool  
 Project Location: Fircrest, Washington  
 Project Number: 4369-005-00

Figure A-4  
 Sheet 1 of 1



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Symbol	Boring Number	Depth (feet)	Moisture (%)	USCS Soil Classification
◆	B-1	3.25	21	Silty sand (SM)
■	MW-2	16	20	Silty sand (SM)

Note: This report may not be reproduced, except in full, without written approval of GeoEngineers, Inc. Test results are applicable only to the specific sample on which they were performed, and should not be interpreted as representative of any other samples obtained at other times, depths or locations, or generated by separate operations or processes.

The grain size analysis results were obtained in general accordance with ASTM D 6913.

## **APPENDIX B**

### **Report Limitations and Guidelines for Use**

## **APPENDIX B**

### **REPORT LIMITATIONS AND GUIDELINES FOR USE<sup>1</sup>**

This appendix provides information to help you manage your risks with respect to the use of this report.

#### **Read These Provisions Closely**

It is important to recognize that the geoscience practices (geotechnical engineering, geology and environmental science) rely on professional judgment and opinion to a greater extent than other engineering and natural science disciplines, where more precise and/or readily observable data may exist. To help clients better understand how this difference pertains to our services, GeoEngineers includes the following explanatory “limitations” provisions in its reports. Please confer with GeoEngineers if you need to know more how these “Report Limitations and Guidelines for Use” apply to your project or site.

#### **Geotechnical Services Are Performed for Specific Purposes, Persons and Projects**

This report has been prepared for ARC Architects for the project(s) specifically identified in the report. The information contained herein is not applicable to other sites or projects. GeoEngineers structures its services to meet the specific needs of its clients. No party other than the party to whom this report is addressed may rely on the product of our services unless we agree to such reliance in advance and in writing. Within the limitations of the agreed scope of services for the Project, and its schedule and budget, our services have been executed in accordance with our Agreement with ARC Architects authorized on December 12, 2015 and generally accepted geotechnical practices in this area at the time this report was prepared. We do not authorize, and will not be responsible for, the use of this report for any purposes or projects other than those identified in the report.

#### **A Geotechnical Engineering or Geologic Report is Based on a Unique Set of Project-Specific Factors**

This report has been prepared for the Fircrest Community Center and Pool project, located in Fircrest, Washington. GeoEngineers considered a number of unique, project-specific factors when establishing the scope of services for this project and report. Unless GeoEngineers specifically indicates otherwise, it is important not to rely on this report if it was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

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<sup>1</sup> Developed based on material provided by ASFE, Professional Firms Practicing in the Geosciences; [www.asfe.org](http://www.asfe.org).

For example, changes that can affect the applicability of this report include those that affect:

- the function of the proposed structure;
- elevation, configuration, location, orientation or weight of the proposed structure;
- composition of the design team; or
- project ownership.

If changes occur after the date of this report, GeoEngineers cannot be responsible for any consequences of such changes in relation to this report unless we have been given the opportunity to review our interpretations and recommendations. Based on that review, we can provide written modifications or confirmation, as appropriate.

### **Subsurface Conditions Can Change**

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. The findings and conclusions of this report may be affected by the passage of time, by man-made events such as construction on or adjacent to the site, new information or technology that becomes available subsequent to the report date, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations. If more than a few months have passed since issuance of our report or work product, or if any of the described events may have occurred, please contact GeoEngineers before applying this report for its intended purpose so that we may evaluate whether changed conditions affect the continued reliability or applicability of our conclusions and recommendations.

### **Topsoil**

For the purposes of this report, we consider topsoil to consist of generally fine-grained soil with an appreciable amount of organic matter based on visual examination, and to be unsuitable for direct support of the proposed improvements. However, the organic content and other mineralogical and gradational characteristics used to evaluate the suitability of soil for use in landscaping and agricultural purposes was not determined, nor considered in our analyses. Therefore, the information and recommendations in this report, and our logs and descriptions should not be used as a basis for estimating the volume of topsoil available for such purposes.

### **Geotechnical and Geologic Findings Are Professional Opinions**

Our interpretations of subsurface conditions are based on field observations from widely spaced sampling locations at the site. Site exploration identifies the specific subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoEngineers reviewed field and laboratory data and then applied its professional judgment to render an informed opinion about subsurface conditions at other locations. Actual subsurface conditions may differ, sometimes significantly, from the opinions presented in this report. Our report, conclusions and interpretations are not a warranty of the actual subsurface conditions.



## **Geotechnical Engineering Report Recommendations Are Not Final**

The construction recommendations included in this report are preliminary and should not be considered final. GeoEngineers' recommendations can be finalized only by observing actual subsurface conditions revealed during construction. GeoEngineers cannot assume responsibility or liability for the recommendations in this report if we do not perform construction observation.

We recommend that you allow sufficient monitoring, testing and consultation during construction by GeoEngineers to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes if the conditions revealed during the work differ from those anticipated, and to evaluate whether earthwork activities are completed in accordance with our recommendations. Retaining GeoEngineers for construction observation for this project is the most effective means of managing the risks associated with unanticipated conditions.

## **A Geotechnical Engineering or Geologic Report Could Be Subject to Misinterpretation**

Misinterpretation of this report by members of the design team or by contractors can result in costly problems. GeoEngineers can help reduce the risks of misinterpretation by conferring with appropriate members of the design team after submitting the report, reviewing pertinent elements of the design team's plans and specifications, participating in pre-bid and preconstruction conferences, and providing construction observation.

## **Do Not Redraw the Exploration Logs**

Geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. The logs included in a geotechnical engineering or geologic report should never be redrawn for inclusion in architectural or other design drawings. Photographic or electronic reproduction is acceptable, but separating logs from the report can create a risk of misinterpretation.

## **Give Contractors a Complete Report and Guidance**

To help reduce the risk of problems associated with unanticipated subsurface conditions, GeoEngineers recommends giving contractors the complete geotechnical engineering or geologic report, including these "Report Limitations and Guidelines for Use." When providing the report, you should preface it with a clearly written letter of transmittal that:

- advises contractors that the report was not prepared for purposes of bid development and that its accuracy is limited; and
- encourages contractors to confer with GeoEngineers and/or to conduct additional study to obtain the specific types of information they need or prefer.

## **Contractors Are Responsible for Site Safety on Their Own Construction Projects**

Our geotechnical recommendations are not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and adjacent properties.

## **Biological Pollutants**

GeoEngineers' Scope of Work specifically excludes the investigation, detection, prevention or assessment of the presence of Biological Pollutants. Accordingly, this report does not include any interpretations, recommendations, findings or conclusions regarding the detecting, assessing, preventing or abating of Biological Pollutants, and no conclusions or inferences should be drawn regarding Biological Pollutants as they may relate to this project. The term "Biological Pollutants" includes, but is not limited to, molds, fungi, spores, bacteria and viruses, and/or any of their byproducts.

A Client that desires these specialized services is advised to obtain them from a consultant who offers services in this specialized field.