File No. EA2020-125

CITY OF RICHLAND
Determination of Non-Significance

Description of Proposal: Excavation of approximately 3,000 cubic yards and filling/grading of approximately 8,000 cubic yards of material in order to prepare the site for the future construction of 19 residential dwelling units.

Proponent: Knutzen Engineering
Attn: Paul Knutzen
5401 Ridgeline Dr., Suite 160
Kennewick, WA 99338

Location of Proposal: The project site is located at 1380 Duportail, Richland, WA 99352.

Lead Agency: City of Richland

The lead agency for this proposal has determined that it does not have a probable significant adverse impact on the environment. An environmental impact statement (EIS) is not required under RCW 43.21C.030(2)(c). This decision was made after review of a completed environmental checklist and other information on file with the lead agency. This information is available to the public on request.

( ) There is no comment for the DNS.

(**X**) This DNS is issued under WAC 197-11-340(2); the lead agency will not act on this proposal for fourteen days from the date of issuance.

( ) This DNS is issued after using the optional DNS process in WAC 197-11-355. There is no further comment period on the DNS.

Responsible Official: Mike Stevens
Position/Title: Planning Manager
Address: 625 Swift Blvd., MS #35, Richland, WA 99352
Date: October 6, 2020

Signature______________________________

SEPA ENVIRONMENTAL CHECKLIST

Purpose of checklist:

Governmental agencies use this checklist to help determine whether the environmental impacts of your proposal are significant. This information is also helpful to determine if available avoidance, minimization or compensatory mitigation measures will address the probable significant impacts or if an environmental impact statement will be prepared to further analyze the proposal.

Instructions for applicants:

This environmental checklist asks you to describe some basic information about your proposal. Please answer each question accurately and carefully, to the best of your knowledge. You may need to consult with an agency specialist or private consultant for some questions. You may use "not applicable" or "does not apply" only when you can explain why it does not apply and not when the answer is unknown. You may also attach or incorporate by reference additional studies reports. Complete and accurate answers to these questions often avoid delays with the SEPA process as well as later in the decision-making process.

The checklist questions apply to all parts of your proposal, even if you plan to do them over a period of time or on different parcels of land. Attach any additional information that will help describe your proposal or its environmental effects. The agency to which you submit this checklist may ask you to explain your answers or provide additional information reasonably related to determining if there may be significant adverse impact.

Instructions for Lead Agencies:

Please adjust the format of this template as needed. Additional information may be necessary to evaluate the existing environment, all interrelated aspects of the proposal and an analysis of adverse impacts. The checklist is considered the first but not necessarily the only source of information needed to make an adequate threshold determination. Once a threshold determination is made, the lead agency is responsible for the completeness and accuracy of the checklist and other supporting documents.

Use of checklist for nonproject proposals:

For nonproject proposals (such as ordinances, regulations, plans and programs), complete the applicable parts of sections A and B plus the SUPPLEMENTAL SHEET FOR NONPROJECT ACTIONS (part D). Please completely answer all questions that apply and note that the words "project," "applicant," and "property or site" should be read as "proposal," "proponent," and "affected geographic area," respectively. The lead agency may exclude (for non-projects) questions in Part B - Environmental Elements –that do not contribute meaningfully to the analysis of the proposal.

A. Background [HELP]

1. Name of proposed project, if applicable:
   WELLHOUSE HEIGHTS
2. Name of applicant:
   Knutzen Engineering, Paul Knutzen
3. Address and phone number of applicant and contact person:

5401 Ridgeline Dr, Suite 160, Kennewick WA 99338 Phone: (509) 222-0959

4. Date checklist prepared:
09/09/2020

5. Agency requesting checklist:
City of Richland

6. Proposed timing or schedule (including phasing, if applicable):
Will begin moving dirt approximately October 15th 2020 and finish by April 15th 2021.

7. Do you have any plans for future additions, expansion, or further activity related to or connected with this proposal? If yes, explain.
None at this time.

8. List any environmental information you know about that has been prepared, or will be prepared, directly related to this proposal.
A geotechnical report and a hydrology/stormwater report will be prepared.

9. Do you know whether applications are pending for governmental approvals of other proposals directly affecting the property covered by your proposal? If yes, explain.
None known.

10. List any government approvals or permits that will be needed for your proposal, if known.
DOE Erosivity Waiver will need to be completed.

11. Give brief, complete description of your proposal, including the proposed uses and the size of the project and site. There are several questions later in this checklist that ask you to describe certain aspects of your proposal. You do not need to repeat those answers on this page. (Lead agencies may modify this form to include additional specific information on project description.) A multi-family residential subdivision containing approximately 1.81 acres. 19 dwelling units are proposed for this subdivsion.

12. Location of the proposal. Give sufficient information for a person to understand the precise location of your proposed project, including a street address, if any, and section, township, and range, if known. If a proposal would occur over a range of area, provide the range or boundaries of the site(s). Provide a legal description, site plan, vicinity map, and topographic map, if reasonably available. While you should submit any plans required by the agency, you are not required to duplicate maps or detailed plans submitted with any permit applications related to this checklist. The site is located at 1380 Duportail Street in Richland, WA. Benton County Parcel number 115981013592002.

B. Environmental Elements [HELP]

1. *Earth* [help]

a. General description of the site:

(circle one): Flat, rolling, hilly, steep slopes, mountainous, other gently sloping

b. What is the steepest slope on the site (approximate percent slope)?

2-15% slopes (USGS Web Soil Survey)

c. What general types of soils are found on the site (for example, clay, sand, gravel, peat, muck)? If you know the classification of agricultural soils, specify them and note any agricultural land of long-term commercial significance and whether the proposal results in removing any of these soils.

Quincy Loamy Sand is the soil on-site. This is in the Hydrologic Soil Group A.

Type text here

d. Are there surface indications or history of unstable soils in the immediate vicinity? If so, describe. No.

e. Describe the purpose, type, total area, and approximate quantities and total affected area of any filling, excavation, and grading proposed. Indicate source of fill.
Approximately 3,000 CY of soil will be excavated on-site and 8,000 CY of Quincy Loamy sand will be imported for fill from parcel 115981013592004. Total affected area is approximately 82,000 SF.

f. Could erosion occur as a result of clearing, construction, or use? If so, generally describe.
Wind erosion could occur if no erosion control measures are in place.

g. About what percent of the site will be covered with impervious surfaces after project construction (for example, asphalt or buildings)?
Approximately 47% of the site or 37,350 SF of impervious will be added.

h. Proposed measures to reduce or control erosion, or other impacts to the earth, if any:
Water trucks will be used to minimize erosion.

2. Air [help]

a. What types of emissions to the air would result from the proposal during construction, operation, and maintenance when the project is completed? If any, generally describe and give approximate quantities if known. Minor dust and exhaust during construction and exhaust after construction.

b. Are there any off-site sources of emissions or odor that may affect your proposal? If so, generally describe. None known.

c. Proposed measures to reduce or control emissions or other impacts to air, if any:
Water will be sprinkled on the construction area for dust constrol.

3. Water [help]

a. Surface Water: [help]

1) Is there any surface water body on or in the immediate vicinity of the site (including year-round and seasonal streams, saltwater, lakes, ponds, wetlands)? If yes, describe type and provide names. If appropriate, state what stream or river it flows into.

Not in the immediate vicinity. The Yakima River is about 0.6 miles south west and the Columbia River is approximately 1 mile east.

2) Will the project require any work over, in, or adjacent to (within 200 feet) the described waters? If yes, please describe and attach available plans.

No.

3) Estimate the amount of fill and dredge material that would be placed in or removed from surface water or wetlands and indicate the area of the site that would be affected. Indicate the source of fill material. None.

4) Will the proposal require surface water withdrawals or diversions? Give general description, purpose, and approximate quantities if known. No.

5) Does the proposal lie within a 100-year floodplain? If so, note location on the site plan.

No.

6) Does the proposal involve any discharges of waste materials to surface waters? If so, describe the type of waste and anticipated volume of discharge.

No.

b. Ground Water: [help]

1) Will groundwater be withdrawn from a well for drinking water or other purposes? If so, give a general description of the well, proposed uses and approximate quantities withdrawn from the well. Will water be discharged to groundwater? Give general description, purpose, and approximate quantities if known.

No withdrawal. Storm water will be indirectly discharged to the ground through infiltration facilities.

2) Describe waste material that will be discharged into the ground from septic tanks or other sources, if any (for example: Domestic sewage; industrial, containing the following chemicals. . . ; agricultural; etc.). Describe the general size of the system, the number of such systems, the number of houses to be served (if applicable), or the number of animals or humans the system(s) are expected to serve.

None.

c. Water runoff (including stormwater):

1) Describe the source of runoff (including storm water) and method of collection and disposal, if any (include quantities, if known). Where will this water flow? Will this water flow into other waters? If so, describe.

Stormwater runoff from roofing, paving, and other impervious surfaces will be captured, retained, and infiltrated on-site via subsurface infiltration.

2) Could waste materials enter ground or surface waters? If so, generally describe.

Minimal pollutants from the proposed road.

3) Does the proposal alter or otherwise affect drainage patterns in the vicinity of the site? If so, describe. No.

d. Proposed measures to reduce or control surface, ground, and runoff water, and drainage pattern impacts, if any: All runoff will be retained on-site.

4. Plants [help]

a. Check the types of vegetation found on the site:

__✓__ deciduous tree: alder, maple, aspen, other
____evergreen tree: fir, cedar, pine, other
__✓__ shrubs
____grass
____pasture
____crop or grain
____ Orchards, vineyards or other permanent crops.
____ wet soil plants: cattail, buttercup, bullrush, skunk cabbage, other
____water plants: water lily, eelgrass, milfoil, other
____other types of vegetation

b. What kind and amount of vegetation will be removed or altered?
Existing shrubs and two deciduous trees will be removed.

c. List threatened and endangered species known to be on or near the site.
None known per the Washington Department of Fish and Wildlife (WDFW).

d. Proposed landscaping, use of native plants, or other measures to preserve or enhance vegetation on the site, if any:
Site will be landscaped with drought tolerant and native plants recommended by the City of Richland.

e. List all noxious weeds and invasive species known to be on or near the site.
None known.

5. Animals [help]

a. List any birds and other animals which have been observed on or near the site or are known to be on or near the site.

Examples include:

birds: hawk, heron, eagle, songbirds, other:
mammals: deer, bear, elk, beaver, other: small rodents and mice
fish: bass, salmon, trout, herring, shellfish, other ________

b. List any threatened and endangered species known to be on or near the site.
None known per the Washington Department of Fish and Wildlife (WDFW).

c. Is the site part of a migration route? If so, explain.
Yes the columbia basin is part of the Pacific Flyway.

d. Proposed measures to preserve or enhance wildlife, if any:
None.

e. List any invasive animal species known to be on or near the site.
None known.

6. *Energy and Natural Resources* [help]

a. What kinds of energy (electric, natural gas, oil, wood stove, solar) will be used to meet the completed project's energy needs? Describe whether it will be used for heating, manufacturing, etc. Electricity will be used for lighting, heating and cooling the dwelling units. Natural gas will also be utilized.

b. Would your project affect the potential use of solar energy by adjacent properties? If so, generally describe. No.

c. What kinds of energy conservation features are included in the plans of this proposal? List other proposed measures to reduce or control energy impacts, if any:

The project will comply with Washington State Residential Energy Code

7. *Environmental Health* [help]

a. Are there any environmental health hazards, including exposure to toxic chemicals, risk of fire and explosion, spill, or hazardous waste, that could occur as a result of this proposal? If so, describe.

1) Describe any known or possible contamination at the site from present or past uses.
None known.

2) Describe existing hazardous chemicals/conditions that might affect project development and design. This includes underground hazardous liquid and gas transmission pipelines located within the project area and in the vicinity.
Gas lines have been located on the property just southwest of the project site.

3) Describe any toxic or hazardous chemicals that might be stored, used, or produced during the project's development or construction, or at any time during the operating life of the project.

Fuel for construction vehicles will be used on-site during construction of the access road.

4) Describe special emergency services that might be required.
None.

5) Proposed measures to reduce or control environmental health hazards, if any:
Fuel for construction vehicles will be handled properly and with care to prevent spills.

b. Noise

1) What types of noise exist in the area which may affect your project (for example: traffic, equipment, operation, other)?
Normal vehicle traffic noise from Duportail Street and Thayer Drive. This will not impact the project.

2) What types and levels of noise would be created by or associated with the project on a short-term or a long-term basis (for example: traffic, construction, operation, other)? Indicate what hours noise would come from the site. Short term: construction noises
Long term: traffic noise from residents

3) Proposed measures to reduce or control noise impacts, if any:

All noises will be in compliance with City of Richland code 9.16.

8. Land and Shoreline Use [help]

a. What is the current use of the site and adjacent properties? Will the proposal affect current land uses on nearby or adjacent properties? If so, describe. The site is currently undeveloped. Adjacent sites include undeveloped property, a fraternal organization, and sports fields to the north. This project will not affect nearby or adjacent properties.

b. Has the project site been used as working farmlands or working forest lands? If so, describe. How much agricultural or forest land of long-term commercial significance will be converted to other uses as a result of the proposal, if any? If resource lands have not been designated, how many acres in farmland or forest land tax status will be converted to nonfarm or nonforest use? No.

1) Will the proposal affect or be affected by surrounding working farm or forest land normal business operations, such as oversize equipment access, the application of pesticides, tilling, and harvesting? If so, how: No.

c. Describe any structures on the site.

No existing structures on-site.

d. Will any structures be demolished? If so, what?

No.

e. What is the current zoning classification of the site?

Multiple Family Residential R-3

f. What is the current comprehensive plan designation of the site?

High Density Residential

g. If applicable, what is the current shoreline master program designation of the site?

N/A

h. Has any part of the site been classified as a critical area by the city or county? If so, specify.

The site is located in an aquifer recharge area classified by the City of Richland. There is also an area to the north east of the site classified as wetlands but will not be touched by this project.

i. Approximately how many people would reside or work in the completed project?

Based on the assumption of three people per family, approximately 60 people will reside in the completed project.

j. Approximately how many people would the completed project displace?

None.

k. Proposed measures to avoid or reduce displacement impacts, if any:

None.

L. Proposed measures to ensure the proposal is compatible with existing and projected land uses and plans, if any: A zone change has already occured to allow multi-family dwellings.

m. Proposed measures to reduce or control impacts to agricultural and forest lands of long-term commercial significance, if any: None.

9. *Housing* [help]

a. Approximately how many units would be provided, if any? Indicate whether high, middle, or low-income housing. Approximately 20 units will be provided by this project. This will be middle-income housing.

b. Approximately how many units, if any, would be eliminated? Indicate whether high, middle, or low-income housing. None.

c. Proposed measures to reduce or control housing impacts, if any:

None.

10. *Aesthetics* [help]

a. What is the tallest height of any proposed structure(s), not including antennas; what is the principal exterior building material(s) proposed?

Tallets height of building is approximately 36 feet. Exterior materials include glass, wood and fiber-cement siding.

b. What views in the immediate vicinity would be altered or obstructed?

None.

b. Proposed measures to reduce or control aesthetic impacts, if any:

None.

11. *Light and Glare* [help]

a. What type of light or glare will the proposal produce? What time of day would it mainly occur? Street lighting and exterior lighting on residential buildings. This will occur during evening hours.

b. Could light or glare from the finished project be a safety hazard or interfere with views?

No.

c. What existing off-site sources of light or glare may affect your proposal?

None.

d. Proposed measures to reduce or control light and glare impacts, if any:

Lighting will be compliant with City of Richland Chapter 23.58 Outdoor Lighting Standards.

12. Recreation [help]

a. What designated and informal recreational opportunities are in the immediate vicinity?
There is a large field for sports located north of the site. Additional recreation is located in the central business district about 0.6 miles north east.

b. Would the proposed project displace any existing recreational uses? If so, describe.
The current walking path on the site will be displaced.

c. Proposed measures to reduce or control impacts on recreation, including recreation opportunities to be provided by the project or applicant, if any:

The walking path on the site will be relocated.

13. Historic and cultural preservation [help]

a. Are there any buildings, structures, or sites, located on or near the site that are over 45 years old listed in or eligible for listing in national, state, or local preservation registers ? If so, specifically describe. No.

b. Are there any landmarks, features, or other evidence of Indian or historic use or occupation? This may include human burials or old cemeteries. Are there any material evidence, artifacts, or areas of cultural importance on or near the site? Please list any professional studies conducted at the site to identify such resources.

This is considered an area of interest for the Confederated Tribes of the Warm Springs per the Department of Archaeology and Historic Preservation but no evidence has been found to our knowledge.

c. Describe the methods used to assess the potential impacts to cultural and historic resources on or near the project site. Examples include consultation with tribes and the department of archeology and historic preservation, archaeological surveys, historic maps, GIS data, etc.

The WISAARD system of the DAHP was used to assess potential impacts.

d. Proposed measures to avoid, minimize, or compensate for loss, changes to, and disturbance to resources. Please include plans for the above and any permits that may be required.
Upon any discovery of potential or known archaeological resources at the property prior to or during on-site construction, the developer, contractor, and/or any other parties involved in construction shall immediately cease all on-site construction, shall act to protect the potential or known historical and cultural resources area from outside intrusion, and shall notify within a maximum period of twenty-four hours from the time of discovery, City of Richland officials of said discovery.

14. Transportation [help]

a. Identify public streets and highways serving the site or affected geographic area and describe proposed access to the existing street system. Show on site plans, if any.
The site will be accessed from Duportail Street.

b. Is the site or affected geographic area currently served by public transit? If so, generally describe. If not, what is the approximate distance to the nearest transit stop?
There is a transit stop approximately 500 feet east on Duportail street and a stop approximately 650 feet north west on Thayer Drive.

c. How many additional parking spaces would the completed project or non-project proposal have? How many would the project or proposal eliminate?
There will be approximately 34 parking stalls added (2 per dwelling unit)

d. Will the proposal require any new or improvements to existing roads, streets, pedestrian, bicycle or state transportation facilities, not including driveways? If so, generally describe (indicate whether public or private).

No improvements will be required for this project as Duportail Street is fully developed.

e. Will the project or proposal use (or occur in the immediate vicinity of) water, rail, or air transportation? If so, generally describe.

No.

f. How many vehicular trips per day would be generated by the completed project or proposal? If known, indicate when peak volumes would occur and what percentage of the volume would be trucks (such as commercial and nonpassenger vehicles). What data or transportation models were used to make these estimates?

111 vehicle trip ends are expected to be generated on a weekday per Code 230 Residential Condominium/Townhouse in the 9th edition ITE Trip Generation Manual. Peak trip generation will occur between 7 and 9 am.

g. Will the proposal interfere with, affect or be affected by the movement of agricultural and forest products on roads or streets in the area? If so, generally describe.

No.

h. Proposed measures to reduce or control transportation impacts, if any:

None.

15. Public Services [help]

a. Would the project result in an increased need for public services (for example: fire protection, police protection, public transit, health care, schools, other)? If so, generally describe.

Yes, the site will utilize fire and police protection, as well as public transportation. Residents will also utilize health care and schools.

b. Proposed measures to reduce or control direct impacts on public services, if any.

The completed project will provide additional tax revenue for the City.

16. Utilities [help]

a. Circle utilities currently available at the site:
electricity, natural gas, water, refuse service, telephone, sanitary sewer, septic system, other ___________

c. Describe the utilities that are proposed for the project, the utility providing the service, and the general construction activities on the site or in the immediate vicinity which might be needed.

Electricity - Richland Energy Services
Sewer - City of Richland
Water - City of Richland
Telephone - Charter/Ziply
Refuse - City of Richland
Natural Gas - Cascade Natural Gas

C. Signature [HELP]

The above answers are true and complete to the best of my knowledge. I understand that the lead agency is relying on them to make its decision.

Signature: Paul Knutzen

Name of signee: Paul Knutzen

Position and Agency/Organization: Civil Engineering / Knutzen Engneering

Date Submitted: 9/11/2020

D. Supplemental sheet for nonproject actions [HELP]

(**IT IS NOT NECESSARY** to use this sheet for project actions)

Because these questions are very general, it may be helpful to read them in conjunction with the list of the elements of the environment.

When answering these questions, be aware of the extent the proposal, or the types of activities likely to result from the proposal, would affect the item at a greater intensity or at a faster rate than if the proposal were not implemented. Respond briefly and in general terms.

1. How would the proposal be likely to increase discharge to water; emissions to air; production, storage, or release of toxic or hazardous substances; or production of noise?

   The project will increase discharge of stormwater to the ground due to increased impervious area. Future residents will add traffic and therefore emissions to the air. Noise production will be minimal and normal of multi-family properties.

   Proposed measures to avoid or reduce such increases are:

   Stormwater will be controlled through on-site infiltration facilities. No measures are proposed for vehicle emissions.

2. How would the proposal be likely to affect plants, animals, fish, or marine life?

   Shrubs and small rodents may be affected by the development but they are not threatened species.

   Proposed measures to protect or conserve plants, animals, fish, or marine life are:

   No measures are proposed.

3. How would the proposal be likely to deplete energy or natural resources?

   Dwelling units will need power and water.

   Proposed measures to protect or conserve energy and natural resources are:

   Homes will be built to the current energy codes to conserve energy and natural resources.

4. How would the proposal be likely to use or affect environmentally sensitive areas or areas designated (or eligible or under study) for governmental protection; such as parks,

wilderness, wild and scenic rivers, threatened or endangered species habitat, historic or cultural sites, wetlands, floodplains, or prime farmlands?

This project is not likely to affect environmentally sensitive areas however it is located in a critical aquifer recharge area.

Proposed measures to protect such resources or to avoid or reduce impacts are:

None at this time.

5. How would the proposal be likely to affect land and shoreline use, including whether it would allow or encourage land or shoreline uses incompatible with existing plans?

The project will not affect land/shorline use.

Proposed measures to avoid or reduce shoreline and land use impacts are:

N/A

6. How would the proposal be likely to increase demands on transportation or public services and utilities?

The project will increase demands to transportation and public utilities.

Proposed measures to reduce or respond to such demand(s) are:

The project will increase tax revenue.

7. Identify, if possible, whether the proposal may conflict with local, state, or federal laws or requirements for the protection of the environment.

No known conflict exists.

GENERAL NOTES

GENERAL NOTES

1. ALL CONSTRUCTION SHALL BE IN ACCORDANCE WITH THE CURRENT EDITION OF THE INTERNATIONAL BUILDING CODE (IBC), THE CURRENT EDITION OF WSDOT STANDARD SPECIFICATION FOR ROAD, BRIDGE, AND MUNICIPAL CONSTRUCTION M41-10, THE CITY STANDARDS AND SPECIFICATIONS, EASTERN WASHINGTON STORMWATER MANUAL, AND LOCAL RULES AND STANDARDS OF GOVERNING AGENCIES HAVING JURISDICTION.
2. PRIOR TO DIGGING VERIFY LOCATION AND DEPTH OF UTILITIES AND ANY OTHER UNDERGROUND INTERFERENCE. CALL TWO BUSINESS DAYS BEFORE YOU DIG AT 811.
3. STATEMENT OF ERRORS, AMBIGUITIES AND OMISSIONS: ANY ERRORS, AMBIGUITIES, AND OMISSION IN DRAWINGS AND/OR SPECIFICATIONS SHALL BE REPORTED TO KNUTZEN ENGINEERING FOR CORRECTION BEFORE ANY PART OF THE WORK IS STARTED. UNLESS EXPRESSLY STIPULATED NO ADDITIONAL ALLOWANCE WILL BE MADE IN THE CONTRACTOR AND/OR MANUFACTURE'S FAVOR BY VIRTUE OF ERRORS, AMBIGUITIES, AND/OR OMISSIONS WHICH SHOULD HAVE BEEN DISCOVERED DURING THE PREPARATION OF BID ESTIMATE AND DIRECTED TO THE ATTENTION OF KNUTZEN ENGINEERING IN A TIMELY MANNER. KNUTZEN ENGINEERING ACCEPTS NO RESPONSIBILITY FOR WORK DONE BY THE CONTRACTOR OR SUBCONTRACTORS CONTRARY TO THE PLANS OR SPECIFICATIONS. SUBSTITUTION OR CHANGES WILL NOT BE ACCEPTED UNLESS APPROVED IN WRITING. THE SUBCONTRACTOR SHALL REVIEW ALL SECTIONS OF SPECIFICATIONS AND ALL SHEETS OF THE PLANS FOR ANY INFORMATION OR DETAILS PERTAINING TO THEIR SPECIFIC TRADE.
4. CONTRACTOR IS RESPONSIBLE FOR VERIFICATION OF SITE CONDITIONS, INSTALLATION STANDARDS AND CONSTRUCTION CONDITIONS. CONTRACTOR SHALL FIELD VERIFY ALL DIMENSIONS PRIOR TO SHOP FABRICATION AND/OR FIELD ERECTION. DISCREPANCIES BETWEEN SITE CONDITIONS AND THE CONSTRUCTION DRAWINGS SHALL BE CALLED TO THE ATTENTION OF THE ENGINEER. WORK DONE WITHOUT THE ENGINEERS APPROVAL IS THE RESPONSIBILITY OF THE CONTRACTOR. LOCATIONS OF EXISTING UTILITIES SHOWN ON THESE DRAWINGS ARE APPROXIMATE ONLY. CONTRACTOR IS FULLY RESPONSIBLE FOR ANY AND ALL DAMAGE WHICH MIGHT OCCUR TO EXISTING UTILITIES.
5. CONTRACTOR IS TO PROVIDE A METHOD OF CONSTRUCTION OF OFF-SITE WORK THAT WILL ALLOW MINIMAL DISTURBANCE TO TRAFFIC FLOWS ON PUBLIC AND PRIVATE WAYS.
6. ALL SPECIAL INSPECTION AND TESTING SHALL BE PERFORMED BY AN INDEPENDENT INSPECTION AND TESTING AGENCY HIRED BY THE OWNER. CONTRACTOR TO COORDINATE WITH INSPECTION AND TESTING AGENCY FOR REQUIRED CONSTRUCTION INSPECTIONS AND MATERIAL TESTING.
7. CONTRACTOR SHALL PROTECT EXISTING PROPERTY CORNERS, IF CORNERS ARE DISTURBED THE CONTRACTOR SHALL BE RESPONSIBLE FOR HIRING A PROFESSIONAL LAND SURVEYOR TO RE-ESTABLISH THE PROPERTY CORNER(S).
8. THE CONTRACTOR SHALL REFERENCE RECOMMENDATIONS OF THE GEO-TECHNICAL ENGINEERS SOILS REPORT BY WHITE SHIELD, INC. DATED SEP 25, 2020 PROJECT NUMBER 119-054-01.
9. CONTRACTOR SHALL REPAIR OR REPLACE ANY DAMAGED CURBING OR SIDEWALK WITH IN THE RIGHT OF WAY PER CITY SPECIFICATIONS.
10. ALL ACCESSIBLE ACCESS PATHS, RAMPS, PARKING, AND SIGNAGE SHALL BE TO CURRENT ACCESSIBLE CODES.
11. CONTRACTOR TO CONTRACT WITH A PROFESSIONAL LAND SURVEYOR REGISTERED IN THE STATE OF WASHINGTON TO PROVIDE CONSTRUCTION STAKING SERVICES. IN ACCORDANCE WITH CITY REQUIREMENTS, CONTRACTED SURVEYOR SHALL PROVIDE SURVEYED ASBUILTS AS WELL AS LEGAL DESCRIPTIONS REQUIRED TO RECORD NEW EASEMENTS OR VACATED OLD EASEMENTS (WHERE APPLICABLE) UPON COMPLETION OF PROJECT, 4 WEEKS PRIOR TO GOAL FOR OBTAINING CERTIFICATE OF OCCUPANCY.
12. COSTS FOR GENERAL CONSTRUCTION ITEMS WHICH ARE NOT SHOWN ON THESE DRAWINGS, BUT ARE NECESSARY AND NORMAL FOR COMPLETION OF THIS PROJECT, SHALL BE CONSIDERED INCIDENTAL AND INCLUDED IN THE CONTRACTORS BID FOR THIS PROJECT.

EARTHWORK

1. ALL STRUCTURAL FILL OR BACKFILL SHALL BE COMPACTED TO 95% OF MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D1557. ALL STRUCTURAL FILL AND BACKFILL SHALL BE PLACED IN MAXIMUM 8" LIFTS. MOISTURE CONDITIONED TO WITHIN 2% OF OPTIMUM MOISTURE CONTENT.
2. REMOVE ALL DEBRIS FROM THE AREA TO BE BACKFILLED PRIOR TO BACKFILLING.
3. SATISFACTORY NATIVE SOILS SHALL BE FREE OF ROCK OR GRAVELS LARGER THAN 3" IN ANY DIMENSION, DEBRIS, WASTE OR FROZEN MATERIAL, NATIVE VEGETATION, OR OTHER DELETERIOUS MATTER.
4. PLACE LOAD BEARING BACKFILL IN LAYERS NOT MORE THAN 8" THICK, LOOSE MEASUREMENT. SPREAD AND COMPACT EACH LAYER UNIFORMLY TO THE REQUIRED DENSITY.
5. THE CONTRACTOR SHALL BE RESPONSIBLE TO REPLACE IN KIND ANY UTILITIES AND OR IRRIGATION PIPING DISTURBED AND OR DAMAGED DURING THE WORK.
6. ALL AREAS TO RECEIVE STRUCTURAL IMPROVEMENTS, PARKING IMPROVEMENTS, AND ROADWAY IMPROVEMENTS SHALL BE STRIPPED OF ALL VEGETATION, ORGANIC MATERIAL, DEMOLITION DEBRIS, THE SOIL SHALL BE SCARIFIED TO A DEPTH OF 12 INCHES AND COMPACTED TO 92% MDD IN ACCORDANCE WITH ASTM D1557.
7. ALL EXPOSED CUT SLOPES SHALL BE STABILIZED WITH HYDROMULCH TO PREVENT EROSION.
8. STORM PONDS/SWALES SIDEWALLS SHALL BE COMPACTED TO 85% MDD PER ASTM D1557. THE POND BOTTOM SHALL BE SCARIFIED TO A DEPTH OF 18 INCHES WITH A RIPPER UPON COMPLETION OF THE PONDS/SWALES PUSH OUT.

SITE UTILITIES

1. A PRE-CONSTRUCTION CONFERENCE SHALL BE SCHEDULED WITH THE CONTRACTOR, ENGINEER, ARCHITECT, CITY PERSONNEL, AND ANY AFFECTED UTILITIES PRIOR TO START OF UTILITY WORK.
2. MAINTAIN A MINIMUM OF 5' HORIZONTAL SEPARATION OF WATER LINE FROM BURIED POWER LINES. MAINTAIN 1' HORIZONTAL SEPARATION OF GAS LINES FROM BURIED POWER LINES.
3. POLYVINYL CHLORIDE (PVC) IRRIGATION AND WATER PIPE SHALL BE AWWA C900 CLASS 235.
4. PIPE FITTINGS FOR PVC AND DI PIPE SHALL BE MORTAR LINED CAST OR DUCTILE IRON AND SHALL BE MANUFACTURED IN ACCORDANCE WITH AWWA C110. FITTING CLASS AND JOINTS SHALL BE COMPATIBLE TO CONNECTING PIPE.
5. STORM DRAINAGE PIPE SHALL BE PVC OR CORRUGATED POLYETHYLENE (PE). PVC PIPE SHALL BE MANUFACTURED TO ASTM D3034-SDR 35 WITH RUBBER GASKETED JOINTS. PE PIPE SHALL BE MANUFACTURED TO AASHTO M252 OR M294 WITH SMOOTH INTERIOR.
6. INFILTRATION RATE OF 1.6 IN/HR USED IN DESIGN OF INFILTRATION SYSTEMS PER THE 25 YR/24 HR.
7. ALL BEDDING AND BACKFILL SHALL BE COMPACTED TO 95% OF MAXIMUM DENSITY IN ACCORDANCE WITH ASTM D1557. REMOVE ALL DEBRIS FROM THE AREA TO BE BACKFILLED PRIOR TO BACKFILLING. PLACE BACKFILL IN LAYERS NOT MORE THAN 12 INCHES THICK, LOOSE MEASUREMENT. SPREAD AND COMPACT EACH LAYER UNIFORMLY TO THE REQUIRED DENSITY.
8. PERFORATED STORM DRAINAGE PIPE SHALL BE CORRUGATED POLYETHYLENE (PE) TUBING AND FITTINGS WITH SMOOTH INTERIOR MANUFACTURED TO ASHTO M-252 AND M-294.

SPECIAL INSPECTION

1. PER IBC 1705.6, PRIOR TO PLACEMENT OF PREPARED FILL, THE SPECIAL INSPECTOR SHALL DETERMINE THAT THE SITE HAS BEEN PREPARED IN ACCORDANCE WITH THE APPROVED SOILS REPORT.
2. PER IBC 1705.6, WHERE FILL EXCEEDS 12" IN DEPTH, THE SPECIAL INSPECTOR SHALL HAVE CONTINUOUS INSPECTION OF FILL PLACEMENT AND COMPACTION.
3. TESTING AGENCY WILL TEST COMPACTION OF SOILS IN PLACE ACCORDING TO ASTM D 1557, ASTM D 2167, ASTM D 2937, ASTM D 6938, AS APPLICABLE. TESTS WILL BE PERFORMED AT THE FOLLOWING LOCATIONS AND FREQUENCIES:
   A. FOUNDATION, PAVING, AND ADJACENT: AT SUBGRADE AND AT EACH COMPACTED FILL AND BACKFILL LAYER, AT LEAST 1 TEST FOR EVERY 5,000 SQ. FT. OR LESS OF PAVED AREA OR BUILDING SLAB, BUT IN NO CASE FEWER THAN 1 TEST PER DAY.
   B. TRENCH BACKFILL: AT EACH COMPACTED INITIAL AND FINAL BACKFILL LAYER, AT LEAST 1 TEST FOR EACH 150 FEET OR LESS OF TRENCH LENGTH, BUT NO LESS THAN 1 TEST PER DAY.
4. COMPACTION TESTING IS REQUIRED AT THE ABOVE SCHEDULE UNLESS GREATER TESTING IS RECOMMENDED BY STRUCTURAL DRAWINGS. LESS TESTING WOULD BE ACCEPTABLE IF APPROVED IN WRITING BY GEOTECHNICAL ENGINEER, SPECIAL INSPECTOR, FOUNDATION ENGINEER, AND KNUTZEN ENGINEERING.

EROSION CONTROL

1. PROVIDE TEMPORARY EROSION AND SEDIMENTATION CONTROL MEASURES TO PREVENT SOIL EROSION AND DISCHARGE OF SOIL-BEARING WATER RUNOFF OR AIRBORNE DUST TO ADJACENT PROPERTIES, WALKWAYS, AND DESIGNATED STORMWATER SWALES ACCORDING TO REQUIREMENTS OF AUTHORITIES HAVING JURISDICTION.
2. ESTABLISH CONSTRUCTION ACCESS.
   A. CONSTRUCTION VEHICLE ACCESS AND EXIT SHALL BE LIMITED TO ONLY NECESSARY LOCATIONS. ACCESS POINTS SHALL BE STABILIZED WITH QUARRY SPALL OR CRUSHED ROCK TO MINIMIZE THE TRACKING OF SEDIMENT ONTO PUBLIC ROADS, MINIMUM 100 FEET LONG.
   B. WHEEL WASH OR TIRE BATHS SHOULD BE LOCATED ON-SITE, IF NEEDED TO PREVENT EXCESSIVE TRACKING OF SEDIMENT ON ROADS.
   C. PUBLIC ROADS SHALL BE CLEANED THOROUGHLY AT THE END OF EACH DAY. SEDIMENT SHALL BE REMOVED FROM ROADS BY SHOVELING OR PICKUP SWEEPING AND SHALL BE TRANSPORTED TO A CONTROLLED SEDIMENT DISPOSAL AREA. STREET WASHING WILL BE ALLOWED ONLY AFTER SEDIMENT IS REMOVED IN THIS MANNER.
   D. STREET WASH WASTEWATER SHALL BE CONTROLLED BY PUMPING BACK ON-SITE, OR OTHERWISE BE PREVENTED FROM DISCHARGING INTO SYSTEMS TRIBUTARY TO STATE SURFACE WATERS.
   E. A SEPARATION GEOTEXTILE SHALL BE PLACED UNDER THE SPALLS TO PREVENT FINE SEDIMENT FROM PUMPING UP INTO THE ROCK PAD. THE GEOTEXTILE SHALL MEET THE FOLLOWING STANDARDS:
      I. GRAB TENSILE STRENGTH (ASTM D4632) 200 PSI/MINUTE.
      II. GRAB TENSILE ELONGATION (ASTM D4632) 30% MAXIMUM.
      III. MULLEN BURST STRENGTH (ASTM D3786-80A) 400 PSI/MINUTE.
      IV. AOS (ASTM D4751) 20 TO 45 (US STANDARD SIEVE SIZE).
   F. CONSIDER EARLY INSTALLATION OF THE FIRST LIFT OF ASPHALT IN AREAS THAT WILL BE PAVED; THIS CAN BE USED AS A STABILIZED ENTRANCE. ALSO CONSIDER THE INSTALLATION OF EXCESS CONCRETE AS A STABILIZED ENTRANCE. DURING LARGE CONCRETE POURS, EXCESS CONCRETE IS OFTEN AVAILABLE FOR THIS PURPOSE.
   G. WHENEVER POSSIBLE, THE ENTRANCE SHALL BE CONSTRUCTED ON A FIRM, COMPACTED SUBGRADE. THIS CAN SUBSTANTIALLY INCREASE THE EFFECTIVENESS OF THE PAD AND REDUCE THE NEED FOR MAINTENANCE.
   H. QUARRY SPALLS SHALL BE ADDED IF THE PAD IS NO LONGER IN ACCORDANCE WITH THE SPECIFICATIONS.
   I. IF THE ENTRANCE IS NOT PREVENTING SEDIMENT FROM BEING TRACKED ONTO PAVEMENT, THEN ALTERNATIVE MEASURES TO KEEP THE STREETS FREE OF SEDIMENT SHALL BE USED. THIS MAY INCLUDE STREET SWEEPING, AN INCREASE IN THE DIMENSIONS OF THE ENTRANCE, OR THE INSTALLATION OF A WHEEL WASH.
   J. ANY QUARRY SPALLS THAT ARE LOOSENED FROM THE PAD, WHICH END UP ON THE ROADWAY, SHALL BE REMOVED IMMEDIATELY.
   K. UNTIL PROJECT COMPLETION AND SITE STABILIZATION, ALL CONSTRUCTION ACCESSES INTENDED AS PERMANENT ACCESS FOR MAINTENANCE SHALL BE PERMANENTLY STABILIZED.
3. CONTRACTOR SHALL INSTALL AND MAINTAIN TEMPORARY SILT FENCING TO PREVENT ANY WATER RUNOFF FROM ANY DISTURBED AREAS. AT A MINIMUM, SILT FENCE WILL BE ALONG THE DOWN SLOPE PROPERTY LINES. THE SILT FENCES SHALL BE CONSTRUCTED IN THE AREAS OF CLEARING, GRADING, OR DRAINAGE PRIOR TO STARTING THOSE ACTIVITIES. THE SILT FENCE SHALL PREVENT SOIL CARRIED BY RUNOFF WATER FROM GOING BENEATH, THROUGH, OR OVER THE TOP OF THE SILT FENCE, BUT SHALL ALLOW THE WATER TO PASS THROUGH THE FENCE.
4. CONTRACTOR SHALL BE RESPONSIBLE FOR DEVELOPING AND MAINTAINING A DUST CONTROL PLAN. DUST CONTROL SHALL BE IN ACCORDANCE WITH ALL LOCAL ORDINANCES. ALL DUST CONTROL MEASURES SHALL BE DONE WITH A PERSON OPERATED WATERING DEVICE (E.G. WATER TRUCK, WATER WAGON, ETC.) NO UNATTENDED WATERING ALLOWED. NO IRRIGATION LINES OR OTHER IRRIGATION/SPRINKLER TYPE WATERING DEVICES ALLOWED.
5. CONTRACTOR SHALL PROTECT EXISTING STORMWATER INLETS WITH INLET PROTECTION.
6. INSPECT, REPAIR, AND MAINTAIN EROSION AND SEDIMENTATION CONTROL MEASURES DURING CONSTRUCTION UNTIL PERMANENT VEGETATION HAS BEEN ESTABLISHED.
7. REMOVE EROSION AND SEDIMENTATION CONTROLS ONCE THEY ARE NO LONGER NEEDED AND RESTORE AND STABILIZE AREAS DISTURBED DURING REMOVAL.

STORMWATER SYSTEM OPERATION AND MAINTENANCE

1. CATCH BASINS
   A. REMOVE SEDIMENT, TRASH AND DEBRIS WHEN GRATE BECOMES CLOGGED MORE THAN 10%.
   B. REMOVE SEDIMENT, TRASH AND DEBRIS IN SUMP THAT EXCEEDS 60% OF SUMP DEPTH AS MEASURED FROM BOTTOM OF BASIN TO INVERT OF LOWEST PIPE, BUT IN NO CASE SHALL THE CLEARANCE FROM TOP OF DEBRIS TO INVERT OF LOWEST PIPE BE LESS THAN 6". NO VEGETATION SHALL BE ALLOWED TO GROW IN SUMP. AT A MINIMUM, REMOVE SEDIMENT, TRASH AND DEBRIS IN SUMP ANNUALLY.
   C. STRUCTURAL DAMAGE TO FRAME, GRATE, TOP SLAB, OR SUMP, SHALL BE REPAIRED OR REPLACED. STRUCTURAL DAMAGE INCLUDES CRACKS GREATER THAN 1/4" OR HOLES GREATER THAN 2" IN TOP SLAB, FRAME NOT SITTING FLUSH ON TOP SLAB (MORE THAN 3/4" SEPARATION) OR NOT SECURELY ATTACHED, CRACKS GREATER THAN 1/4" IN SUMP WALLS, SOIL ENTERING SUMP, CRACKS AT GROUT FILLET AROUND PIPES IN EXCESS OF 1/2", SETTLEMENT OF ENTIRE BASIN SUCH THAT IT CREATES A SAFETY, FUNCTION OR DESIGN PROBLEM.
   D. REPLACE ANY MISSING GRATE OR REPAIR IF GRATE IS DIFFICULT TO REMOVE. REPLACE GRATE IF OPENINGS GREATER THAN 7/8" OR GRATE HAS MISSING OR BROKEN BARS.

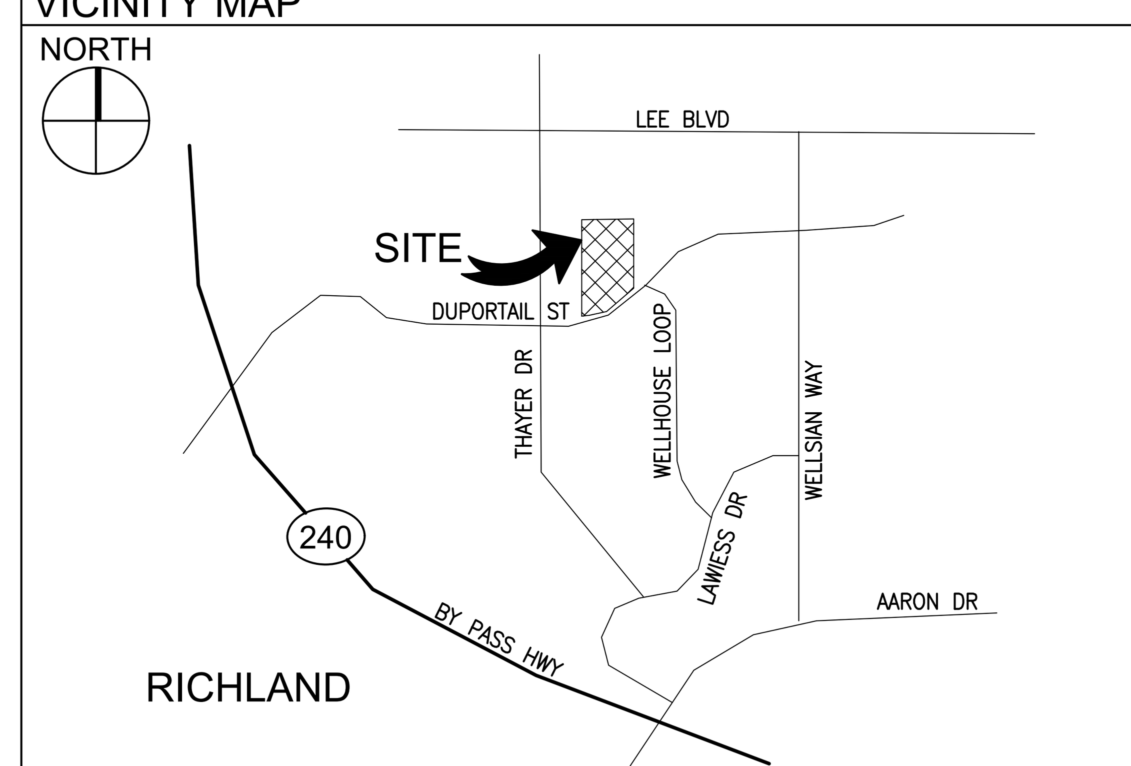
STORMWATER PREVENTION POLLUTION PLAN

1. CONTRACTOR SHALL BE RESPONSIBLE FOR PREPARING AND IMPLEMENTING A STORMWATER POLLUTION PREVENTION PLAN (SWPPP) IN ACCORDANCE WITH STORMWATER MANAGEMENT MANUAL FOR EASTERN WASHINGTON (SWMMEW).
2. WHENEVER INSPECTION AND OR MONITORING REVEALS THAT THE BMP'S IDENTIFIED IN THE CONSTRUCTION SWPPP ARE INADEQUATE, DUE TO THE ACTUAL DISCHARGE OF OUR POTENTIAL TO DISCHARGE A SIGNIFICANT AMOUNT OF ANY POLLUTANT, THE SWPPP SHALL BE MODIFIED, AS APPROPRIATE AND IN A TIMELY MANNER.
3. UPON PROJECTS COMPLETION THE CONTRACTOR SHALL FILE NOTICE OF TERMINATION FOR THE STORMWATER PERMIT WITH ECOLOGY.

REFERENCE SOURCES

1. EASTERN WASHINGTON STORMWATER MANUAL CAN BE FOUND AT: (https://fortress.wa.gov/ecy/publications/documents/1810044.pdf).
2. THE CITY OF RICHLAND STANDARD SPECIFICATIONS AND DRAWINGS CAN BE FOUND AT: (https://www.ci.richland.wa.us/departments/public-works/engineering-and-private-development/standard-details).
3. THE CITY OF RICHLAND MUNICIPAL CODE CAN BE FOUND AT: (https://www.codepublishing.com/WA/Richland/).

VICINITY MAP



LEGEND AND ABBREVIATIONS

NEW	EXISTING	
		ACCESSIBLE PARKING MARKER
AVR	(E)AVR	AIR VAC RELIEF
AD	(E)AD	AREA DRAIN
GUY	(E)GUY	GUY WIRE
BOA	(E)BOA	BLOW OFF ASSEMBLY
BO	(E)BO	BOLLARD
		CAP
CB	(E)CB	CATCH BASIN ROUND/SQUARE
CB		CATCH BASIN SOLID
CO	(E)CO	CLEAN OUT
CDS	CDS	CONTINUOUS DEFLECTIVE SEPARATION UNIT
DS	(E)DS	DOWN SPOUT
DW	(E)DW	DRY WELL
EM	(E)EM	ELECTRICAL METER
EV	EV	ELECTRICAL VAULT
GM	(E)GM	GAS METER
FDC	(E)FDC	FIRE DEPARTMENT CONNECTION
FH	(E)FH	FIRE HYDRANT
FP	(E)FP	FLAG POLE
IV	(E)IV	IRRIGATION VALVE
LP	(E)LP	LIGHT POLE
SD SS MH	SD SS (E)MH	MANHOLE
		PAVEMENT ARROWS
PIV	(E)PIV	POST INDICATOR VALVE
PP	(E)PP	POWER POLE
		REDUCER
		SHRUB
		SLOPE DIRECTION/PIPE SLOPE
SB	(E)SB	STORM BUBBLER
SIGN	(E)SIGN	STREET SIGN
SL	(E)SL	STREET LIGHT
TP	(E)TP	TELEPHONE PEDESTAL
		THRUST BLOCK
XFMR	(E)XFMR	TRANSFORMER
		TREE
T C P J	T C P J	UTILITY BOX
VAN		VAN PAVEMENT MARKING
WV	(E)WV	WATER VALVE
WM/IM	(E)WM/IM	WATER/IRRIGATION METER
WP	MON	WORK/MONUMENT POINT
YH	YH	YARD HYDRANT

NEW	EXISTING / REMOVE
NEW ASPHALT	EXISTING ASPHALT
NEW HEAVY ASPHALT	EXISTING CONCRETE
NEW HEAVY CONCRETE	EXISTING GRAVEL
NEW CONCRETE	EXISTING LAWN
NEW GRAVEL	EXISTING LANDSCAPE
NEW LAWN	EXISTING UNDEVELOPED
NEW LANDSCAPE	REMOVE LANDSCAPE
NEW PLAY ASPHALT	REMOVE ASPHALT
NEW NATIVE	REMOVE CONCRETE
NEW TRUNCATED DOMES	REMOVE GRAVEL
NEW RIP RAP	REMOVE LAWN
	REMOVE UNDEVELOPED

ABAND	ABANDONED
BOT	BOTTOM
BW	BOTTOM OF WALL ELEVATION
COM	COMMUNICATIONS
(E)	EXISTING
FO	FIBER OPTICS LINE
FF	FINISH FLOOR
FG	FINISH GRADE
FR	FIRE RISER
FW	FIRE WATER
GL	GUTTER LINE
IE	INVERT ELEVATION
IR	IRRIGATION
LS	LANDSCAPE
MON	MONUMENT
NG	NATURAL GAS
NIC	NOT IN CONTRACT
NTS	NOT TO SCALE
OHP	OVERHEAD POWER
P	POWER
PDP	PERFORATED DRAIN PIPE
PE	POLYETHYLENE
PS	PRESSURE SEWER
ROW	RIGHT-OF-WAY
R	RADIUS
RWL	RAIN WATER LEADER
SS	SANITARY SEWER
SLV	PIPE SLEEVE
XXX.XX	SPOT ELEVATION
SD	STORM DRAIN
T	TELEPHONE
TV	TELEVISION
TA	TOP OF ASPHALT ELEVATION
TC	TOP OF CONCRETE ELEVATION
TG	TOP OF GRAVEL ELEVATION
TW	TOP OF WALL ELEVATION
TYP	TYPICAL
W	WATER

SAWCUT LINE
NEW EASEMENT LINE
PROPERTY LINE
100 EXISTING CONTOUR
100 NEW CONTOUR
EXISTING FENCE
NEW FENCE
REMOVE FENCE
REMOVE SURFACE FEATURE
REMOVE UNDERGROUND UTILITY
ABANDONED UNDERGROUND UTILITY
EXISTING UNDERGROUND UTILITY
NEW UNDERGROUND UTILITY
RAIL ROAD TRACKS

DRAWING INDEX

UNDERGROUND INJECTION CONTROL

SITE NUMBER: -

KNUTZEN ENGINEERING
5401 RIDGELINE DR.
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KENNEWICK, WA 99338
1-509-222-0959
www.knutzenengineering.com

No.	REVISIONS	DATE	DESIGN	CHKD	APPD

PAUL T. KNUTZEN
STATE OF WASHINGTON
44313
REGISTERED PROFESSIONAL ENGINEER
9/29/20

GENERAL NOTES AND LEGEND

BUSH PROPERTIES
WELLHOUSE HEIGHTS
1380 DUPORTAIL ST. RICHLAND WA 99354

APPROVAL		
DESIGN	DWW/SJT	9/22/20
CHECKED	PTK	9/22/20
APPROVED	PTK	9/22/20

SCALE: AS NOTED
CADFILE: 19023C000-MG
JOB No. 19023
REV.
DWG. No. C001

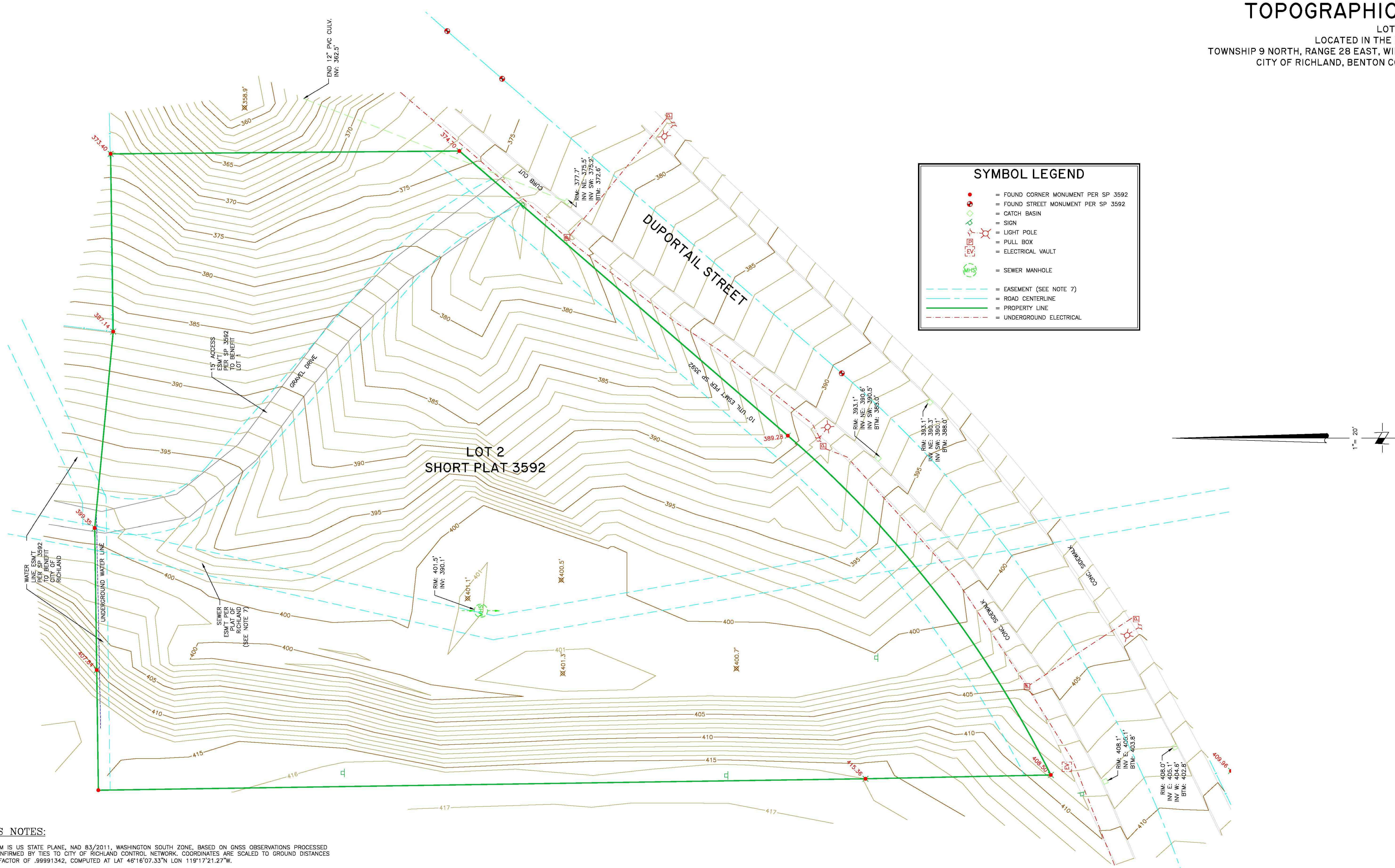
1380 Duportail St

20-02419

\2019\19023-Bush Duportail Residential\DWG\19023C000-MG.dwg - Sep 29,2020 - 09:30am - gge

TOPOGRAPHIC SURVEY

LOT 2 SHORT PLAT 3592
LOCATED IN THE NE1/4 OF SECTION 15
TOWNSHIP 9 NORTH, RANGE 28 EAST, WILLAMETTE MERIDIAN
CITY OF RICHLAND, BENTON COUNTY, WASHINGTON



SURVEYOR'S NOTES:

1. HORIZONTAL DATUM IS US STATE PLANE, NAD 83/2011, WASHINGTON SOUTH ZONE, BASED ON GNSS OBSERVATIONS PROCESSED BY NGS OPUS & CONFIRMED BY TIES TO CITY OF RICHLAND CONTROL NETWORK. COORDINATES ARE SCALED TO GROUND DISTANCES USING A COMBINED FACTOR OF .99991342, COMPUTED AT LAT 46°16'07.33"N LON 119°17'21.27"W.

2. VERTICAL DATUM IS NAVD 88, BASED ON GNSS OBSERVATIONS PROCESSED BY NGS OPUS & CONFIRMED BY TIES TO CITY OF RICHLAND CONTROL NETWORK.

3. TOPOGRAPHIC SURVEY PERFORMED MARCH–APRIL, 2019 USING A PAIR OF TRIMBLE R8 GNSS RECEIVERS CONFIGURED FOR REAL TIME KINEMATIC SURVEYING.

4. CONTOUR INTERVAL IS 1'.

5. UTILITIES SHOWN HEREON ARE PER OBSERVED FIELD EVIDENCE & UNDERGROUND LOCATES REQUESTED FOR THIS SURVEY (TICKET NUMBER 19097235)

6. BOUNDARY INFORMATION SHOWN HEREON IS BASED ON FOUND EVIDENCE & RECORD DATA FROM SHORT PLAT 3592.

7. EASEMENTS SHOWN HEREON ARE PER SHORT PLAT 3592 AND TITLE REPORT REQUESTED AS A PART OF THE SHORT PLAT SURVEY. EASEMENTS ORIGINATING FROM THE PLAT OF RICHLAND ARE INDEFINITE IN LOCATION IN SOME AREAS DUE TO LACK OF DIMENSIONS SHOWN ON SAID PLAT.

DAVID P. BAALMAN — STATE OF WASHINGTON — 41028 REGISTERED PROFESSIONAL LAND SURVEYOR

SURVEYOR'S CERTIFICATION

I, DAVID P. BAALMAN, A PROFESSIONAL LAND SURVEYOR IN THE STATE OF WASHINGTON, (REG# 41028) HEREBY CERTIFY THAT THIS TOPOGRAPHIC SURVEY WAS CONDUCTED UNDER MY DIRECT SUPERVISION, AND THE CONTOURS AND PLANIMETRIC FEATURES SHOWN HEREON ARE ACCURATELY DEPICTED.

4-24-19

NOT TO SCALE

20 10 0 20 40 60
SCALE IN FEET

SITE SURVEY PROVIDED FOR INFORMATION ONLY

RSI ROGERS SURVEYING INC., P.S.
1455 COLUMBIA PARK TRAIL
RICHLAND, WA. 99352
PHONE (509) 783-4141
FAX: (509) 783-8994
www.rogerssurveying.com

REV: NONE

CLIENT	KNUTZEN ENGINEERING			JOB 04019
PROJECT	TOPOGRAPHIC SURVEY LOT 2 SHORT PLAT 3592			
DRN. BY DPB	SCALE 1"= 20'	F. B. NO. 852 ACAD VER -2019 FILE: 04019.DWG		SHEET 1 OF 1
APPROVED DPB	DATE 4-24-19			

A1 SURVEY
SCALE: NOT TO SCALE

KNUTZEN ENGINEERING
5401 RIDGELINE DR.
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KENNEWICK, WA 99338
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www.knutzenengineering.com

No.	REVISIONS	DATE	DESIGN	CHKD	APPD

9/29/20

SURVEY
BUSH PROPERTIES
WELLHOUSE HEIGHTS
1380 DUPORTAIL ST. RICHLAND WA 99354

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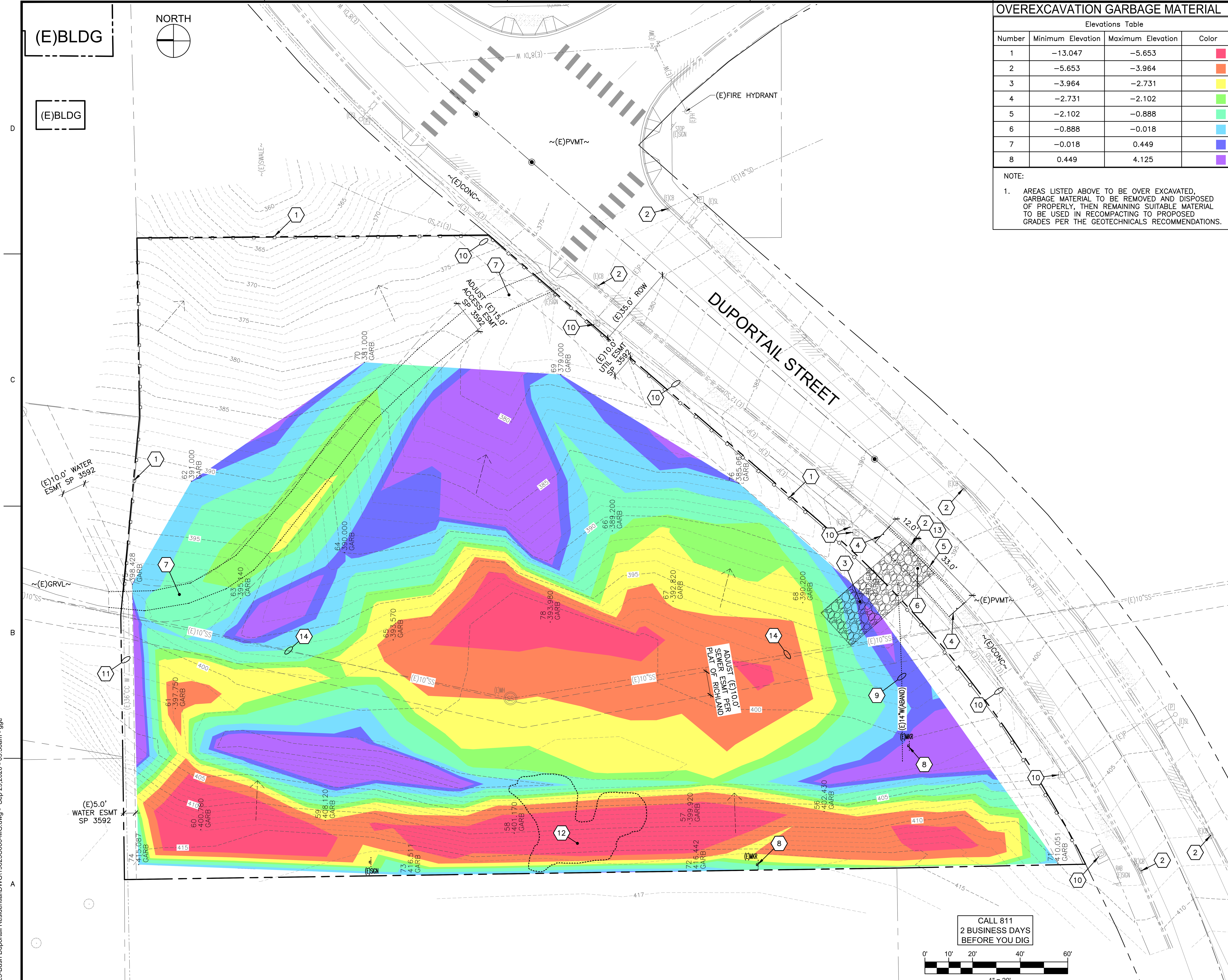

A1 EROSION CONTROL AND DEMOLITION PLAN
SCALE: 1" = 20'–0"

OVEREXCAVATION GARBAGE MATERIAL

Elevations Table			
Number	Minimum Elevation	Maximum Elevation	Color
1	−13.047	−5.653	
2	−5.653	−3.964	
3	−3.964	−2.731	
4	−2.731	−2.102	
5	−2.102	−0.888	
6	−0.888	−0.018	
7	−0.018	0.449	
8	0.449	4.125	

NOTE:

1. AREAS LISTED ABOVE TO BE OVER EXCAVATED, GARBAGE MATERIAL TO BE REMOVED AND DISPOSED OF PROPERLY, THEN REMAINING SUITABLE MATERIAL TO BE USED IN RECOMPACTING TO PROPOSED GRADES PER THE GEOTECHNICALS RECOMMENDATIONS.

KEY NOTES

1. SILT FENCING SHALL BE INSTALLED AT LOCATIONS SHOWN AND AS NEEDED AT ANY LOCATIONS OF SITE WHERE SURFACE RUNOFF MAY ERODE SOILS AWAY FROM SITE, CONTRACTOR SHALL INSTALL ADDITIONAL SILT FENCING AS NECESSARY, REFER TO DETAIL A2/C500
2. EXISTING AND PROPOSED DRAINAGE STRUCTURE TO BE PROTECTED WITH FILTER FABRIC, SEE DETAIL A1/C500
3. CONSTRUCTION ACCESS, SEE GENERAL NOTES ON SHEET C000
4. SAWCUT CONCRETE SIDEWALK AS NECESSARY FOR NEW CONSTRUCTION AT NEAREST EXPANSION/CONTROL JOINT AS INDICATED, PROVIDE NEAT CUT EDGE
5. SAWCUT DOWN CONCRETE CURBING FOR NEW DRIVE ENTRANCE AND DISPOSE OF PROPERLY
6. REMOVE CONCRETE AND DISPOSE OF PROPERLY, REMOVE GRAVEL BASE AND SALVAGE FOR REUSE
7. REMOVE GRAVEL PATH
8. REMOVE SIGN, POLE AND BASE THEN BACKFILL
9. REMOVE PORTION OF ABANDONED WATER LINE WITH IN PROPERTY LINE, CAP AT PIPE TO REMAIN
10. PROTECT UTILITY IN PLACE
11. PROTECT WATER MAIN IN PLACE, NO GRADING WITH IN EASEMENT
12. REMOVE VEGETATION AND DISPOSE OF PROPERLY
13. REMOVE AND REPLACE CATCH BASIN LID AND RIM TO WORK WITH DRIVE DROP CURB
14. FIELD LOCATE SEWER MAIN PRIOR TO MASS GRADING, WALLS AND FOUNDATION PREPARATION

LEGEND

- EXISTING STORMWATER FLOW PATH
- NEW STORMWATER FLOW PATH
- LIMITS OF CONSTRUCTION LINE
- SILT FENCE
- CONSTRUCTION VEHICLE ACCESS POINTS TO PUBLIC ROADS
- CONSTRUCTION ACCESS EROSION CONTROL

NOTES

1. SEE SHEET C000 FOR GENERAL NOTES AND LEGEND, SEE SHEET C110 FOR EXISTING AND PROPOSED CONTOURS.
2. MOST SUITABLE LOCATION FOR CONSTRUCTION ENTRANCE TO BE DETERMINED BY GENERAL CONTRACTOR. CONSTRUCTION ENTRANCE SHOWN ON DRAWING IS A SUGGESTED LOCATION ONLY.
3. FINAL CONSTRUCTION LAY–DOWN AREA AND STOCKPILE AREA LOCATION AND SIZE TO BE DETERMINED BY THE GENERAL CONTRACTOR WITH APPROVAL OF OWNER.
4. CUT & FILL SLOPES SHOULD BE CONSTRUCTED WITH INCLINATION NO STEEPER THEN 2H:1V AND MUST BE PROTECTED FROM WIND AND EROSION.
5. PLACE TOPSOIL, COMPACT, AND PROVIDE TEMPORARY SOIL STABILIZATION. PERMANENT LANDSCAPING CAN BE INSTALLED ONCE LIKELIHOOD OF SEDIMENTATION DURING CONSTRUCTION IS REDUCED, UPSTREAM AREAS ARE FULLY STABILIZED, AND IRRIGATION SYSTEM IS OPERATIONAL.
6. EROSION, SEDIMENT, AND AIR QUALITY CONTROL SHALL COMPLY WITH THE COUNTY AND CITY AIR QUALITY CONTROL ORDINANCES, AND THE NOTES AND DETAILS ON THESE PLANS.
7. PROVIDE INLET PROTECTION ON ALL STORM DRAIN INLETS SURROUNDING SITE, INSPECT FABRIC REGULARLY AND REPLACE AS NECESSARY IF FOUND TO BE RIPPED OR TORN.
8. ANYTIME AN OPEN TRENCH AND DEMOLITION AREAS ARE PRESENT DURING NON WORK HOURS THE CONTRACTOR SHALL HAVE PORTABLE 6.0' CHAIN LINK CONSTRUCTION FENCE IN PLACE AROUND THE WORK AREA.
9. NOT ALL UNDERGROUND UTILITIES ON THESE DRAWINGS MAY BE SHOWN. FIELD LOCATE AND VERIFY ALL UNDERGROUND UTILITIES. COORDINATE ALL RELOCATION WORK WITH THE APPROPRIATE UTILITY COMPANY AND/OR OWNER PRIOR TO ANY EXCAVATION WORK.
10. FIELD VERIFY ALL MEASUREMENTS AND INVERTS PRIOR TO START OF WORK.
11. ACP AND CONCRETE CUT LINES ARE BASED ON NEW SURFACE FEATURES TO BE INSTALLED. CUT LINES DO NOT ACCOUNT FOR GRADING, TRENCHING, GRADE TRANSITIONS, OR OVERLAY WORK. ADJUST ACTUAL CUT AS NECESSARY FOR RELATED NEW WORK.
12. REMOVE ALL EXISTING IRRIGATION SYSTEM COMPONENTS WITHIN NEW CONSTRUCTION AREAS THAT WILL INTERFERE WITH NEW WORK. CUT, CAP, AND SEAL WATERTIGHT EXISTING PIPING TO REMAIN.
13. ALL UTILITY MAINS MUST REMAIN OPERATIONAL DURING CONSTRUCTION. COORDINATE WITH THE CITY TO SCHEDULE SERVICE OUTAGES AS NEEDED.
14. CONTRACTOR TO REMOVE ANY ABANDONED UTILITY LINES AS NEEDED FOR NEW CONSTRUCTION AND PROPOSED GRADES.

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No.	REVISIONS	DATE	DESIGN	CHKD	APPD

PAUL T. KNUTZEN, STATE OF WASHINGTON, 44313, REGISTERED PROFESSIONAL ENGINEER 9/29/20

EROSION CONTROL AND DEMOLITION PLAN
BUSH PROPERTIES
WELLHOUSE HEIGHTS
1380 DUPORTAIL ST. RICHLAND WA 99354

APPROVAL		
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DWG. No. C004

\2019\19023-Bush Duportail Residential\DWG\19023C000-MG.dwg - Sep 29,2020 - 09:30am - gge

A1 GRADING PLAN

SCALE: 1" = 20'-0"

KEY NOTES

1. MEET AND MATCH EXISTING ELEVATION
2. RAISE EXISTING LID TO NEW GRADE ELEVATIONS
3. MAXIMUM 2:1 SLOPE IN LAWN AREAS
4. PREPARE PADS AT PROPOSED BUILDINGS PER GEOTECHNICAL REPORTS RECOMMENDATIONS
5. PILE WALL AT WATER ESMT, CONTRACTOR NOT TO DISTURB EXISTING WATER MAIN, WALL TO BE DESIGN BUILD BY OTHERS, GRADING SHOWN FOR DESIGN PARAMETERS HEIGHTS VARIES AND WIDTH VARY DEPENDING ON REQUIRED HEIGHTS
6. ROCKERY WALL TO BE DESIGN BUILD BY OTHERS, GRADING SHOWN FOR DESIGN PARAMETERS HEIGHTS VARIES AND WIDTH VARY DEPENDING ON REQUIRED HEIGHTS, WALL NOT TO GO BEYOND PROPERTY OR INTO EASEMENTS
7. 4"ø FOUNDATION DRAIN WITH IN 24"Wx36"DEEP FRENCH DRAIN, PLACED AT BOTTOM OF WALL AND PIPED TO UNDERGROUND DRAIN SYSTEM, SEE DETAIL A4/C500
8. LOWER SEWER MANHOLE TO MASS GRADING ELEVATION, INSTALL A MIN 6" OF ADJUSTMENT RINGS FOR FUTURE ADJUSTMENTS
9. INSTALL CATCH BASIN AND INSTALL INLET PROTECTION AND INSTALL TEMPORARY CAP ON OUTLET PIPE TILL FUTURE CONCRETE VALLEY GUTTER IS INSTALLED SEE DETAIL A1/C500 AND A3/C500
10. INSTALL 10.0'Wx35.0'Lx4.0'DEEP ROCK POCKET, WITH 25 LF OF (2)8"PDP CONNECTED TO 12 LF OF 8"SD HEADER AND 8"SD INLET WITH TEES AND ELBOWS, SEE DETAIL A5/C500
11. MAXIMUM 18% SLOPE IN DIRECTION OF TRAVEL WITH 2% CROSS SLOPE IN GRAVEL PATH AREA
12. 8"x4" ECCENTRIC REDUCER

MATERIAL LEGEND

- 4" CONCRETE OVER 4" BASE
- 6" CONCRETE OVER 6" BASE
- VALLEY GUTTER
- 2.5" ASPHALT OVER 6" BASE
- 6" GRAVEL PATH
- 18" BELOW FINISH FLOOR
- 8" BELOW FINISH FLOOR
- ROCKERY WALL
- PILE WALL

NOTES:

1. GRADES SHOWN AT CONCRETE, HEAVY CONCRETE, VALLEY GUTTER, ASPHALT AND GRAVEL ARE TO TOP OF MATERIAL, FOR MASS GRADING PORPOISES SUBTRACT MATERIALS.
2. GRADES SHOWN FOR FINISH FLOOR ARE TO UNDER SLAB.

NOTES

1. SEE DRAWING C000 FOR GENERAL NOTES AND LEGEND.
2. CONTOURS ARE TO THE TOP OF SIDEWALK, CURB, OR PAVEMENT FINISHED SURFACE UNLESS NOTED OTHERWISE.
3. FIELD VERIFY ALL MEASUREMENTS AND INVERTS PRIOR TO START OF WORK. IMMEDIATELY NOTIFY ARCHITECT OF DISCREPANCIES BEFORE WORK COMMENCES.
4. DO NOT EXCEED MAXIMUM SLOPE OF 2:1 IN ALL AREAS OF SITE.
5. FIELD VERIFY ALL MEASUREMENTS AND INVERTS PRIOR TO START OF WORK. IMMEDIATELY NOTIFY ARCHITECT OF DISCREPANCIES BEFORE WORK COMMENCES.
6. ALL SITE ELECTRICAL WORK MAY NOT BE SHOWN ON THE CIVIL SITE DRAWINGS, SITE ELECTRICAL IS SHOWN FOR REFERENCE PURPOSES ONLY. REFER TO ELECTRICAL PLANS IN THIS CONSTRUCTION PACKAGE FOR ELECTRICAL DEMOLITION, RELOCATION, AND NEW INSTALLATION.

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No.	REVISIONS	DATE	DESIGN	CHKD	APPD

PAUL T. KNUTZEN, STATE OF WASHINGTON, 44313, REGISTERED PROFESSIONAL ENGINEER

9/29/20

GRADING PLAN

BUSH PROPERTIES

WELLHOUSE HEIGHTS

1380 DUPORTAIL ST. RICHLAND WA 99354

APPROVAL		
DESIGN	DWW/SJT	9/22/20
CHECKED	PTK	9/22/20
APPROVED	PTK	9/22/20

SCALE: AS NOTED

CADFILE: 19023C000-MG

JOB No. 19023

REV.

DWG. No. C110

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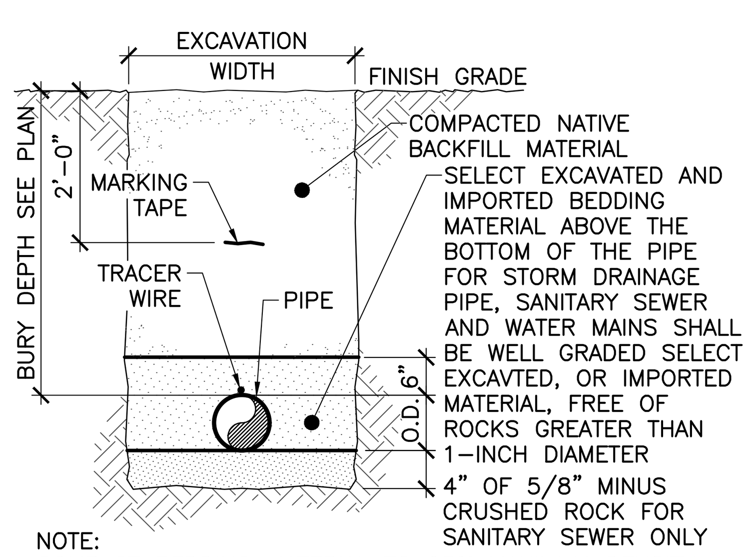
No.	REVISIONS	DATE	DESIGN	CHKD	APPD

PAUL T. KNUTZEN, STATE OF WASHINGTON, 44313, REGISTERED PROFESSIONAL ENGINEER — 9/29/20

SECTIONS AND DETAILS
BUSH PROPERTIES
WELLHOUSE HEIGHTS
1380 DUPORTAIL ST. RICHLAND WA 99354

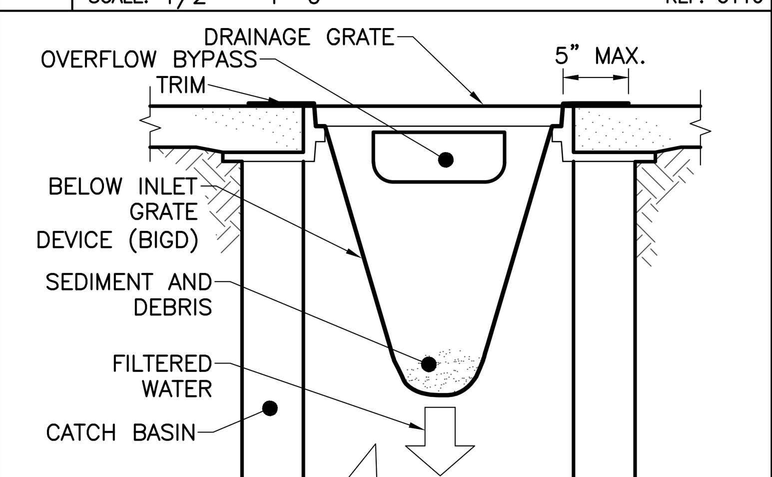
APPROVAL		
DESIGN	DWW/SJT	9/22/20
CHECKED	PTK	9/22/20
APPROVED	PTK	9/22/20

SCALE: AS NOTED
CADFILE: 19023C000-MG
JOB No. 19023
REV.
DWG. No. C500



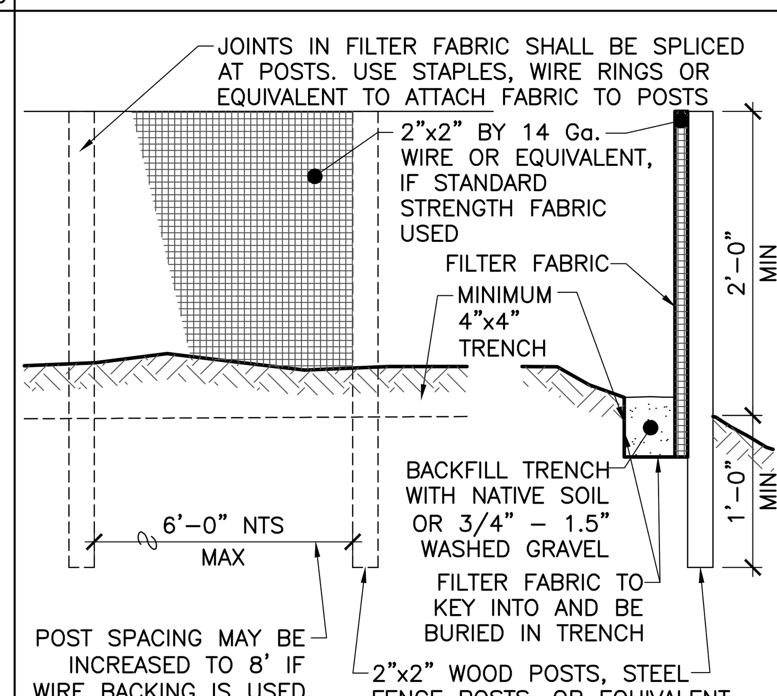
NOTE:
COMPACT BEDDING MATERIAL TO 95% MAXIMUM DENSITY PER ASTM D1557 EXCEPT DIRECTLY OVER THE PIPE, WHERE BEDDING MATERIAL SHALL BE HAND TAMPED ONLY.

B1 PIPE TRENCH
SCALE: 1/2" = 1'-0" REF: C110

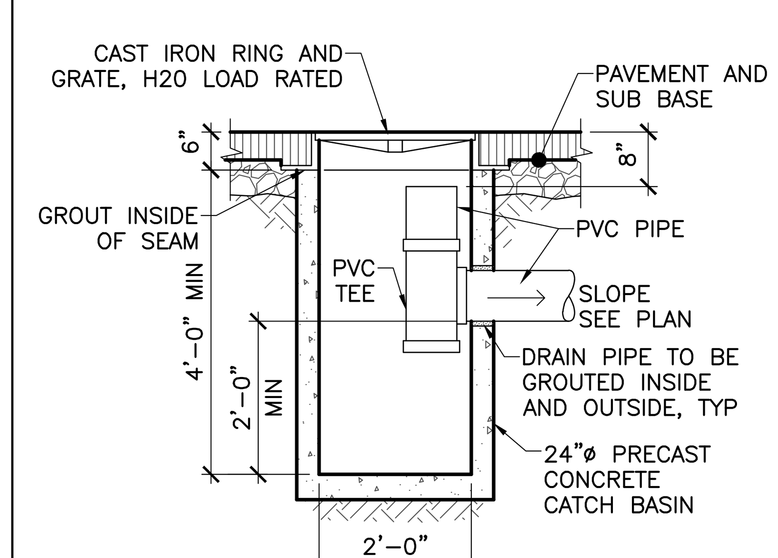


NOTES:
1. SIZE THE BELOW INLET GRATE DEVICE (BIGD) FOR THE STORMWATER STRUCTURE IT WILL SERVE.
2. THE BIGD SHALL HAVE A BUILT-IN HIGH-FLOW RELIEF SYSTEM (OVERFLOW BYPASS).
3. THE RETRIEVAL SYSTEM MUST ALLOW REMOVAL OF BIGD WITHOUT SPILLING THE COLLECTED MATERIAL.
4. PERFORM MAINTENANCE IN ACCORDANCE WITH WSDOT STANDARD SPECIFICATION 8.01.3.

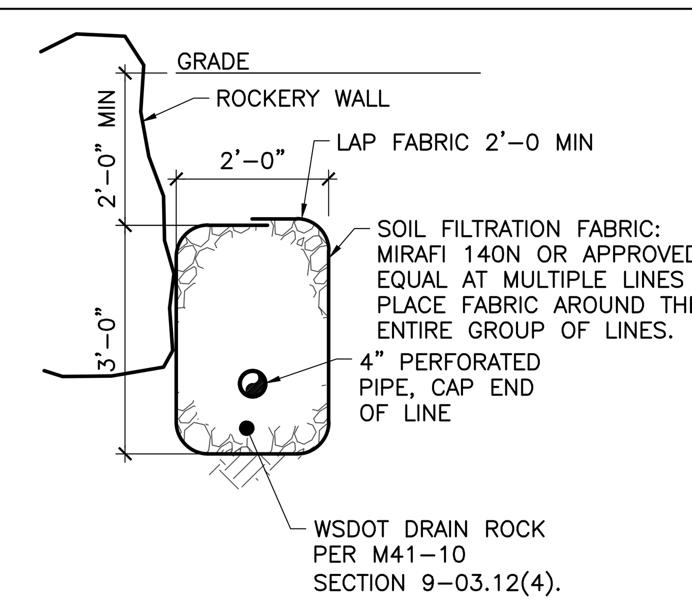
A1 INLET PROTECTION
SCALE: 1" = 1'-0" REF: C004



A2 SILT FENCE
SCALE: 1" = 1'-0" REF: C004

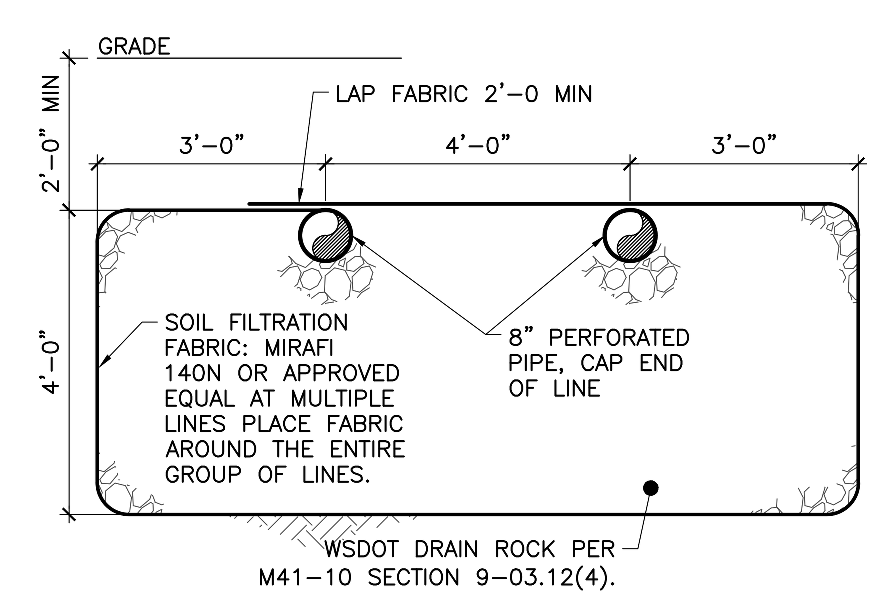


A3 CATCH BASIN
SCALE: 1/2" = 1'-0" REF: C110



NOTE: INCREASE STORM DRAIN INLET PIPE WITH ECCENTRIC REDUCERS AS REQUIRED.

A4 FOUNDATION DRAIN
SCALE: 1/2" = 1'-0" REF: C110



NOTE: INCREASE STORM DRAIN INLET PIPE WITH ECCENTRIC REDUCERS AS REQUIRED.

A5 PERFORATED DRAIN SYSTEM
SCALE: 1/2" = 1'-0" REF: C110

\2019\19023-Bush Duportail Residential\DWG\19023C000-MG.dwg - Sep 29,2020 - 09:30am - gge

Geotechnical Investigation Report
Bush Townhome Development
1380 Duportail Street
Richland, WA

September 25, 2020

Submitted To:

Tim Bush
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Prepared By:

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White Shield, Inc. Project No. 119-054-01

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APPENDIX A

APPENDIX B

CERTIFICATE OF ENGINEER

Geotechnical Investigation Report

Bush Townhomes

Richland, Washington

The technical information and data contained in this report were prepared by, or under the direction and supervision of the undersigned, whose seal, as a professional engineer licensed to practice as such, is affixed below.

Prepared by:

Benjamin P. Staehr, PE
Senior Geotechnical Engineer

1.0 INTRODUCTION

1.1 Project Description and Background Information

White Shield, Inc. (WSI) is pleased to present this Geotechnical Investigation Report for the construction of proposed townhomes at 1380 Duportail Street in Richland, WA. The location of the site is shown in Figure 1, Vicinity Map and preliminary site plan is provided on Figure 2, Exploration Site Plan. This area will include 8 townhome buildings consisting of 19 units with associated parking, utilities, and stormwater infiltration.

The site slopes moderately to the east and is bordered to the west by the Masonic Lodge, the southeast by Duportail Street, the north by undeveloped land and soccer fields, and to the east by a City of Richland storm pond.

This report presents the results of our geotechnical investigation of this site. It includes a review of the site geology, a description of site soils and subsurface profile, and geotechnical recommendations and specifications for site grading and construction of home foundations consistent with International Residential Code requirements.

1.2 Scope of Services

Our scope of services for this project included the following:

- **Geologic Literature Review:** Relevant, readily-available geologic information on the site and surrounding area was reviewed for information regarding geologic conditions at or near the site.
- **Site Exploration:** Sixteen exploration test pits were excavated at the site to assess the soil conditions and to obtain representative soil samples for laboratory testing.
- **Laboratory Testing:** Soil testing included index properties testing, and sieve analyses, as required.
- **Geotechnical Engineering Analysis:** Data collected during the site exploration, literature research, and laboratory testing were analyzed to develop project-specific geotechnical design and construction recommendations for the project.
- **Report Preparation:** This geotechnical report contains the results of our work including information as it relates to the following:
    - Site exploration and laboratory test results
    - Soil/rock conditions and subsurface profile
    - Earthwork and site preparation recommendations
    - Site grading and soil placement recommendations
    - Slope design and construction recommendations
    - Foundation subgrade soil preparation recommendations
    - Allowable soil bearing capacities and maximum foundation bearing pressures
    - Foundation wall design parameters and design earth pressures
    - Pavement and slab-on-grade recommendations
    - International Residential Code (IRC) 2015 seismic design parameters
    - General site grading and drainage control requirements

- **Geotechnical Construction Observation:** This report includes the outline of basic geotechnical requirements for construction observation and documentation to be performed during the construction process.

2.0 SITE INVESTIGATION

2.1 Literature Review

Information about the basic geology of the Pasco Basin was obtained from Lindsey (1996) and a discussion of the underlying Miocene-age basalt bedrock structure was provided from Reidel (et al., 1994). Information about the geologic setting of the site comes from many years of exploration work throughout Richland, West Richland, and Kennewick and from correlating the site data with regional geologic conditions.

2.2 Field Investigation

The subsurface investigation of this site included excavation of fifteen exploration test pits and two infiltration test pits at locations shown on Figure 2.

The test pits were excavated with a tracked excavator. In general, test pits 1-9 encountered varying amounts of concrete and asphalt debris up to 13 feet in depth. Test pit 11 encountered 4 feet of loose gravelly fill soils. Beneath any fill encountered, the site soils are predominantly fine to medium sands with occasional thin layers of gravel, generally at the top of the native soil deposits

INF TP-1 encountered 3.2 feet of fill soils, with fine to medium sands to a depth of 10 feet. INF TP-2 encountered 1 foot of fill soils with fine to medium sands to a depth of 11 feet. Hydrogeologic testing was performed and can be seen in section 6.0 Site Drainage and Infiltration Analysis.

The test pit logs, provided in Appendix A (TP-1 through TP-15 and INF TP-1 through INF TP-2), include detailed descriptions of the subsurface soil types and condition.

2.3 Laboratory Testing and Analysis

All soil samples were classified under the Unified Soil Classification System (USCS). The soil descriptions were prepared according to the Burmister Classification System. All soils were easily classified using visual manual procedures. Laboratory gradation analysis of soils from the infiltration test pits were conducted to aid in the hydrogeologic analysis and are attached to the associated memorandum in Appendix B. Further lab testing will likely be required for soil classification and proctor analysis for use during construction observations.

3.0 SITE CONDITIONS

3.1 Surface Conditions and Lot Slopes

The property is moderately sloping down to the east. The bulk of the site is ungraded native soil deposits. There are some amount of dumped fill soils located along the upper western portion of the site, and just below in the central portion of the site. We discussed these garbage fill areas with Knutzen Engineering and they have incorporated them into their grading plan for removal. Surface or subsurface water was not encountered during our explorations.

3.2 Site Soils

The local soils exposed during our explorations are generally upper outburst flood gravel deposits of the Missoula floods.

3.3 Regional and Local Geology

We reviewed the WADNR Geologic map of the Richland 1:100,000 Quadrangle (Riedel, et al.), 1994. The site is classified as outburst flood deposits of Glacial Lake Missoula, gravels (Qfg_4).

The Qfg deposits are generally described as gravels, grain size ranges from sand to boulders, size generally decreases away from major Pleistocene outburst flood channels. The Qfg_4 are the youngest of such flood deposits.

Based on our explorations we believe that the majority of the site consists of sand size particles that are consistent with the upper portion of the outburst flood gravel deposits.

4.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

4.1 Foundation Configuration

Building foundations should be extended through any fill soils on site and founded on native site soils below or be placed on properly prepared structural fill.

4.2 Site Preparation

Clear and grub all cut and fill areas of all surface vegetation and either use as landscape fill or haul offsite. All dumped garbage fill containing concrete and asphalt debris should be hauled off site. Remove all roots and organic material, loose or soft soil, and old topsoil from all areas to receive fill soil, retaining walls, pavement, foundations, driveways, etc. Positive drainage away from structures and pavement subgrade areas should be constructed and maintained throughout the project.

4.3 Earthwork

4.3.1 Excavations

Excavation of the surface fine sand and silt soil can be accomplished with a backhoe with a smooth bucket to prevent disturbance of subgrades or through mass grading equipment such as scrapers or dozers.

A maximum slope of 1V:1.5H (vertical to horizontal) is recommended for all unsupported excavation sidewalls in the silty sand soils at the site. Any trenching or excavation over 4.0 feet bgs requires either the previously-mentioned side slopes or shoring and bracing of the excavation.

This information on slope protection is based on Occupational Safety and Health Administration (OSHA) regulations and is provided entirely as a service to our Client. Under no circumstances should the Client or their contractors or subcontractors interpret this information to mean, or otherwise imply, that White Shield, Inc. (WSI) assumes responsibility for construction site safety and/or temporary slope stability, or the contractor activities. Such responsibility is not implied and should not be inferred.

4.3.2 Site Grading

All excavated materials will be kept on site and used as backfill around foundation walls and structures and for grading around the homes. All soil fill placed on this property during construction is considered to be structural fill that must be placed and compacted to the specifications listed in the following section 4.4.4 Structural Fill.

4.3.3 Cut and Fill Slopes

All finish slopes shall be graded to a maximum slope of 1V:2H. All fill slopes shall be constructed from the base upward by compacting the soil in layers, overbuilding the slope, and then finish grading to a maximum slope of 1V:2H. Temporary soil cuts should not exceed four feet unless approved by the geotechnical engineer and plans are made for providing immediate permanent structural support.

4.3.4 Structural Fill

For structural fill, use existing onsite soil or imported granular soil. The onsite soil can be used as structural fill provided it is free of organics, it is installed in maximum 8-inch-loose lifts and it is compacted in place. Structural fill soil shall not contain boulders exceeding 6 inches in diameter. Backfill soil next to building foundations shall be classified as primarily sand and gravel with no boulders or clasts exceeding 3 inches in diameter.

Imported fill should be well graded between coarse and fine with a maximum particle size of 1 inch and contain no deleterious materials. Imported fill should have a less than 20 percent by weight passing the No. 200 sieve. Imported soil fill shall be approved for use by a geotechnical engineer and soil compaction criteria shall be established for the specific material.

Knutzen Engineering requested that we analyze site soils from 1383 Lawless Drive in Richland for suitability of these soils for use as import fill. We performed 3 hand auger borings within the site to depths based upon a grading plan provided by Knutzen. We found the soils are similar to those found within the building site and consist mainly of fine to medium sands. These soils should be acceptable for use as import structural fill, however we will need to occasionally observe the soils for continued use as structural fill during construction.

All structural fill shall be installed in 8-inch, maximum loose lifts, it shall be moisture conditioned to optimum moisture content and it shall be compacted to a dry density of at least 95 percent of its maximum dry density as determined by the modified proctor test using ASTM International (ASTM) D1557 or per onsite specification and approval by the geotechnical engineer.

Vibratory roller compactors or wheel roller compaction equipment will produce the best soil compaction results at this site. For backfilling next to the foundation walls, we recommend using a hand-operated jumping jack.

4.4 Foundations

4.4.1 Design

The proposed buildings can be supported on conventional spread footings. All footings should be supported on properly prepared subgrade in native soils or on structural fill as discussed in the previous paragraphs. If we are retained to monitor mass grading, there is no need for further geotechnical evaluation of individual lots.

The minimum widths of the continuous wall footings shall be consistent with current IRC standards. The bottom exterior of all footings shall be at least 24 inches below the lowest adjacent exterior grade for frost protection.

Per IRC code, all buildings should be set back a minimum of H/3 from the edge of any descending slopes, where H is the overall height of the slope. According to the proposed grading plan, this will be required for buildings 6-8.

WSI recommends using a maximum soil bearing pressure of 2,000 pounds per square foot (lb/ft^2) for all footings that bear on the near-surface, or sandy soils consistent with current IRC standards. Please note that this allowable soil bearing pressure assumes a minimum confinement depth, or depth of burial, of 2.0 feet bgs. For interior footings placed directly on the prepared subgrade and not backfilled, reduce the allowable bearing pressure to 1,000 psf.

An assessment of loading on the foundation system by the home designer, architect, or structural engineer is required to verify that the footing sizes comply with the previously-mentioned requirements and the footings are correctly proportioned for the specified bearing capacity.

For consideration of short period seismic and wind pressures, the allowable footing bearing pressure values provided in this section may be increased by one-third. Use a dynamic bearing capacity of 2,000 lb/ft^2 when sizing footings for transient forces. For lateral forces, use a friction coefficient of 0.4 between the base of the footings and the underlying subgrade soil.

4.4.2 Settlement

WSI estimates a maximum total settlement of less than 0.5 inch and a maximum differential settlement on the order of 30 percent of the maximum settlement over 50 feet. Our settlement estimate assumes that no disturbance of the foundation soil would be permitted during excavation and construction and the footings are prepared as described previously.

4.4.3 Foundation Backfill

The clear space around the exterior of all foundations and between the stem walls and footing trenches shall be backfilled in lifts and compacted to a minimum of 90 percent of maximum dry density per ASTM D1557, or per onsite inspection and approval by the geotechnical engineer. Care must be taken with the backfilling operation to provide foundation subgrade soil confinement pressure and to help limit infiltration and future settlement around the foundation. At this site, careful backfilling behind the basement walls is critical for preventing any storm drainage inflow into the foundation area.

4.4.4 Foundation Walls and Lateral Earth Pressure

For the design of elevated stem walls and garage foundation walls, use the data in the following Table 1:

Table 1: Native Soil Design Parameters

Assumed Soil Density		=	120 lb/ft^3
Assumed Soil Internal Friction Angle		=	32 degrees
Coefficient of At-Rest Earth Pressure,	K_o	=	0.47
At-Rest Earth Pressure Equivalent Fluid Density		=	56 lb/ft^3
Coefficient of Active Earth Pressure,	K_a	=	0.31
Active Earth Pressure Equivalent Fluid Density		=	37 lb/ft^3
Coefficient of Passive Earth Pressure,	K_p	=	3.25
Passive Earth Pressure Equivalent Fluid Density		=	390 lb/ft^3

Basement foundation walls should generally be designed using the at-rest lateral earth pressure value.

All foundation walls must be backfilled with compacted soil to fully mobilize the passive earth resistance. Backfill placed within 3 feet of foundation walls should be placed in maximum 12-inch, loose lifts and compacted to at least 90 percent of the maximum dry density, as determined by ASTM D1557.

4.4.5 Seismic Design Criteria

The soil profile at the site consists of silty sand surface soil underlain by dense fine to medium sand followed by dense sandy gravels. This soil profile conforms to a seismic design "Site Class C", very dense soil and soft rock. For this site, use the following seismic design parameters found in the following Table 2:

Table 2: 2015 IBC Seismic Design Parameters

	Short Period	1 sec
Maximum Credible Earthquake Acceleration	S_s = 0.412	S_1 = 0.159
Site Class	C	
Site Coefficient	F_a = 1.200	F_v = 1.641
Adjusted Spectral Acceleration	S_{MS} = 0.495	S_{M1} = 0.261
Design Response Acceleration	S_{DS} = 0.330	S_{D1} = 0.174
Design Peak Ground Acceleration	0.175 g	

Based on the design response acceleration (S_{DS}=0.330) the buildings on this site are assigned a Seismic Design Category C consistent with IRC Table R301.2.2.1.1

Additionally, due to a lack of near surface water, the potential for liquefaction of site soils under seismic loading is considered very low to low for this site.

4.5 Slabs on Grade

Slabs-on-grade should be supported on subgrade soils prepared as described in **Section 4.3.2 Site Grading** subsection of this report. Clean crushed rock, at least 6 inches thick and compacted into place should be placed throughout the planned slab areas and over the exposed native soils We recommend that all floor slabs be underlain by at least four inches of free-draining gravel with less than three percent by weight of the material passing Sieve No. 200 for use as a capillary break. A suitable vapor barrier, such as heavy plastic sheeting (6-mil minimum), should be placed over the capillary break material. An additional 2-inch thick moist sand layer may be used to cover the vapor barrier. This sand layer is optional and is intended to protect the vapor barrier membrane during construction.

4.6 Pavements

Pavement subgrade preparation, and structural filling where required, should be completed as recommended in the **4.3.2 Site Grading** and **4.3.4 Structural Fill** subsections of this report. The pavement subgrade should be proof-rolled with a heavy, rubber-tired piece of equipment to identify soft or yielding areas that require repair. We anticipate the areas needed for repair can be removed and replaced with clean crushed rock, compacted into place. We should be retained to observe the proof rolling and recommend repairs prior to placement of the asphalt or hard surfaces. WSI should approve all pavement subgrades.

Pavement sections should include a minimum of 6 inches of crushed surfacing base course (CSBC) and 2 inches of hot mix asphalt (HMA). Any paving that will experience heavy loading such as for garbage trucks, should consist of 8 inches of CSBC and 3 inches of HMA placed in 2 lifts.

5.0 FINAL SITE GRADING AND EROSION CONTROL

The ground surface adjacent to the building shall slope away from the slab, stem walls, or foundation walls at 5 percent for a minimum distance of 10 feet from the structure per the requirements of the IRC, or an alternative drainage method shall be designed into the site drainage plan. Landscaping and lot grading should consider drainage requirements of the building and prevent ponding of water near the structures or in landscaped areas. All impervious surfaces shall be sloped to drain into an approved catch basin and piped to an appropriate infiltration system on-site.

All final slope surfaces should be moisture conditioned and compacted with a track dozer or some other compaction method that will work on the slope to achieve a smooth slope with a maximum slope angle of 1V:2H. A maximum slope of 1V:3H should be used if the slope will be maintained in grass and mowed. Finish soil slopes that are steeper than 1V:3H require some form of erosion protection to prevent water erosion at the surface in the event of an irrigation or domestic water line break. Erosion protection of these slopes should be designed into the final landscaping plan for the lot. Several options exist for slope protection and erosion control including but not limited to the following:

- The slope can be planted with drought-resistant plants (desert landscape) and watered with drip irrigation systems or light hand watering.

- Erosion control blankets or geotextile can be utilized along with sparsely-placed suitable vegetation. The erosion control blanket provides more immediate slope protection with the vegetation and will aid in long-term stability.
- The slope can be covered with a landscape fabric and then covered with decorative gravel, cobble, or rock.

Existing slopes that are undisturbed and covered with native desert vegetation are all less than 1V:3H and do not require any form of erosion control.

6.0 SITE DRAINAGE AND STORMWATER INFILTRATION

We conducted two on-site infiltration test pits within the proposed stormwater infiltration locations during our site visit. The on-site tests were conducted in INFTP-1 and INFTP-2 at 6.0 feet below grade.

As an alternative to recommendations in the WSDOE Stormwater Manual for Eastern Washington (2019), we performed air entry permeameter testing within the upper soil horizon in both test holes. We further collected samples of each different soil horizon encountered to a depth of 5 feet below the bottom of the proposed infiltration locations. We used the grain size analysis to estimate the saturated hydraulic conductivity of the soils, and used this value to calculate an approximate infiltration rate for both locations. This method exceeds the requirements of the WSDOE for infiltration testing.

The results of our testing can be found in detail in Appendix B: Stormwater Memorandum. Based on our analysis, an infiltration rate of **6.0 inches/hour for INF TP-1** and **8.0 inches/hour for INF TP-2** should be used for design of infiltration systems. These rates are design rates, however do not account for the possibility of silting in of the systems, and thus an appropriate correction factor should be used when designing the stormwater system.

We reviewed nearby well logs in the area and found that the approximate depth to static groundwater is approximately 79 feet below grade in this area. We would anticipate basalt formations to be shallower than this, and based on nearby well logs approximately 68 feet below grade.

The recommended infiltration rates are based on our interpretation of the on-site testing. Soil conditions may vary in different locations and depths. WSI should be retained to evaluate the soils exposed in the bottom of the infiltration system excavations during construction.

7.0 CONSTRUCTION OBSERVATION AND ENGINEERING INSPECTIONS

Geotechnical engineering construction observation is required during construction of both homes to monitor earthwork, soil, and groundwater conditions and to document the geotechnical aspects of constructing the townhomes. Construction observation will allow us to identify unexpected soil or groundwater conditions that were not identified in our site explorations and will allow us to adjust our geotechnical recommendations as required.

This project will require several onsite inspection visits by the geotechnical engineer to observe field conditions and verify the following items:

- Geotechnical engineering review of the building construction plans.

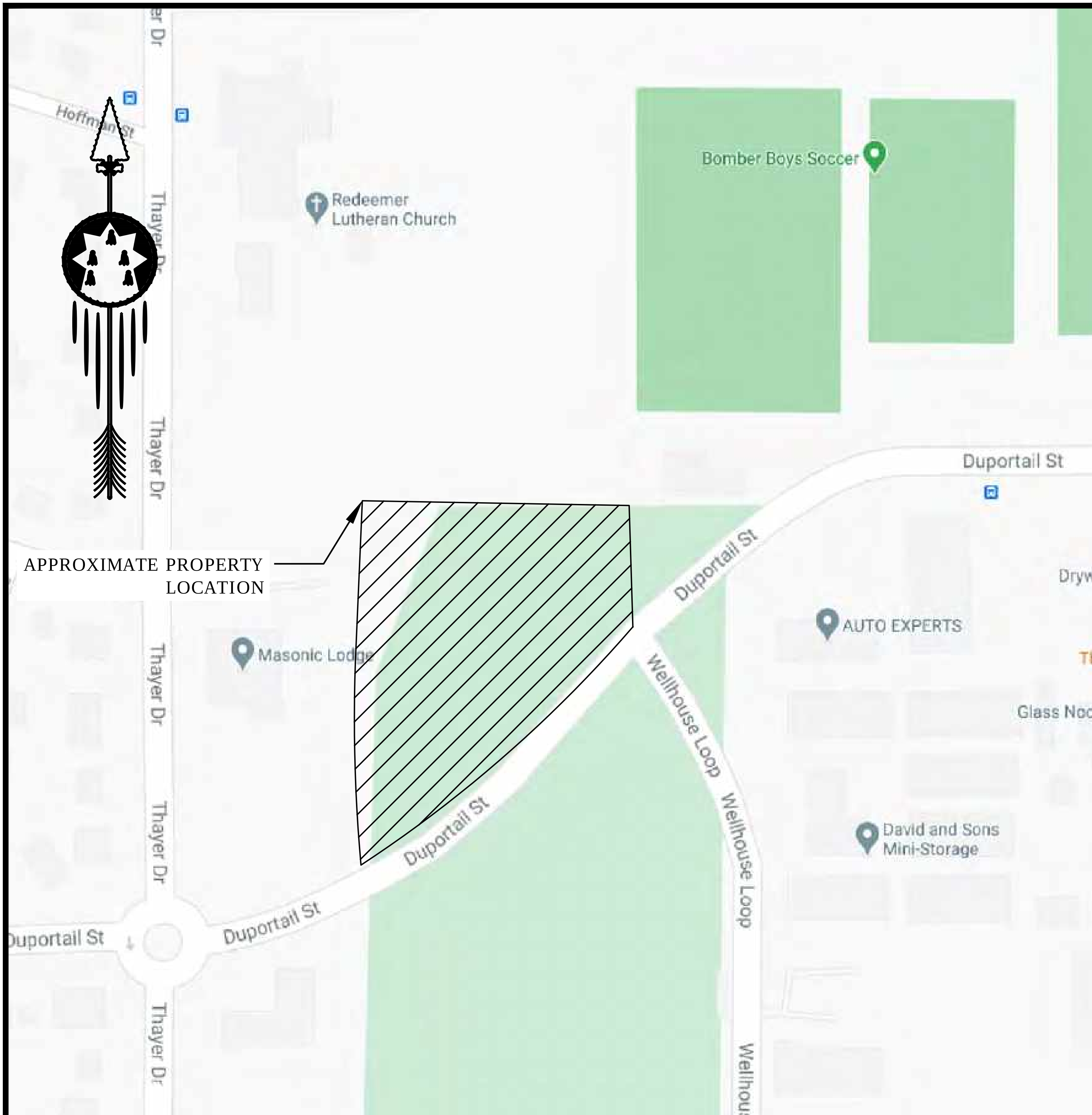
- Geotechnical engineering observation and approval of site grading, soil placement, and compaction.
- Geotechnical engineering inspection, testing, and approval of the building foundation subgrade soil conditions.
- Geotechnical engineering inspection and documentation of the backfill around foundation and stem walls.
- Geotechnical engineering inspection and documentation of the stormwater collection and infiltration system.
- Geotechnical engineering approval of final site grading.

8.0 REFERENCES

Lindsey, K.A. (1996). *The Miocene to Pliocene Ringold Formation and Associated Deposits of the Ancestral Columbia River System, South-Central Washington and North-Central Oregon.* Washington Department of Natural Resources, Division of Geology and Earth Resources, Open-File Report 96-8, 45 p., 4 Appendices.

Reidel, S.P., N.P., Campbell, K.R. Fecht, and K.A. Lindsey (1994). *Late Cenozoic Structure and Stratigraphy of South-Central Washington.* Bulletin 80, Washington Division of Geology and Earth Resources, Washington Department of Natural Resources

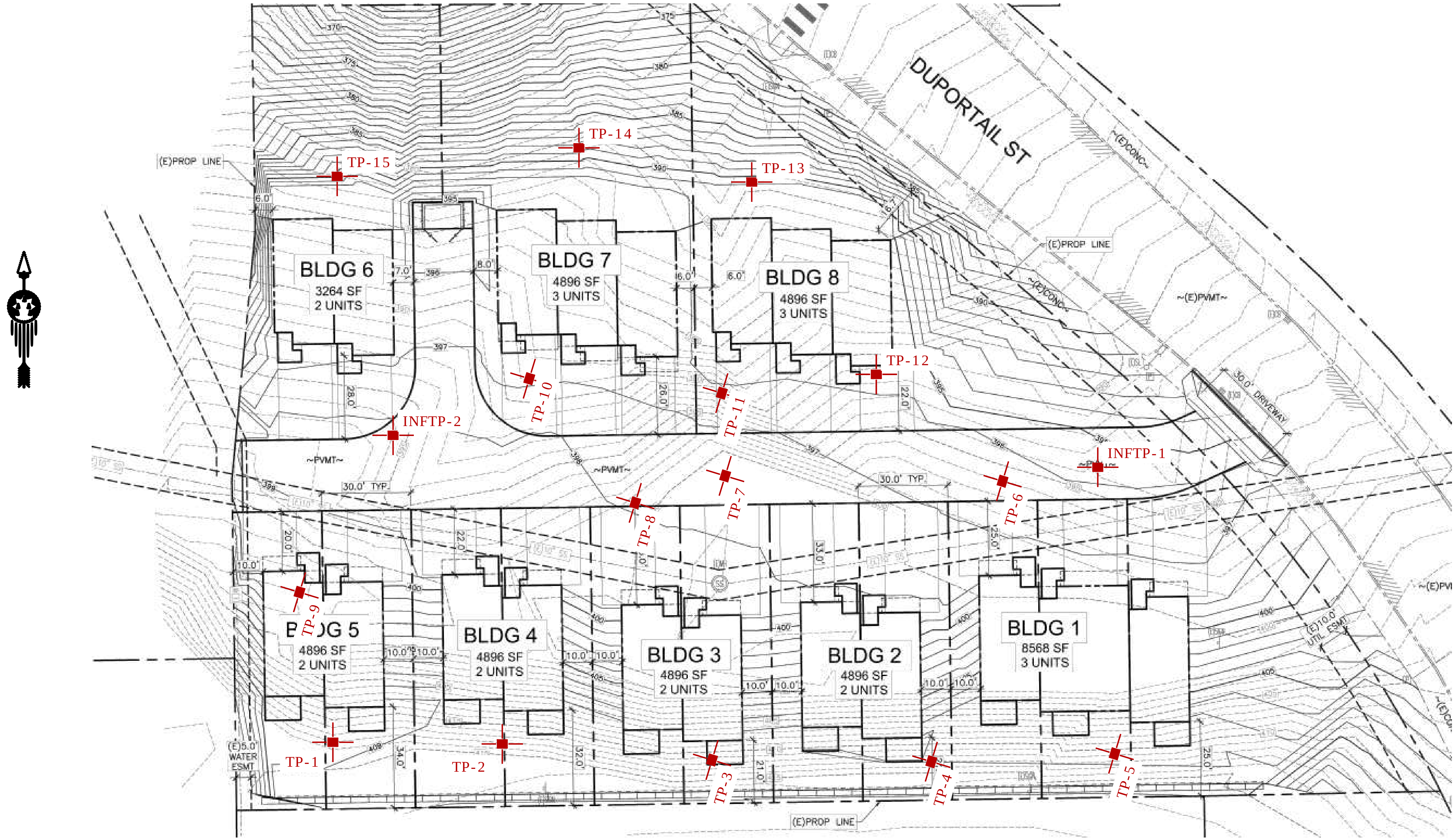
FIGURES



VICINITY MAP

NOT TO SCALE

Project Number	TIM BUSH	WHITE SHIELD, INC	No.	Date	Revision	By	CK
120-054-01	1380 DUPORTAIL	LAND SURVEYING ENVIRONMENTAL ENGINEERING SERVICES	1	9/11/20	Original	CH	BPS
Figure 1	RICHLAND, WA	320 N. 20TH AVENUE PASCO, WA 99301 PHONE 509.547.0100 FAX 509.547.8292					
	VICINITY MAP						



PRELIMINARY SITE PLAN

LEGEND

TP-1 — Number and approximate location of test pit

INF TP-1 — Number and approximate location of infiltration test pit

SCALE

20 0 20 40 80

(FEET)

1 INCH = 40 FEET

NOTE- SITE PLAN FROM "SITE PLAN - BUSH PROPERTIES - DUPORTAIL MULTI-FAMILY" PROVIDED BY KNUTZEN ENGINEERING - 8/4/20.

No.	Date	Revision	By	CK
1	9/11/20	Original	CH	BPS

WHITESHIELD, INC
LAND SURVEYING ENVIRONMENTAL ENGINEERING SERVICES
320 N. 20TH AVENUE
PASCO, WA 99301
PHONE 509.547.0100
FAX 509.547.8292

TIM BUSH
1380 DUPORTAIL ST
RICHLAND, WA
PRELIMINARY SITE PLAN

Project Number 120-054-01

FIGURE 2

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE - GRAINED SOILS MORE THAN 50 % RETAINED ON NO. 200 SIEVE	GRAVEL MORE THAN 50 % OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50 % OF COARSE FRACTION PASSES NO. 4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE - GRAINED SOILS MORE THAN 50 % PASSES NO. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50 %	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 % OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1) Field classification is based on visual examination of soil in general accordance with ASTM D 2488-93.

2) Soil classification using laboratory tests is based on ASTM D 2488-93.

3) Descriptions of soil density or consistency are based on interpretation of blowcount data, visual appearance of soils, and/or test data.

SOIL MOISTURE MODIFIERS:

Dry - Absence of moisture, dusty, dry to the touch

Damp - No visible water, leaves hand dry.

Moist - Leaves water or mud on hand.

Wet - Visible free water or saturated, usually soil is obtained from below water table

Project Number		
120-054-01	TIM BUSH 1380 DUPORTAIL ST RICHLAND, WA SOIL CLASSIFICATION	WHITE SHIELD, INC LAND SURVEYING ENVIRONMENTAL ENGINEERING SERVICES 320 N. 20TH AVENUE PASCO, WA 99301 PHONE 509.547.0100 FAX 509.547.8292
Figure 3		

No.	Date	Revision	By	CK
1	9/11/20	Original	CH	BPS

APPENDIX A

Test Pits TP-1 through TP-15 and INF TP-1 through INF TP-2

TEST PIT TP- 1

PROJECT NUMBER 120-054-01
PROJECT NAME BUSH- Richland Townhome
CLIENT Tim Bush
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352

DRILLING DATE 9/1/20
DRILLING METHOD Excavator
TOTAL DEPTH 15 FT

COORDINATES 46.270535 , -119.289124
COORD SYS GPS
SURFACE ELEVATION 407 FT
LOGGED BY CH
CHECKED BY BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–13	Garbage, concrete asphalt		04			
13–15	Medium dense, 5 YR (2.5/1) black, damp medium SAND		SP			
15–16						
16	Boring terminated at 15 ft on 9/1/20.		Boring terminat at 15			

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TEST PIT TP- 2

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.270338 , -119.289137
PROJECT NAME BUSH- Richland Townhomes		**COORD SYS** GPS
CLIENT Bush		**SURFACE ELEVATION** 407 FT
ADDRESS XXXX Richland, WA	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 11 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–4	Garbage					
4–11	Medium dense, 7.5 YR (2.5/2) brown-blackish, dry Fine-medium SAND, little fine gravel, layered black SAND.		SW			
11–15						
15	Boring terminated at 11 ft on 9/1/20.		Boring terminat at 11			

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TEST PIT TP- 3

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.270230 , -119.289181
PROJECT NAME BUSH- Richland Townhomes		**COORD SYS** GPS
CLIENT Tim Bush		**SURFACE ELEVATION** 409 FT
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 12 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–9	Garbage					
9–12	Medium dense, 7.5 YR (2.5/2) brown blackish, dry Fine-medium SAND, little fine gravel, layered black SAND.		SW			
12–15						
15	Boring terminated at 12 ft on 9/1/20.		Boring terminat at 12			

TEST PIT TP- 4

PROJECT NUMBER 120-054-01
PROJECT NAME BUSH- Richland Townhomes
CLIENT Tim Bush
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352

DRILLING DATE 9/1/20
DRILLING METHOD Excavator
TOTAL DEPTH 14.5 FT

COORDINATES 46.270030 , -119.289184
COORD SYS GPS
SURFACE ELEVATION 411 FT
LOGGED BY CH
CHECKED BY BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–9.5	Garbage					
9.5–10.2	Medium dense, 7.5 YR (5/3) brown, dry Fine-medium GRAVEL, and Fine-medium SAND.		GW			
10.2–12	Medium dense, 2.5 Y (5/2) brown grayish, damp Fine-medium SAND.		SW			
12–14.5	Medium dense, 2.5 Y (2.5/1) black, damp medium SAND, little Medium-coarse GRAVEL.		SP			
16	Boring terminated at 14.5 ft on 9/1/20.		Boring terminat at			

White Shield

TEST PIT TP- 5

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.270338 , -119.289137
PROJECT NAME BUSH- Richland Townhomes		**COORD SYS** GPS
CLIENT Tim Bush		**SURFACE ELEVATION** 406 FT
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 10 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–4	Garbage - Asphalt		04			
4–7	Medium dense, 10 YR (4/3) brown, damp Fine-medium SAND.		SW			
7–10	Medium dense, 10 YR (2/1) black, damp medium SAND layered.		SW			
15	Boring terminated at 10 ft on 9/1/20.		Boring terminat at 10			

TEST PIT TP- 6

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.269967 , -119.288982
PROJECT NAME BUSH- Richland Townhomes		**COORD SYS** GPS
CLIENT Tim Bush		**SURFACE ELEVATION** 401 FT
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 7.0 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0	Fill - roots and trash					
3.7	Medium dense, 10 YR (6/1) gray, damp Coarse-fine GRAVEL (rounded-elong), some medium black SAND.		GP			
4.4	Medium dense , 10 YR (5/3) brown, damp Fine-medium SAND.		SW			
7.0						
15	Boring terminated at 7.0 ft on 9/1/20.		Boring terminat at 7.0			

TEST PIT TP- 7

PROJECT NUMBER 120-054-01
PROJECT NAME BUSH- Richland Townhomes
CLIENT Tim Bush
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352

DRILLING DATE 9/1/20
DRILLING METHOD Excavator
TOTAL DEPTH 8.7 FT

COORDINATES 46.270114 , -119.288965
COORD SYS GPS
SURFACE ELEVATION 401 FT
LOGGED BY CH
CHECKED BY BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–6.5	Garbage - Concrete - Asphalt		04			
6.5–7.4	Medium dense, 2.5 Y (5/1) gray, dry Medium-fine GRAVEL(rounded), some fine SAND.		GM			
7.4–8.7	Medium dense, 7.5 YR (6/3) light brown, dry Fine-medium SAND.		SW			
15	Boring terminated at 8.7 ft on 9/1/20.		Boring terminat at 8.7			

White Shield
Progressive Solutions. Traditional Values.

TEST PIT TP- 8

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.270448 , -119.288917
PROJECT NAME BUSH- Richland Townhomes		**COORD SYS** GPS
CLIENT Tim Bush		**SURFACE ELEVATION** 400 FT
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 7.5 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–4.5	Garbage - Concrete - Asphalt.		04			
4.5–5	Medium dense, 7.5 YR (5/2) brown, dry Medium-fine GRAVEL(rounded), some Fine-medium SAND.		GW			
5–7.5	Medium dense, 7.5 YR (5/2) brown, dry Fine-medium SAND(bedded).		SW			
	Boring terminated at 7.5 ft on 9/1/20.		Boring terminat at 7.5			

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TEST PIT TP- 9

PROJECT NUMBER 120-054-01
PROJECT NAME BUSH- Richland Townhomes
CLIENT Tim Bush
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352

DRILLING DATE 9/1/20
DRILLING METHOD Excavator
TOTAL DEPTH 8.0 FT

COORDINATES 46.270589 , -119.288981
COORD SYS GPS
SURFACE ELEVATION 403 FT
LOGGED BY CH
CHECKED BY BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–5	Garbage - Concrete					
5–8	Medium dense, 10 YR (2/2) brown blackish, dry Fine-medium SAND, layered black SAND.		SW			
	Boring terminated at 8.0 ft on 9/1/20.		Boring terminat at 8.0			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

White Shield

TEST PIT TP- 10

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.270374 , -119.288640
PROJECT NAME BUSH- Richland Townhomes		**COORD SYS** GPS
CLIENT Tim Bush		**SURFACE ELEVATION** 392 FT
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 7.0 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–2.2	Medium dense, 7.5 YR (6/3) light brow, dry Fine-medium SAND, some Fine-medium GRAVEL.		SP			
2.2–7.0	Medium dense, 10 YR (5/2) brown grayish, dry Fine-medium SAND, BEDDED.		SW			
15	Boring terminated at 7.0 ft on 9/1/20.		Boring terminat at 7.0			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

TEST PIT TP- 11

PROJECT NUMBER 120-054-01
PROJECT NAME BUSH- Richland Townhomes
CLIENT Tim Bush
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352

DRILLING DATE 9/1/20
DRILLING METHOD Excavator
TOTAL DEPTH 9.0 FT

COORDINATES 46.270079 , -119.288775
COORD SYS GPS
SURFACE ELEVATION 392 FT
LOGGED BY CH
CHECKED BY BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–4	Loose, 7.5 YR (6/3) light brown, dry Fine-coarse GRAVEL and Fine-medium SAND(FILL).		GW			
4–9	Medium dense, 7.5 YR (4/3) brown, dry Fine - medium SAND, BEDDED.		SW			
15	Boring terminated at 9.0 ft on 9/1/20.		Boring terminat at 9.0			

TEST PIT TP- 12

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.269956 , -119.288737
PROJECT NAME BUSH- Richland Townhomes		**COORD SYS** GPS
CLIENT Tim Bush		**SURFACE ELEVATION** 392 FT
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 7.0 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–2	Loose, 7.5 YR (5/2) brown, dry Fine-medium SAND (FILL).		SW			
2–7	Medium dense, 7.5 (5/2) brown, damp Fine-medium SAND.		SW			
7–15						
15			Boring terminat at 7.0			

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TEST PIT TP- 13

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.270119 , -119.288546
PROJECT NAME Bush- Richland Townhomes		**COORD SYS** GPS
CLIENT Tim Bush		**SURFACE ELEVATION** 385 FT
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 4.0 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–4	Medium dense, 7.5 YR (2.5/2) brown blackish, dry Fine-medium BEDDED SAND.		SP			
15	Boring terminated at 4.0 ft on 9/1/20		Boring terminat at 4.0			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

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TEST PIT TP- 14

PROJECT NUMBER 120-054-01	**DRILLING DATE** 9/1/20	**COORDINATES** 46.270395 , -119.288396
PROJECT NAME Bush - Richland Townhomes		**COORD SYS** GPS
CLIENT TIM Bush		**SURFACE ELEVATION** 379 FT
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352	**DRILLING METHOD** Excavator	**LOGGED BY** CH
	TOTAL DEPTH 6.0 FT	**CHECKED BY** BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–6	Medium dense, 7.5 YR (4/3) brown, dry Fine-medium BEDDED SAND.		SP			
15	Boring terminated at 6.0 ft on 9/1/20		Boring terminat at 6.0			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

TEST PIT TP- 15

PROJECT NUMBER 120-054-01
PROJECT NAME Bush - Richland Townhomes
CLIENT Tim Bush
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352

DRILLING DATE 9/1/20
DRILLING METHOD Excavator
TOTAL DEPTH 8.0 FT

COORDINATES 46.270562 , -119.288486
COORD SYS GPS
SURFACE ELEVATION 387 FT
LOGGED BY CH
CHECKED BY BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0–3.5	Loose, tan, dry Fine SAND, little silt.		SP			
3.5–8	Medium dense, 7.5 YR (5/4) brown, dry Fine-medium SAND.		SW			
8–15						
	Boring terminated at 8.0 ft on 9/1/20		Boring terminat at 8.0			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15

INFILTRATION TEST INFTP- 1

PROJECT NUMBER 120-054-01
PROJECT NAME BUSH- Richland Townhomes
CLIENT Tim Bush
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352

DRILLING DATE 9/1/20
DRILLING METHOD Excavator
TOTAL DEPTH 10 FT

COORDINATES 46.269810 , -119.288857
COORD SYS GPS
SURFACE ELEVATION 395 FT
LOGGED BY CH
CHECKED BY BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance
0	Loose, 10 YR (5/2) brown grayish, dry Coarse-fine GRAVEL, some fine SAND.		GP			
	Loose, 10 YR (4/3) brown, dry Fine-medium SAND(FILL).		SP			
3.3	Medium dense, 10 YR (5/2) brown grayish, damp Fine-medium SAND, trace black SAND.		SW		Sample collected (approx. 3.9–4.5 ft)	
8	Medium dense, 10 YR (5/2) brown gray, damp Fine-medium SAND, trace black SAND.		SM		Sample collected (approx. 7.9–8.5 ft)	
9	Medium dense, 10YR(5/2) brow grayish, damp Fine-medium SAND, trace black SAND.		SW		Sample collected (approx. 8.9–9.5 ft)	
10						
16	Boring terminated at 10 ft on 9/1/20. 2-3 feet : Ash layer in Sand end of the test pit		Boring terminat at 10			

Depth scale: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16

INFILTRATION INFTP- 2

PROJECT NUMBER 120-054-01
PROJECT NAME BUSH- Richland Townhomes
CLIENT Tim Bush
ADDRESS 1380 DUPORTAIL RICHLAND, WA 99352

DRILLING DATE 9/1/20
DRILLING METHOD Excavator
TOTAL DEPTH 7.0 FT

COORDINATES 46.270404 , -119.288705
COORD SYS GPS
SURFACE ELEVATION 399 FT
LOGGED BY CH
CHECKED BY BPS

COMMENTS

Depth (ft)	Material Description	Graphic Log	USCS	Blow Count	Samples	Penetration Resistance (0–60)
0–1	Loose, 7.5 YR (5/3) brown, dry Fine-medium SAND (FILL)		SW			
1–8.5	Medium dense, 7.5 YR (6/4) light brown, dry Fine-medium SAND.		SW		Sample collected; Sample collected	
8.5–11	Medium dense, 10 YR (5/2) brown grayish, damp Medium-fine SAND.		SW		Sample collected	
16	Boring terminated at 11 ft on 9/1/20.		Boring terminat at 11			

Page 1 of 1

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APPENDIX B

Stormwater Memorandum

WHITE SHIELD, INC.

Memo

To: Ben Staehr, P.E.

From: Michael Black, P.E.

cc: Callixte Hirwa

Date: 9/19/20

Re: Bush Geohydrology for Stormwater Design

This memo report provides the results of my analysis for infiltration rates for the Bush Site, 1380 Dupertail, Richland, WA.

Some common definitions as follows:

- *Vadose Zone*- geologic media between the land surface and the regional water table. In the case of this project, all considerations are within the vadose zone.
- *Saturated Hydraulic conductivity*- The ease with which a fluid travels through a given soil (saturated porous medium).
- *Unsaturated hydraulic conductivity*- The ease with which a fluid travels through a given soil at different soil moistures (i.e. different matric pressures or capillary pressures).
- *Infiltration*- The movement of water into the soil column based on the following:
  a. The depth to groundwater or a restrictive layer.
  b. The physical dimensions of the application source.
  c. The pressure head (depth) and the application time.
  d. The saturated and unsaturated hydraulic conductivity.
  e. The initial and full soil saturation values.

Per your direction, I did not consider groundwater or a restrictive layer as your field investigation determined it was at a substantial depth. You also provided guidance that exfiltration trenches were to be used for this site. The design trench depth is 3 ft. for the Test Pit 1 area and 5 ft. for the Test Pit No. 2 area.

INFILTRATION RATE METHODOLOGY

The salient issue for this evaluation is the infiltration rate as previously defined for the proposed stormwater management device (infiltration trench). While a large number of methods exist to estimate the saturated hydraulic conductivity (K_s) there are few recognized by the engineering/geohydrology practice as follows:

1. Performing air-entry permeameter tests in each soil layer accompanied by a field constant head permeameter (K_{sv}) and and Well Pump-In Technique (Ksh), which both are recommended by the ASTM. This is a very expensive protocol.

2. Collecting in-situ, un-disturbed samples, oriented in the vertical and horizontal position for either a falling- or constant head permeameter test. This is a very expensive protocol as well.

3. Collecting samples, at-depth, for Grain Size Analysis (GSD). GSD analysis uses research derived empirical formulas to determine the K_s. Over the years, the engineering professional has lagged well behind the soil science technical community with respect to water flow in soils. The National Resource Conservation Service (NCRS) has sponsored large research efforts and enjoy a database with over 30,000 soil types. Most of these formulas developed by engineers were developed for sand. While the WSDOE uses a much more simplified technique for estimation, we used the Soil Water Characteristic Curve (NCRS) data for our work. Furthermore, we have found the NCRS methods much more accurate when compared to actual field tests.

We used the Saxton[1] method for application to our models. This method includes the soil texture, approximate density, organic content, and salinity. It also provides the hydraulic conductivity at a range of matrix soil suction, both osmotic and capillary.

Vadose zone flow

We used the Green-Ampt Explicit Model to determine the infiltration rate. This model considers the level of ponding (3 ft. and 5 ft.) Using the saturated hydraulic conductivity (K_{SAT}) the model determines the changes to infiltration, over time, based on overcoming the matric suction.

---

[1] Saxton, K.E., Rawls, W.J., *Soil Water Characteristic Estimates by Texture and Organic Matter for Hydrologic Solutions.* Soil Science Society of America Journal, 70:1569-1578, 2006

ANALYSIS

Using the hydrometer data (see Appendix), we calculated the following key information for each soil layer:

- Saturated hydraulic conductivity (K_{sat})
- Soil Saturation (% by volume).
- Various other data included in the Excel Sheets in the Appendix.

Once this data was determined, we calculated the Brooks-Corey Grain Size Distribution and the infiltration rate for each trench area using the Green-Ampt Explicit Model. We used the lowest calculated K_{SAT} is it would provide the controlling layer.

For the Test Pit No. 1 area (3 ft. deep trench), the infiltration rate with start at 15.38 cm/hr (6.1 in/hr) and rise to 70.45 cm/hr (27.7 in/hr) after 1.5 hrs. This assumes a constant 3 ft. head.

For the Test Pit No. 2 area (5 ft. deep trench), the infiltration rate with start at 20.24 cm/hr (8.0 in/hr) and rise to 90.72 in/hr (35.7 in/hr) after 1.5 hours. This assumes a constant 5 ft. head.

CONCLUSIONS AND RECOMMENDATIONS

Depending on the maintenance of the trenches, silt build up over time will decrease the exfiltration capacity. The recommended infiltration rate does not include consideration of silting in. We recommend the following infiltration values:

- Test Pit No. 1 Area; **6.0 inches/hr**
- Test Pit No. 2 Area; **8.0 inches/hr**

The pore size distribution is used in many infiltration models. The Brooks-Corey parameter is most commonly used and is calculated here. The variables include the following:

- C= percent clay (5<%<60)
- S= percent sand (5<%<70)
- ϕ= porosity (volume fraction)

INPUT VARIABLES

$C := 0.024$

$S := 84$

$\phi := 0.402$

$$\lambda := \exp\begin{bmatrix} -0.7842831 + 0.0177544\cdot S - 1.062498\cdot\phi - 0.00005304\cdot S^2 - 0.00273493\cdot C^2 \ldots \\ + 1.1113496\cdot\phi^2 - 0.03088295\cdot S\cdot\phi + 0.00026587\cdot S^2\cdot\phi^2 - 0.00610522\cdot C^2\cdot\phi^2 \ldots \\ + \left(-0.00000235\cdot S^2\cdot C\right) + 0.00798746\cdot C^2\cdot\phi - 0.00674491\cdot\phi^2\cdot C \end{bmatrix} = 0.52$$

Green-Ampt Explicit Model (GAEXP)

A. Description

The Green-Ampt model is the first physically-based equation describing the infiltration of water into a soil. It has been the subject of considerable developments in soil physics and hydrology owing to its simplicity and satisfactory performance for a great variety of water infiltration problems. This model yields cumulative infiltration and infiltration rate as implicit functions of time, *i.e.*, given a value of time, *t*, *q* and *I* cannot be obtained by direct substitution. The equations have to be solved in an iterative manner to obtain these quantities. Therefore, the required functions are *q(t)* and *I(t)* instead of *t(q)* and *t(I)*. The Green Ampt explicit model (GAEXP) for *q(t)* and *I(t)*, developed by Salvucci and Entekhabi (1994), facilitated a straight forward and accurate estimation of infiltration for any given time. This model supposedly yield less than 2% error at all times when compared to the exact values from the implicit Green-Ampt model. A scenario was chosen to simulate the water infiltration into a sandy soil under ponding conditions by using the GAEXP model. A ponding depth of 1 cm was applied at the soil surface. Input parameters and simulation results were given below.

B. Definition of Variables

$h_e := -82$	**Air entry head from test (cm)**
$\lambda := 0.52$	**The exponent of the Brooks-Corey water retention model**
$\theta_s := 0.402$	**Saturated volumetric water content (cm³/cm³)**
$\theta_0 := 0.04$	**Initial volumetric water content (cm³/cm³)**
$K_s := 14.0$	**Saturated hydraulic conductivity (cm/h)**
$h_s := 91.4$	**Ponding depth or capillary pressure head at the surface (cm)**
$t := 0.1, 0.2 .. 1.5$	**Duration of infiltration (h)**

Values given above were obtained from Carsel and Parrish (1988) for a sandy soil.

C. Equations

$$\eta := (2 + 3\cdot\lambda) \quad (1)$$

$$h_f := \frac{\eta}{(\eta - 1)}\cdot h_e \quad (2)$$

Capillary pressure head at the wetting front

$$\chi := \frac{(h_s - h_f)\cdot(\theta_s - \theta_0)}{K_s} \quad (3)$$

$$\tau(t) := \frac{t}{(t + \chi)} \quad (4)$$

$$q(t) := \left[\left(\frac{\sqrt{2}}{2}\right)\cdot\tau(t)^{\left(-\frac{1}{2}\right)} + \left(\frac{2}{3}\right) - \left(\frac{\sqrt{2}}{6}\right)\cdot\tau(t)^{\frac{1}{2}} + \left(\frac{1-\sqrt{2}}{3}\right)\cdot\tau(t)\right]\cdot K_s \quad (5)$$

Infiltration rate

$$I(t) := \left[\left(1 - \frac{\sqrt{2}}{3}\right)\cdot t + \frac{\sqrt{2}}{3}\cdot\sqrt{\chi\cdot t + t^2} + \left(\frac{\sqrt{2}-1}{3}\right)\cdot\chi\cdot(\ln(t+\chi) - \ln(\chi)) + \frac{\sqrt{2}}{3}\cdot\chi\cdot\left(\ln\left(t + \frac{\chi}{2} + \sqrt{\chi\cdot t + t^2}\right) - \ln\left(\frac{\chi}{2}\right)\right)\right]\cdot K_s \quad (6)$$

D. Results

t =	q(t) =	I(t) =
0.1	81.68	15.38
0.2	60.6	22.31
0.3	51.28	27.86
0.4	45.73	32.69
0.5	41.95	37.06
0.6	39.16	41.11
0.7	36.99	44.91
0.8	35.25	48.52
0.9	33.8	51.97
1	32.58	55.29
1.1	31.54	58.5
1.2	30.62	61.6
1.3	29.82	64.62
1.4	29.1	67.57
1.5	28.46	70.45

Cumulative infiltration

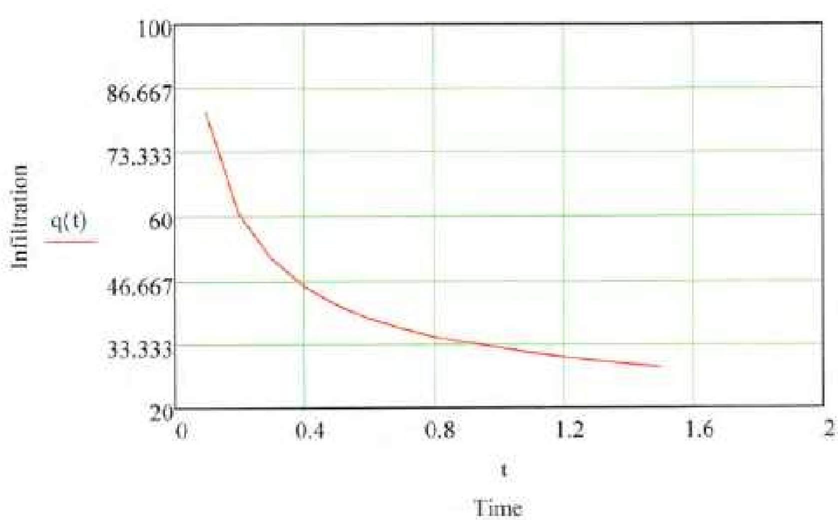


Figure 1. Soil infiltration as a function of time.

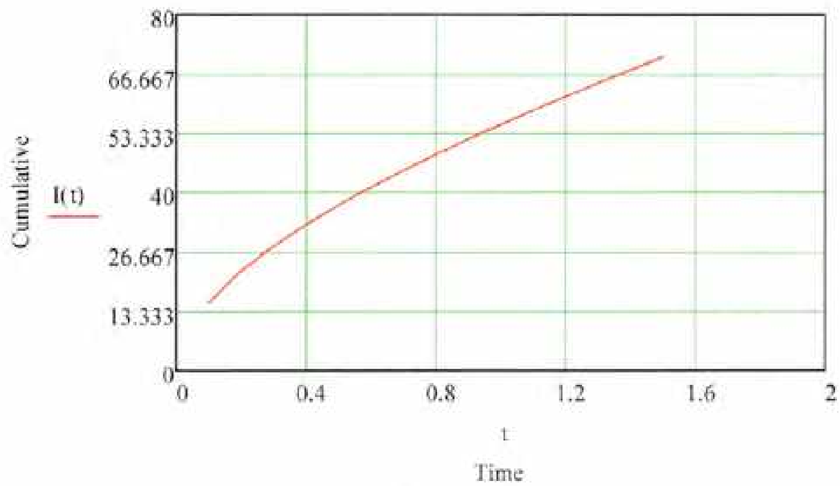


Figure 2. Cumulative Infiltration as a function of time.

E. Discussion

Figures 1 and 2 show the soil water infiltration rate and cumulative infiltration as a function of time, respectively. A rapid decrease in water infiltration rate was observed within the first hour.

F. Sensitivity Analysis of Infiltration Rate to Saturated hydraulic Conductivity

This section shows the sensitivity coefficient (S_s) and the relative sensitivity (S_r) of the surface infiltration rate, q, to the saturated hydraulic conductivity (K_s) at the time of 1 hours. The expressions were obtained by applying Equations 3 and 4 in Section B2 (PHILIP2T model) to Equation 5 in this section.

F.1. Input Data

$K_s := 7.5, 7.6 .. 8.9$ $\qquad t := 5$

F.2. Sensitivity Calculation Equations

$$\chi(K_s) := \frac{(h_s - h_f)\cdot(\theta_s - \theta_0)}{K_s} \qquad (7)$$

$$T(K_s) := \frac{t}{(t + \chi(K_s))} \qquad (8)$$

$$q(K_s) := \left[\left(\frac{\sqrt{2}}{2}\right)\cdot\tau(K_s)^{\left(-\frac{1}{2}\right)} + \left(\frac{2}{3}\right) - \left(\frac{\sqrt{2}}{6}\right)\cdot\tau(K_s)^{\frac{1}{2}} + \left(\frac{1-\sqrt{2}}{3}\right)\cdot\tau(K_s)\right]\cdot K_s \quad (9)$$

$$S_s(K_s) := \frac{d}{dK_s}q(K_s)$$ **Sensitivity** **(10)**

$$S_r(K_s) := \left(\frac{d}{dK_s}q(K_s)\right)\cdot\left(\frac{K_s}{q(K_s)}\right)$$ **Relative Sensitivity** **(11)**

F.3. Results

$K_s =$	$q(K_s) =$	$S_s(K_s) =$	$S_r(K_s) =$
7.5	12.79	1.22	0.72
7.6	12.91	1.22	0.72
7.7	13.03	1.22	0.72
7.8	13.15	1.21	0.72
7.9	13.28	1.21	0.72
8	13.4	1.21	0.72
8.1	13.52	1.21	0.72
8.2	13.64	1.2	0.72
8.3	13.76	1.2	0.72
8.4	13.88	1.2	0.73
8.5	14	1.2	0.73
8.6	14.12	1.19	0.73

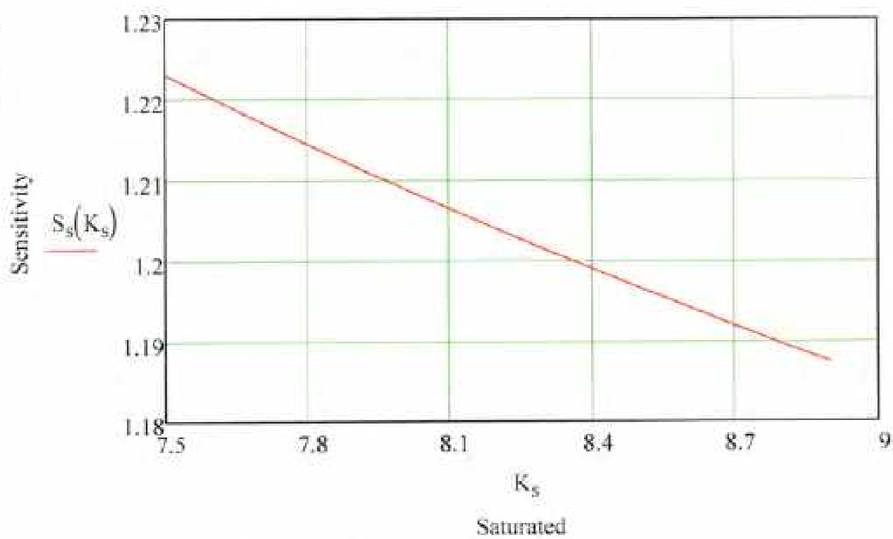


Figure 3. Sensitivity of infiltration rate for different values of saturated hydraulic conductivity at t = 5 hours.

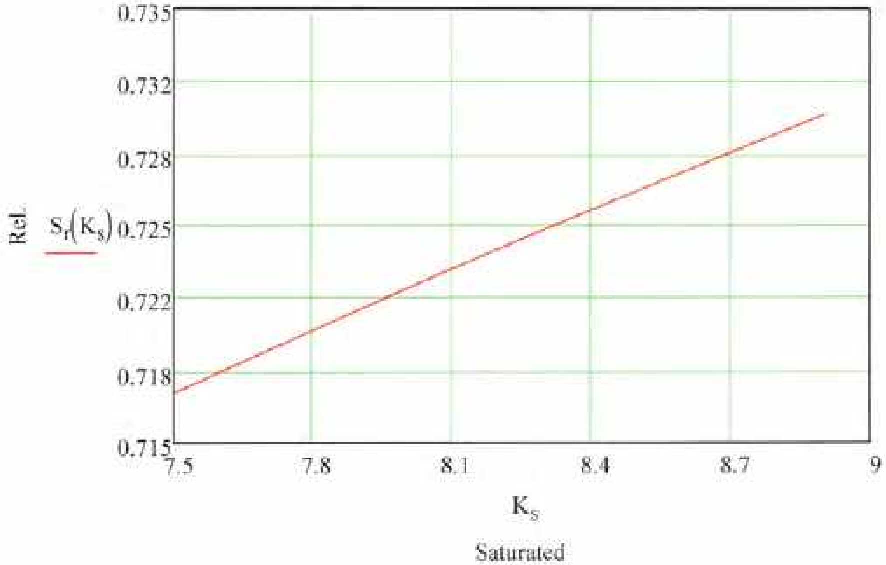


Figure 4. Relative sensitivity of infiltration rate for different values of saturated hydraulic conductivity at t = 5 hours.

F.4. Discussion

Figure 3 shows a sensitivity of the infiltration rate for different values of saturated hydraulic conductivity. The sensitivity decreased as the saturated hydraulic conductivity increased. Figure 4 shows the relative sensitivity of the infiltration rate for different values of saturated hydraulic conductivity. The relative sensitivity increased as the saturated hydraulic conductivity increased.

Soil Sample Analysis Input:

Project: Bush		Sample ID: INFTP-1		Depth: 4.0 - 4.5 ft			
SAND %	CLAY %	SILT %	Saturation % (vol.)	Bulk Density (lb/ft^3)	Effective Porosity % (vol.)	Saturated Hydraulic Conductivity K_s (in/hr)	In-Situ Soil Moisture %
87.6	2.4	10.0	41.4	96.86	5.2	7.31	2.82

Moisture Calculation:

Water %	Matric Potential (bars)	Matic Potential (ft)	K (in/hr)
0.4	13.56	453.67	9.57E-12
3.0	0.73	24.42	1.38E-06
6.0	0.33	11.04	8.22E-05
9.0	0.30	10.04	8.98E-04
12.0	0.27	9.03	4.90E-03
15.0	0.24	8.03	1.82E-02
18.0	0.22	7.36	5.35E-02
21.0	0.19	6.36	1.33E-01
24.0	0.16	5.35	2.92E-01
27.0	0.13	4.35	5.84E-01
30.0	0.11	3.68	1.09E+00
33.0	0.08	2.68	1.91E+00
36.0	0.05	1.67	3.18E+00
41.0	0.01	0.33	6.85E+00

Figure-1:

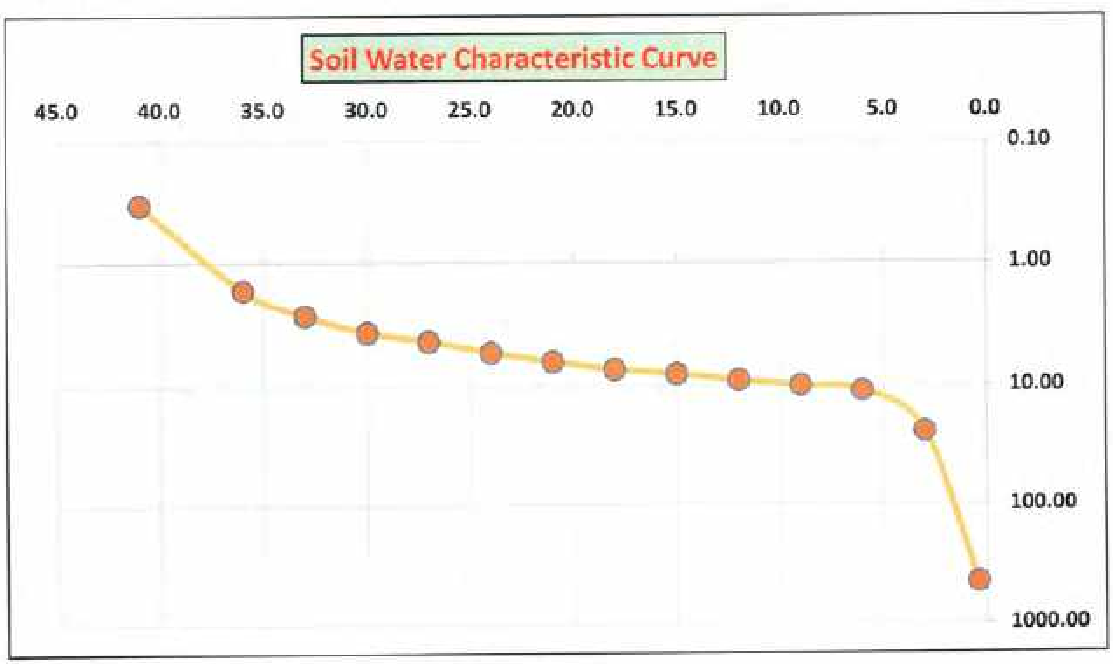
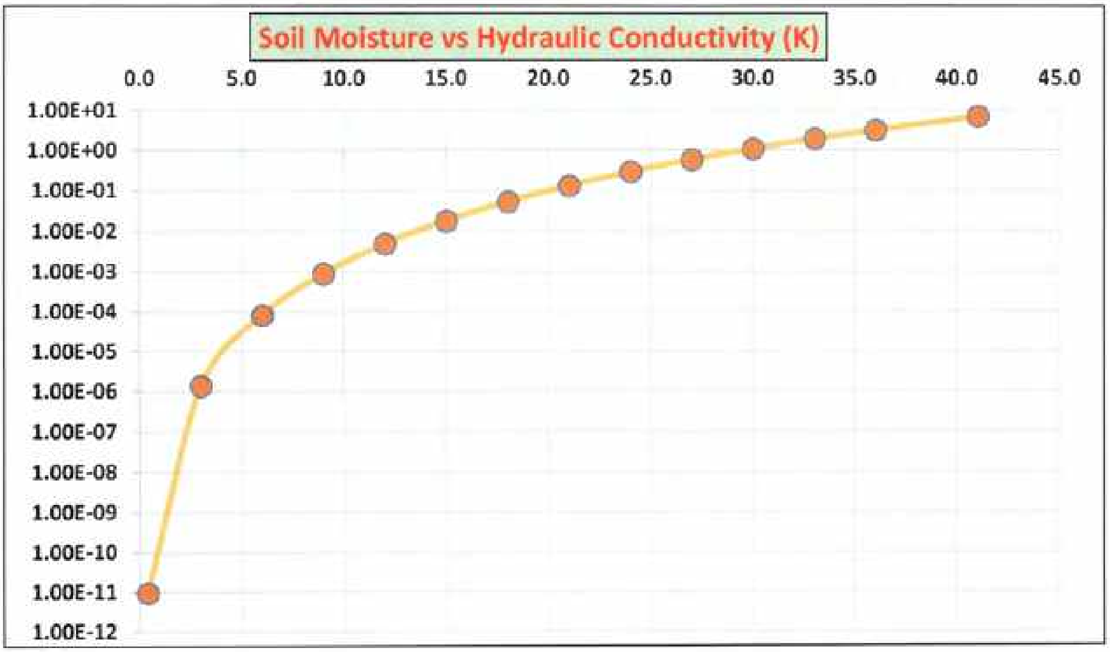


Figure-2:


Soil Moisture vs Hydraulic Conductivity (K)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12

Soil Sample Analysis Input:

Project: Bush		Sample ID: INFTP-1		Depth: 8.0 - 8.5 ft			
SAND %	CLAY %	SILT %	Saturation % (vol.)	Bulk Density (lb/ft^3)	Effective Porosity % (vol.)	Saturated Hydraulic Conductivity K_s (in/hr)	In-Situ Soil Moisture %
77.6	2.4	20.0	40.2	98.91	7.3	5.53	3.48

Moisture Calculation:

Water %	Matric Potential (bars)	Matic Potential (ft)	K (in/hr)
0.6	14.68	491.14	5.78E-11
3.0	1.33	44.50	7.23E-07
6.0	0.45	15.06	4.98E-05
9.0	0.32	10.71	5.93E-04
12.0	0.29	9.70	3.43E-03
15.0	0.26	8.70	1.34E-02
18.0	0.23	7.69	4.09E-02
21.0	0.20	6.69	1.05E-01
24.0	0.17	5.69	2.37E-01
27.0	0.14	4.68	4.86E-01
30.0	0.11	3.68	9.25E-01
33.0	0.08	2.68	1.65E+00
36.0	0.05	1.67	2.82E+00
40.1	0.01	0.33	5.44E+00

Figure-1:

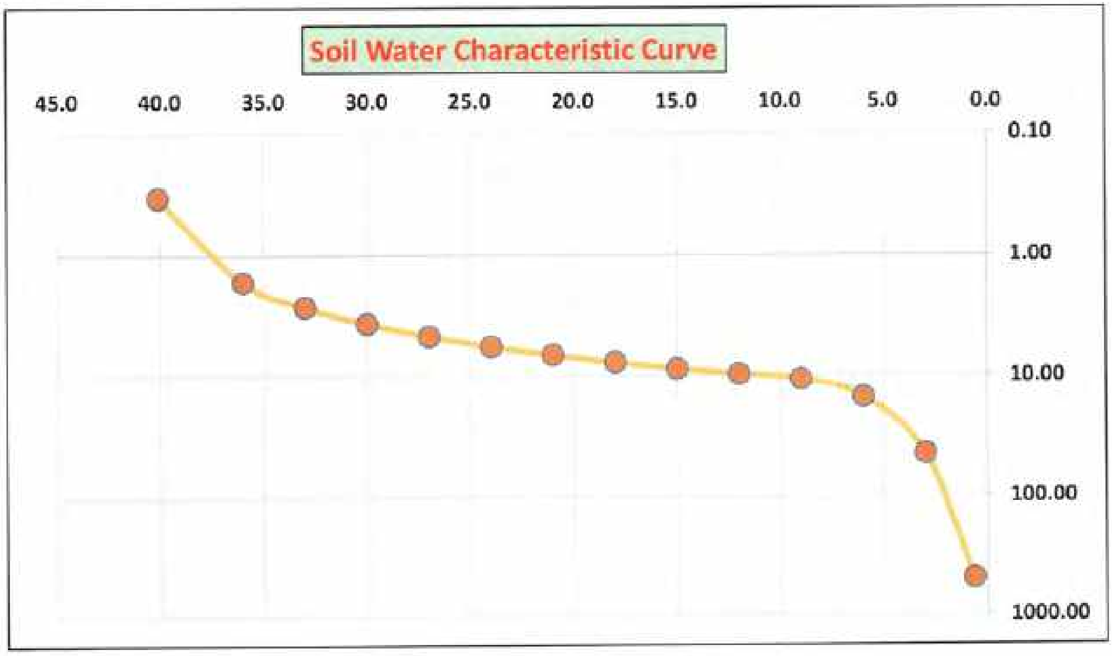
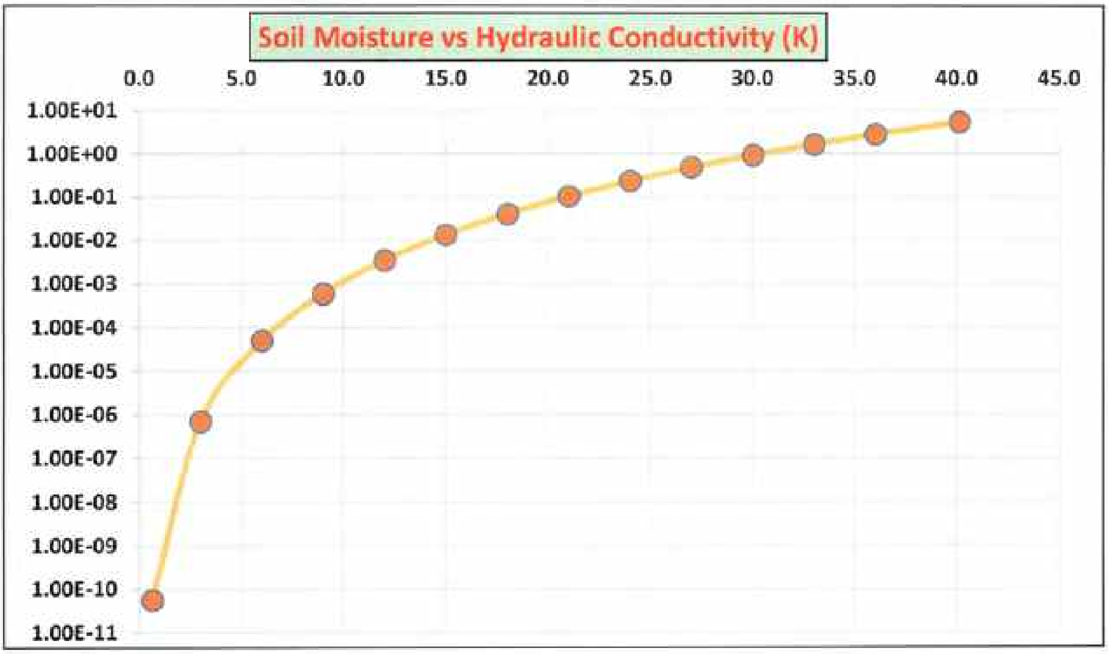


Figure-2:


Soil Moisture vs Hydraulic Conductivity (K)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11

Soil Sample Analysis Input:

Project: Bush		Sample ID: INFTP-1		Depth: 9.0 - 9.5 ft			
SAND %	CLAY %	SILT %	Saturation % (vol.)	Bulk Density (lb/ft^3)	Effective Porosity % (vol.)	Saturated Hydraulic Conductivity K_s (in/hr)	In-Situ Soil Moisture %
89.6	2.4	8.0	41.7	96.42	4.8	7.76	2.86

Moisture Calculation:

Water %	Matric Potential (bars)	Matic Potential (ft)	K (in/hr)
0.3	14.46	483.78	4.43E-12
3.0	0.64	21.41	1.70E-06
6.0	0.32	10.71	9.64E-05
9.0	0.30	10.04	1.02E-03
12.0	0.27	9.03	5.47E-03
15.0	0.24	8.03	2.01E-02
18.0	0.21	7.03	5.80E-02
21.0	0.19	6.36	1.42E-01
24.0	0.16	5.35	3.10E-01
27.0	0.13	4.35	6.16E-01
30.0	0.11	3.68	1.14E+00
33.0	0.08	2.68	1.98E+00
36.0	0.05	1.67	3.29E+00
41.2	0.01	0.33	7.22E+00

Figure-1:

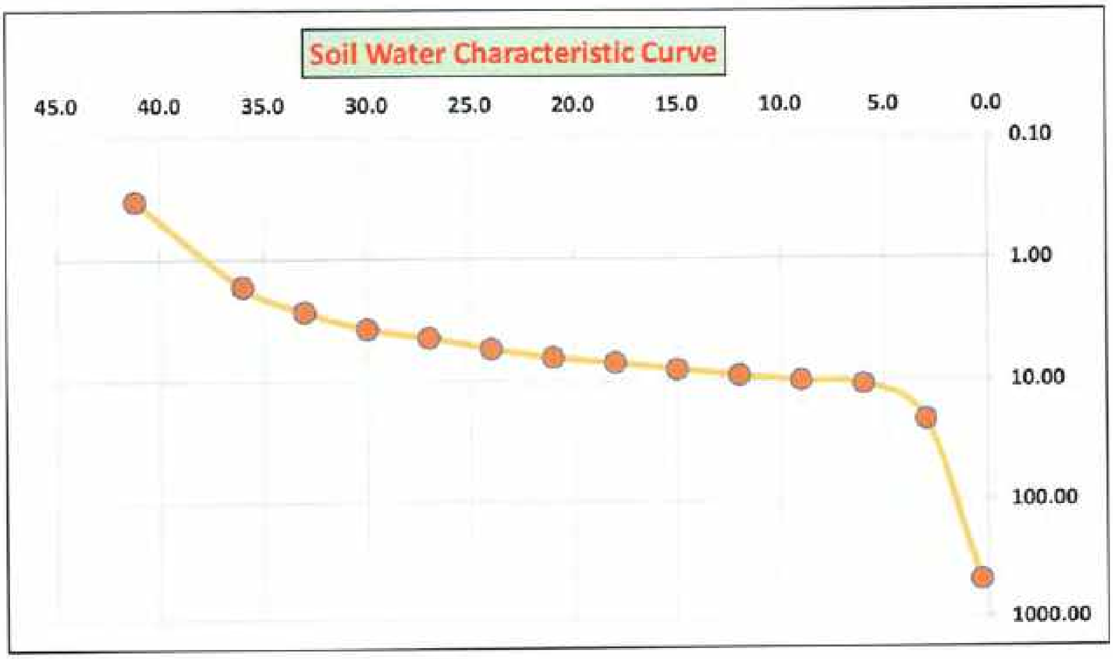
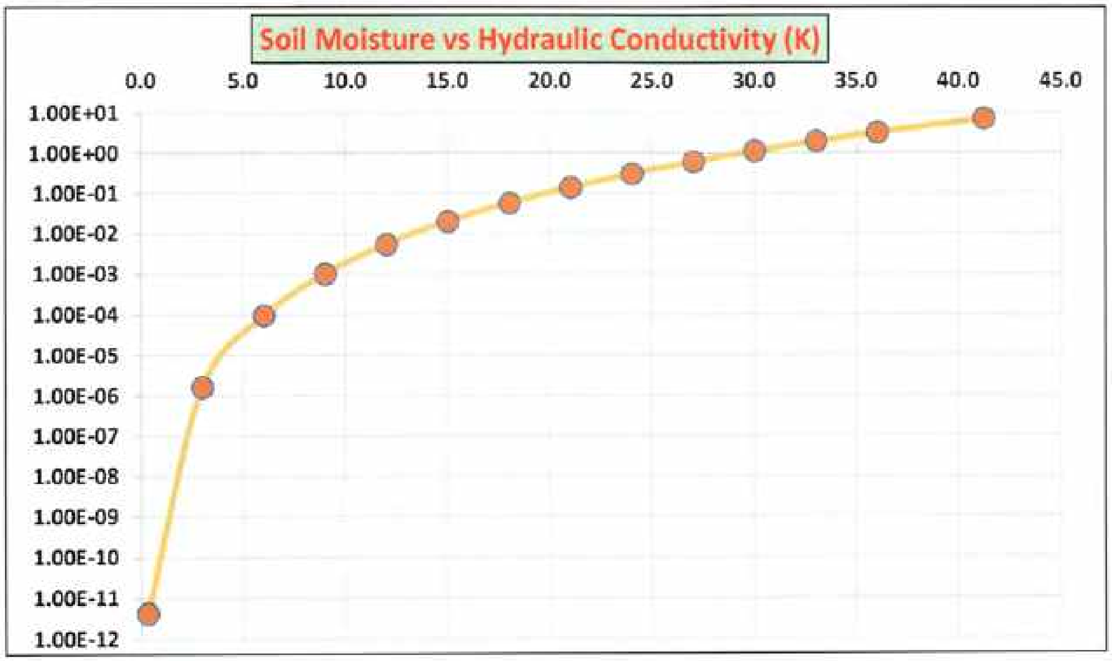


Figure-2:


Soil Moisture vs Hydraulic Conductivity (K)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12

The pore size distribution is used in many infiltration models. The Brooks-Corey parameter is most commonly used and is calculated here. The variables include the following:

- C= percent clay (5<%<60)
- S= percent sand (5<%<70)
- ϕ= porosity (volume fraction)

INPUT VARIABLES

$C := 0.24$

$S := 90.6$

$\phi := 0.418$

$$\lambda := \exp\begin{bmatrix} -0.7842831 + 0.0177544 \cdot S - 1.062498 \cdot \phi - 0.00005304 \cdot S^2 - 0.00273493 \cdot C^2 \ldots \\ + 1.1113496 \cdot \phi^2 - 0.03088295 \cdot S \cdot \phi + 0.00026587 \cdot S^2 \cdot \phi^2 - 0.00610522 \cdot C^2 \cdot \phi^2 \ldots \\ + \left(-0.00000235 \cdot S^2 \cdot C\right) + 0.00798746 \cdot C^2 \cdot \phi - 0.00674491 \cdot \phi^2 \cdot C \end{bmatrix} = 0.52$$

Green-Ampt Explicit Model (GAEXP)

A. Description

The *Green-Ampt model* is the first physically-based equation describing the infiltration of water into a soil. It has been the subject of considerable developments in soil physics and hydrology owing to its simplicity and satisfactory performance for a great variety of water infiltration problems. This model yields cumulative infiltration and infiltration rate as implicit functions of time, *i.e.*, given a value of time, *t*, *q* and *I* cannot be obtained by direct substitution. The equations have to be solved in an iterative manner to obtain these quantities. Therefore, the required functions are *q(t)* and *I(t)* instead of *t(q)* and *t(I)*. The Green Ampt explicit model (GAEXP) for *q(t)* and *I(t)*, developed by Salvucci and Entekhabi (1994), facilitated a straight forward and accurate estimation of infiltration for any given time. This model supposedly yield less than 2% error at all times when compared to the exact values from the implicit Green-Ampt model. A scenario was chosen to simulate the water infiltration into a sandy soil under ponding conditions by using the GAEXP model. A ponding depth of 1 cm was applied at the soil surface. Input parameters and simulation results were given below.

B. Definition of Variables

$h_e := -104$	Air entry head from test (cm)
$\lambda := 0.51$	The exponent of the Brooks-Corey water retention model
$\theta_s := 0.418$	Saturated volumetric water content (cm^3/cm^3)
$\theta_0 := 0.029$	Initial volumetric water content (cm^3/cm^3)
$K_s := 15.9$	Saturated hydraulic conductivity (cm/h)
$h_s := 152$	Ponding depth or capillary pressure head at the surface (cm)
$t := 0.1, 0.2 .. 1.5$	Duration of infiltration (h)

Values given above were obtained from Carsel and Parrish (1988) for a sandy soil.

C. Equations

$$\eta := (2 + 3 \cdot \lambda) \quad (1)$$

$$h_f := \frac{\eta}{(\eta - 1)} \cdot h_e \quad (2)$$

Capillary pressure head at the wetting front

$$\chi := \frac{(h_s - h_f) \cdot (\theta_s - \theta_0)}{K_s} \quad (3)$$

$$\tau(t) := \frac{t}{(t + \chi)} \quad (4)$$

$$q(t) := \left[\left(\frac{\sqrt{2}}{2}\right) \cdot \tau(t)^{\left(-\frac{1}{2}\right)} + \left(\frac{2}{3}\right) - \left(\frac{\sqrt{2}}{6}\right) \cdot \tau(t)^{\frac{1}{2}} + \left(\frac{1 - \sqrt{2}}{3}\right) \cdot \tau(t)\right] \cdot K_s \quad (5)$$

Infiltration rate

$$I(t) := \left[\left(1 - \frac{\sqrt{2}}{3}\right)\cdot t + \frac{\sqrt{2}}{3}\cdot\sqrt{\chi\cdot t + t^2} + \left(\frac{\sqrt{2}-1}{3}\right)\cdot\chi\cdot(\ln(t+\chi) - \ln(\chi)) + \frac{\sqrt{2}}{3}\cdot\chi\cdot\left(\ln\left(t + \frac{\chi}{2} + \sqrt{\chi\cdot t + t^2}\right) - \ln\left(\frac{\chi}{2}\right)\right)\right]\cdot K_s \quad (6)$$

D. Results

t =	q(t) =	I(t) =
0.1	$1.07\cdot10^2$	20.24
0.2	78.63	29.27
0.3	66.24	36.45
0.4	58.86	42.68
0.5	53.83	48.3
0.6	50.11	53.49
0.7	47.23	58.35
0.8	44.91	62.95
0.9	42.99	67.34
1	41.36	71.56
1.1	39.96	75.62
1.2	38.75	79.56
1.3	37.67	83.38
1.4	36.72	87.09
1.5	35.86	90.72

Cumulative infiltration

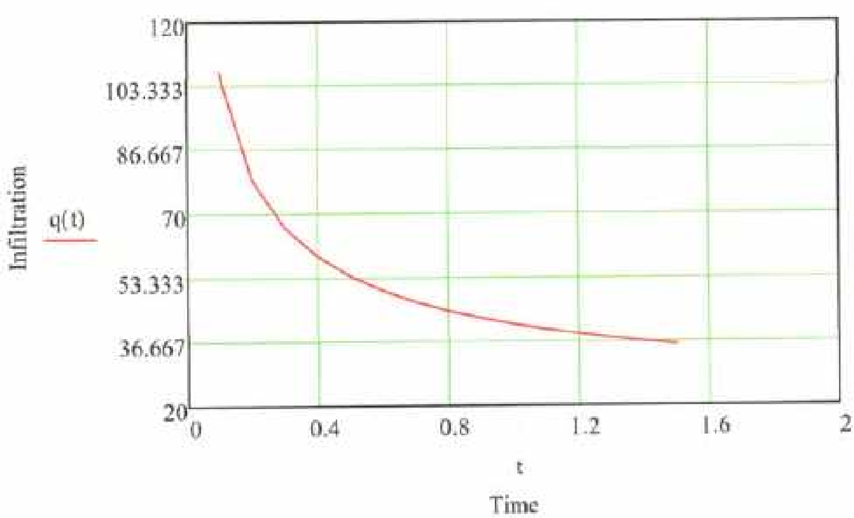


Figure 1. Soil infiltration as a function of time.

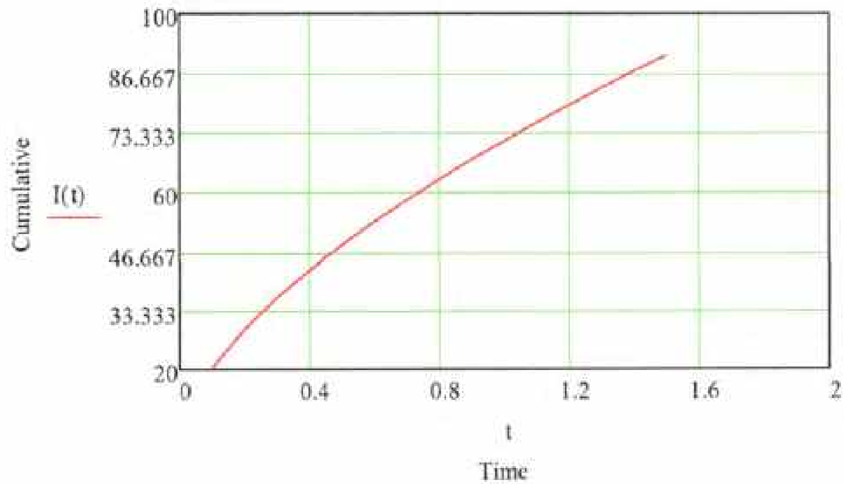


Figure 2. Cumulative Infiltration as a function of time.

E. Discussion

Figures 1 and 2 show the soil water infiltration rate and cumulative infiltration as a function of time, respectively. A rapid decrease in water infiltration rate was observed within the first hour.

F. Sensitivity Analysis of Infiltration Rate to Saturated hydraulic Conductivity

This section shows the sensitivity coefficient (S_s) and the relative sensitivity (S_r) of the surface infiltration rate, q, to the saturated hydraulic conductivity (K_s) at the time of 1 hours. The expressions were obtained by applying Equations 3 and 4 in Section B2 (PHILIP2T model) to Equation 5 in this section.

F.1. Input Data

$K_s := 7.5, 7.6..8.9 \qquad t := 5$

F.2. Sensitivity Calculation Equations

$$\chi(K_s) := \frac{(h_s - h_f)\cdot(\theta_s - \theta_0)}{K_s} \quad (7)$$

$$\pi(K_s) := \frac{t}{(t + \chi(K_s))} \quad (8)$$

$$q(K_s) := \left[\left(\frac{\sqrt{2}}{2}\right)\cdot\tau(K_s)^{\left(-\frac{1}{2}\right)} + \left(\frac{2}{3}\right) - \left(\frac{\sqrt{2}}{6}\right)\cdot\tau(K_s)^{\frac{1}{2}} + \left(\frac{1-\sqrt{2}}{3}\right)\cdot\tau(K_s)\right]\cdot K_s \qquad (9)$$

$$S_s(K_s) := \frac{d}{dK_s}q(K_s) \qquad \textbf{Sensitivity} \qquad (10)$$

$$S_r(K_s) := \left(\frac{d}{dK_s}q(K_s)\right)\cdot\left(\frac{K_s}{q(K_s)}\right) \qquad \textbf{Relative Sensitivity} \qquad (11)$$

F.3.Results

$K_s =$	$q(K_s) =$	$S_s(K_s) =$	$S_r(K_s) =$
7.5	14.59	1.34	0.69
7.6	14.72	1.33	0.69
7.7	14.85	1.33	0.69
7.8	14.99	1.32	0.69
7.9	15.12	1.32	0.69
8	15.25	1.32	0.69
8.1	15.38	1.31	0.69
8.2	15.51	1.31	0.69
8.3	15.64	1.31	0.69
8.4	15.77	1.3	0.69
8.5	15.9	1.3	0.7
[illegible]	[illegible]	[illegible]	[illegible]

8.6	16.03	1.3	0.7

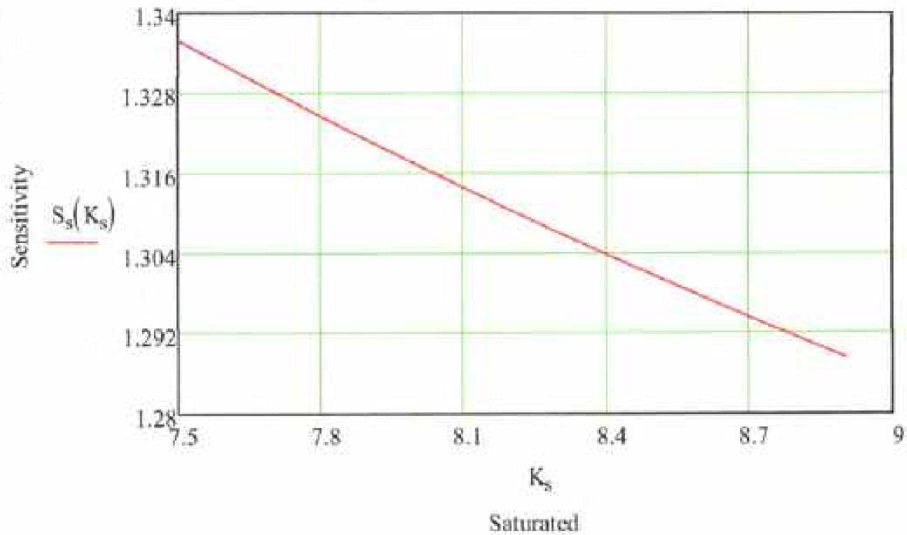


Figure 3. Sensitivity of infiltration rate for different values of saturated hydraulic conductivity at t = 5 hours.

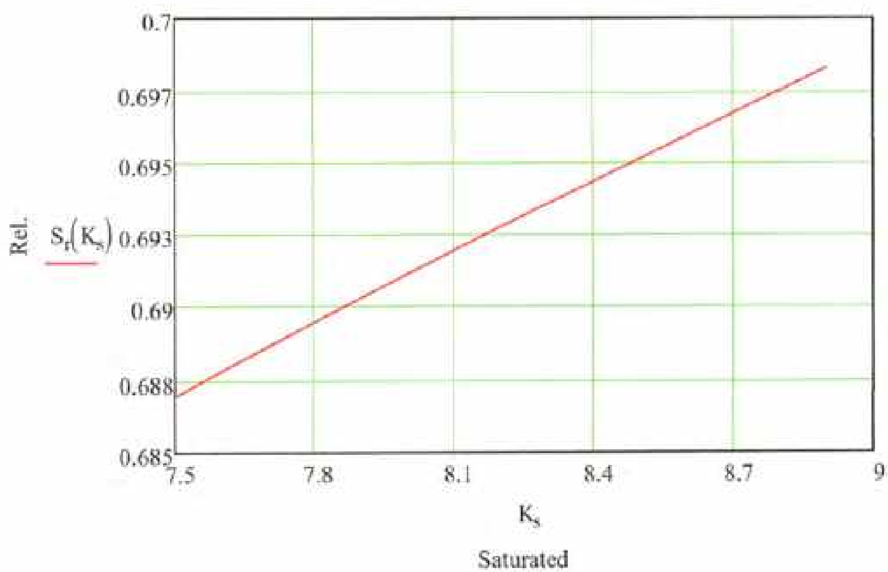


Figure 4. Relative sensitivity of infiltration rate for different values of saturated hydraulic conductivity at t = 5 hours.

F.4. Discussion

Figure 3 shows a sensitivity of the infiltration rate for different values of saturated hydraulic conductivity. The sensitivity decreased as the saturated hydraulic conductivity increased. Figure 4 shows the relative sensitivity of the infiltration rate for different values of saturated hydraulic conductivity. The relative sensitivity increased as the saturated hydraulic conductivity increased.

Soil Sample Analysis Input:

Project: Bush		Sample ID: INFTP-2		Depth: 2.5 - 3.0 ft			
SAND %	CLAY %	SILT %	Saturation % (vol.)	Bulk Density (lb/ft^3)	Effective Porosity % (vol.)	Saturated Hydraulic Conductivity K_s (in/hr)	In-Situ Soil Moisture %
90.6	2.4	7.0	41.8	96.20	4.6	8.01	2.90

Moisture Calculation:

Water %	Matric Potential (bars)	Matic Potential (ft)	K (in/hr)
0.3	14.70	491.81	3.16E-12
3.0	0.60	20.07	1.92E-06
6.0	0.32	10.71	1.06E-04
9.0	0.29	9.70	1.10E-03
12.0	0.27	9.03	5.83E-03
15.0	0.24	8.03	2.12E-02
18.0	0.21	7.03	6.08E-02
21.0	0.19	6.36	1.48E-01
24.0	0.16	5.35	3.21E-01
27.0	0.13	4.35	6.35E-01
30.0	0.11	3.68	1.17E+00
33.0	0.08	2.68	2.03E+00
36.0	0.05	1.67	3.35E+00
41.4	0.01	0.33	7.52E+00

Figure-1:

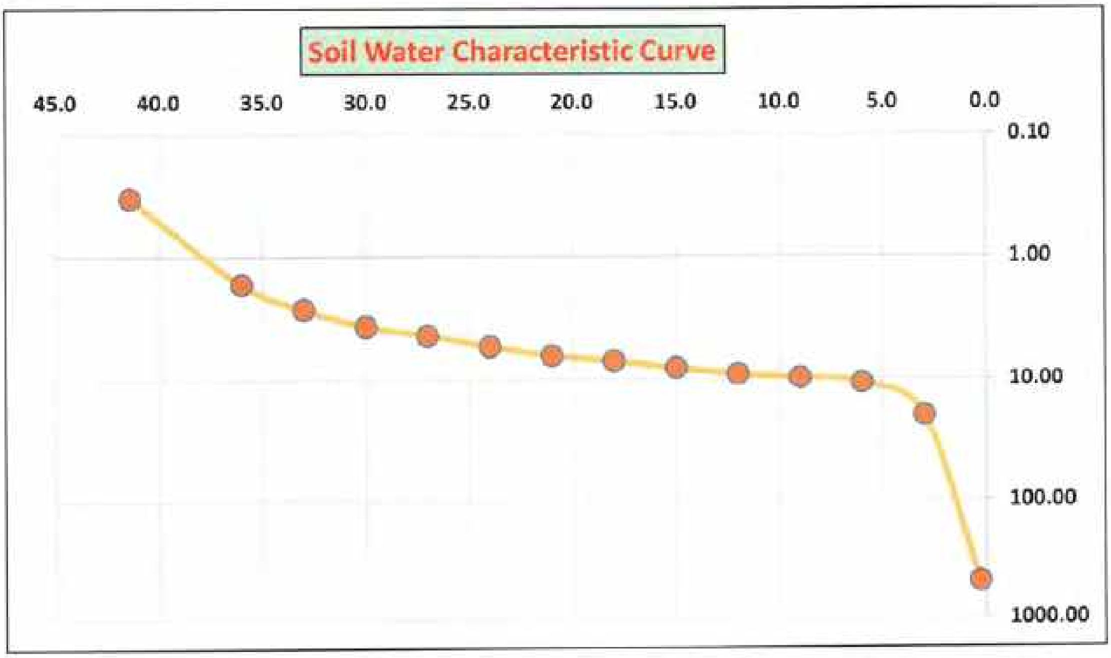
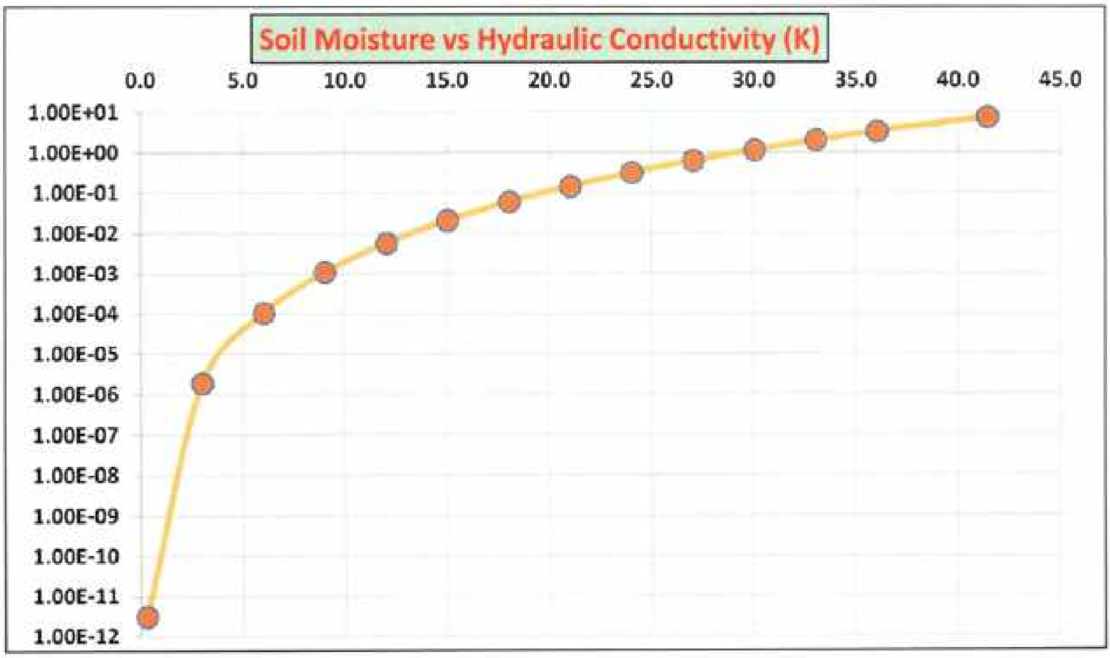


Figure-2:


Soil Moisture vs Hydraulic Conductivity (K)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12

Soil Sample Analysis Input:

Project: Bush		Sample ID: INFTP-15		Depth: 3.0 - 3.5 ft			
SAND %	CLAY %	SILT %	Saturation % (vol.)	Bulk Density (lb/ft^3)	Effective Porosity % (vol.)	Saturated Hydraulic Conductivity K_s (in/hr)	In-Situ Soil Moisture %
95.6	2.4	2.0	42.5	95.05	3.6	9.61	2.93

Moisture Calculation:

Water %	Matric Potential (bars)	Matic Potential (ft)	K (in/hr)
0.2	11.96	400.14	1.62E-12
3.0	0.41	13.72	4.61E-06
6.0	0.31	10.37	2.07E-04
9.0	0.29	9.70	1.91E-03
12.0	0.26	8.70	9.26E-03
15.0	0.24	8.03	3.15E-02
18.0	0.21	7.03	8.57E-02
21.0	0.18	6.02	2.00E-01
24.0	0.16	5.35	4.15E-01
27.0	0.13	4.35	7.92E-01
30.0	0.11	3.68	1.41E+00
33.0	0.08	2.68	2.38E+00
36.0	0.06	2.01	3.84E+00
39.0	0.03	1.00	5.96E+00
42.0	0.01	0.33	8.95E+00

Figure-1:

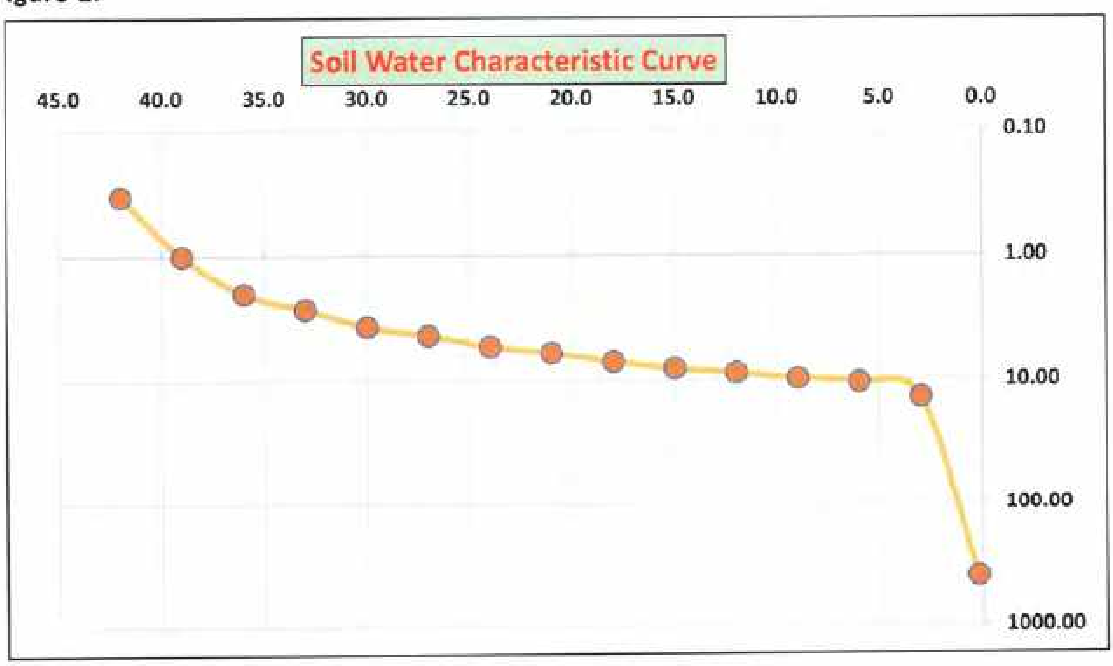
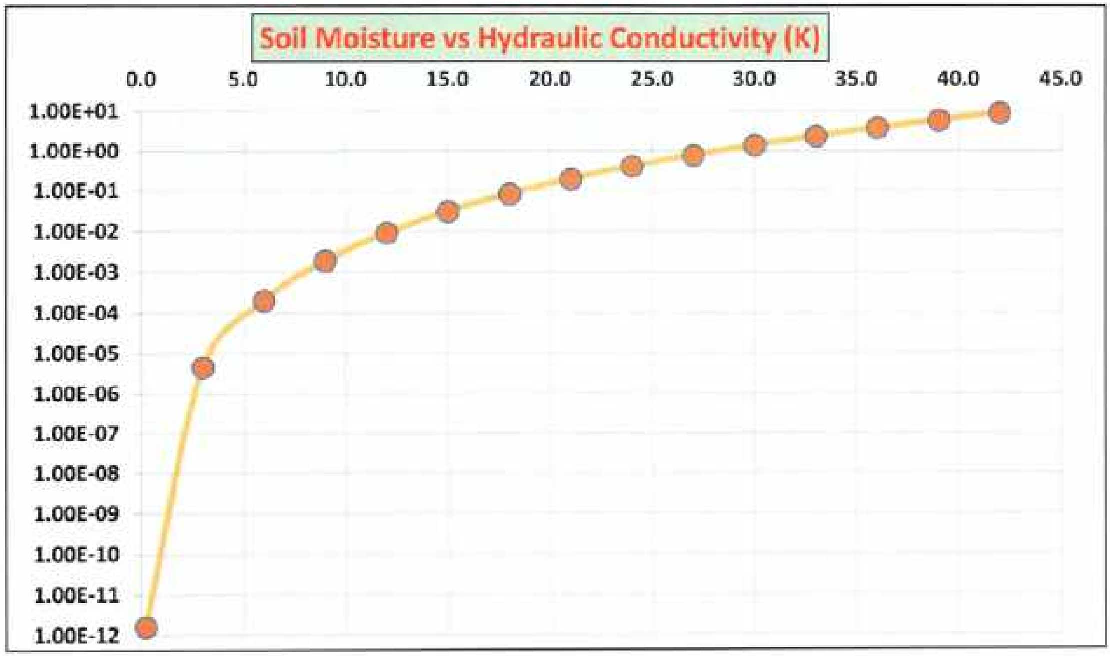


Figure-2:


Soil Moisture vs Hydraulic Conductivity (K)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12

Soil Sample Analysis Input:

Project: Bush		Sample ID: INFTP-2		Depth: 9.0 - 9.5 ft			
SAND %	CLAY %	SILT %	Saturation % (vol.)	Bulk Density (lb/ft^3)	Effective Porosity % (vol.)	Saturated Hydraulic Conductivity K_s (in/hr)	In-Situ Soil Moisture %
95.6	3.4	1.0	42.1	95.84	4.3	6.25	2.82

Moisture Calculation:

Water %	Matric Potential (bars)	Matic Potential (ft)	K (in/hr)
0.8	15.00	501.84	5.92E-13
3.0	0.75	25.09	1.15E-08
6.0	0.32	10.71	2.25E-06
9.0	0.29	9.70	4.94E-05
12.0	0.27	9.03	4.42E-04
15.0	0.24	8.03	2.42E-03
18.0	0.21	7.03	9.71E-03
21.0	0.19	6.36	3.14E-02
24.0	0.16	5.35	8.69E-02
27.0	0.13	4.35	2.13E-01
30.0	0.11	3.68	4.76E-01
33.0	0.08	2.68	9.84E-01
36.0	0.05	1.67	1.91E+00
39.0	0.03	1.00	3.51E+00
40.6	0.01	0.33	3.80E+00

Figure-1:

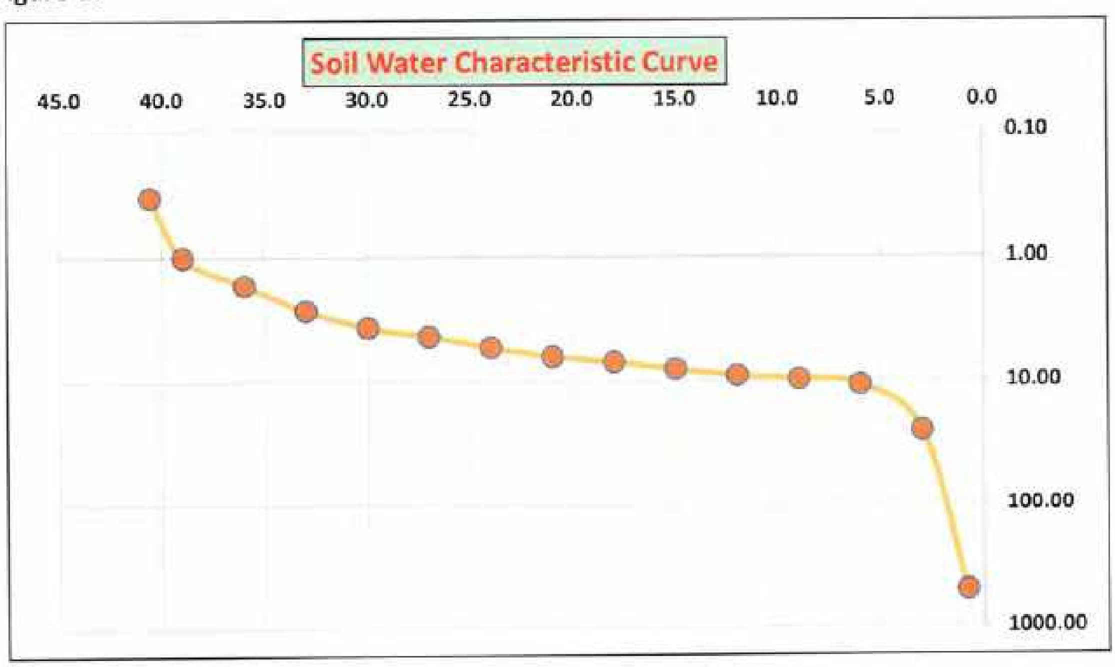
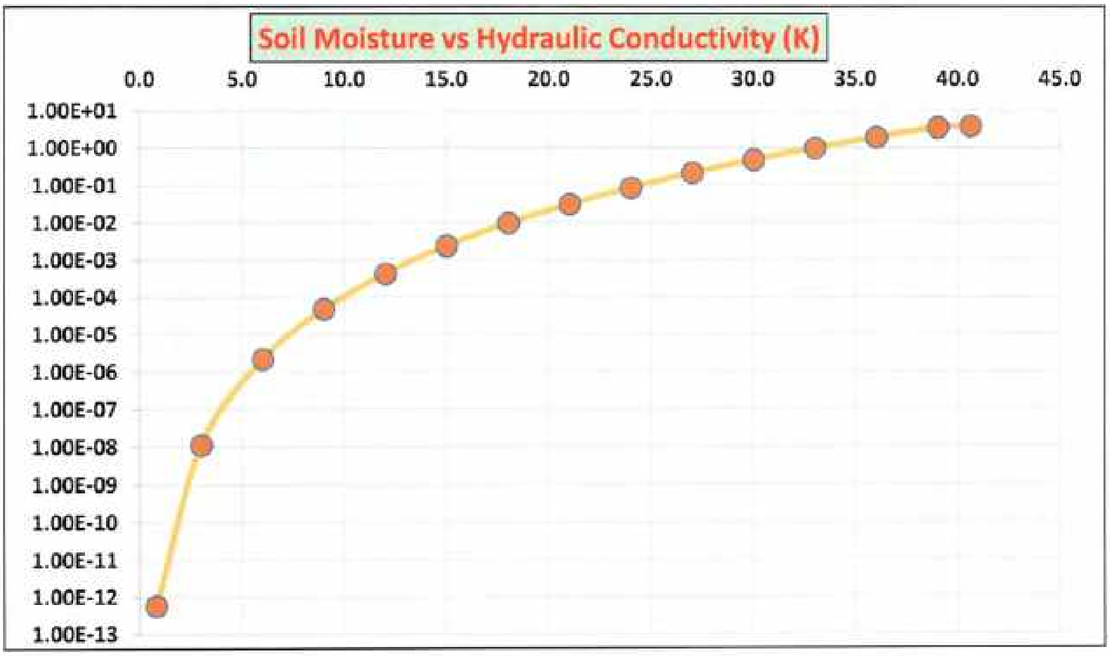


Figure-2:


Soil Moisture vs Hydraulic Conductivity (K)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
1.00E+01
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
1.00E-08
1.00E-09
1.00E-10
1.00E-11
1.00E-12
1.00E-13

KUO TESTING LABS

AGRICULTURAL | INDUSTRIAL | ENVIRONMENTAL

Main Office: 337 1st Ave, Othello, WA 99344
Oregon Office: 1300 Sixth St., Suite J, Umatilla, OR 97882
Pasco Office: 1320 E Spokane St., Pasco, WA 99301
(509) 488-0112
info@kuotestinglabs.com

Sample Analysis Report

Date: September 4, 2020
Report No: 64818
Grower: Bush
Client: White Shield, Inc.
Sampler: Michael Black

Sample Date: 9/1/2020
Sample ID: INFTP-1 4-4.5ft
Sample Type:
Lab No: 370122
Depth: 48-54

Analysis	Unit	Result
Clay	%	**2.4**
Moisture-Soil	%	**2.82**
Sand	%	**87.6**
Silt	%	**10**
Texture		**Sand**

KTL
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Pasco Office: 1320 E Spokane St., Pasco, WA 99301
(509) 488-0112 info@kuotestinglabs.com

Sample Analysis Report

Date:	September 4, 2020	Sample Date:	9/1/2020
Report No:	64818	Sample ID:	INFTP-1 8-8.5ft
Grower:	Bush	Sample Type:	
Client:	White Shield, Inc.	Lab No:	370123
Sampler:	Michael Black	Depth:	96-102

Analysis	Unit	Result
Clay	%	**2.4**
Moisture-Soil	%	**3.48**
Sand	%	**77.6**
Silt	%	**20**
Texture		**Loamy Sand**

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Sample Analysis Report

Date:	September 4, 2020	**Sample Date:**	9/1/2020
Report No:	64818	**Sample ID:**	**INFTP-1 9-9.5ft**
Grower:	**Bush**	**Sample Type:**	
Client:	**White Shield, Inc.**	**Lab No:**	370124
Sampler:	**Michael Black**	**Depth:**	108-114

Analysis	Unit	Result
Clay	%	**2.4**
Moisture-Soil	%	**2.86**
Sand	%	**89.6**
Silt	%	**8**
Texture		**Sand**

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info@kuotestinglabs.com

Sample Analysis Report

Date: September 4, 2020	Sample Date: 9/1/2020
Report No: 64818	Sample ID: INFTP-2 2.5-3ft
Grower: Bush	Sample Type:
Client: White Shield, Inc.	Lab No: 370125
Sampler: Michael Black	Depth: 30-36

Analysis	Unit	Result
Clay	%	**2.4**
Moisture-Soil	%	**2.9**
Sand	%	**90.6**
Silt	%	**7**
Texture		**Sand**

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info@kuotestinglabs.com

Sample Analysis Report

Date: September 4, 2020
Report No: 64818
Grower: Bush
Client: White Shield, Inc.
Sampler: Michael Black

Sample Date: 9/1/2020
Sample ID: INFTP-2 9-9.5ft
Sample Type:
Lab No: 370126
Depth: 108-114

Analysis	Unit	Result
Clay	%	**3.4**
Moisture-Soil	%	**2.82**
Sand	%	**95.6**
Silt	%	**1**
Texture		**Sand**

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(509) 488-0112
info@kuotestinglabs.com

Sample Analysis Report

Date:	September 4, 2020	Sample Date:	9/1/2020
Report No:	64818	Sample ID:	INFTP-15 3-3.5ft
Grower:	Bush	Sample Type:	
Client:	White Shield, Inc.	Lab No:	370127
Sampler:	Michael Black	Depth:	36-42

Analysis	Unit	Result
Clay	%	2.4
Moisture-Soil	%	2.93
Sand	%	95.6
Silt	%	2
Texture		Sand

Project : **Air Entry Permeameter Test**

Client : **BUSH**

Date : 9/1/2020

INFTP-1

Pmin=	7.70 in H20 (0.64 ft)	**Time (in Min)**	**Level of reservoir(Drop)**
Hr =	1.77 ft	0:00	0.50 ft
G =	1.01 ft	0:30	0.47 ft
Lf =	1.03 ft	1:00	0.44 ft
Pa =	Pmin + G + Lf	1:30	0.42 ft
Pa =	0.64 ft +1.01 ft +1.03 = **2.68 ft**	2:00	0.40 ft

Permeameter = 2.68 ft (Expressed in negative water-pressure head)

82cm ~~81cm~~ 82cm

Vertical Hydraulic Conductivity (K)

K = (Lf(dHr/dt)(rr/rc)^2)/(Hr+Lf-0.5Pa)

K = [(1.03 ft)((0.03 ft/30 sec)(3600 sec/1hr))((0.5 ft)/(1.0 ft))^2]/{(1.77 ft + 1.03 ft-0.5(2.68ft)} =0.635 ft/hr = 7.62in/hr

Vertical Hydraulic Conductivity = 0.635 ft/hr = 7.62 in/hr

INFTP-2

		Time (in Min)	Level of reservoir(Dro
Pmin=	11.40 in H20 (0.95 ft)	0:00	0.49 ft
Hr =	1.81 ft	0:30	0.39 ft
G =	1.02 ft	1:00	0.31 ft
Lf =	1.45ft	1:30	0.23 ft
Pa =	Pmin + G + Lf	2:00	0.15 ft
Pa =	0.95 ft +1.02 ft +1.45 ft = **3.42 ft**		

Permeameter = 3.42 ft(expressed in negative water-pressure head)
104 cm

Vertical Hydraulic Conductivity (K)

K = (Lf(dHr/dt)(rr/rc)^2)/(Hr+Lf-0.5Pa)

K = [(1.45 ft)((0.08ft/30 sec)(3600 sec/1hr))((0.5 ft)/(1.0 ft))^2]/{(1.81 ft +1.45 ft-0.5(3.24ft)} = 2.12 ft/hr = 25.44 in/hr

Vertical Hydraulic Conductivity = 2.12 ft/hr = 25.44 in/hr