J.C. Mc DONNELL ENGINEERING, P.C.
Consulting Civil Engineers
P.O. Box 13199
Mill Creek, WA. 98082

DRAINAGE REPORT

FOR

Loney 2-Lot Short Plat
PFN: _____

IN
CITY OF MUKILTEO, WA.

SITE ADDRESS:
1603 Debrelon Lane
Sec. 03, T 28 N, R 4E WM
Snohomish County, Washington

TAX ID: 2804300200200
DATE: MAY 31, 2019
REVISED:

LEGAL DESCRIPTION:
SEC 03 TWP 28 RGE 04 BEG AT NW COR GOVT LOT 3 TH ELY ALG N LN SD GOVT LOT 3 DIST 569.59FT TH S32*10 50E DIST 412.8FT TH S62*05 10W DIST 35FT TO MOST ELY COR TR DEEDED TO ELLIOT F. BROWN JULY 18,1957TH S32*10 50E DIST 40FT TH S32*10 50E DIST 90FT TPB TH CONT S32*10 50E DIST OF 100FT TH N62*05 10E DIST 190FT TH N32*10 50W FOR DIST 100FT TH S62*10 10W DIST 190FT TO TPB

OWNER: LONEY DAVID/JOAN
ADDRESS: 12661 WEST SAN JUAN COURT,
LITCHFIELD PARK, AZ 85340

PREPARED BY:
John McDonnell, MS, PE

LAND SURVEYOR:
PGIS INC. – RON HILLIARD, PLS
(425) 778-5620

(off) 425 744-0916 *(cell) 425 359-2717* *(fax) 425 744-0946*

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SECTION I - PROJECT OVERVIEW

Project Description: The Loney SP is located on the east end of Debrelon at 1603 Debrelon. The 0.435 AC project lot was created in a prior three lot Mukilteo subdivision . The subject lot is remote to the south from the Debrelon frontage and is accessed by a long curving easement driveway to the east and south on property described as NGPA or "To Remain Undeveloped". There is an existing Concrete Detention Vault off the SE corner of the Loney lot, which was originally desgned to serve the Kailash Heights plat of 8-lots was used to serve the subsequent project known as the Kari Short Plat, a project constructed to the west of the Loney's. See discussion on the following pages. The Lot-2 access proposed will be via an existing paved driveway apron constructed off of the existing Lot access driveway adjacent to the detention vault.

There is an existing house on the west half of the parcel and a large vacant area on the east half of the parcel. The vacant area will become a new 8,500 SF lot with a building envelope facing east and access provided from the ASPH apron mentioned above. A tiered elevation of the Lot, stepping up the slope to the new house, will require that access be taken from the apron into a basement garage.

The 0.435 acre parcel is to be subdivided into 2 lots. The existing house will be described as Lot 1. The proposed Lot will be described as Lot 2.

Drainage Concept: The Geotechnical Engineer has required that infiltration **not be used** based upon the steep embankment east of the building site and the fill nature of the soils involved. Therefore, the overall drainage concept for the roof areas will direct the roof runoff to the downstream conveyance, the pipe discharging from the existing detention vault located at the southeast corner of the property. This is in conformance with Section 3.1.1 of the 2012 DOE Storm Drainage Manual. The driveway area will be diverted via existing Storm Drain into the detention vault as elevation permits. *Since the Site is generally not suitable for LID by Geotechnical determination. Since the Project does not meet the threshold of 10,000 sf of new or replacement Impervious Surface for detention under the 2014 Department of Ecology manual requirement, it is totally appropriate to route the site stormwater through the available proven storm conveyance to the Downstream Channel. Q100 flow is far less than 0.15 cfs so impacts to the facility are expected to be insignificant.*

Therefore, runoff from the proposed building rooftop will be directly discharged into the existing pipe conveyance east of the vault without restriction. The total area of roof top is 1,377 sf. Affected driveway surface is 673 SF. Total proposed impervious is 2,050 SF.

Runoff quality control: Runoff from Pollution Generating Surfaces (PGIS) will not receive treatment for water quality as the 673 SF driveway and concrete surfaces are much less in square footage than the 5,000 SF treatment threshold. Thus no water quality or detention is actually required.

Soil Conditions: Soil exploration indicated that the site area was generally underlain by loose to medium dense undocumented fill soils with localized areas underlain by medium dense sand or better, fine to medium sand with silt interpreted by the Geotechnical Engineers as native standard outwash soils. Based upon the fill conditions, it was further recommended by Nelson Geotechnical Group, that the structure be developed on 4-inch driven piles to place building loads on deeper "more competent native deposits.

The geotechnical Storm Drainage recommendation was to collect surface water into a storm collection system and safely discharge into an appropriate drainage system. Specifically, infiltration was not recommended on the site based upon the nature of the fill and the upstream and downstream slopes. Therefore, LID compliance cannot be achieved based upon the Geotechnical recommendations. The remainder of this report discusses the details.

There is an existing Concrete Detention Vault off the SE corner of the Loney lot, which was originally desgned to serve the Kailash Heights plat of 8-lots was used to serve the subsequent project known as the Kari Short Plat, a project constructed to the west of the Loney's. The situation was clearly discussed in the Kari SP Drainage Report by MAC Engineering. Our evaluation of the vault with WWHM2012 indicates there is no extra volume available in this vessel to serve the proposed house development. OHowever, one potential alternative not evaluated is to direct the flow from the proposed surfaces therough the Vault as a Bypass or overflow to the downstream. This option would accomplish the same purpose as the option selected with a much lower construction cost.

SECTION II – CONDITIONS AND REQUIREMENT SUMMARY

2012 Stormwater Management Manual for Western Washington:

***Minimum Requirement #1**: Preparation of Stormwater Site Plans*

The final engineering plans include existing conditions, a SWPPP, road / lot grading and how the storm water runoff will either be collected and routed to drainage facilities for detention and restricted discharge in conjunction with this Drainage Report.

Minimum Requirement #2: Construct Stormwater Prevention Plan (SWPPP)

A SWPPP has been prepared as part of the final construction plans and addresses the following:

a) Safe Construction access will be established for construction traffic.

b) Haul-out trucks will be confined to travelling on pavement and maintained surfaces. Construction truck routing will be limited to Debrelon.

c) Sediment controls may include silt traps in CB's and silt fencing as needed. The volume of silt collection needed is expected to be small based upon the COM "Determining Construction Site Sediment Damage Potential" worksheet (Attached in Section V, Special Report).

Minimum Requirement #3: Source Control of Pollution
Pollution control is not required for this project as the proposed driveway surface is much less than the 5,000 SF threshold triggering a treatment response.

Minimum Requirement #4: *Preservation of Natural Drainage Systems & Outfalls*
The Short Plat project creates a single new residential lot, which currently drains by sheet flow to the downstream. The site has already been cleared as part of the construction of the existing house.

Minimum Requirement #5: On-site Stormwater Management
Geotechnical Site Analysis and Infiltration Assessment: The Report by Nelson admonishes Contractors to collect ground water and surface drainage to be discharged through appropriate drainage systems. No infiltration is permitted on these soils.

Geotechnical Site Analysis and Infiltration Assessment:
A Geotechnical Engineering Study has been completed by Nelson Geotechnical Associates and is discussed in Section V of this report. The report was required by the City of Mukilteo to evaluate the suitability of the Site regarding development and slope issues. Infiltration and the design of Low Impact Development features were not addressed directly in the original Report.

Minimum Requirement #5: On-site Stormwater Management (cont.)

Based upon verbal contacts with the Geotechnical firm, they did not recommend consideration of on-site infiltration for this project. Detention was determined to be the Drainage Management technique of choice by the geotechnical engineer, if necessary. Circumstantially, however, detention is not required by the Ecology 2012 Stormwater Management Manual (SWMMWW) for projects of this size, i.e. developments of less than 10,000 SF on new impervious. This project is 2,050 sf of new impervious.

Lawn and landscaped areas:

Post-Construction Soil Quality and Depth shall be managed in accordance with BMP T5.13 in Chapter 5 of Volume V, DOE 2012. By increasing the depth and water holding capacity of the topsoil, yard areas meeting the guidelines of BMP T5.13 may be modeled as "Pasture" rather than "Lawn".

Roofs,

1. Full Dispersion is not recommended by the Project Geotechnical Engineers on this project because of steep slopes nearby and underlying fill soil conditions. Paved areas are below the plane of the house development but are routable to the downstream storm system via a proposed Storm Drain .There is no suitable path for dispersion

2. **Bioretention** ***facilities are specifically rejected due*** to *the transitional slopes in question, unavailable useable land area for the footprint, proximity of "wetland & buffer" and the soil conditions previously identified.*

3. Downspout Dispersion Systems in accordance with BMP T5.10B in Chapter 3 of the manual. ***Downspout Dispersion is not proposed for the project due to the lack of enough vegetated flow path.***

4. Perforated Stub-out Connections in accordance with BMP T5.10C in Section 3.1.3 in Chapter 3 of DOE 2012 Volume III.

   Perforated stub-out connections are NOT feasible for roof drain connections in the landscaping. Dispersion is not recommended by the Geotechnical Engineer due to the fill soils on the site and other related issues.

SECTION II – CONDITIONS AND REQUIREMENT SUMMARY (cont.)

Driveway:

1. Full Dispersion in accordance with BMP T5.30 in Chapter 5 of DOE 2012 Volume V
   Full dispersion is <u>not proposed</u> because there is not any suitable vegetated flow path available.
2. Permeable pavement in accordance with BMP T5.15 in chapter 5 of Volume V.

   Permeable pavement is <u>not proposed</u> due to the fill characteristics if the property.

3. Bioretention BMP's (See Chapter 7, Volume V) are not selected due to the specific geotechnical characterizations of the Site.

   Bioretention is <u>not proposed</u> for the project. No suitable site area available.

4. Sheet Flow Dispersion in accordance with BMP T5.12,

   Sheet Flow Dispersion <u>is not proposed</u> for roadway surfaces due to the limited or unavailable flow paths.

SECTION III– OFFSITE ANALYSIS

TASK 1: Upstream Analysis:

Field reconnaissance shows that potential upstream flows are very limited and will not be considered in the proposed development.

TASK 2: Downstream Analysis:

The Kari Short Plat Drainage Report explains that the entire hillside surrounding this proposed lot drains east into the large Ravine that drains from the Boeing Everett facility and Paine Field directly to Puget Sound.

McCall, et al. explains: "The Boeing airfield and plant site south of the site contribute runoff to the Ravine that flows north through the undeveloped portion of the site. The Ravine discharges to the Puget Sound at an oval culvert (24" wide by 28" high) crossing the existing railroad right-of-way lines approximately 1800 feet downstream of the site. The culvert has an 8-foot potential headwater depth. The Ravine banks are vegetated with native 2nd and 3rd growth forest with thick underbrush. Natural dead fall litters the stream throughout the majority of the downstream system. Sloughing of the ravine banks was noted along the drainage course, however no sloughing was observed within the stream bed itself. Numerous above ground culvert discharge to the ravine from public and private offsite drainage systems that contribute runoff to this stream. "

Therefore, no adverse impacts to the upstream or downstream drainage courses are anticipated with the addition of a single residence in the Loney Short Plat.

TASK 3: Drainage System and Problem Description:

Based upon the WWHM2012 Hydraulic Analysis of the impact of the proposed 2 lot development, there should be no impact by one individual house development on the existing downstream conveyance system. Low flow portions will infiltrate via the routing of roof runoff through the pervious roof drain connection pipes to the existing Detention Vault.

SECTION IV – FLOW CONTROL AND WATER QUALITY ANALYSIS AND DESIGN

EXISTING CONDITIONS OF PROPERTY

Exist Property SA	=	18,947 SF (0.435 AC)
Exist IMPERVIOUS	=	2,944 SF (0.0676 AC)
Exist PERVIOUS	=	16,003 SF (0.3674 AC)
TOTAL SITE	=	18,947 SF (0.435 AC)

Lot Slopes are steep on the front & back of the Lot #2 as proposed for a new building lot. Soils are medium sand to a depth of 3-4 feet. Deeper soils were described as either silt or fine/medium sand.

PROPOSED CONDITIONS

Lot #1 = 10,447 SF (0.2349 AC) This EXISTING CONDITION will remain and will be considered outside the DEVELOPMENT AREA.

DEVELOPMENT AREA
Lot #2 = 8,500 SF (0.195 AC)

ROOFTOP	=	1,377 SF
CONCRETE DRIVE	=	673 SF
PROPOSED IMPERVIOUS	=	2,050 SF (0.0471AC)

PROPOSED PERVIOUS = 6,444 SF (0.1479 AC)

This Site is unable to provide complete Infiltration on-site based upon the recommendations of the Geotechnical Engineer, Nelson Geotechnical Associates, Inc. The Site is classified as a Tributary Area (Sub-Basin 4) flowing into the existing Detention Vault for the Kari Short Plat (aka the Kailash Heights Plat, City File SD 2008-04). Therefore, it is proposed that the Site roof drain will be directed through a conventional "yard drain" structure into the existing Concrete Vault for Bypass into the controlled downstream discharge.

The Detention Vault was designed and constructed for the previously failed 8-lot the Kailash Heights project and was subsequently used for a 4-lot short plat development called the Kari Short Plat. Therefore, it is reasonable to expect that there remains excess detention capacity in the existing vault sufficient to manage runoff from one additional house. Since the SFR project does not trigger the appropriate thresholds in the DOE Manual, no hydraulic analysis beyond determination of undeveloped and developed flows (Delta Q100 << 0.1 cfs) is proposed at this writing to document said capacity.

Delta Q100 = 0.075 – 0.0068 = 0.068 cfs <<< 0.150 CFS

Conclusion:

Since the Site is not suitable for LID by Geotechnical determination and since the Project does not meet the detention threshold of 10,000 sf NPGIS for detention under the 2014 Department of Ecology manual requirement, it is totally appropriate to route the site stormwater through the available storm conveyance to the downstream. Q100 flow is far less than 0.15 cfs allowed by the Ecology Manual so impacts to the drainage system are expected to be insignificant.

Pipe Capacity

A 6" conveyance pipe is selected to carry the roof and driveway water in the road row to the 12" Storm Drain discharge line from the vault. A 6" pipe at 0.9 % has capacity of 0.57 cfs flowing full compared to a calculated Q100 runoff of 0.075 cfs. At the second run pipe slope increases to 421% for a full capacity of3.89 cfs. Pipes can easily contain the project runoff.

WATER QUALITY

Runoff treatment will not be required for this Project in accordance with Section 2.5.6, Volume 1, Minimum Technical Requirements. Water Quality Design Storm Volume has been calculated in this drainage report.

SECTION V– SPECIAL REPORTS

A. GEOTECHNICAL ENGINEERING STUDY by Nelson Geotechnical, Inc dated January 8, 2016.

B. AMENDED DRAINAGE REPORT FOR KARI SHORT PLAT dated 11/19/2012

NELSON GEOTECHNICAL ASSOCIATES, INC.
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November 3, 2016

Mr. and Mrs. David and Joan Loney
c/o Larry Throndsen - LOT Design Group
lthrondsen@msn.com

Geotechnical Engineering Evaluation
Loney Residence Development
1603 Debrelon Lane
Mukilteo, Washington
NGA File No. 971416

Dear Mr. and Mrs. Loney:

We are pleased to submit the attached report titled "Geotechnical Engineering Evaluation – Loney Residence Development – 1603 Debrelon Lane – Mukilteo, Washington." Our services were completed in general accordance with the proposal signed by you on September 20, 2016.

The property is currently occupied by an existing single-family residence within an upper relatively level bench area within the western portion of the property. The ground surface below and to the east of the existing residence descends moderately to steeply down from the upper bench area to east to a lower gentle to moderately sloping area within the eastern portion of the property. We understand that the proposed development will subdivide the existing property into separate western and eastern lots, and constructing a new single-family residence within the lower eastern portion of the property. The existing residence will remain as a part of the overall development plans. Specific grading and stormwater plans were not available at the time this proposal was prepared.

We explored the site with seven track-hoe excavated test pits extending to depths in the range of 7.0 to 11.0 feet below the existing ground surface. We also performed one hand auger exploration within the steep slope above the proposed residence. Our explorations indicated that the proposed new residence area is generally underlain by loose to medium dense, undocumented fill soils with localized areas of the site underlain by medium dense or better, fine to medium sand with silt, which we interpreted as native advanced outwash soils.

It is our opinion from a geotechnical standpoint that the site is compatible with the planned development provided that our recommendations are incorporated into the design and construction of this project. In our opinion, the significant amount of undocumented fill soils that underlie a majority of the proposed residence are not suitable to provide adequate support for foundation and slab loads utilizing conventional shallow foundations, without experiencing significant settlement and distress to the structure. Based on our explorations, we recommend that the proposed residence be supported on a deep foundation system consisting of 4-inch driven pin piles in order to advance the structure loads through the loose upper soils, down to more competent native deposits interpreted to underlie the site at depth. Due to our explorations

being generally unable to encounter medium dense or better soils to the depths explored, we would recommend that one or more test piles be installed within the proposed residence area to confirm design assumptions and estimate overall pile depths, prior to finalizing the foundation plan. We also recommend that if a basement slab-on-grade is proposed, it should also be supported on pin piles and be designed as a structural slab.

It is also our opinion that the soils that underlie the site and form the core of the site slopes should be stable with respect to deep-seated earth movements, due to their inherent strength and slope geometry. However, there is a potential for shallow sloughing and erosion events to occur on the steeper site slopes within the property. Based on our site observations, it is our opinion that the proposed structure setback of 25 feet from the toe of the steep slopes should provide adequate protection for the proposed residence from shallow failures originating on the steep slopes above, and help maintain the existing stability of the slopes. In the attached report, we have also included recommendations for site grading, foundation support, retaining walls and site drainage.

We should be retained to review and comment on final development plans and observe the earthwork phase of construction. We also recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications.

We appreciate the opportunity to provide service to you on this project. Please contact us if you have any questions regarding this report or require further information.

Sincerely,

NELSON GEOTECHNICAL ASSOCIATES, INC.

Khaled M. Shawish, PE
Principal

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Geotechnical Engineering Evaluation
Loney Residence Development
1603 Debrelon Lane
Mukilteo, Washington

INTRODUCTION

This report presents the results of our geotechnical engineering investigation and evaluation of the Loney Residence Development project located at 1603 Debrelon Lane in Mukilteo, Washington, as shown on the Vicinity Map in Figure 1. The purpose of this study is to explore and characterize the site's surface and subsurface conditions and to provide geotechnical recommendations for site development. For our use in preparing this report, we have been provided with a plan set titled "Preliminary Short Plat," dated June 22, 2016 and prepared by Pacific Geomatic Services, Inc., showing the existing site conditions and proposed development.

The site consists of a relatively level upper bench within the western portion of the property where a single-family residence and attached garage are located. The site extends moderately to steeply down from the bench to the east. The site is bounded to the south and east by wooded areas, and to the north and west by existing single-family residences properties. We understand development plans consist of subdividing the property into two separate western and eastern lots. A new single-family residence will be constructed with the lower eastern lot. Specific grading and stormwater handling plans were not available at the time this report was prepared. The existing site conditions and proposed development areas are shown on the Schematic Site Plan in Figure 2.

SCOPE

The purpose of this study is to explore and characterize the site surface and subsurface conditions, and provide opinions and recommendations for the proposed site development. Specifically, our scope of services included the following:

1. Review available soil and geologic maps of the area.
2. Explore the subsurface soil and groundwater conditions within the site with backhoe/trackhoe excavated test pits. Backhoe/trackhoe was subcontracted by NGA.
3. Map the conditions on the slope, evaluate current slope stability conditions.
4. Perform shallow hand explorations on the site slopes, as needed.
5. Provide our opinion regarding the stability conditions of the site slopes.
6. Provide recommendations for setbacks from the steep slopes.

7. Perform grain-size sieve analysis on soil samples, as needed.
8. Provide recommendations for earthwork, foundation support, and slabs-on-grade.
9. Provide recommendations for retaining walls.
10. Provide recommendations for temporary and permanent slopes.
11. Provide recommendations for pavement subgrade.
12. Provide recommendations for site drainage and erosion control.
13. Document the results of our findings, conclusions, and recommendations in a written geotechnical report.

SITE CONDITIONS

Surface Conditions

The site consists of a rectangular-shaped parcel covering approximately 0.41 acres. The property is currently occupied by an existing single-family residence structure and attached garage located within the upper western portion of the site. There is an approximately twelve-foot-tall, block retaining wall located to the east of the existing residence. From the existing residence, driveway, and block retaining wall, the site slopes moderately to steeply down to the east to a gently sloping bench area and then continues to slope moderately down to the east to the eastern property line at gradients in the range of 7 to 28 degrees (12 to 53 percent) as shown on Cross Sections A-A' and B-B' in Figures 3 and 4, respectively. The site is generally vegetated with grass and landscaping vegetation with a few scattered young to mature deciduous trees. The property is bordered to the south and east by wooded areas and an access driveway, and to the north and west by existing single-family residences properties. We did not observe any surface water within the proposed development areas during our site visit on October 6, 2016.

Subsurface Conditions

Geology: The Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington, by James P. Minard (USGS, 1982), was reviewed for this site. The site is mapped as Advance Outwash (Qva). The Advance Outwash deposits are described as mostly clean, gray, well stratified, unconsolidated sand with pebbles and some cobbles. Our explorations generally encountered medium dense to dense, brown, fine to medium sand with silt, on and directly adjacent to the steep slope area within the western portion of the property, which we interpreted as native advanced outwash deposits. Our explorations within the eastern portion of the property underlying the proposed building area encountered loose to medium dense, undocumented fill soils to the depths explored.

Explorations: The subsurface conditions within the site were explored on October 6, 2016 with seven track-hoe excavated test pits and one hand-augered exploration. The approximate locations of our explorations are shown on the Schematic Site Plan in Figure 2.

A geologist from NGA was present during the explorations, examined the soils and geologic conditions encountered, obtained samples of the different soil types, and maintained logs of the explorations. The soils were visually classified in general accordance with the Unified Soil Classification System, presented in Figure 5. The logs of our explorations are attached to this report and are presented as Figures 6 through 8. We present a brief summary of the subsurface conditions in the following paragraph. For a detailed description of the subsurface conditions, the boring logs should be reviewed.

At the surface of Hand Auger 1 and Test Pits 1 through 2 we encountered approximately 0.6 to 3.3 feet of surficial grass and topsoil. Underlying the topsoil, we encountered medium dense or better gray brown, fine to medium sand with silt, gravel, and iron-oxide weathering. We interpreted these soils to be native advanced outwash deposits. Hand Auger 1 and Test Pits 1 and 2 were terminated within the native advanced outwash soils at respective depths of 7.5, 9.0, and 7.0 feet below the existing ground surface.

Within Test Pits 3 through 7, we encountered approximately 0.5 to 1.8 feet of surficial grass and topsoil. Underlying the topsoil in Test Pits 3 through 7, we generally encountered approximately 3.7 to 10.5 feet of loose to medium dense, dark brown to gray silty fine to medium sand and silt with sand and varying amounts of organics and debris that we interpreted as undocumented fill soils. Underlying the undocumented fill soils in Test Pit 3 and 7 at 5.5 and 7.0 feet below the existing ground surface respectively, we encountered medium dense/very stiff to dense/hard, gray-brown fine to medium sand with silt and trace gravel, and gray-brown silt with fine sand and gravel that we interpreted as native advance outwash soils. Test Pits 3 and 7 were terminated within competent native glacial soils at depths of 10.5 and 8.5 feet below the existing ground surface, respectively. Test Pits 4 through 6 were terminated within the undocumented fill soils at depths in the range of 10.0 and 11.0 feet below the existing ground surface.

Hydrogeologic Conditions

Groundwater seepage was not encountered in our explorations. However, we anticipate that perched water conditions could develop on this site during extended periods of wet weather. Perched water occurs when surface water infiltrates through less dense, more permeable soils, such as topsoil and the weathered horizon, and accumulates on top of a less permeable soil. Perched water does not represent a regional

groundwater "table" within the upper soil horizons. Perched water tends to vary spatially and is dependent upon the amount of rainfall. We would expect the amount of groundwater to decrease during drier times of the year and increase during wetter periods.

SENSITIVE AREA EVALUATION

Seismic Hazard

We reviewed the 2015 International Building Code (IBC) for seismic site classification for this project. Since medium dense or better native glacial soils were encountered at depth in most of our explorations, the site conditions best fit the description for Site Class D.

Hazards associated with seismic activity include liquefaction potential and amplification of ground motion by soft deposits. Liquefaction is caused by a rise in pore pressures in a loose, fine sand deposit beneath the groundwater table. The loose to medium dense native soils and undocumented fill interpreted to underlie the site have a low to moderate potential for liquefaction or amplification of ground motion. The deep foundation systems recommended for residence support should alleviate such issues.

The medium dense or better outwash soil interpreted to form the core of the site slopes is considered stable with respect to deep-seated slope failures. All steep slopes have the potential for shallow sloughing failures during seismic events. Such events should not affect the planned residence provided the foundations are designed with the recommended setback values and the slope and drainage systems are maintained as described in this letter.

Erosion Hazard

The criteria used for determining the erosion hazard for the site soils includes soil type, slope gradient, vegetation cover, and groundwater conditions. The erosion sensitivity is related to vegetative cover and the specific surface soil types, which are related to the underlying geologic soil units. The Soil Survey of Snohomish County Area, Washington, by the Soil Conservation Service (SCS), was reviewed to determine the erosion hazard of the on-site soils. The site surface soils were classified using the SCS classification system as Alderwood-Everett gravelly sandy loams, 25 to 70 percent slopes. The Alderwood-Everett gravelly sandy loam is listed as having a severe erosion hazard. It is our opinion that the site soils should have a slight to moderate hazard for erosion in areas that are not disturbed and where vegetation cover is not removed.

Landslide Hazard/Slope Stability

The criteria used for evaluation of landslide hazards include soil type, slope gradient, and groundwater conditions. The ground surface within the proposed development area slopes gently to steeply from the west to the east within the proposed property at gradients in the range of 7 to 28 degrees (12 to 53 percent). We did not observe evidence of significant slope instability within the site slopes or within the immediate vicinity of the property during our investigation, such as deep-seated landsliding. We also did not observe groundwater seepage or recent indications of erosion or sloughing on the steep slopes at the time of our visit.

The core of the steep slopes is inferred to consist primarily of competent native glacial outwash soils. Inclinations of up to 28 degrees on the site slopes indicate high internal strength within the underlying soils. Relatively shallow sloughing failures as well as surficial erosion are natural processes and should be expected on the steeper site slopes during extreme weather conditions or a seismic event, especially in areas with surficial undocumented fill soils. It is our opinion that while there is potential for erosion, soil creep, and shallow failures within the loose surficial soils on the steeper site slopes and steep west-facing slope below and to the west of the site, there is not a significant potential for deep-seated slope failures under current site conditions. Proper site grading and drainage, as well as foundation placement and setbacks as recommended in this report, should help maintain current stability conditions.

CONCLUSIONS AND RECOMMENDATIONS

General

It is our opinion that the planned development within the property is feasible from a geotechnical standpoint. Our explorations indicate that the proposed residence area is underlain by loose to medium dense undocumented fill soils along the eastern portion of the proposed development area to the depth explored. However, we did encounter competent native glacial soils within the very western portion of the proposed development area. In our opinion, the undocumented fill soils that underlie a majority of the proposed development area are not suitable to provide adequate support for foundation and slab loads utilizing conventional foundations, without experiencing significant settlement and distress to the structure. Based on our explorations, we recommend that the proposed residence be supported on a deep foundation system consisting of 4-inch driven pin piles in order to advance the structure loads through the loose fill soils down to more competent native deposits at depth. Due to our explorations being unable to encounter medium dense or better soils to the depths explored, we would recommend that one or more test piles be installed within the proposed residence area to confirm design assumptions and estimate

overall pile depths prior to finalizing the foundation plan. Depending on final grading plans, residence foundations within the western portion of the property may expose competent native glacial soils at the proposed subgrade. These foundations could possibly be supported on shallow conventional foundations, however, some minor settlement between the portion of the residence supported on the deep foundation system and the conventional foundations is possible. If desired, we can review grading and development plans as they are being finalized to better assess this potential.

We recommend that the slab-on-grade within the basement portion of the residence be designed as a structural slab and be supported on the deep foundation system. Other hard surfaces, such as paved areas, patios or walkways that are supported on the existing undocumented fill soil within the eastern portion of the property have some risk of future settlement, cracking, and the need for maintenance. To reduce this risk, we recommend over-excavating a minimum of two feet of the upper soil from these areas and replacing this material with compacted pit run or crushed rock structural fill. The subgrade should be compacted to a firm condition prior to placing the pit run. This recommendation is only for exterior hard surfaces to be supported on grade and does not apply for the interior slab.

It is also our opinion that the soils that underlie the site and form the core of the site slope should be stable with respect to deep-seated earth movements, due to their inherent strength and slope geometry. However, there is a potential for shallow sloughing and erosion events to occur on the moderate to steep slope along the western side of the site. Based on our site observations, it is our opinion that the proposed structure setback of 25 feet from the toe of the steep slopes should provide adequate protection for the proposed residence from shallow failures originating on the steep slopes above and help maintain the existing stability of the slopes. Proper setbacks, erosion and drainage control measures, along with long-term maintenance of the slope and drainage systems as recommended in this report, should reduce this potential. We recommend that we review the project plans after they have been developed.

The soils encountered on this site are considered moisture-sensitive, and will disturb when wet. We recommend that construction take place during the drier summer months, if possible. If construction is to take place during wet weather, the soils may disturb and additional expenses and delays may be expected due to the wet conditions. Additional expenses could include the need for placing a blanket of rock spalls to protect exposed subgrades and construction traffic areas. Some of the more granular non-organic on-site soils could be used as structural fill provided they could be compacted to specifications. This will depend on the moisture content of the soils at the time of construction. NGA should be retained to determine if the on-site soils can be used as structural fill material during construction.

Erosion Control

The erosion hazard for the on-site soils is interpreted to be slight for exposed soils, but actual erosion potential will be dependent on how the site is graded and how water is allowed to concentrate. Best Management Practices (BMPs) should be used to control erosion. Areas disturbed during construction should be protected from erosion. Erosion control measures may include diverting surface water away from the stripped or disturbed areas. Silt fences and/or straw bales should be erected to prevent muddy water from leaving the site. Disturbed areas should be planted as soon as practical and the vegetation should be maintained until it is established. The erosion potential of areas not stripped of vegetation should be low.

Protection of the setback and steep slope area should be performed as required by the City of Mukilteo. Specifically, we recommend that the setback area and toe of slope not be disturbed or modified through placement of any fill or removal of the existing vegetation. No additional material of any kind should be placed on the slope or be allowed to reach the slope, such as excavation spoils, lawn clippings, and other yard waste, trash, and soil stockpiles. Trees should not be cut down or removed from the slope unless a mitigation plan is developed, such as the replacement of vegetation for erosion protection. Vegetation should not be removed from the slopes. Replacement of vegetation should be performed in accordance with City of Mukilteo code. Any proposed development within the slope setback area, should be the subject of a specific geotechnical evaluation. Under no circumstances should water be allowed to concentrate on the steep slopes above the proposed development area.

Site Preparation and Grading

Plans for site grading should be devised such that cuts and fills are kept to a minimum if possible. Site preparation should consist of excavating the residence footprint down to planned elevations. Site preparation should also consist of overexcavating subgrades for future hard surfaces such as exterior walkways, patios, or pavement by a minimum of two feet and the resulting overexcavation backfilled with crushed rock or granular pit-run soils compacted to structural fill specifications. The stripped material should be removed from the site. If the exposed soils after overexcavating the minimum two feet are deemed loose, they should be compacted to a non-yielding condition. Areas observed to pump or weave during compaction should be additionally overexcavated and replaced with rock spalls. If significant surface water flow is encountered during construction, this flow should be diverted around areas to be developed and the exposed subgrade maintained in a semi-dry condition. In wet conditions, the exposed subgrade should not be compacted, as compaction of a wet subgrade may result in further

disturbance of the soils. A layer of crushed rock may be placed over the prepared areas to protect them from further disturbance.

The site soils are considered moisture sensitive and will disturb easily when wet. We recommend that earthwork construction take place during periods of extended dry weather, and suspended during periods of precipitation if possible. If work is to take place during periods of wet weather, care should be taken during site preparation not to disturb the site soils. This can be accomplished by utilizing large excavators equipped with smooth buckets and wide tracks to complete earthwork, and diverting surface and groundwater flow away from the prepared subgrades. Also, construction traffic should not be allowed on the exposed subgrade. A blanket of rock spalls should be used in construction access areas if wet conditions are prevalent. The thickness of this rock spall layer should be based on subgrade performance at the time of construction. For planning purposes, we recommend a minimum one-foot thick layer of rock spalls.

Temporary and Permanent Slopes

Temporary cut slope stability is a function of many factors, including the type and consistency of soils, depth of the cut, surcharge loads adjacent to the excavation, length of time a cut remains open and the presence of surface or groundwater. It is exceedingly difficult under these variable conditions to estimate a stable, temporary, cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations since they are continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered.

The following information is provided solely for the benefit of the owner and other design consultants and should not be construed to imply that Nelson Geotechnical Associates, Inc. assumes responsibility for job site safety. Job site safety is the sole responsibility of the project contractor.

For planning purposes, we recommend that temporary cuts in the on-site undocumented fill and native glacial soils be no steeper than two units horizontal to one unit vertical (2H:1V). If the groundwater table is encountered, we would expect that significantly flatter inclinations would be necessary. We should be retained to specifically review proposed geometry for significant cuts planned on this site. We recommend that cut slopes be protected from erosion. Erosion control measures may include covering cut slopes with plastic sheeting and diverting surface water runoff away from the top of cut slopes. We do

not recommend vertical slopes for cuts deeper than four feet, if worker access is necessary. We recommend that cut slope heights and inclinations conform to appropriate OSHA/WISHA regulations.

Permanent cut and fill slopes above the groundwater table should be no steeper than 3H:1V. However, flatter inclinations may be required in areas where loose soils are encountered. Permanent slopes should be covered with erosion control matting and vegetated. The vegetative cover should be maintained until established. We should specifically review all plans for grading on this project.

Foundation Support

We recommend that the proposed residence be supported on 4-inch pin piles to transfer foundation loads through the upper loose undocumented fill soils to the underlying native competent materials interpreted to underlie the site at depth. Our explorations did encounter some organic debris within the upper soils that have the possibility to impede some of the piles. There should be contingencies in the budget and design for additional/relocated piles to replace piles that may be obstructed by debris. We also recommend that excavation equipment be available on site during pile installation so that shallow obstructions can be removed from the planned pile locations.

We recommend that the four-inch pipe piles be utilized and should be driven using a tractor-mounted hydraulic hammer, with an energy rating of at least 1,100 foot-lb. For this pile and hammer size, we recommend a design capacity of eight tons for each pile driven to refusal. The refusal criterion for this pile and hammer size is defined as less than one-inch of movement during 15 seconds of continuous driving at a rate of 550 blows per minute or higher. We recommend using galvanized schedule 40 pipe for the 4-inch pin piles. Maintaining these recommendations for minimum hammer size and refusal criteria is essential for obtaining a successful outcome.

Final pile depths should be expected to vary and will depend on the depth to competent soils. Our explorations performed as a part of this evaluation were unable to encounter competent native soils to the depths explored within the eastern portion of the proposed development area. Due to the limited nature of the explorations, we recommend that one or more "test" piles be installed to verify design parameters and estimate an approximate depth of the piles that will be needed for budgeting purposes. The piles should be spaced a minimum of three feet apart to avoid a grouping effect on the piles.

Due to the relatively small slenderness ratio of pin piles, maintaining pin pile confinement and lateral support is essential in preventing pile buckling. Pin piles should be suitably embedded into the reinforced concrete. The structural engineer should design the connections of the piles to the foundations.

Vertically driven pin piles do not provide meaningful lateral capacity. Due to the rigid pile support, friction between the foundation and subgrade soil should not be considered as resisting lateral pressures on this structure. We recommend that all lateral loads be resisted on battered pin piles and/or passive resistance on the below-grade portions of the foundations. The upper foot of soil should be neglected when calculating the passive resistance. We recommend using an equivalent fluid density of 150 pcf for calculating the passive resistance.

Retaining Walls

We understand that retaining walls may be incorporated into project plans. The lateral pressure acting on subsurface retaining walls is dependent on the nature and density of the soil behind the wall, the amount of lateral wall movement which can occur as backfill is placed, wall drainage conditions, the inclination of the backfill, and other possible surcharge loads. For walls that are free to yield at the top at least one thousandth of the height of the wall (active condition), soil pressures will be less than if movement is limited by such factors as wall stiffness or bracing (at-rest condition). We recommend that walls supporting horizontal backfill and not subjected to hydrostatic forces be designed using a triangular earth pressure distribution equivalent to that exerted by a fluid with a density of 40 pcf for yielding (active condition) walls, and 60 pcf for non-yielding (at-rest condition) walls.

These recommended lateral earth pressures are for a drained granular backfill and are based on the assumption of a horizontal ground surface behind the wall for a distance of at least the subsurface height of the wall, and do not account for surcharge loads. Additional lateral earth pressures should be considered for surcharge loads acting adjacent to subsurface walls and within a distance equal to the subsurface height of the wall. This would include the effects of surcharges such as traffic loads, floor slab and foundation loads, slopes, or other surface loads. Also, hydrostatic and buoyant forces should be included if the walls could not be drained. We could consult with the structural engineer regarding additional loads on retaining walls during final design, if needed. Retaining walls that are part of the residence should be supported on pin piles as described above.

All wall backfill should be well compacted; however, care should be taken to prevent the buildup of excess lateral soil pressures, due to over-compaction of the wall backfill. This can be accomplished by placing wall backfill in thin loose lifts and compacting it with small, hand-operated compactors within a distance behind the wall equal to at least one-half the height of the wall. The thickness of the loose lifts should be reduced to accommodate the lower compactive energy of the hand-operated equipment.

Permanent drainage systems should be installed for retaining walls. Recommendations for these systems are found in the **Subsurface Drainage** subsection of this report. We recommend that we be retained to evaluate the proposed wall drain backfill material and drainage system installation.

Structural Fill

General: Fill placed beneath foundations, pavement, or other settlement-sensitive structures should be placed as structural fill. Structural fill, by definition, is placed in accordance with prescribed methods and standards, and is monitored by an experienced geotechnical professional or soils technician. Field monitoring procedures would include the performance of a representative number of in-place density tests to document the attainment of the desired degree of relative compaction. The area to receive the fill should be suitably prepared as described in the **Site Preparation and Grading** subsection prior to beginning fill placement.

Materials: Structural fill should consist of a good quality, granular soil, free of organics and other deleterious material, and be well graded to a maximum size of about three inches. All-weather fill should contain no more than five-percent fines (soil finer than U.S. No. 200 sieve, based on that fraction passing the U.S. 3/4-inch sieve). Some of the more granular on-site soils may be suitable for use as structural fill depending on the moisture content of the soil during construction. We should be retained to evaluate all proposed structural fill material prior to placement.

Fill Placement: Following subgrade preparation, placement of structural fill may proceed. All filling should be accomplished in uniform lifts up to eight inches thick. Each lift should be spread evenly and be thoroughly compacted prior to placement of subsequent lifts. All structural fill underlying building areas and pavement subgrade should be compacted to a minimum of 95 percent of its maximum dry density. Maximum dry density, in this report, refers to that density as determined by the ASTM D-1557 Compaction Test procedure. The moisture content of the soils to be compacted should be within about two percent of optimum so that a readily compactable condition exists. It may be necessary to over-excavate and remove wet soils in cases where drying to a compactable condition is not feasible. All compaction should be accomplished by equipment of a type and size sufficient to attain the desired degree of compaction.

Basement Slab

As mentioned earlier, we recommend that the basement floor slab be designed as a structural slab and fully supported on pin piles. We recommend that slabs be underlain by at least six inches of free-draining gravel with less than three percent by weight passing the Sieve #200 for use as a capillary break. We recommend that the capillary break be hydraulically connected to the footing drain system to allow free drainage from under the slab. 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 may be used to protect the vapor barrier membrane and to aid in curing the concrete; however, this sand layer is optional and is intended to protect the vapor barrier membrane during construction. Other slabs and hard surfaces that may be supported on the existing soils should be underlain by a minimum of two feet of crushed rock or pit-run soils in addition to the capillary break and vapor barrier.

Pavement Subgrade and Other Exterior Hard Surfaces

Pavement and walkway subgrade preparation should be completed as recommended in the **Site Preparation and Grading** and **Structural Fill** subsections of this report. Due to the presence of undocumented fill soils and depending on tolerance to cracking, we recommend that at least the upper two feet of the existing material be removed and replaced with granular structural fill or crushed rock. If possible, the subgrades should be proof-rolled with a heavy, rubber-tired piece of equipment, to identify soft or yielding areas that may require repair prior to placing any structural fill and prior to placing the pavement base course. We should be retained to observe the proof-rolling and to recommend repairs prior to placement of the asphalt or hard surfaces. The hard surface section should be thickened and reinforced with rebar where applicable to further reduce the effects of settlement due to the loose/soft soils, but potential long-term cracking should still be expected. Some cracking and long-term settlement should still be anticipated.

Site Drainage

Surface Drainage: The finished ground surface should be graded such that stormwater is directed to an appropriate stormwater collection system. Water should not be allowed to stand in any areas where footings, slabs, or pavements are to be constructed. Final site grades should allow for drainage away from the residence. We suggest that the finished ground be sloped at a minimum gradient of three percent, for a distance of at least 10 feet away from the residence. Surface water should be collected by permanent

catch basins and drain lines, and be discharged into an appropriate discharge system. The overflow water should be dispersed to discharge into an appropriate location.

Subsurface Drainage: If groundwater is encountered during construction, we recommend that the contractor slope the bottom of the excavation and collect the water into ditches and small sump pits where the water can be pumped out and routed into a permanent storm drain.

We recommend the use of footing drains around the structures. Footing drains should be installed at least one foot below planned finished floor elevation. The drains should consist of a minimum 4-inch-diameter, rigid, slotted or perforated, PVC pipe surrounded by free-draining material wrapped in a filter fabric. We recommend that the free-draining material consist of an 18-inch-wide zone of clean (less than three-percent fines), granular material placed along the back of walls. Pea gravel is an acceptable drain material. The free-draining material should extend up the wall to one foot below the finished surface. The top foot of backfill should consist of impermeable soil placed over plastic sheeting or building paper to minimize surface water or fines migration into the footing drain. Footing drains should discharge into tightlines leading to an appropriate collection and discharge point with convenient cleanouts to prolong the useful life of the drains. Roof drains should not be connected to wall or footing drains.

CONSTRUCTION MONITORING

We recommend that NGA be retained to provide monitoring and consultation services during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork and foundation installation activities comply with contract plans and specifications. We should be contacted a minimum of one week prior to construction activities and could attend pre-construction meetings if requested.

USE OF THIS REPORT

NGA has prepared this report for David and Joan Loney and their agents, for use in the planning and design of the development planned on this site only. The scope of our work does not include services related to construction safety precautions and our recommendations are not intended to direct the contractors' methods, techniques, sequences, or procedures, except as specifically described in our report for consideration in design. There are possible variations in subsurface conditions between the explorations and also with time. Our report, conclusions, and interpretations should not be construed as a

warranty of subsurface conditions. A contingency for unanticipated conditions should be included in the budget and schedule.

Within the limitations of scope, schedule, and budget, our services have been performed in accordance with generally accepted geotechnical engineering practices in effect in this area at the time this report was prepared. No other warranty, expressed or implied, is made. Our observations, findings, and opinions are a means to identify and reduce the inherent risks to the owner.

o-o-o

It has been a pleasure to provide service to you on this project. If you have any questions or require further information, please call.

Sincerely,

NELSON GEOTECHNICAL ASSOCIATES, INC.

Lee S. Bellah, LG
Project Geologist

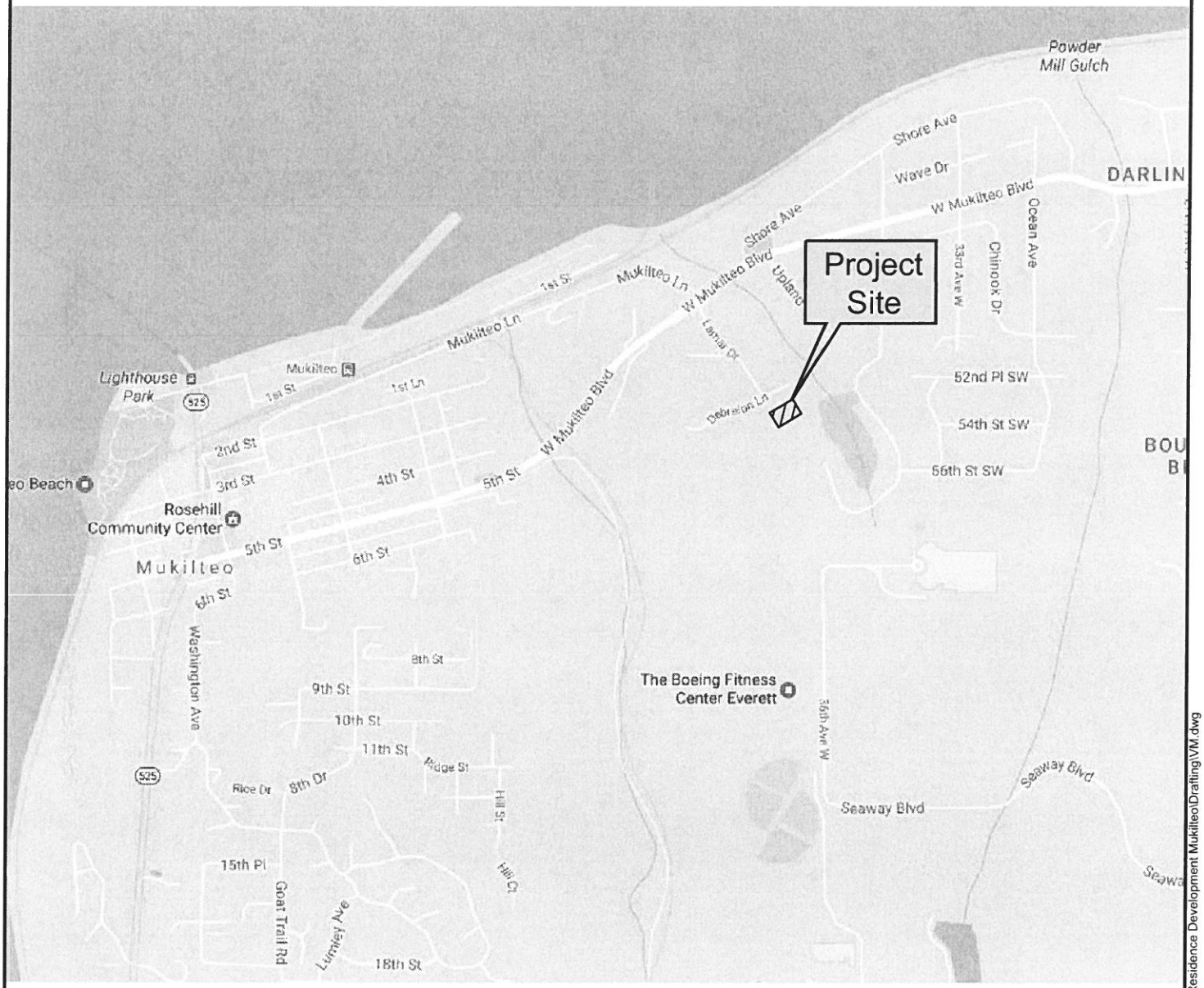
Khaled M. Shawish, PE
Principal

ABR:LSB:KMS:dy

Eight Figures Attached

VICINITY MAP

Not to Scale



Mukilteo, WA

Project Number 971416	Loney Residence Development Vicinity Map	NELSON GEOTECHNICAL ASSOCIATES, INC. NGA GEOTECHNICAL ENGINEERS & GEOLOGISTS 17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax 481-2510 Snohomish County (425) 339-1669 Wenatchee/Chelan (509) 665-7696 www.nelsongeotech.com	No.	Date	Revision	By	CK
Figure 1			1	10/7/16	Original	DPN	ABR

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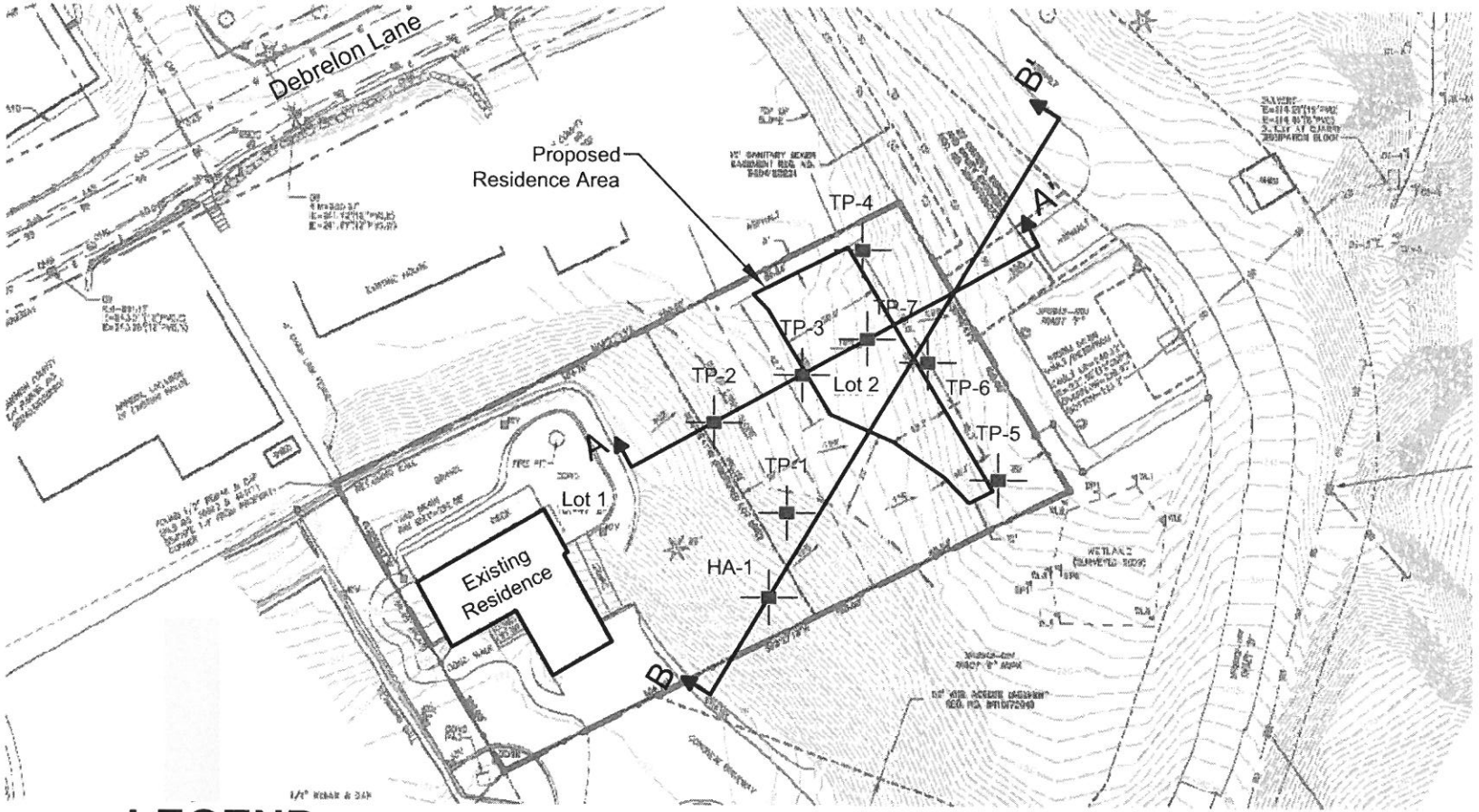
Site Plan



LEGEND

Property line

TP-1
Number and approximate location of test pit

HA-1
Number and approximate location of hand auger

A A'
Approximate location of cross-section

0 50 100

Scale: 1 inch = 50 feet

Reference: Site plan based on a plan dated June 7, 2016 titled "Preliminary Short Plat," prepared by Pacific Geomatic Services, Inc.

Project Number 971416

Figure 2

Loney Residence Development Site Plan

NELSON GEOTECHNICAL ASSOCIATES, INC.
GEOTECHNICAL ENGINEERS & GEOLOGISTS
NGA
17311-135th Ave NE, A-500
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(425) 486-1669 / Fax 487-2510
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Project Number
971416

Figure 3

Loney Residence
Development
Cross-Section A-A'

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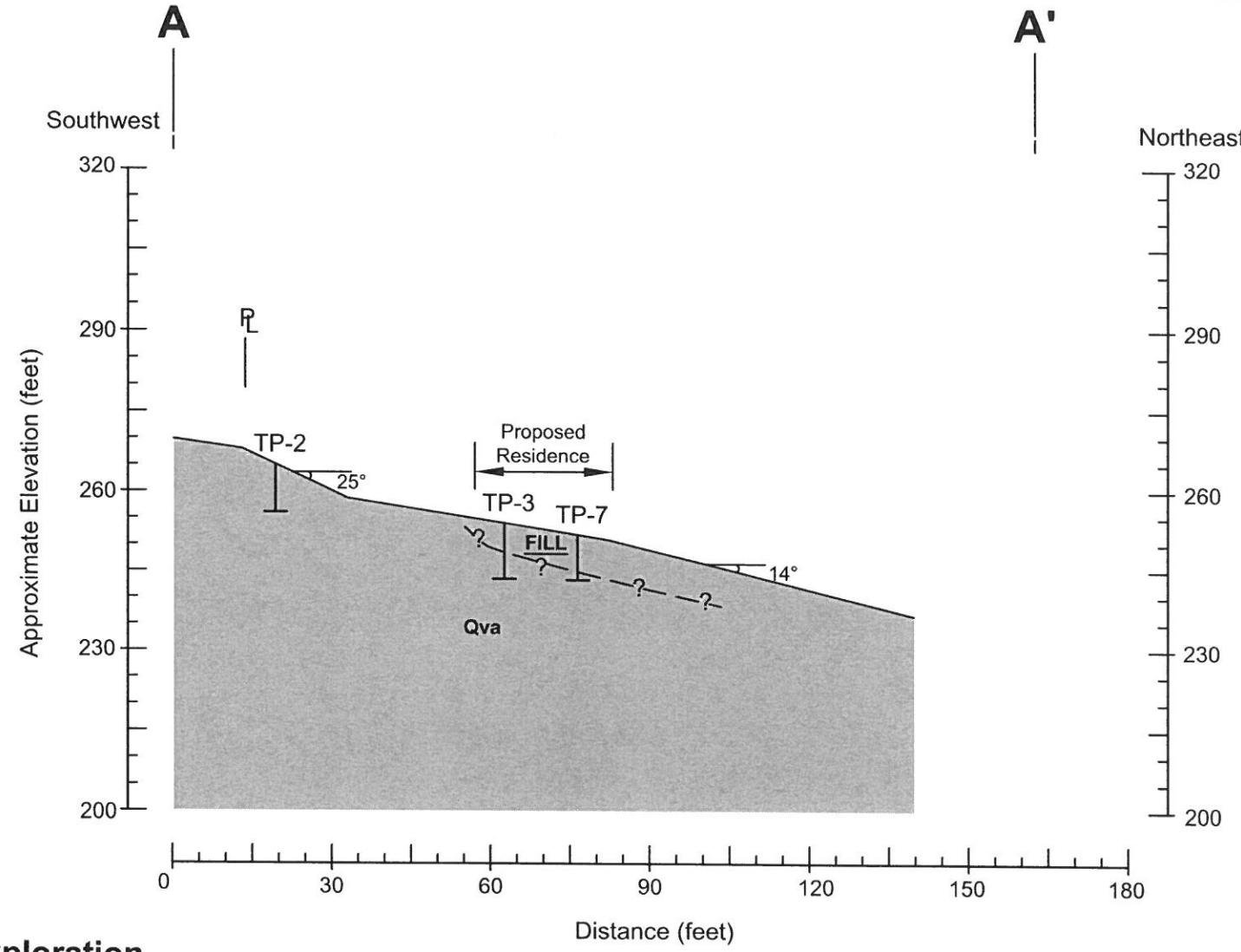
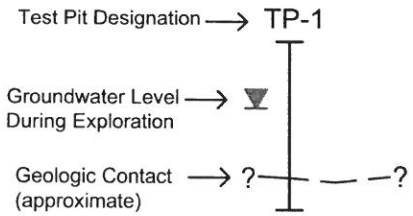


Exploration



NOTES:
1) Stratigraphic conditions are interpolated between the explorations. Actual conditions may vary.
2) Elevations are approximate.

Reference: Cross Section is based on field measurements using a hand-held clinometer and 100-ft tape measure.

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Project Number
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Figure 4

Loney Residence
Development
Cross-Section B-B'

NELSON GEOTECHNICAL ASSOCIATES, INC.
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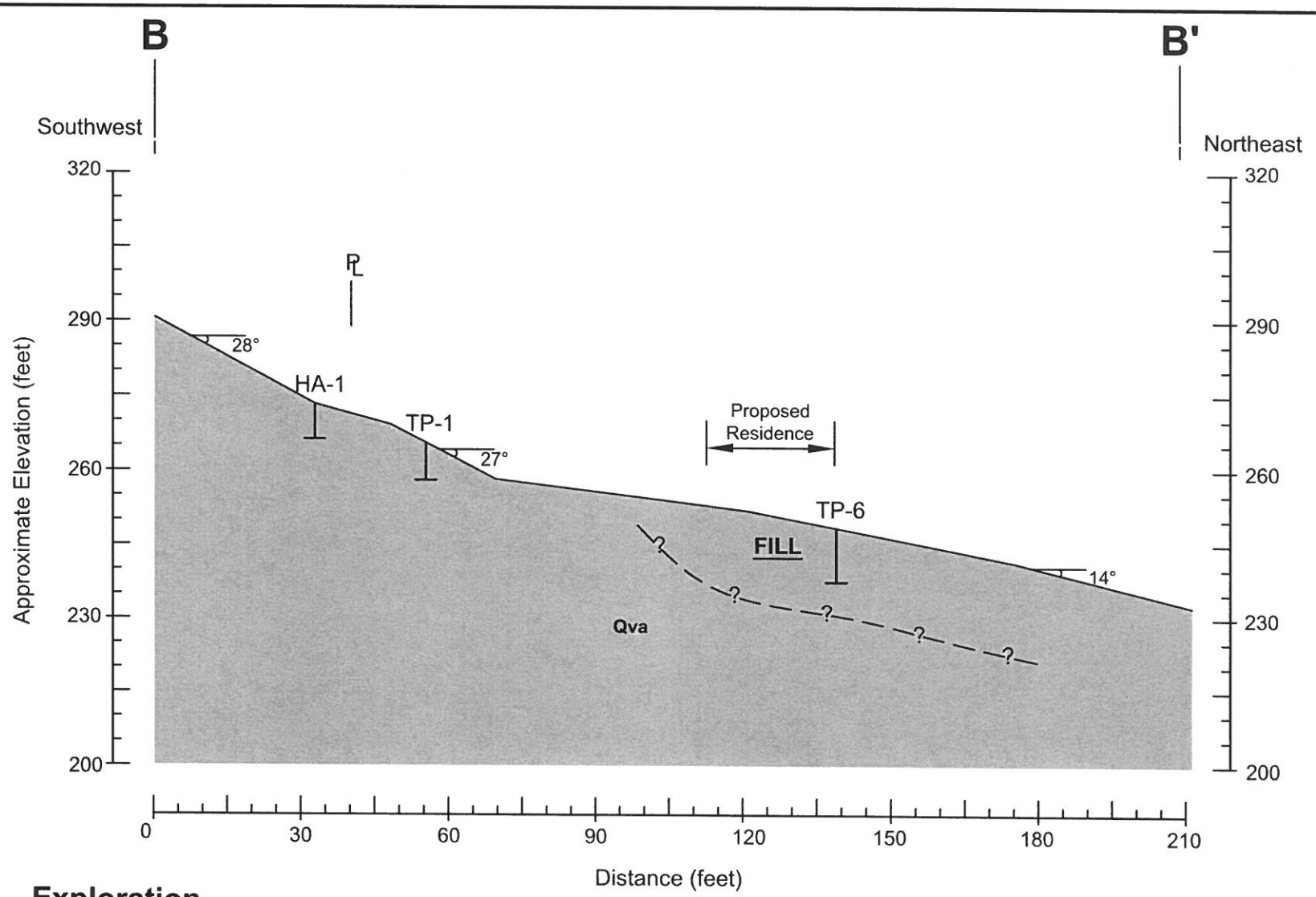
No.	Date	Revision	By	CK
1	10/7/16	Original	DPN	ABR



Exploration

Hand Auger/Test Pit Designation → HA/TP-1

Groundwater Level During Exploration →

Geologic Contact (approximate) → ? – – ?

NOTES:
1) Stratigraphic conditions are interpolated between the explorations. Actual conditions may vary.
2) Elevations are approximate.

Reference: Cross Section is based on field measurements using a hand-held clinometer and 100-ft tape measure.

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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, FLAT 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

Moist - Damp, but no visible water.

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

Project Number 971416	Loney Residence Development Soil Classification Chart	NELSON GEOTECHNICAL ASSOCIATES, INC. NGA GEOTECHNICAL ENGINEERS & GEOLOGISTS	No.	Date	Revision	By	CK
Figure 5		17311-135th Ave. NE, A-500 Woodinville, WA 98072 (425) 486-1669 / Fax 481-2510 Snohomish County (425) 337-1669 Wenatchee/Chelan (509) 665-7696 www.nelsongeotech.com	1	10/7/16	Original	DPN	ABR

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LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
TEST PIT ONE		
0.0 – 0.3		GRASS AND ROOTS
0.3 – 3.3		ORANGE-BROWN, SILTY FINE SAND WITH ROOTS, ORGANICS, GRAVEL, AND IRON-OXIDE WEATHERING (LOOSE TO MEDIUM DENSE, MOIST)
3.3 – 7.5	SM	GRAY-BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, COBBLES, AND TRACE IRON-OXIDE WEATHERING (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 3.0, 5.5, 7.0, AND 7.5 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED SLIGHT TEST PIT CAVING WAS ENCOUNTERED TEST PIT WAS COMPLETED AT 7.5 FEET ON 10/6/16
TEST PIT TWO		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 1.2		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, ROOTS/ORGANICS, AND IRON-OXIDE WEATHERING (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
1.2 – 6.0	SP-SM	BROWN TO ORANGE-BROWN, FINE SAND WITH SILT, IRON-OXIDE WEATHERING, TRACE ROOTS AND GRAVEL (MEDIUM DENSE TO DENSE, MOIST)
6.0 – 9.0	SP-SM	GRAY-BROWN, FINE SAND WITH SILT, COARSE SAND POCKETS, SILT LENSES, AND TRACE IRON-OXIDE WEATHERING (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 3.0, 5.5, 7.5, AND 9.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT WAS COMPLETED AT 9.0 FEET ON 10/6/16
TEST PIT THREE		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 1.8		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE STAINING, AND ROOTS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
1.8 – 5.5		BROWN TO ORANGE-BROWN, FINE TO MEDIUM SAND WITH SILT, IRON-OXIDE WEATHERING, ROOTS, ORGANICS, AND DRAIN PIPE AT APPROXIMATELY 2.0 FEET (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
5.5 – 8.0	ML	GRAY-BROWN SILT WITH FINE SAND IRON-OXIDE WEATHERING, ORGANICS, AND TRACE GRAVEL (VERY STIFF, MOIST)
8.0 – 10.5	SP-SM	GRAY-BROWN, FINE TO MEDIUM SAND WITH SILT, TRACE GRAVEL, AND IRON-OXIDE STAINING (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 3.0, 5.0, 7.5, AND 10.5 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT COMPLETED AT 10.5 FEET ON 10/6/16

LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
TEST PIT FOUR		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 0.5		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE STAINING, AND ROOTS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
0.5 – 9.0		BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE WEATHERING, METAL SCRAPS, PLASTIC GARBAGE, AND IRON-OXIDE WEATHERING (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
9.0 – 10.0		GRAY, SILT WITH FINE SAND INTERMIXED WITH BROWN, FINE TO MEDIUM SAND WITH SILT, WOOD DEBRIS (BURIED LOG) AND TRACE GRAVEL (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
		SAMPLES WERE COLLECTED AT 2.5, 5.5, 8.3, AND 10.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT COMPLETED AT 10.0 FEET ON 10/6/16
TEST PIT FIVE		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 1.0		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH IRON-OXIDE STAINING, ROOTS, AND TRACE GRAVEL (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
1.0 – 9.5		BROWN TO ORANGE-BROWN, FINE TO MEDIUM SAND WITH SILT, GRAVEL, WOOD DEBRIS, ORGANICS, AND INTERMIXED SILT WITH FINE SAND LAYERS (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
9.5 – 10.5		GRAY-BROWN TO ORANGE BROWN, FINE TO MEDIUM SAND WITH SILT, GRAVEL, COARSE SAND POCKETS, AND IRON-OXIDE WEATHERING (MEDIUM DENSE TO DENSE) (**FILL**)
		SAMPLES WERE COLLECTED AT 4.0, 8.5, 9.4, AND 10.5 GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT COMPLETED AT 10.5 FEET ON 10/6/16
TEST PIT SIX		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 0.8		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE STAINING, AND ROOTS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
0.8 – 11.0		ORANGE-BROWN TO GRAY-BROWN, FINE TO MEDIUM SAND WITH SILT, INTERMIXED GRAVELLY FINE TO COARSE SAND POCKETS AND SILT WITH FINE SAND LENSES, ASPHALT GRINDINGS AT APPROXIMATELY 1.0 FEET, ORGANIC DEBRIS, BURIED LOG AT APPROXIMATELY 6.0 FEET, AND IRON-OXIDE STAINING (LOOSE TO MEDIUM DENSE, MOIST) (**FILL**)
		SAMPLES WERE COLLECTED AT 4.0, 6.0, 10.5, AND 11.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT COMPLETED AT 11.0 FEET ON 10/6/16

LOG OF EXPLORATION

DEPTH (FEET)	USC	SOIL DESCRIPTION
TEST PIT SEVEN		
0.0 – 0.2		GRASS AND ROOTS
0.2 – 1.0		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE STAINING, AND ROOTS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
1.0 – 7.0		ORANGE-BROWN TO GRAY-BROWN, SILTY FINE SAND WITH ORGANICS, WOOD DEBRIS, AND IRON-OXIDE STAINING (MEDIUM DENSE TO DENSE, MOIST) (**FILL**)
7.0 – 8.5	ML	GRAY-BROWN SILT WITH FINE SAND, IRON-OXIDE STAINING, GRAVEL AND TRACE ORGANICS (VERY STIFF, MOIST) (**FILL**)
		SAMPLES WERE COLLECTED AT 3.5, 5.5, AND 8.5 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED TEST PIT CAVING WAS NOT ENCOUNTERED TEST PIT COMPLETED AT 8.5 FEET ON 10/6/16
HAND AUGER ONE		
0.0 – 0.2		GRASS AND UNDERBRUSH
0.2 – 0.6		DARK BROWN, SILTY FINE TO MEDIUM SAND WITH GRAVEL, IRON-OXIDE STAINING, AND ROOTS (LOOSE TO MEDIUM DENSE, MOIST) (**TOPSOIL**)
0.6 – 5.0	SP-SM	DARK BROWN TO BROWN, FINE TO MEDIUM SAND WITH IRON-OXIDE STAINING, TRACE ROOTS AND ORGANICS (LOOSE TO MEDIUM DENSE, MOIST)
5.0 – 5.5	SM	GRAY-BROWN SILTY FINE SAND, IRON-OXIDE STAINING, TRACE ORGANICS AND GRAVEL (MEDIUM DENSE TO DENSE, MOIST)
5.5 – 7.0	SP-SM	GRAY-BROWN, FINE TO MEDIUM SAND WITH SILT AND TRACE GRAVEL (MEDIUM DENSE TO DENSE, MOIST)
		SAMPLES WERE COLLECTED AT 2.0, 3.0, 5.0, 6.0, AND 7.0 FEET GROUNDWATER SEEPAGE WAS NOT ENCOUNTERED HAND AUGER CAVING WAS NOT ENCOUNTERED HAND AUGER COMPLETED AT 7.0 FEET ON 10/6/16

APPENDICES:

1. SITE MAPS
2. WWHM 2012 NO MITIGATION DESIGN CALCULATIONS
3. DRAINAGE REPORT FOR KARI SHORT PLAT
4. MAINTENTANCE MANUAL

APPENDICES:

1. SITE MAPS
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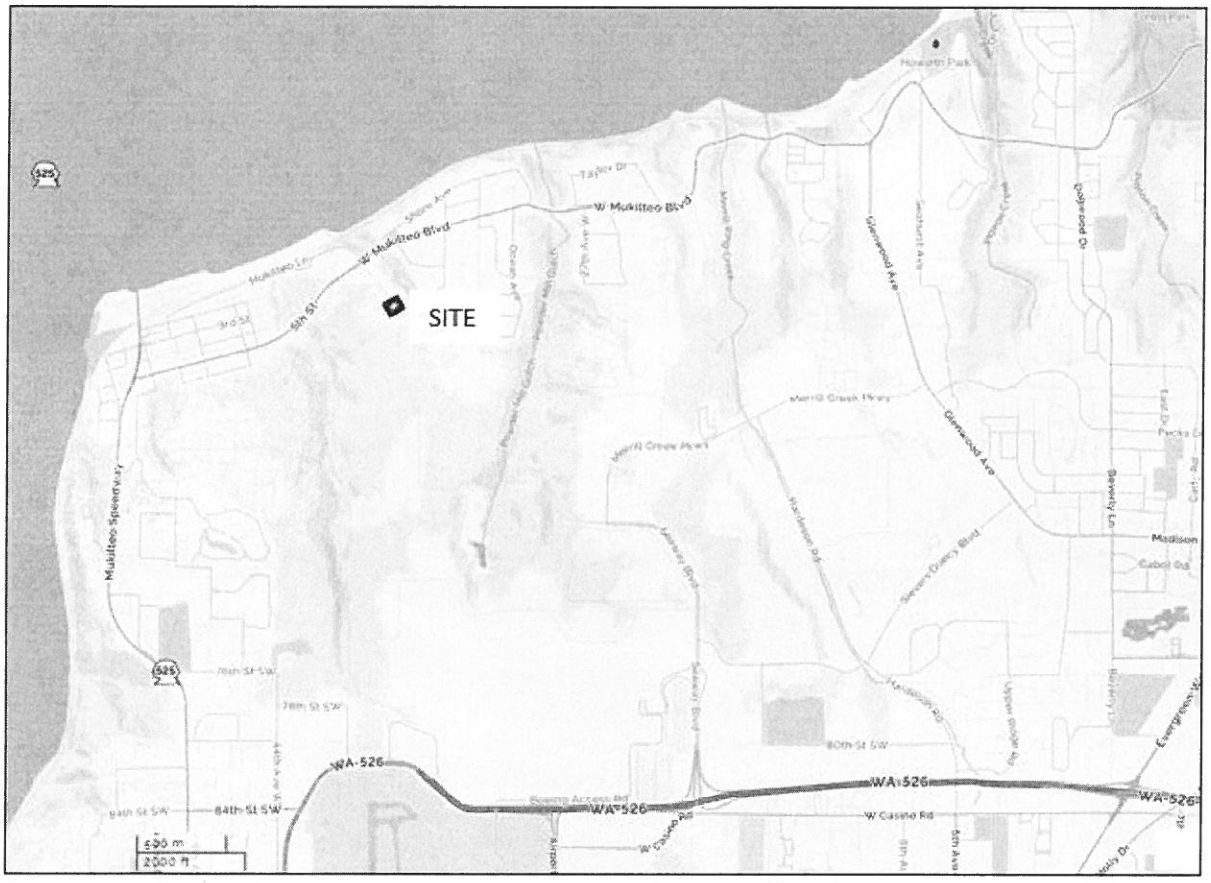
5. PIPE CAPACITY

Appendix 1:

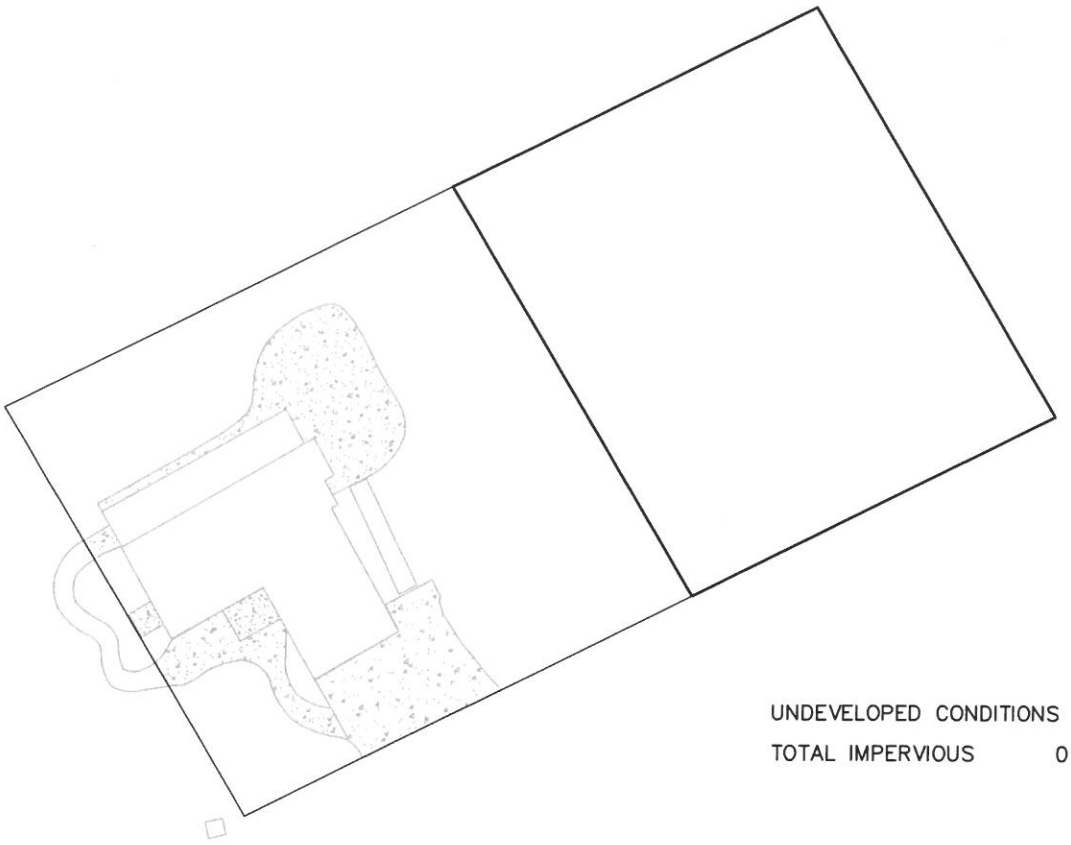
- VICINITY MAP
- DRAINAGE BASIN MAP
- AERIAL PHOTO

#05999
Loney Short Plat
5/02/2019

VICINITY MAP



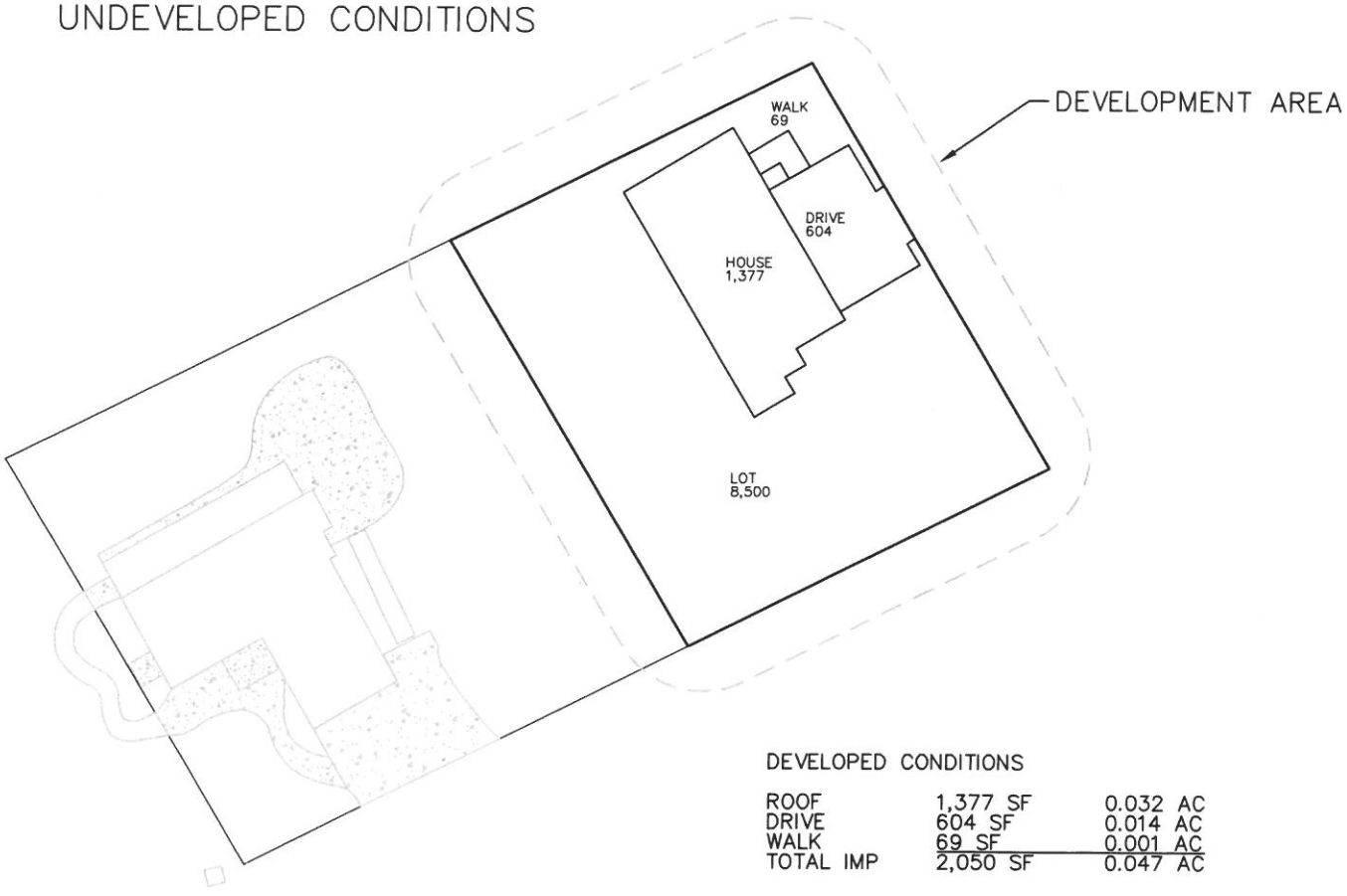
- DRAINAGE BASIN MAP



UNDEVELOPED CONDITIONS

TOTAL IMPERVIOUS 0

UNDEVELOPED CONDITIONS



DEVELOPED CONDITIONS

ROOF	1,377 SF	0.032 AC
DRIVE	604 SF	0.014 AC
WALK	69 SF	0.001 AC
TOTAL IMP	2,050 SF	0.047 AC

DEVELOPED CONDITIONS

- AERIAL PHOTO

Appendix 2

WWHM 2012 NO MITIGATION DESIGN CALCULATIONS

RESULT: LESS THAN 0.15 CFS OF RUNOFF IS CREATED IN THE TRANSITION FROM THE CURRENT SITE CONDITION TO THE NEW IMPERVIOUS SURFACE.

WWHM2012
PROJECT REPORT

Project Name: NO MITIGATION CONDITION
Site Name: Loney
Timesteps = 15-minutes
Site Address: Debrelon Ave
City : Mukilteo
Report Date: 5/3/2019
Gage : Everett
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 0.80
Version Date: 2018/10/10
Version : 4.2.16

Low Flow Threshold for POC 1 : 50 Percent of the 2 Year

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

Ground Water: No

Pervious Land Use	acre
C, Forest, Mod	0.1951
Pervious Total	0.1951

Impervious Land Use	acre
Impervious Total	0
Basin Total	0.1951

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin 1
Bypass: No

Ground Water: No

Pervious Land Use	acre
C, Lawn, Mod	.1481
Pervious Total	0.1481

Impervious Land Use	acre
ROOF TOPS FLAT	0.0316
DRIVEWAYS FLAT	0.0154
Impervious Total	0.047
Basin Total	0.1951

Element Flows To:
Surface Interflow Groundwater

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:0.1951
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:0.1481
Total Impervious Area:0.047

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.002402
5 year	0.003757
10 year	0.004601
25 year	0.005583
50 year	0.006253
100 year	0.006873

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.019882
5 year	0.030528
10 year	0.039108
25 year	0.051875
50 year	0.062902
100 year	0.075335

Delta Q100 = 0.075 - 0.0068 = 0.068 <<< 0.150 CFS

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.000	0.022
1950	0.003	0.029
1951	0.002	0.016
1952	0.002	0.019
1953	0.001	0.021
1954	0.004	0.051
1955	0.004	0.029
1956	0.003	0.011
1957	0.004	0.026
1958	0.003	0.052
1959	0.003	0.017
1960	0.002	0.018
1961	0.003	0.091
1962	0.002	0.018
1963	0.002	0.037
1964	0.002	0.016
1965	0.002	0.011
1966	0.001	0.011
1967	0.003	0.032
1968	0.003	0.021
1969	0.002	0.071
1970	0.002	0.014
1971	0.003	0.024
1972	0.003	0.033
1973	0.001	0.024
1974	0.003	0.029
1975	0.002	0.026
1976	0.002	0.015
1977	0.001	0.012
1978	0.002	0.012
1979	0.004	0.039
1980	0.002	0.017
1981	0.002	0.014
1982	0.003	0.014
1983	0.003	0.024
1984	0.002	0.015
1985	0.004	0.023
1986	0.009	0.036
1987	0.003	0.023
1988	0.002	0.015
1989	0.001	0.023
1990	0.003	0.012
1991	0.003	0.014
1992	0.002	0.020
1993	0.001	0.013
1994	0.001	0.011
1995	0.002	0.012
1996	0.005	0.024
1997	0.010	0.041
1998	0.001	0.023

1999	0.003	0.012
2000	0.001	0.029
2001	0.000	0.011
2002	0.002	0.011
2003	0.002	0.014
2004	0.002	0.033
2005	0.002	0.014
2006	0.005	0.030
2007	0.004	0.027
2008	0.005	0.018
2009	0.002	0.016

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.0099	0.0906
2	0.0091	0.0711
3	0.0055	0.0518
4	0.0054	0.0510
5	0.0053	0.0408
6	0.0042	0.0390
7	0.0041	0.0366
8	0.0041	0.0363
9	0.0038	0.0331
10	0.0035	0.0328
11	0.0035	0.0317
12	0.0034	0.0298
13	0.0033	0.0295
14	0.0033	0.0292
15	0.0030	0.0291
16	0.0030	0.0289
17	0.0028	0.0270
18	0.0028	0.0260
19	0.0027	0.0259
20	0.0027	0.0242
21	0.0026	0.0242
22	0.0026	0.0236
23	0.0026	0.0236
24	0.0025	0.0233
25	0.0025	0.0228
26	0.0025	0.0226
27	0.0025	0.0225
28	0.0024	0.0223
29	0.0024	0.0207
30	0.0024	0.0207
31	0.0023	0.0197
32	0.0023	0.0188
33	0.0023	0.0185
34	0.0023	0.0182
35	0.0023	0.0177
36	0.0021	0.0173
37	0.0020	0.0167
38	0.0020	0.0161
39	0.0020	0.0161
40	0.0020	0.0156

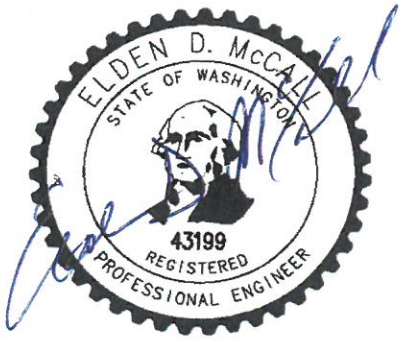
41	0.0020	0.0154
42	0.0019	0.0150
43	0.0019	0.0148
44	0.0019	0.0143
45	0.0018	0.0143
46	0.0018	0.0142
47	0.0017	0.0142
48	0.0017	0.0141
49	0.0016	0.0136
50	0.0015	0.0129
51	0.0015	0.0125
52	0.0014	0.0121
53	0.0014	0.0121
54	0.0014	0.0120
55	0.0014	0.0118
56	0.0013	0.0115
57	0.0013	0.0114
58	0.0009	0.0113
59	0.0009	0.0111
60	0.0003	0.0108
61	0.0003	0.0106

Appendix 3

DRAINAGE REPORT REFERENCE
FOR
KARI SHORT PLAT

AMENDED DRAINAGE REPORT FOR KARI SHORT PLAT

AMENDED ANALYSIS, FORMALLY KAILASH HEIGHTS PLAT, CITY OF MUKILTEO, WA
CITY FILE # SD2008-04/SEP A 2008-23



DATE: 11/19/12

Phone: 425-652-5820
Prepared by: James A. Kresge PE
Date: NOVEMBER 13, 2012
MAC #: 20096

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TABLE OF CONTENTS

SECTION 1: EXECUTIVE SUMMARY:

The KARI – SP (Short Plat, Formally Kailash Heights plat) project proposes to construct a 4 lot short plat within the City of Mukilteo, Washington. The project site area is 7.86 ac and is located near the intersection of Lamar Road and Debrelon Lane with a site address of 15XX Debrelon Lane in the City of Mukilteo. The earlier 8 lot plat Kailash Heights plat project was not completed on this site. This short plat project will utilize the existing detention vault, outfall and private road access that was constructed earlier on this site. The project will include needed corrections on the site including but not limited to retaining wall removal and replacement walls, revised utilities, drainage improvements and new tract and easements as required. The detention vault and control structure will be reviewed and sized based on a revised analysis sized to the 2005 DOE Stormwater Management Manual for Western Washington.

SECTION 2: EXISTING SITE CONDITIONS:

The proposed development area is vegetated with grass with some underbrush and sparse trees. Tracts A, F and H will preserve native growth and steep slope areas. Earlier block retaining walls and road construction (curbs, sidewalks, ATB pavement and utilities) will be revised or relocated prior to construction. The topography of the development area of the site is steep with grades ranging from 15 to 30%. The ravine within the eastern portion of the site has slopes that exceed 30% and is covered with 2nd growth forest with thick underbrush and will become a native growth protection area (NGPA).

A small wetland (Category IV) and its buffer are believed to exist within Proposed Tract F designated as a Native Growth Protection Area. Buffer mitigation is proposed in conjunction with this small wetland to allow for roadway construction.

There are several steep slope areas identified on site and each includes a 25 foot setback and corrective action to stabilize slopes.

As identified in the Soil survey of the Snohomish County Area, Washington, soils on site are Alderwood-Everett gravelly sandy loam, which is classified by the NRCS as a type "CIA" soil (Table 2.1, Volume III of the DOE Manual). A geotechnical investigation of the site was performed by GEOTEST, dated November 2012 and the report has been submitted to the City.

SECTION 3: DEVELOPED SITE CONDITIONS:

The 4 lot short plat development proposes to construct 4 new single family residences. Access to the site will be provided from the construction of a private road system with access off Debrelon Lane. Runoff from the new development will be conveyed to an existing detention vault. The 4 lots will provide a maximum 35% building foot print area per lot. New retaining walls have been designed to stabilize some steep slope areas adjacent to the existing private road system (removal and replacement of existing wall and use of existing and new blocks) and a block wall will be set adjacent to the north side of Lot 1. Walls will be constructed of Redi-Rock and will be geo designed walls with geo fabric and footing drains.

An identified wetland of approximately 1,150 sf will be provided with vegetation and a mitigated buffer area as well. The steep slope area in Tract F will be dispersed to maintain runoff to the wetland area.

SECTION 4: OFF SITE ANALYSIS:

The project is located in a relatively hilly area of the City of Mukilteo. Soils onsite and within the surrounding areas are Alderwood/Everett type soils. Approximately 1.21 acres of partially cleared land adjacent the south boundary contributes runoff to the development area of this site. The detention facility control structure will be sized to allow for the additional offsite up-stream runoff. The Boeing air field and plant site south of the site contribute runoff to the Ravine that flows north through the undeveloped portion of the site. The Ravine discharges to the Puget Sound at an oval culvert (24" wide by 28" high) crossing the existing rail road right-of-way lines approximately 1800 ft downstream of the site. The culvert has an 8 ft potential headwater depth. The Ravine banks are vegetated with native 2nd and 3rd growth forest with thick underbrush. Natural dead fall litters the stream throughout the majority of the downstream system. Sloughing of the ravine banks was noted along the drainage course, however no sloughing was observed within the stream bed itself. Numerous above ground culvert discharge to the ravine from public and private offsite drainage systems that contribute runoff to this stream. No adverse impacts to the upstream or downstream drainage courses are anticipated with the development of the Kari Short Plat.

SECTION 5: MINIMUM REQUIREMENTS

Per Volume I, Figure 2.2 of the 2005 DOE manual, All Minimum Requirements #1 through #10 apply. To meet these requirements, a Construction Storm Water Pollution Prevention Plan (SWPPP) will be provided with the construction plan set. The following address the Minimum Requirements:

Requirement # 1: Preparation of Stormwater Site Plans

A Stormwater Site Plan will be prepared and included with the construction plan set.

Requirement #2: Construction Stormwater Pollution Prevention (SWPP)

The 12 elements of the Construction SWPPP have been addressed in Section 7 of this report.

Requirement #3: Source Control of Pollution

The development site is in a residential area. Contamination of the soils on site is not anticipated. This project is not expected to require additional source control of pollutants.

Requirement #4: Preservation of Natural Drainage and Outfalls

This project will use the existing detention vault and the ravine outfall to preserve the natural drainage course per the 2005 DOE manual to maintain the natural drainage patterns into the groundwater table.

Requirement #5: On-Site Stormwater Management

Runoff from the new buildings, driveways, public and private road system will be conveyed to the existing detention facility and control structure to maintain the pre-developed runoff rates. A WET VAULT (Existing Detention Vault) provides water quality. Temporary erosion control will be provided to minimize impacts that are anticipated with this project.

Requirement #6: Runoff Treatment

The wet vault provides basic water quality per the DOE manual.

Requirement #7: Flow Control

An original multiple orifice control structure was sized to the allowable forested pre-developed runoff rates in the developed area. "Storm water discharges from the developed area in discharge durations to the pre-developed duration for the range of pre-developed rates from 50% of the 2-year peak flow up to the full 50-year peak flow." The WWHM 3 hydraulic model as provided by DOE was utilized for sizing the detention facility.

Requirement #8: Wetlands Protection

The existing detention facility outfall location within the Ravine Wetland Corridor will be maintained to avoid impacts to downstream wetlands.

Requirement #9: Basin/Watershed Planning

The detention facility will contribute to the maintenance of the basin and watershed by returning runoff to the existing downstream wetland drainage course.

Requirement #10: Operation and Maintenance

The operation and maintenance manual will be included with the construction plan submittal.

SECTION 6: STORMWATER CONTROL PLAN:

EXISTING SITE HYDROLOGY:

The Snohomish County Soil Survey indicated that the soils on site are classified as AlderwooddEverett gravelly sandy loam, which is classified by the NRCS as a type "C/ A" soil (Table 2.1, Volume III of the DOE Manual). The development area of the site has been cleared from the earlier incomplete project. The site is "Steep" (greater than 15% slopes) as determined by the WWHM 3 hydraulic model criteria and will be modeled as forested for the pre-developed runoff rates. In the pre-developed condition, runoff collected along and sheet flowed to the Ravine Drainage Corridor flowing north to the Puget Sound.

DEVELOPED SITE HYDROLOGY:

The KARI SHORT PLAT development proposes to construct 4 new single family residences with associated public and private accesses. The development area of the 7.86 acres site is approximately 2.02 acres.

To determine the applicable flow control and runoff treatment standards, the pollution generating impervious surfaces (PGIS), the total impervious areas, and lawn and landscape areas were calculated for the pre and post-developed site conditions.

Per minimum requirement #6, runoff treatment, any project that creates greater than 5,000 sf of PGIS is required to provide water quality for stormwater runoff. To meet this minimum requirement, runoff will be directed to a catch basin system and flow into a wet

vault detention facility. For further information, refer to the Water Quality System section below.

All calculations were performed using Western Washington Hydrology Model 3 (WWHM 3). See sizing calculations in Appendix A of this report.

For offsite upstream and downstream basin analysis see the USGS Stream Stats attached to Appendix C of this report.

TREATMENT AND FLOW CONTROL SYSTEM NEEDED:

Per the attached Treatment Facility Selection Flow Chart (Volume I, Figure 4.1), a Basic Treatment Facility consisting of a wet vault (Detention Vault) will be utilized for water quality requirements.

PERFORMANCE STANDARDS AND GOALS:

Per the 2005 DOE flow control requirements "Stormwater discharges from the developed discharge durations to the pre-developed duration for the range of pre-developed rates from 50% of the 2-year peak flow up to the full 50-year peak flow." As determined by the WWHM3 analysis this criterion has been meet. For additional information see the WWHM3 hydraulic analysis attached to Appendix A of this drainage report.

Per the 2005 DOE the water quality design flow rate downstream of detention facility is the full 2-year release rate from the detention facility.

FLOW CONTROL SYSTEM:

A multiple (3) orifice control structure was sized to allow forested pre-developed runoff rates. For additional information see the WWHM3 hydraulic analysis in Appendix A of this report.

WATER QUALITY SYSTEM:

To meet City and DOE requirements, a Basic Treatment facility must be provided onsite for water quality. To meet City and DOE water quality criteria, runoff will be routed through a wet vault (Detention Vault) system.

CONVEYANCE SYSTEM ANALYSIS:

Storm water runoff from the development is conveyed to the detention vault facility via 12" HDPE storm pipe. The shallowest pipe slope leading to the detention vault is 8.31 %. Conservatively, the 12" diameter conveyance pipe was evaluated for the 100 yr storm event. The 100 yr peak flow rate for this project was calculated by WWHM 3 at 1.86 cfs. To adjust peak flows calculated by WWHM 3, the peak flow rate is multiplied by 1.6 to

approximate the IS-minute flow rate. The conveyance analysis was performed using a peak flow rate of2.98 cfs. The pipe system was evaluated using Manning's Equation and determined to have a normal flow depth of 0.35 ft (4.2"). Calculations are attached in the Appendix A of this report. No concerns regarding the proposed conveyance system's ability to convey the developed flow rates have been observed.

SECTION 7: SWPPP:

The 12 elements of the SWPPP are addressed as follows.

1. Mark Clearing Limits: The clearing limits are indicated on the plan sheet. Furthermore, clearing and grading will be limited to only areas that need to be disturbed for grading, placing or stock piling fill and to preserve as much natural vegetation and the duff layer as possible. Field marking the clearing limits shall be completed prior to any clearing and grubbing activities.

   BMP's: CI0l Preserve Natural Vegetation

   CI03 Field Marking Clearing Limits with Orange Filter Fence

2. Establish Construction Access: Access to the construction site shall be limited to the rock construction entrance. The construction entrance shall be extended to provide access to the construction vehicle/equipment staging and employee parking areas as necessary.

   BMP's: C105 Stabilized Construction Entrance
   C107 Parking area stabilization

3. Detain Flows: Limited stormwater is expected to leave the development area of the site due to the sloping of the site and the existing soil conditions. In the event that stormwater begins to leave the site, a temporary sediment pond may be built on site and flows will be directed there.

4. Install Sediment Controls: Sediment control will be provided through a combination of filtration through filter fence or an approved equivalent.

5. Stabilize Soils: Temporary and permanent soil stabilization will be provided. Temporary stabilization will be provided through the application of straw and/or plastic sheeting to exposed worked earth. From October 1 until April 30, no exposed soil may remain exposed and unworked for more than two days; after May 1, no exposed soil may remain exposed and unworked for more than seven days.

12. Manage the Project: The project shall be managed in a cooperative effort by the project manager, contractor, engineer, and the city inspector. During the construction process, if unforeseen issues arise that cannot be resolved on site, construction activity (other than SWPPP maintenance) shall be halted and the city inspector and project engineer are to be contacted and informed of the situation.

SECTION 8: PROJECT OVERVIEW:

This project will develop a 7.86 acre site into a 4-lot single-family residential short plat development. The site will provide public road and a private road tract for access to the lots. An earlier project on this site was not completed. This project will utilize portions of the detention vault, outfall and driveway accesses of the earlier improvements that were installed that for that site. The detention vault and control structure will be sized to the 2005 DOE Stormwater Management Manual for Western Washington.

For drainage, runoff will be directed to the existing outfall to the Ravine flowing to Puget Sound.

The detention facility has been sized to maintain the pre-developed stormwater runoff conditions. A soils map has been provided in Appendix C to show the existing soil around the site.

APPENDIX A

BASIN BREAKDOWN - KARI SHORT PLAT					
	Basin I and Basin 6 have existing and developed areas.				
	Existing areas treated vas forested condition.				
	Basin 2, 3, 4, & 5 have the same condition for				
	existing and developed conditions.				
	These basins flow through the existing vault				
	but do not change in the developed condition				
	and are not a part of the proposed development.				
	BASINS PREDEVELOPED				
BASIN - 1 - DEVELOPED					
	TOTAL AREA	88,074	SF	2.02	AC
	MOD SLOPES	24,332	SF	0.56	AC
	STEEP SLOPES	63,598	SF	1.46	AC
BASIN - 2 - OFFSITE UPSTREAM BASIN AREA					
	TOTAL AREA	52,653	SF	1.21	AC
	FLAT PERVIOUS AREA	52,653	SF	1.21	AC
BASIN 3- EXSTING RESDENCE AREA					
	TOTAL AREA	16,260	SF	0.37	AC
	EXISTING BUILDING	3,485	SF	0.08	AC
	EXISTING DRIVEWAY	2,614	SF	0.06	AC
	LANDSCAPE	10,161	SF	0.23	AC
BASIN 4- EXSTING RESDENCE AREA					
	TOTAL AREA	50,656	SF	1.16	AC
	EXISTING BUILDING	35,719	SF	0.82	AC
	EXISTING DRIVEWAY	6,970	SF	0.16	AC
	LANDSCAPE	7,967	SF	0.18	AC
BASIN 5- EXISTING ROADWAY					
	TOTAL AREA	8,225	SF	0.19	AC
	EXISTING ROADWAY	8,225	SF	0.19	AC

BASIN 6- DETENTION AREA					
	TOTAL AREA	6,776	SF	0.16	AC
	PERVIOUS	6,776	SF	0.16	AC
TOTAL BASIN AREA		222,644	SF	5.11	AC
INCLUDES ALL BASINS					
	BASINS DEVELOPED				
BASIN - 1 - DEVELOPED					
	TOTAL AREA	88,074	SF	2.02	AC
	LOT 1 RESIDENCE	10,106	SF	0.23	AC
	LOT 2 RESIDENCE	4,849	SF	0.11	AC
	LOT 3 RESIDENCE	5,298	SF	0.12	AC
	LOT 4 RESIDENCE	5,114	SF	0.12	AC
	TOTAL RES AREA	25,367	SF	0.58	AC
	LOT 1 DRIVEWAY	1,550	SF	0.04	AC
	LOT 2 DRIVEWAY	800	SF	0.02	AC
	LOT 3 DRIVEWAY	2,000	SF	0.05	AC
	LOT 4 DRIVEWAY	850	SF	0.02	AC
	TOTAL DW AREA	5,200	SF	0.12	AC
	LOT 1 LANDSCAPE	12,217	SF	0.28	AC
	LOT 2 LANDSCAPE	8,206	SF	0.19	AC
	LOT 3 LANDSCAPE	7,840	SF	0.18	AC
	LOT 4 LANDSCAPE	14,612	SF	0.34	AC
	TOTAL LS AREA	42,875	SF	0.98	AC
	PRIVATE ROAD	14,632	SF	0.34	AC
		88,074			
BASIN 6- DETENTION AREA					
	TOTAL AREA	6,970	SF	0.16	AC
	PERVIOUS	4,792	SF	0.11	AC
	VAULT	2,178	SF	0.05	AC
TOTAL BASIN AREA		222,644	SF	5.11	AC
INCLUDES ALL BASINS					
	PREDEVELOPED				
	PERVIOUS MOD	24,332	SF	0.56	AC

	PERVIOUS STEEP	63,598	SF	1.46	AC
	PERVIOUS DETENTION	6,776	SF	0.16	AC
	PERVIOUS FLAT	52,653	SF	2.17	AC
	LANDSCAPE	18,128	SF	0.42	AC
	IMPERVIOUS BLD	39,204	SF	0.90	AC
	IMPERVIOUS DW	9,584	SF	0.22	AC
	IMPERVIOUS PVT ROAD	8,225	SF	0.19	AC
	TOTAL IMPERVIOUS	57,013	SF	1.31	AC
	TOTAL PREDEVELOPED	222,500	SF	5.11	AC
	DEVELOPED				
	LANDSCAPE	112,591	SF	2.58	AC
	IMPERVIOUS VAULT	6,970	SF	0.16	AC
	IMPERVIOUS BLD	64,571	SF	1.48	AC
	IMPERVIOUS DW	15,655	SF	0.36	AC
	IMPERVIOUS PVT ROAD	22,857	SF	0.52	AC
	TOTAL IMPERVIOUS	222,644	SF	5.11	AC

Appendix 4

MAINTENANCE MANUAL

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

No. 6 – Debris Barriers (e.g., Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars.	Bars are bent out of shape more than 3 inches.	Bars in place with no bends more than 3/4 inch.
		Bars are missing or entire barrier missing.	Bars in place according to design.
		Bars are loose and rust is causing 50% deterioration to any part of barrier.	Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

No. 18 – Catchbasin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/or unit.	No sediment cap on the insert media and its unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Media Insert Not Removing Oil	Effluent water from media insert has a visible sheen.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert Water Saturated	Catch basin insert is saturated with water and no longer has the capacity to absorb.	Remove and replace media insert
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	Media Insert Use Beyond Normal Product Life	Media has been used beyond the typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

Appendix 5

CULVERT PIPE CAPACITY

Free Online Manning Pipe Flow Calculator

>> Drop your fears at the door; love is spoken here. <<

Manning Formula Uniform Pipe Flow at Given Slope and Depth

Can you help me translate, program, or host these calculators? (../contact.php) [Hide this request]

Check out our newest spreadsheet update: Download Spreadsheet (spreadsheet/Manning-Pipe-Flow.xlsx) Open Google Sheets version (spreadsheet/Manning-Pipe-Flow.php) View All Spreadsheets (http://www.hawsedc.com/engcalcs/SpreadsheetLibrary.php)

--CAUTION: If you have downloaded the spreadsheet prior to September 24, you may have received incorrect results!--

Point of Compliance

12"Culvert Capacity

Set units: m | mm | ft | in

Pipe diameter, d_0	6	in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	0.012	
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	0.9	% rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	100	%

Results

Flow, Q	0.5766	cfs
Velocity, v	2.9368	ft/sec
Velocity head, h_v	1.6085	in
Flow area	28.2744	sq. in.
Wetted perimeter	18.8496	in
Hydraulic radius	1.5000	in
Top width, T	0.0000	in
Froude number, F	0.00	
Shear stress (tractive force), tau	0.0702	psf

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Manning Formula Uniform Pipe Flow at Given Slope and Depth

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--CAUTION: If you have downloaded the spreadsheet prior to September 24, you may have received incorrect results!--

Point of Compliance

12"Culvert Capacity

Set units: m | mm | ft | in

Pipe diameter, d_0	6 in
Manning roughness, n ? (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html)	0.012
Pressure slope (possibly ? (../pressureslope.php) equal to pipe slope), S_0	41 % rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	100 %

Results

Flow, Q	3.8919	cfs
Velocity, v	19.8217	ft/sec
Velocity head, h_v	73.2767	in
Flow area	28.2744	sq. in.
Wetted perimeter	18.8496	in
Hydraulic radius	1.5000	in
Top width, T	0.0000	in
Froude number, F	0.00	
Shear stress (tractive force), tau	3.1999	psf