SEPA Environmental Checklist
Mercer Island Center for the Arts

Attachment G
Slope Stability Review

January 2017

November 22, 2016

Bruce Lorig, Building Committee Chair
Mercer Island Center for the Arts
P.O. Box 1702
Mercer Island, WA 98040

Re: **Mercer Island Center for the Arts**
Slope Stability Study
19120-01

Dear Bruce:

We have conducted an additional site visit and further analyses to assess the landslide risks for the proposed development site. We developed a cross section through the site and the adjacent hillside. It is presented as Figure 1 attached to this letter. Figure 1 also demonstrates the changing steepness of the slopes, from near flat at the building site, to 15% - 30% directly behind the building, to average slopes steeper than 40% up the rest of the hill.

General Geologic Conditions

Based on our borings, other borings in the vicinity, geologic mapping, and published sources, we prepared a subsurface cross section as shown in Figure 2. The different layering is approximate, both in depth and thickness. As noted, the soils are generally glacial in origin and very dense, except for surficial deposits.

During our recent site reconnaissance at the end of October 2016 we did not observe groundwater seepage on the slope, even though this past October has been the wettest on record. Groundwater levels and/or seepage rates are not static and we expect that groundwater conditions will vary depending on local subsurface conditions, season, precipitation, changes in land use both on and off site, and other factors.

Geologic Hazards and Recommended Mitigation

The City of Mercer Island Municipal Code establishes that any ground with a grade of 40 percent or more is considered a "steep slope". However, the code also establishes that classification as a Landslide Hazard Area requires slopes steeper than 15 percent, a hillside that intersects geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock, and the presence of springs or groundwater seepage. Therefore, it is possible to have a site that contains steep slopes, but is not considered a Landslide Hazard Area, and vice versa.

Based on our surface and subsurface investigation, it is our opinion that a Landslide Hazard Area does not exist on the development property because of the absence of seepage and the expected and mapped layering of the soil units. Nor is the property a steep slope, since the average slopes are near flat.

Much of the near surface soils in the 15-40% upslope area are landslide debris from much older landslides probably occurring approximately 650 to 800 ft. upslope from the proposed building location. The presence of these soils raises the risk of reactivation of slide debris, or soil creep, and suggests past instability. However, we noted that an existing rockery wall near the base of the slope behind the existing structure has shown no signs of movement or displacement due to soil creep or landslide reactivation.

To further analyze the conditions Hart Crowser assigned reasonable soil properties to the soil units and used the computer program Slope/W to calculate safety factors on presumed critical surfaces. The first analysis is shown in Figure 3, and assumes a critical failure surface through the surficial soils. Such a failure surface would result in soil slumping on the slope, but would not be catastrophic. The calculated factor of safety (ratio of the resisting forces to the driving forces along the potential failure surface) for this surface and static load conditions is about 2.4, indicating that a slope stability failure of this sort is unlikely to occur.

Figure 4 presents a critical failure surface that is deep seated, starts near the top of the hill, and is long enough to intersect the new arts structure. Movement on such a surface would be a major landslide. We calculated a factor of safety of about 2.6 for this surface under static loading conditions, again indicating that a deep seated slope failure such as this is unlikely to occur.

We also estimated the safety factor for this deep seated failure surface under seismic loading by applying forces to the slope that would only occur during a major event. We conducted pseudo-static analysis with a seismic coefficient of 0.286g. This value represents the imparted forces from an earthquake with a return period of 2, 475 years, referred to as the maximum considered earthquake. This is the most severe earthquake typically used in the design of new structures. The value of 0.286g is one-half the maximum credible peak ground acceleration. This is a catastrophic seismic event. For buildings the code is roughly based on “collapse prevention” performance under the 2,475-year return period earthquake and “life safety” performance under 2/3 of this earthquake. Although not directly comparable, an earthquake with a magnitude of 7.5 to 9 could cause such accelerations, depending on the depth and location of the epicenter. If such an earthquake would hit the region many buildings and infrastructure would be severely damaged or could collapse. Yet even during this extreme seismic event the factor of safety for the slope above the MICA development area on this deep potential failure surface is nearly 1.1, as shown on Figure 5.

Our conclusion is that this is a relatively stable, low risk slope under static conditions. Although a major earthquake would increase the risk of a slope failure, the safety factor is still above 1.0 (and thus the slope is still stable) even under a major seismic event, based on our assumptions of stratigraphy and soil properties. The stability of the slope is enhanced or maintained if the slope remains vegetated and relatively undisturbed.

Erosion

According to the United States Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) website, soil within the property is mapped as Bellingham Silt Loam and Kitsap Silt Loam. The steepest portions of the property are sloped greater than 40 percent, but a large majority of the site is sloped between 0 and 20 percent.

The Bellingham Silt Loam has an erosion K factor (susceptibility of a soil to sheet and rill erosion by water) of 0.28. Values of K range from 0.02 to 0.69, and, the higher the value, the more susceptible the soil is to water erosion based on the mapped K factor. Therefore, Bellingham Silt Loam has an average susceptible to erosion. Kitsap Silt Loam does not have a mapped erosion K factor per the NRCS website. It should be noted, however, that the portions of the site mapped as Kitsap Silt Loam is low sloped (KpB 2-8% slope) and moderately sloped (KpD 15-30%) are estimated to be less than 10 percent of the proposed disturbed area of the site. Our opinion is that the Kitsap Silt Loam is unlikely to have substantial contributions to off-site erosion due to the small percentage that will be disturbed during construction based on the NRCS mapping and the soil types observed during our on-site explorations.

Site development is anticipated to include a Washington State Department of Ecology Construction Storm Water General Permit to mitigate the erosion potential of soils exposed during construction or site grading activities. In order to meet the criteria established by the Department of Ecology, an erosion control plan consistent with the governing municipal standards and best management practices will be required for this project. The contractor will be responsible for implementing the erosion control plan as established in the plans and specifications approved by the governing municipality for the project.

We reviewed the following documents as part of this work:

Troost, K G, Wisher, A P,. Geologic Map of Mercer Island, Washington [map]. 1:12,000. Mercer Island, 2006.; and

Troost, K G, Wisher, A P,. Mercer Island Landslide Hazard Assessment [map]. 1:12,000. Mercer Island, 2009.; and

Troost, K G, Wisher, A P,. Mercer Island Erosion Hazard Assessment [map]. 1:12,000. Mercer Island, 2009.

We also reviewed the following items as part of this work:

Existing King County 2016 LiDAR data and
The City of Mercer Island Municipal Code.

Please contact me directly if you have any questions, or if you would like additional information or review. We are available to meet with the team if needed to work through these issues on your behalf.

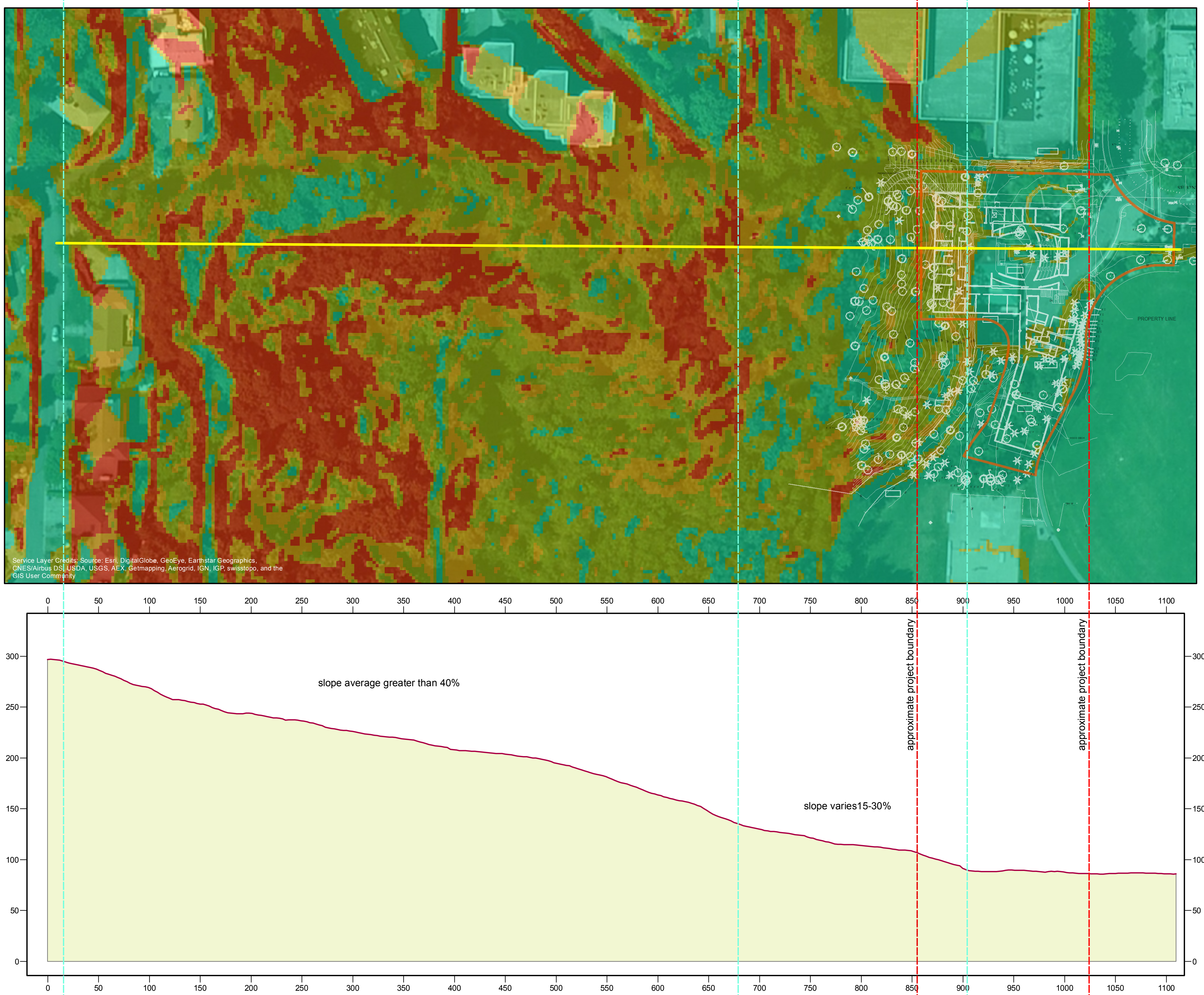
Sincerely,

HART CROWSER, INC.

DAVID G. WINTER, PE, LEED AP
Chief Executive Officer

Attached: Figures 1 – 5

L:\Notebooks\1912001_Mercer Island Center for the Arts Report Update\Deliverables\Letters\Slope Stability Review 11-22-16\MICA Slope Stability Review 11-22-16.docx



Slope

- 0-14%
- 15%-29%
- 30%-39%
- >40%
- profile

N

0 100 200 Feet

Mercer Island Center for the Arts Geotechnical Report
Mercer Island, Washington

Slope and Profile

1912001 10/16

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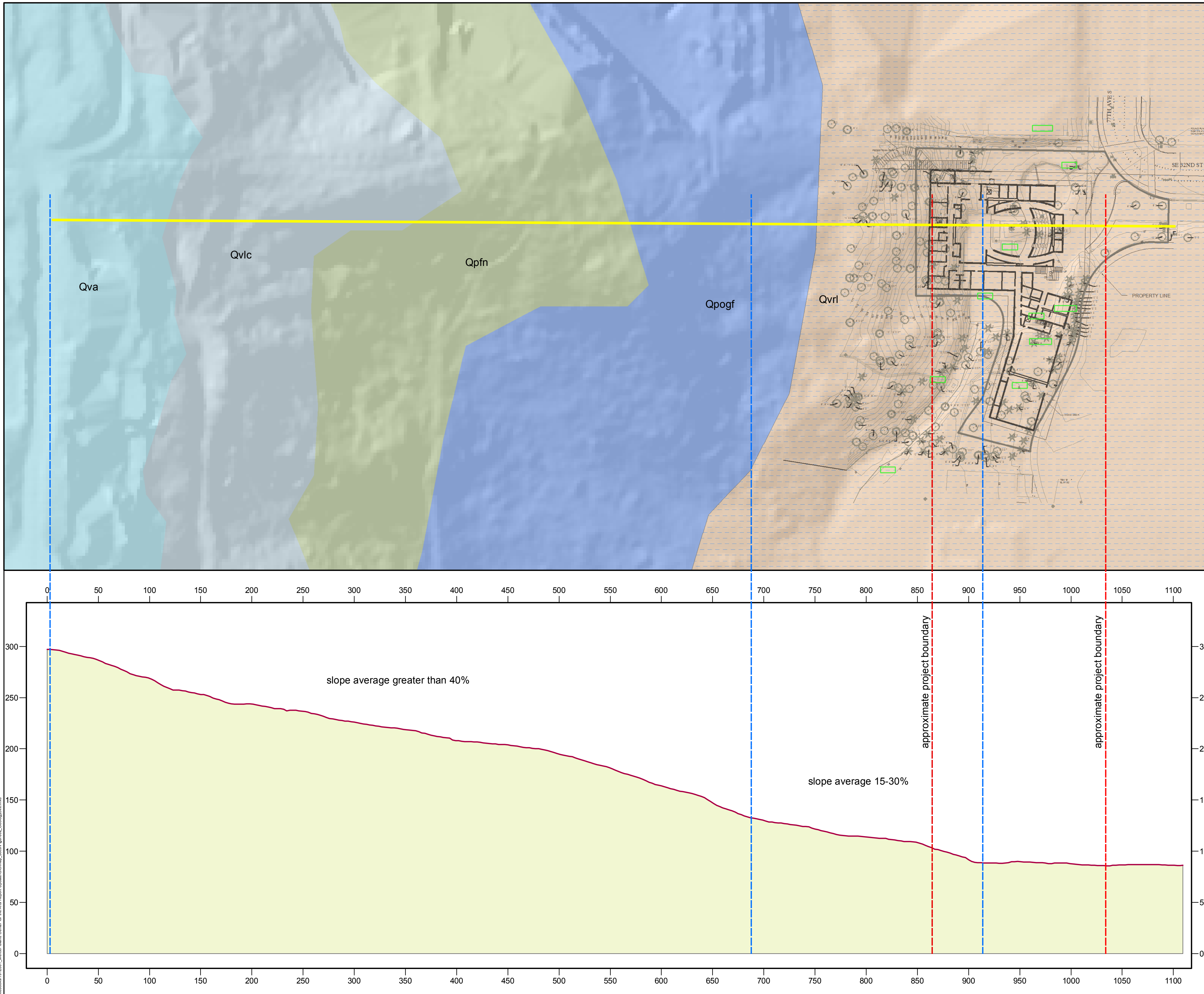
Figure 1



Geologic Units

- Qpfn - Pre-Fraser age nonglacial deposits
- Qpogf - Olympia glaciation age fine-grained glacial deposits
- Qva - Vashon glaciation age advanced outwash deposits
- Qvlc - Vashon glaciation age Lawton clay deposits
- Qvrl - Vashon glaciation age recessional lacustrine deposits
- profiles

N

0 100 200 Feet

Mercer Island Center for the Arts Geotechnical Report
Mercer Island, Washington

Surface Geology

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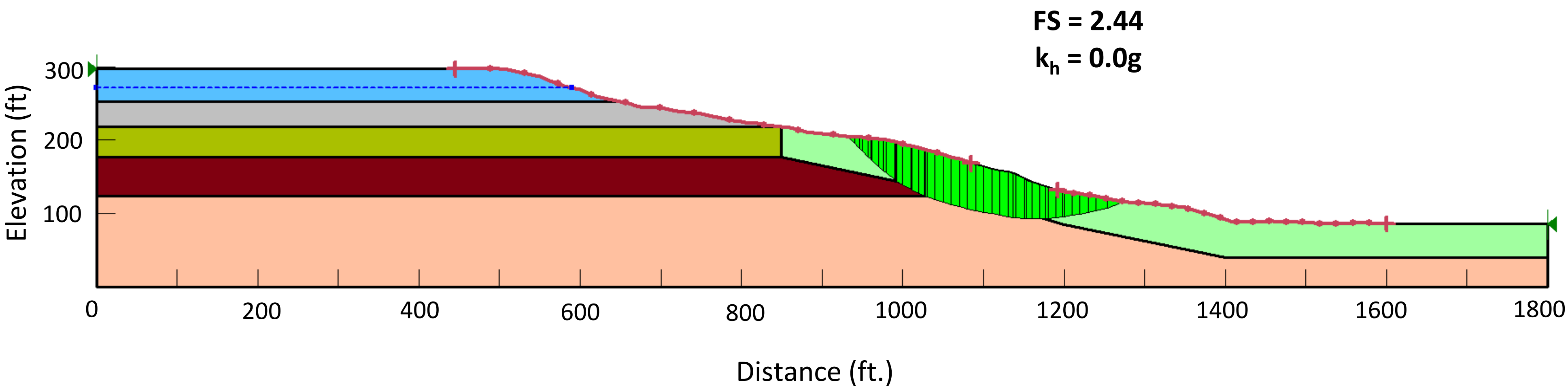
Figure

02

MBC 11/08/2016



SLOPE/W Soil Profile Model Inputs

Geologic Unit	Color	Material Model	Unit Weight (pcf)	Friction Angle (°)	Cohesion (psf)
Vashon Advance Outwash		Mohr-Coulomb	120	40	250
Lawton Clay		Mohr-Coulomb	115	26	600
Pre-Fraser Non-Glacial		Mohr-Coulomb	125	34	400
Pre-Olympia Fine-Grain		Mohr-Coulomb	120	26	600
Recessional Lacustrine		Mohr-Coulomb	115	24	400
Landslide Deposits		Mohr-Coulomb	120	32	400

Mercer Island Center for the Arts
Seattle, WA

Limit Equilibrirum Slope Stability Analysis: Shallow Static Conditions

19120-01
11/8/16

Figure
3

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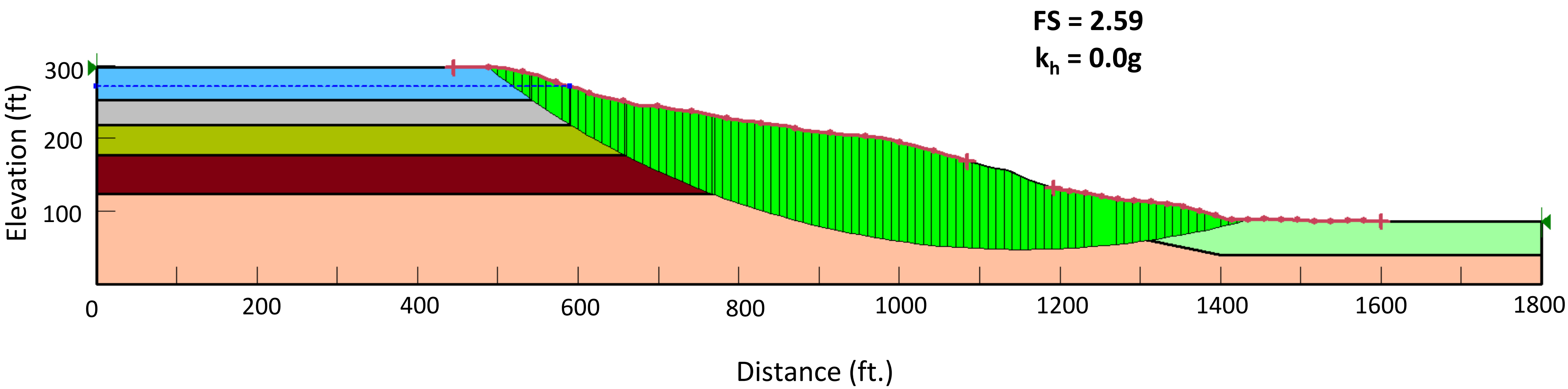

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Seattle, WA

Limit Equilibrirum Slope Stability Analysis: Deep Static Condition

19120-01

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Figure **4**

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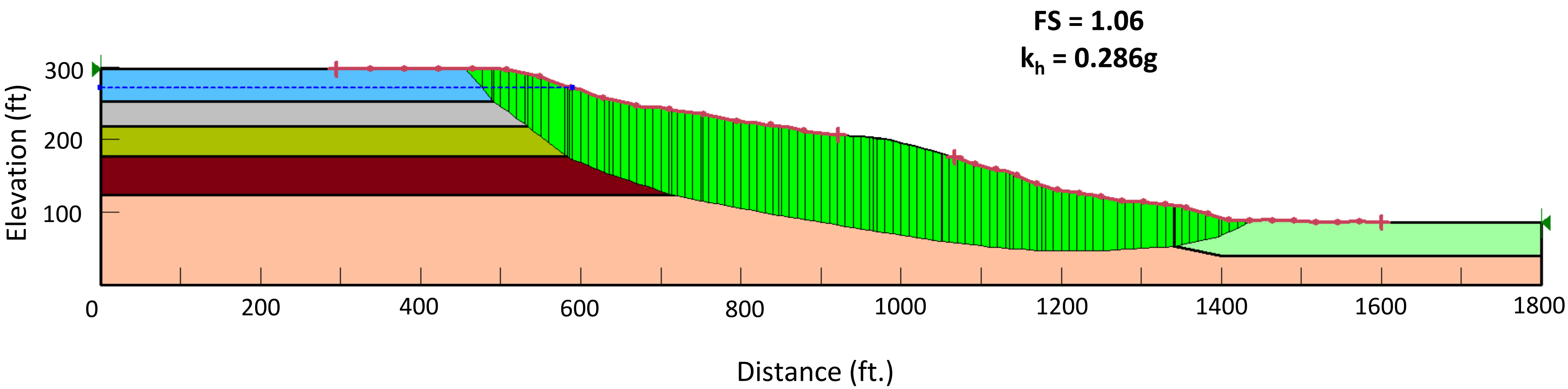

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Recessional Lacustrine		Mohr-Coulomb	115	24	400
Landslide Deposits		Mohr-Coulomb	120	32	400

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Seattle, WA

Limit Equilibrirum Slope Stability Analysis: Deep Seismic Condition

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Figure
5