

February 5, 2024
PanGEO Project No. 23-386

Mercer Island Beach Club
8326 Avalon Drive
Mercer Island, WA 98040
Attn: Gardner Morelli

Subject: Geotechnical Engineering Report
Mercer Island Beach Club - Proposed Bulkhead Removal
8326 Avalon Drive, Mercer Island, Washington 98040

Dear Gardner:

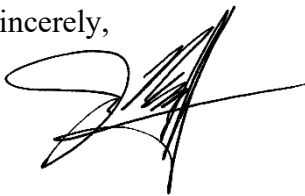
As requested, PanGEO, Inc. is pleased to present the following geotechnical report to assist you and your project team with the planning, permitting and implementation of the proposed bulkhead removal project within the southern portion of the Mercer Island Beach Club property, at the above address.

In preparing this report, we reviewed existing subsurface information in the vicinity of the site, performed a site reconnaissance, and reviewed the proposed bulkhead removal plans provided to us.

Based on the results of our study, in our opinion the proposed bulkhead removal and beach restoration is acceptable from the geotechnical standpoint, and in our opinion will not adversely affect the existing property or adjacent properties.

We appreciate the opportunity to be of service.

Sincerely,



Jon C. Rehkopf, P.E.
Principal Geotechnical Engineer

Enclosed: Geotechnical Engineering Report

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- Figure 1 Vicinity Map
Figure 2 Site and Exploration Plan

Appendix A Existing Exploration Log Log of Test Boring EB-1 (AESI, 2005)

GEOTECHNICAL ENGINEERING REPORT
MERCER ISLAND BEACH CLUB - PROPOSED BULKHEAD REMOVAL
8326 AVALON DRIVE
MERCER ISLAND, WASHINGTON

1.0 GENERAL

As requested, PanGEO, Inc. is pleased to present this geotechnical report to assist the project team with the planning, permitting, and implementation of the proposed bulkhead replacement project at the Mercer Island Beach Club, in Mercer Island, Washington. This study was performed in general accordance with our mutually agreed scope of services outlined in our proposal dated December 3, 2023, which was subsequently authorized on December 5, 2023. Our scope of services included reviewing readily available geologic and geotechnical data in the vicinity of the site, conducting a site reconnaissance, and developing the conclusions and recommendations presented in this report.

2.0 SITE AND PROJECT DESCRIPTION

The site is located at 8326 Avalon Drive, on the property owned by the Mercer Island Beach Club, situated at the south end of Mercer Island, Washington, as depicted in Figure 1. The site, which has a total area of about 7½ acres, includes over 600 feet of Lake Washington shoreline. The site is developed with a main clubhouse building, two swimming pools, and numerous amenities including tennis courts, picnic areas, play areas, a marina, boat launch, beach area, and grass play fields, as well as paved parking lots.

The specific portion of the subject site that pertains to the currently proposed bulkhead removal project is the waterfront area along the southern approximately 60 feet of the Lake Washington shoreline, or about 10% of the parcel's waterfront. At this location, the shoreline is lined with a deteriorating timber bulkhead about 2 to 3 feet tall, along with a low, approximately 2-foot-tall rockery.

Plates 1 and 2 on the following page depict current site conditions in the area of the proposed bulkhead removal project.



Plate 1. Looking south along shoreline of Lake Washington at failing timber bulkhead



Plate 2. Looking north along top of failing timber bulkhead

We understand the Mercer Island Beach Club is proposing a significant marina reconstruction project, as much of the marina has reached the end of its service life. A relatively small part of the project will include the removal of an existing timber bulkhead, consisting of creosote treated dimensional timbers, at the south end of the waterfront, as shown above in Plates 1 and 2. The focus of our current study is the evaluation of the bulkhead removal project. Our current study does not address the marina reconstruction.

Based on our review of the project plans provided to us, we understand that the bulkhead will be replaced with a sloped beach area. The removal of the bulkhead will also include the removal of existing soils behind the bulkhead to allow grading for the new beach. The upland area disturbed by the removal of the bulkhead fill will receive new landscaping with a lawn picnic area and ornamental plantings. An approximately 6-foot-wide cobble path will be constructed from the beach area up to the existing wood-chip play area, to provide easy access to the beach.

The project may also include the replacement of a low timber retaining wall with a concrete cast-in-place wall that is currently located upland of the existing beach area, above the ordinary high-water mark, directly north of the proposed bulkhead to be removed.

We understand that the City of Mercer Island is requiring a geotechnical report to support the bulkhead removal and replacement with a beach, and to address any geologic hazards at the site that may impact the project.

The conclusions and recommendations in this report are based on our understanding of the proposed project, which is in turn based on the project information provided. If the above project description is incorrect, or the project information changes, we should be consulted to review the recommendations contained in this study and make modifications, if needed. PanGEO should be retained to provide a review of the final design to confirm that our geotechnical recommendations have been correctly interpreted and adequately implemented in the construction documents.

3.0 SUBSURFACE CONDITIONS

3.1 SITE GEOLOGY

According to the geologic map of Mercer Island (Troost and Wisher, 2006), the project site is underlain by a series of deposits that include:

- **Lake Deposits (map unit Q_l)** – Lake deposits are mapped along the shoreline of Lake Washington and are described as very soft to medium stiff, or very loose to medium dense, silt and clay with local sand layers, peat and other organic sediments.
- **Pre-Olympia Nonglacial Deposits (map unit Q_{pon})** – Directly upland of the mapped Lake Deposits, the geologic map depicts older, nonglacial pre-Olympia deposits that are described as very dense and hard, sand, gravel, silt, clay and organic deposits of inferred nonglacial origin. These deposits typically contain localized iron-oxide cemented layers, interbedded and intermixed fine and coarse-grained layers.
- **Lawton Clay (map unit Q_{vlc})** – Lastly, upslope of the mapped pre-Olympia deposits, the geology map indicates the western portion of the site is underlain by Lawton Clay. Lawton Clay is described as very stiff to hard, laminated to massive silt, clayey silt and silty clay with scattered drop stones deposited in lowland proglacial lakes. Lawton Clay may contain vertical fractures or fine sand partings near the top and bottom of the unit. When Lawton Clay is fractured, or has become disturbed, it is known to be weak, and prone to downslope movements.

3.2 PREVIOUS SUBSURFACE EXPLORATIONS

To gain a better understanding the subsurface conditions at the site, we reviewed the results of test borings that were performed by others (AESI, 2005) at the site to support the design of the new swimming pools. In particular, we reviewed the results of test boring EB-1, which was located in close proximity to the proposed bulkhead removal. EB-1 was advanced to a depth of 21 feet below the ground surface.

Test boring EB-1 encountered about five feet of silty fine sand with wood debris, over loose becoming medium dense, fine to medium sand with trace silt to a depth of 15 feet. Below 15 feet the boring encountered dense to very dense sand with fine sand lenses.

The approximate location of the previous test boring EB-1 is shown on the attached Figure 2 (Site and Exploration Plan). The summary test boring log is included in Appendix A.

3.3 SOIL CONDITIONS

Based on the results of the previous test boring, as well as our observations of exposed soils at the site, we anticipate that the bulkhead removal area is underlain by loose fill over dense sand and hard silt, that we interpret to be the mapped pre-Olympia deposits.

Fill: We anticipate that the area upland of the failing timber bulkhead was originally a beach, and therefore backfill was used to raise grade behind the bulkhead. Using a ½-inch diameter soil probe, we were able to easily probe to a depth of three feet below the ground surface in the area behind the existing bulkhead (see Plate 3 to the right). Based on the loose nature of the soil, and the location, we interpret the soils behind the bulkhead to be fill.



Plate 3. Note 3-foot-long steel hand probe pushed to full depth through loose fill soils.



Plate 4. Exposed soils at the base of the failing bulkhead consisted of dense silty fine sand and very stiff sandy silt.

Pre-Olympia Deposits: We observed exposed soil conditions along the base of the deteriorating bulkhead to consist of dense silty sand and very stiff sand silt, which we interpreted to be the mapped older nonglacial deposits. We were unable to probe more than an inch into this soil unit with the ½-inch diameter steel hand probe. Plate 4 to the left depicts soils exposed at the base of the failing bulkhead.

4.0 GEOLOGIC HAZARD AREAS

Based on our review of the City of Mercer Island GIS maps, the project site includes the following geologic hazards: potential landslide hazard area, seismic hazard area, and erosional hazard area.

4.1 POTENTIAL LANDSLIDE HAZARDS

The subject site is mapped within a potential landslide hazard area according to the City of Mercer Island's Geologic Hazards Map. However, slopes greater than 40% are not mapped in the vicinity of the proposed project. The map indicates that slopes of 15% or more are present at the site, as well as landslide and mass wasting deposits. According to the map, a previously documented landslide is located several parcels to the north of the subject site, but no landslides have been recorded at the site.

Site Reconnaissance: A site reconnaissance was conducted on December 12, 2023. As part of our site reconnaissance, we walked the site to look for evidence of past or on-going slope instability. During our site reconnaissance we did not observe evidence of significant recent or ongoing instability in the project area, such as hummocky terrain, obvious slide scarps, uneven topography, or tension cracks. No evidence of mass wasting deposits were noted in the immediate vicinity of the proposed work area, nor were mass wasting deposits encountered in the previous test borings advanced near the project area at the site.

We observed the topography of the site in and around the area of the proposed bulkhead removal to be only gently sloping down to the east, towards Lake Washington. Plate 5 on the following page depicts ground conditions in the proposed bulkhead removal area.

During our site reconnaissance we also observed the condition of the existing site features in the area of the proposed bulkhead removal area, to look for signs of settlement and distress, which may indicate ground movement. No significant cracks in the surrounding concrete retaining walls were noted.

Conclusions: Based on our reconnaissance and our understanding of subsurface conditions at the site, in our opinion a large, deep-seated type of slope failure is unlikely on the subject property. In addition, due to the limited amount of surficial loose soils encountered in the test borings, the lack of observed evidence of recent shallow slides, and the relatively gentle topography, in our opinion the potential for shallow slides at the site is also relatively low.

It is our opinion that the proposed bulkhead removal project, as currently planned, is feasible from a geotechnical engineering standpoint, and in our opinion will not adversely affect the overall stability of the site or adjacent properties, provided the recommendations outlined herein are followed and the proposed development is properly design and constructed.



***Plate 5.** Looking southwest at area of proposed bulkhead removal. Bulkhead is located below the picnic tables, but is obscured by vegetation growth.*

4.2 SEISMIC HAZARDS

Based on our review of the City of Mercer Island’s Geologic Hazards Maps, the entire subject site is mapped as a seismic hazard area. The City of Mercer Island Code defines seismic hazard areas as those areas subject to risk of damage as a result of earthquake-induced ground shaking, slope failure, soil liquefaction or surface faulting.

Because the proposed project only includes the removal of a bulkhead, and replacement with a beach, in our opinion the proposed beach will not be at risk from seismic hazards such as liquefaction, which could potentially cause ground settlement or lateral displacement. However, it may be noted that based on the dense soils exposed at the base of the existing bulkhead, and the results of the previous borings, the underlying soils have a density that makes them unlikely to liquefy during the code-level seismic event. As such, in our opinion, the currently proposed bulkhead removal project will not be significantly affected by the potential liquefaction of site soils or associated seismic hazards.

It is also our opinion that the potential for significant seismic-induced land sliding is relatively low at the site due to the anticipated dense and hard glacial soils underlying the slope, and lack of steep slopes.

4.3 EROSION HAZARDS

The subject site is mapped within a potential erosion hazard area according to the City of Mercer Island's Geologic Hazards Map. Based on soil conditions encountered in the borings, the near-surface site soils are likely to exhibit moderate to low erosion potential. In our opinion, the erosion hazards at the site can be effectively mitigated with the best management practices during construction and with properly designed and implemented landscaping for permanent erosion control. During construction, the temporary erosion hazard can be effectively managed with an appropriate erosion and sediment control plan, including, but not limited to, installing silt fencing at the construction perimeter, limiting removal of vegetation around the construction area, placing gravel or hay bales at the disturbed/traffic areas, covering stockpile soil or cut slopes with plastic sheets, constructing a temporary drainage pond to control surface runoff and sediment trap, and maintaining a stabilized access road to the site.

Permanent erosion control measures should include establishing vegetation, landscape plants, and beach gravel.

4.4 SUMMARY

It is our opinion that the proposed bulkhead removal project, as currently planned, is feasible from the geotechnical engineering standpoint, and will not adversely affect the mapped geologic hazards at the site, and the geologic hazards will not adversely impact the proposed bulkhead removal and beach re-establishment.

5.0 GEOTECHNICAL CONCLUSIONS & RECOMMENDATIONS

5.1 BULKHEAD REMOVAL

We understand that the proposed development plan includes the removal of the low timber bulkhead that is currently failing, as well as several boulders that are functioning as part of the bulkhead. In addition, the fill soil behind the bulkhead will be removed, so that the area can be re-graded at a low angle to generally match the existing beach area directly north of the bulkhead removal area.

Based on our review of the landscaping plan, beach nourishment gravel, 1-inch minus, per Washington Department of Fish and Wildlife (WDFW), will be placed in the reconstructed

beach area in all areas below the ordinary high water mark of 21.8 feet (MLLW – Locks Datum per Corps of Engineering).

Based on our understanding of the proposed project, in our opinion the bulkhead removal and beach replacement will not adversely affect the upland areas of the site, and will not result in an increased risk of slope movements or increased erosion. In addition, we anticipate that the new beach area will perform similarly as the adjacent existing



Plate 6. Looking south along existing beach area. Proposed bulkhead removal area in the distance. Proposed beach reconstruction will generally match the existing beach condition shown in photo.

beach area to the north, which we understand has performed well.

5.2 EROSION CONTROL CONSIDERATIONS

Surface runoff can be controlled during construction by careful grading practices. This may include the construction of shallow, upgrade perimeter ditches or low earthen berms to collect runoff and prevent water from entering the excavation area. Silt fences and straw rolls may also be included around the work area to control erosion. All collected water should be directed to a positive and permanent discharge system such as a storm sewer. It should be noted that some of the site soils are prone to surficial erosion. Special care should be taken to avoid surface water on open cut excavations, and exposed slopes should be protected with plastic sheeting.

Permanent erosion control measures such as placing gravel, covering exposed ground surfaces with topsoil and mulch, and installing landscaping, should be performed as soon as possible after construction to limit the time the exposed surfaces are susceptible to erosion.

5.3 SITE RETAINING WALLS

We understand that the project may include the replacement of an upland timber retaining wall, which has a height of about three feet, with a new cast-in-place concrete wall, to reduce future maintenance efforts. The existing timber wall is located just north of the bulkhead that will be removed, and is shown in Plate 6 on the previous page. We anticipate that the new wall will also have a height of approximately three feet. In our opinion, the proposed cast-in-place concrete wall is feasible from the geotechnical perspective.

Site retaining walls should be properly designed to resist the pressure exerted by the soils behind the walls. Proper drainage provisions should also be provided behind the walls to intercept and remove any groundwater from behind the wall. Our geotechnical recommendations for the design and construction of the below-grade walls are presented below.

5.3.1 Wall Foundations

Based on our understanding of soil conditions at the site, and minimal observed penetrations of a ½-inch diameter steel hand probe into the near-surface soils along the face of the existing wall, the foundation subgrade soils will most likely consist of medium dense to dense silty sand and sandy silt. We recommend a maximum allowable soil bearing pressure of 2,000 pounds per square foot (psf) be used to size the footings for the new wall.

For allowable stress design, the recommended bearing pressure may be increased by one-third for transient loading, such as seismic forces.

5.3.2 Lateral Earth Pressures

The below grade portions of the walls should be designed for an earth pressure based upon an equivalent fluid weight of 35 pcf for a wall that is allowed to yield (active condition). For the seismic condition, we recommend a uniform lateral earth pressure of at least $9H$ psf (where H is the height of the below grade portion of the wall in feet) be added to the static pressure for sizing the walls for the ultimate condition. The recommended lateral pressures assume that adequate wall drainage will be incorporated into the design and construction of the walls to prevent the development of hydrostatic pressure.

5.3.3 Lateral Resistance

Lateral forces may be resisted by the combination of passive earth pressures acting against the embedded portions of the foundations and by friction acting on the base of the

foundations. Passive resistance values may be determined using an equivalent fluid weight of 250 pounds per cubic foot (pcf). This value includes a geotechnical factor of safety of at least 1.5 assuming that a properly compacted structural fill will be placed adjacent to the sides of the footings. A coefficient friction of 0.40 may be used to determine the frictional resistance at the base of the footings.

5.3.4 Wall Drainage

Provisions for permanent control of subsurface water should be incorporated into the design and construction of below-grade walls. For walls constructed with conventional free-draining backfill, a footing drain consisting of a 4-inch diameter perforated pipe embedded in at least 12 inches of washed gravel wrapped with a geotextile fabric should be placed at the base of the wall footings. The drain pipe may daylight at the end of the wall onto the beach. The volume of groundwater water collected by the footing drain is expected to be very minor.

Alternatively, 2-inch diameter weep pipes, spaced 10-feet on center, may be placed along the base of the wall, to allow for wall drainage. If weep pipes are utilized, a minimum 12-inch-thick layer of free-draining washed gravel should be placed behind the wall to promote drainage. The washed rock should be covered with a geotextile fabric to prevent backfill soils from migrating into the voids of the washed rock.

5.3.5 Wall Backfill

Wall backfill should consist of free draining granular soils. If the on-site soils have a high silt content, they may not be suitable to be re-used as backfill, and imported soils may be needed. PanGEO will be available during construction to evaluate the potential re-use of on-site soils. If needed, imported wall backfill should consist of granular soils such as City of Seattle Type 17 mineral aggregate, or a PanGEO approved equivalent.

Wall backfill should be moisture conditioned to within about 3 percent of optimum moisture content, placed in loose, horizontal lifts less than 8 inches in thickness, and systematically compacted to a dense and relatively unyielding condition and to at least 95 percent of the maximum dry density, as determined using test method ASTM D 1557 (Modified Proctor). Within 5 feet of the wall, the backfill should be compacted to 90 percent of the maximum dry density.

6.0 STATEMENT OF RISK

The site is mapped by the City of Mercer Island as containing geologic hazard areas. As such, we anticipate that the City of Mercer Island may require the following Statement of Risk.

Per Mercer Island City Code, development within geologic hazard areas and critical slopes may occur if the geotechnical engineer provides a statement of risk with supporting documentation indicating that one of the following conditions can be met:

- a. The geologic hazard area will be modified, or the development has been designed so that the risk to the lot and adjacent property is eliminated or mitigated such that the site is determined to be safe; or
- b. An evaluation of site-specific subsurface conditions demonstrates that the proposed development is not located in a geologic hazard area; or
- c. Development practices are proposed for the alteration that would render the development as safe as if it were not located in a geologic hazard area; or
- d. The alteration is so minor as not to pose a threat to the public health, safety, and welfare.

It is our opinion that Criterion A, C, and D can be met provided that the development is designed and constructed in accordance with the recommendations in this report.

In our opinion the proposed bulkhead removal project will not increase the risk to the subject lot or adjacent property, and the site can be considered safe, thus meeting Criterion A.

In addition, in our opinion Criterion C can be met through best management practices during construction, including the proper use of temporary erosion control measures.

Lastly, due to the limited amount of earthwork, and because no new wall will be constructed, in our opinion Criterion D applies to the subject project as well.

7.0 ADDITIONAL SERVICES

PanGEO is available to provide additional consultation during final design and permitting, and to monitor geotechnical aspects of construction, if requested.

8.0 CLOSURE

We have prepared this report for the Mercer Island Beach Club, and the project design team. Recommendations contained in this report are based on a site reconnaissance, review of pertinent subsurface information, and our understanding of the project. The study was performed using a mutually agreed-upon scope of services.

Variations in soil conditions may exist between the locations of the explorations and the actual conditions underlying the site. The nature and extent of soil variations may not be evident until construction occurs. If any soil conditions are encountered at the site that are different from those described in this report, we should be notified immediately to review the applicability of our recommendations. Additionally, we should also be notified to review the applicability of our recommendations if there are any changes in the project scope.

The scope of our work does not include services related to construction safety precautions. 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. Additionally, the scope of our services specifically excludes the assessment of environmental characteristics, particularly those involving hazardous substances. We are not mold consultants nor are our recommendations to be interpreted as being preventative of mold development. A mold specialist should be consulted for all mold-related issues.

This report has been prepared for planning and design purposes for specific application to the proposed project in accordance with the generally accepted standards of local practice at the time this report was written. No warranty, express or implied, is made.

This report may be used only by the client and for the purposes stated, within a reasonable time from its issuance. Land use, site conditions (both off and on-site), or other factors including advances in our understanding of applied science, may change over time and could materially affect our findings. Therefore, this report should not be relied upon after 24 months from its issuance. PanGEO should be notified if the project is delayed by more than 24 months from the date of this report so that we may review the applicability of our conclusions considering the time lapse.

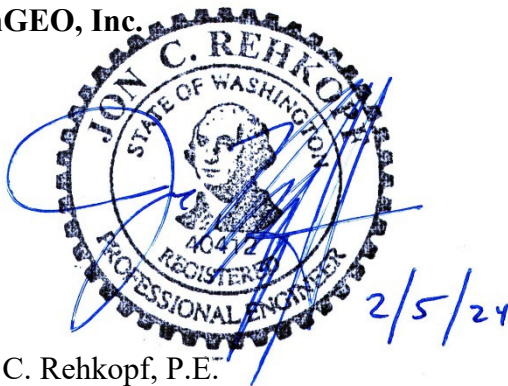
It is the client's responsibility to see that all parties to this project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the contractor's

option and risk. Any party other than the client who wishes to use this report shall notify PanGEO of such intended use and for permission to copy this report. Based on the intended use of the report, PanGEO may require that additional work be performed and that an updated report be reissued. Noncompliance with any of these requirements will release PanGEO from any liability resulting from the use this report.

We appreciate the opportunity to work with you on this project. If you have any questions, please do not hesitate to contact our office.

Sincerely,

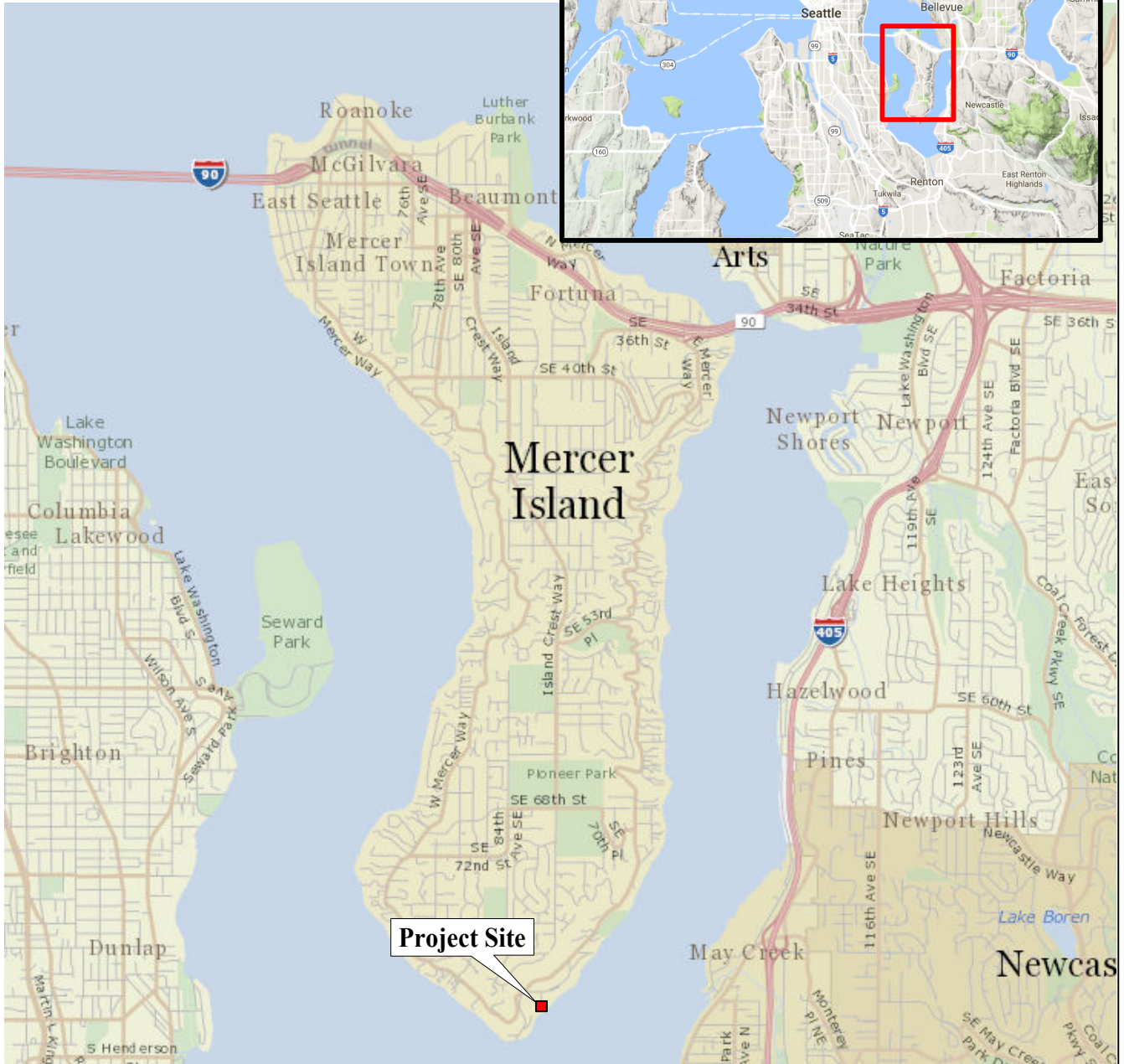
PanGEO, Inc.



Jon C. Rehkopf, P.E.
Principal Geotechnical Engineer
jrehkopf@pangeoinc.com

9.0 REFERENCES

- Associated Earth Sciences, Inc. (2005). *Log of Test Boring EB-1, Mercer Island Beach Club, Mercer Island, WA*, 4/27/2005, project number KE05246A.
- Troost, Kathy G, and Wisner, Aaron P., (2006). *Geologic Map of Mercer Island, Washington*. October 2006.



Not to Scale

Base Map: King County iMap

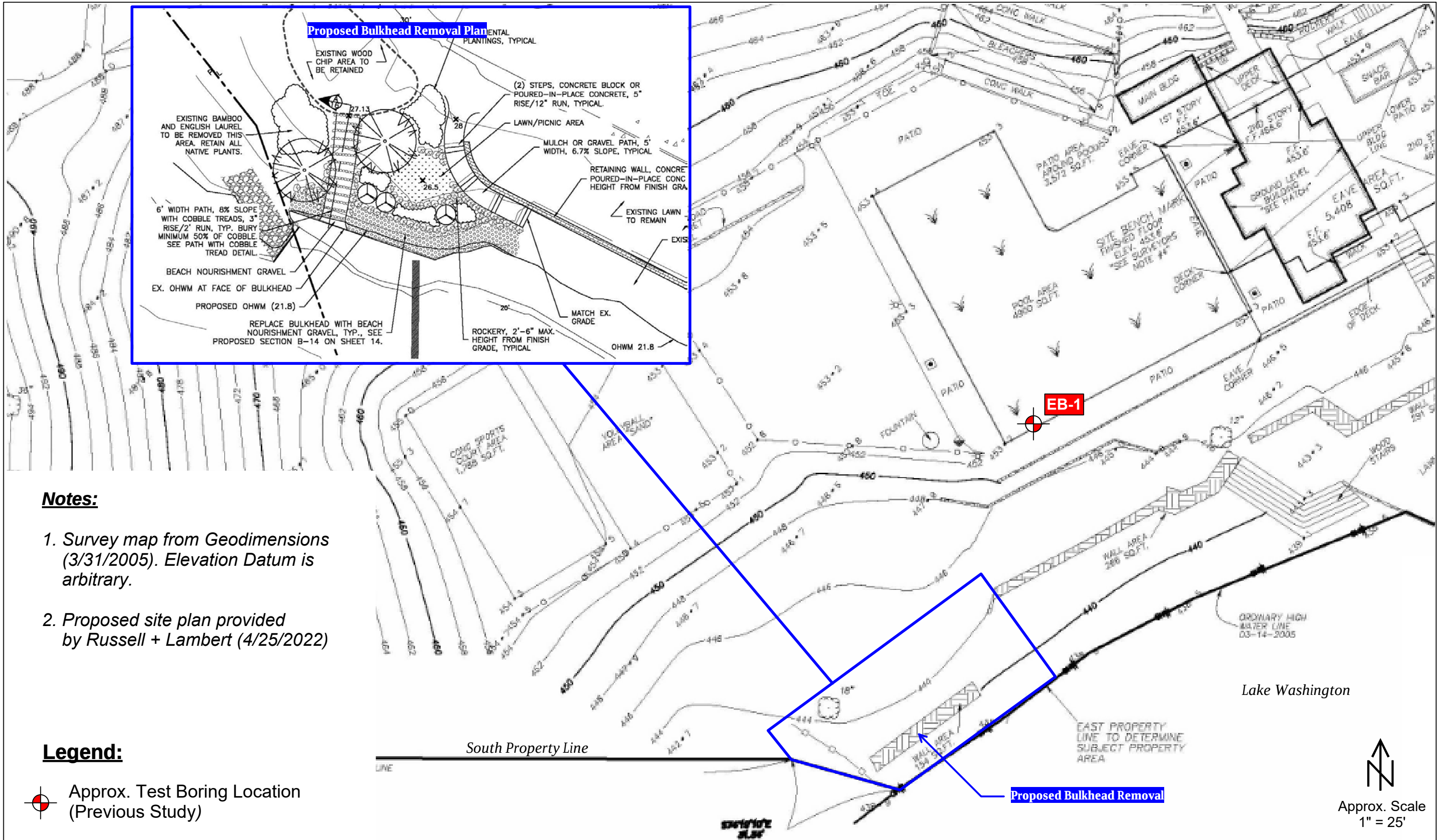


**Proposed Bulkhead
Removal
8326 Avalon Drive
Mercer Island, Washington**

VICINITY MAP

Project No. **23-386**

Figure No. **1**



Notes:

1. Survey map from Geodimensions (3/31/2005). Elevation Datum is arbitrary.
2. Proposed site plan provided by Russell + Lambert (4/25/2022)

Legend:

- Approx. Test Boring Location (Previous Study)
- Approx. Proposed Bulkhead Removal Location (This Study)

APPENDIX A

EXISTING EXPLORATION LOG



Geologic & Monitoring W Construction Log

Project Number
KE05246AWell Number
EB-1Sheet
1 of 1

Project Name Mercer Island Beach Club
 Elevation (Top of Well Casing) 454'
 Water Level Elevation 447.5'
 Drilling/Equipment Geologic Drill/Acker
 Hammer Weight/Drop 140# / 30"

Location Mercer Island, WA
 Surface Elevation (ft) 454'
 Date Start/Finish 4/27/05, 4/27/05
 Hole Diameter (in) 4 1/2"

