

# Proposed “The George” Mixed Use Development

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377, 385 & 407 Gower Point Road, 397 & 689 Winn Road, and  
Winn Road Right-of-Way, Gibsons, BC

## SUMMARY OF GEOTECHNICAL INVESTIGATION REPORT (REVISED) ISSUED APRIL 7, 2015

Karim Karimzadegan, M.A.Sc., P.Eng.  
Jean Cho, Ph.D, P.Eng.  
Horizon Engineering Inc.

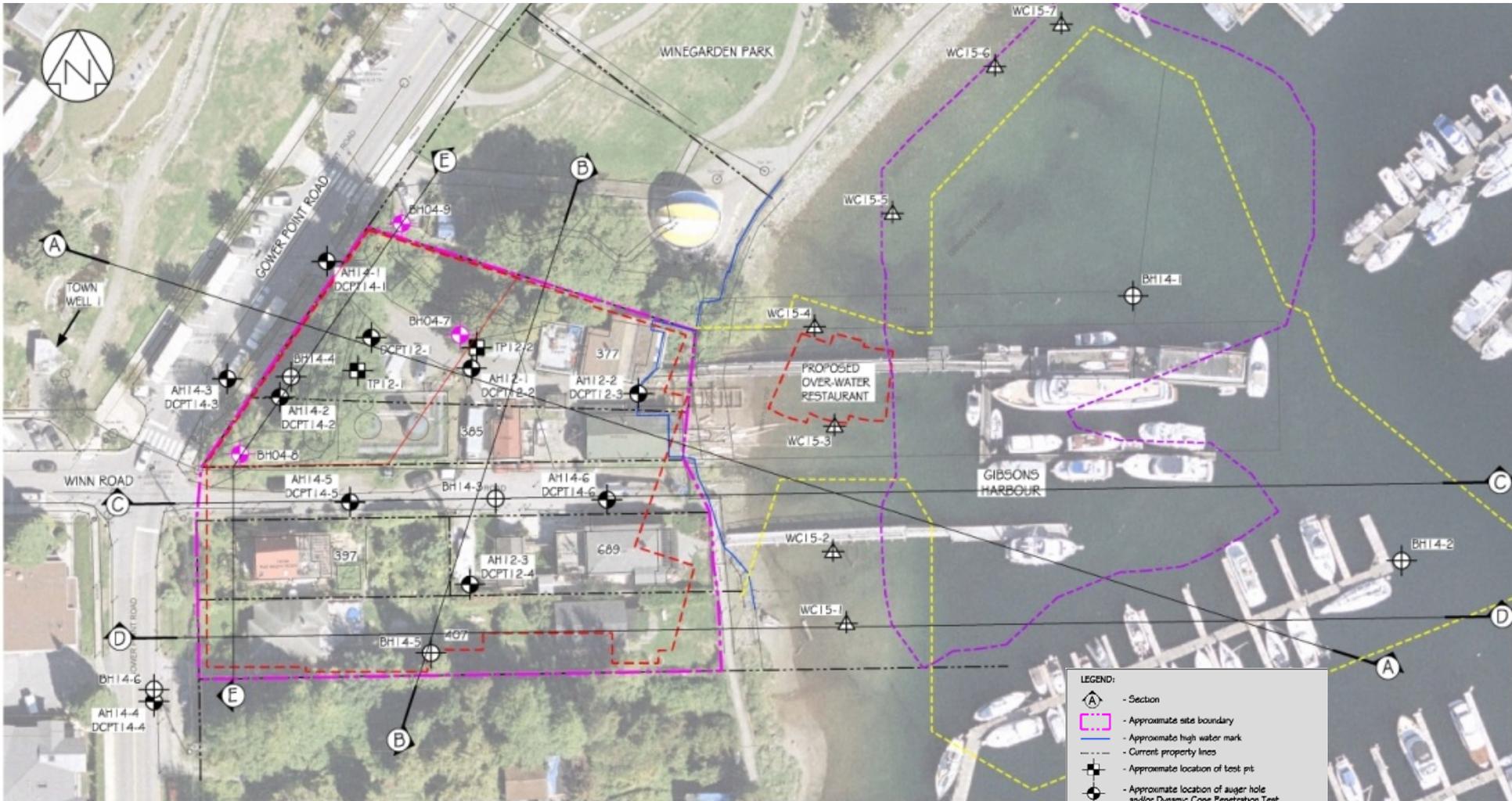
May 12, 2015



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# BACKGROUND DISCUSSION

- General site description



**LEGEND:**

- Section
- Approximate site boundary
- Approximate high water mark
- Current property lines
- Approximate location of test pit
- Approximate location of auger hole and/or Dynamic Cone Penetration Test
- Approximate location of Geo Tac Tics borehole
- Approximate location of sonic borehole
- Approximate location of Wildcat Cone Penetration Test
- Approximate location of proposed building
- Existing water lease & proposed marina area
- Approximate proposed limit of dredging
- Approximate limit of lowest recommended excavation (El. 5.0) (at northwest portion of site)

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- Site geology and hydrogeology

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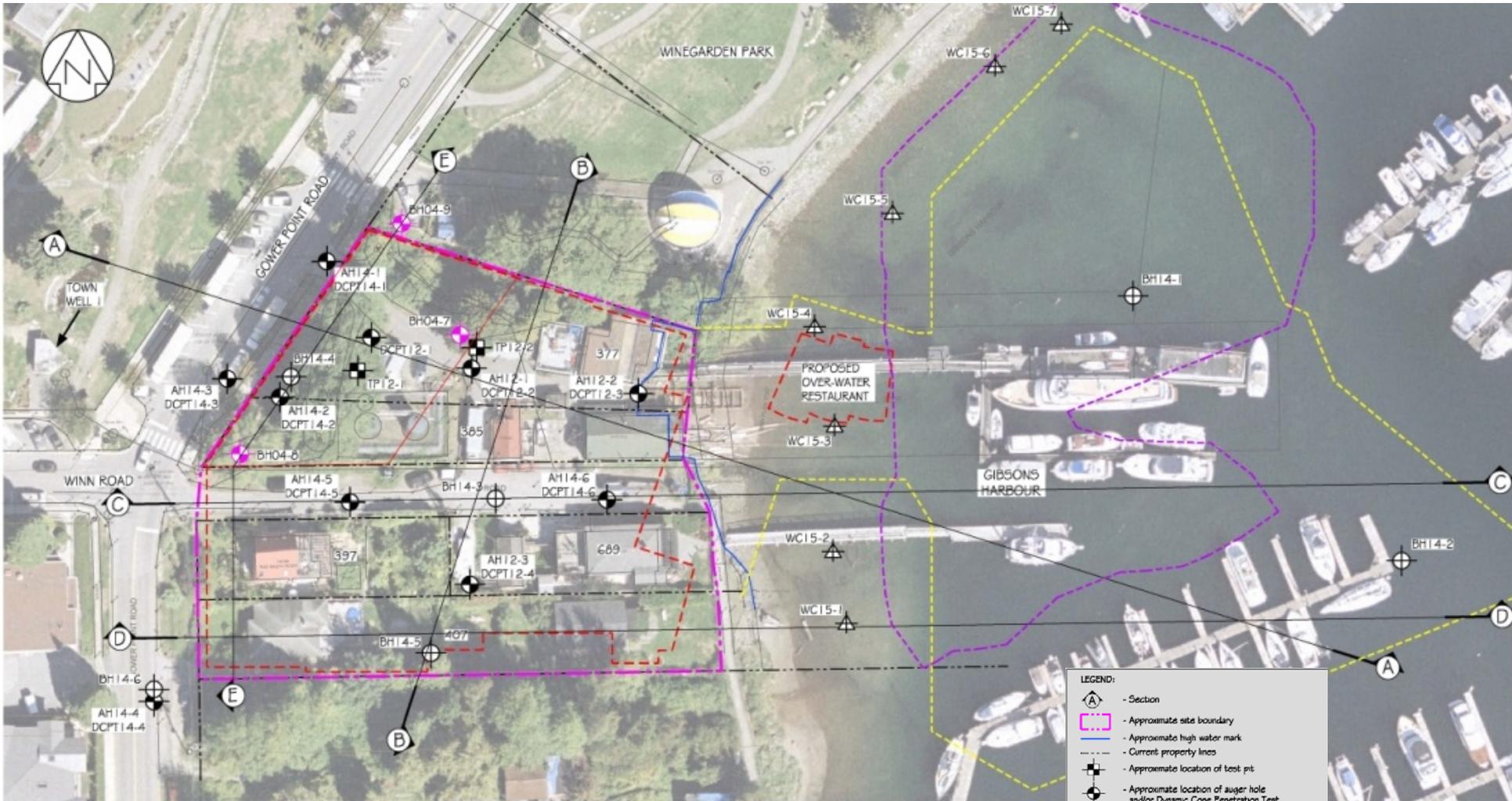




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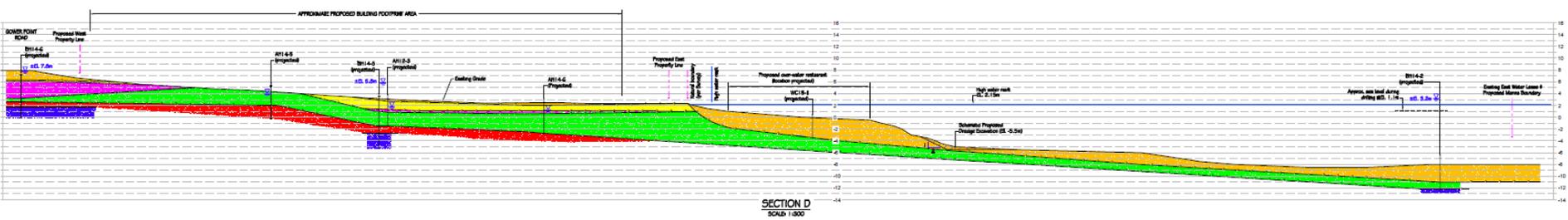
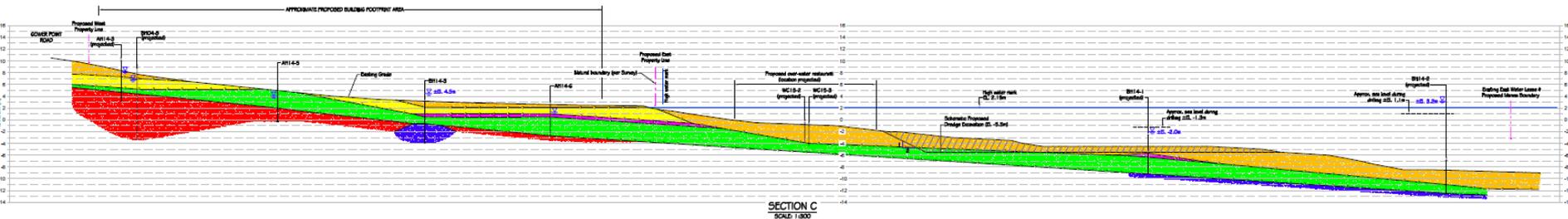
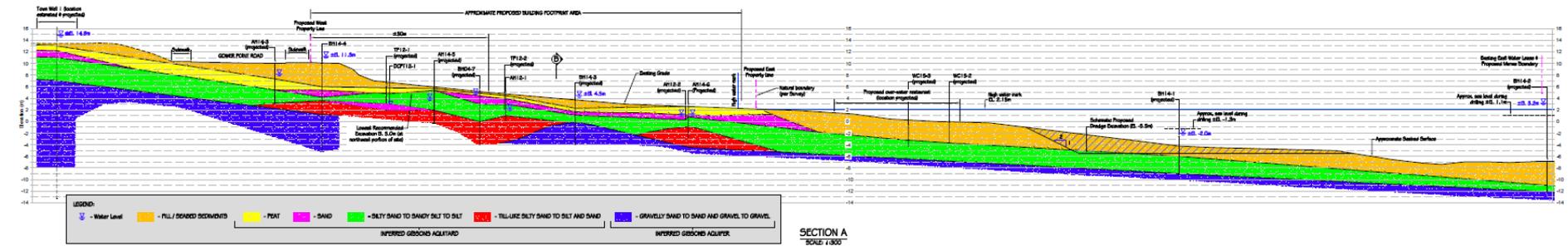
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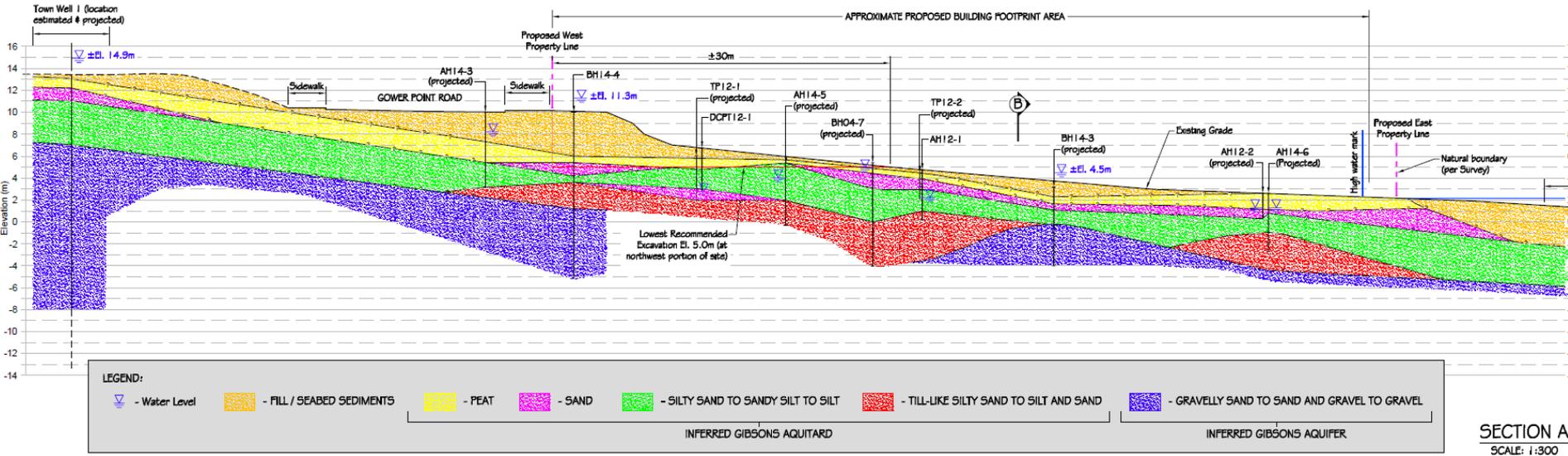
- General site description
- Site geology and hydrogeology
- Background information
- Site investigations
  - September 2012 (test pits and auger test holes)
  - April 2014 (auger test holes and sonic boreholes)
  - December 2014 (sonic boreholes)
  - January 2015 (WildCat holes)



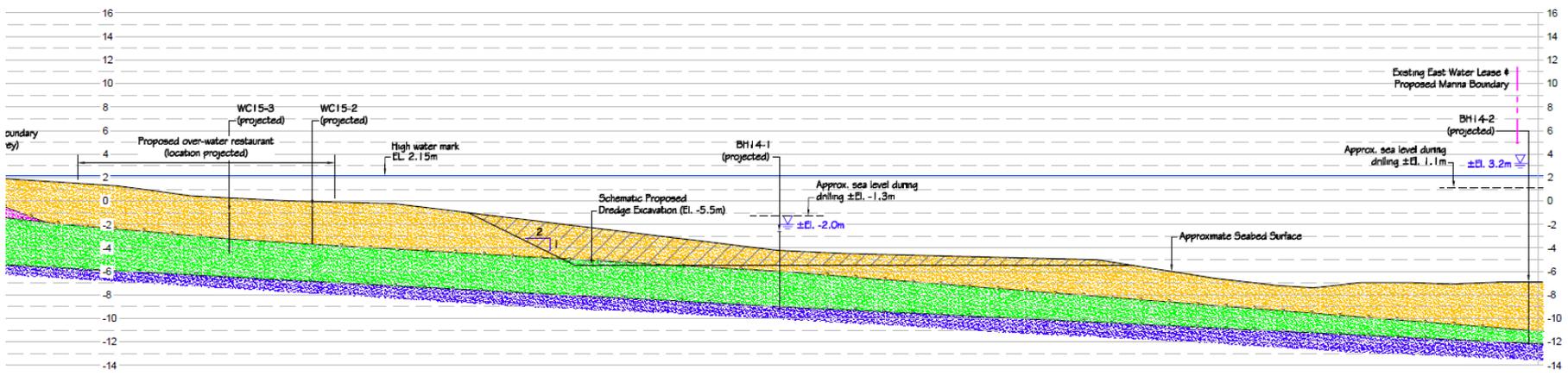
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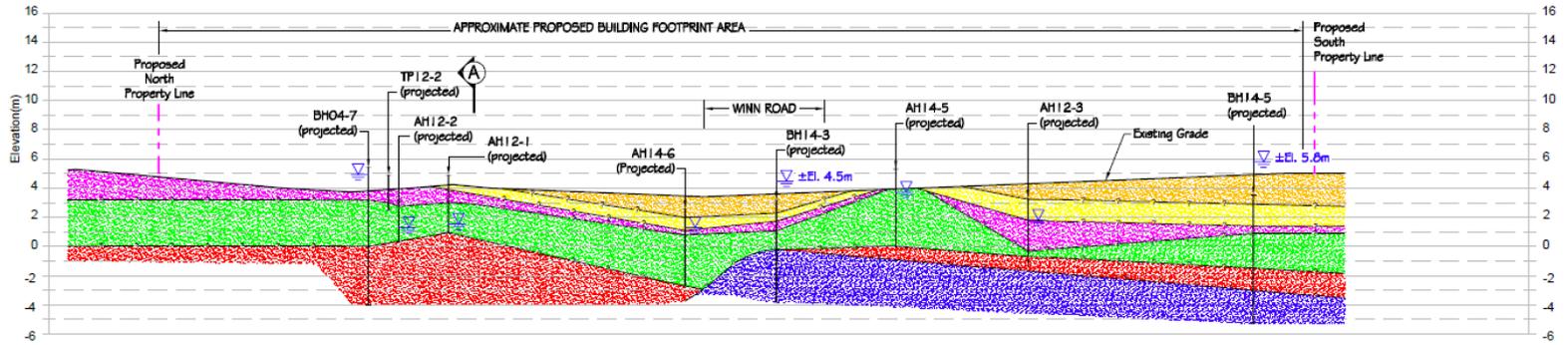




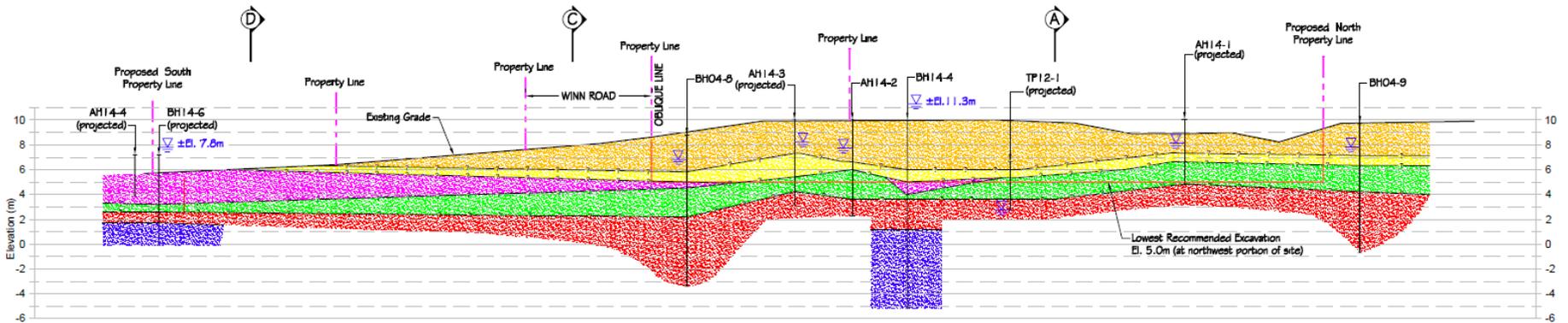
**SECTION A**  
SCALE: 1:300



**SECTION A**  
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SECTION B  
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SECTION E  
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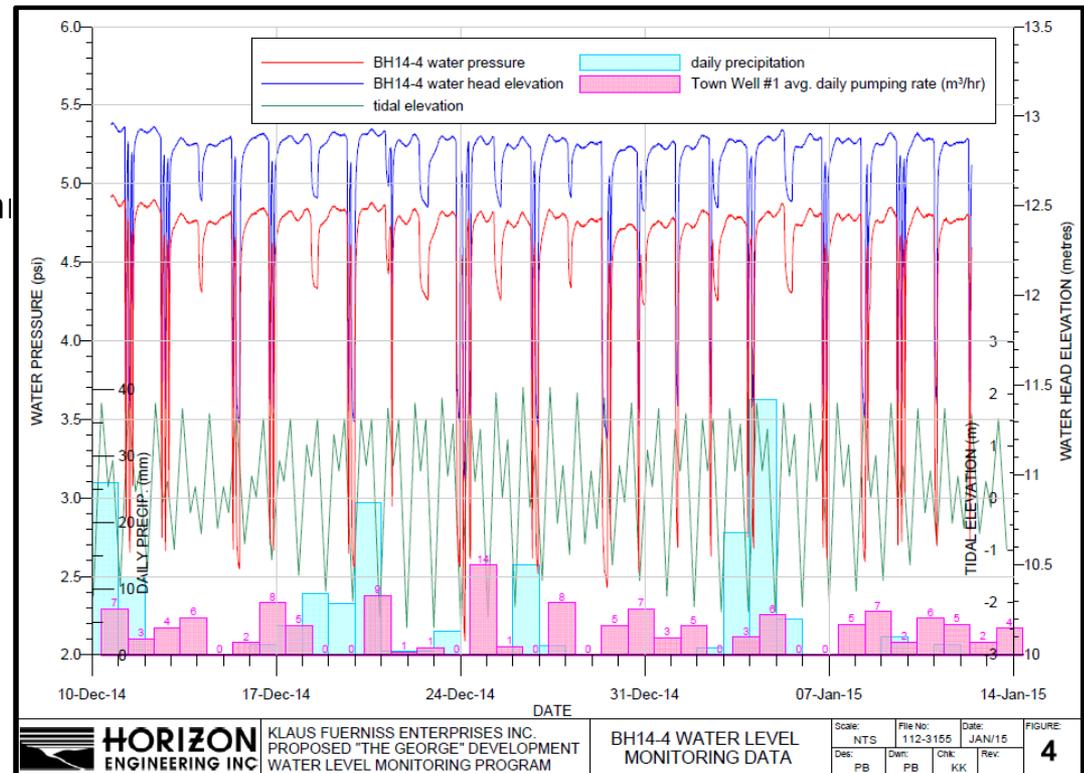
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# BACKGROUND DISCUSSION

- General site description
- Site geology and hydrogeology
- Background information
- Site investigations
- Previous geotechnical investigation reports
  - Horizon (2012, 2014)
  - Thurber (2007)
  - Geotactics (2004)
- Proposed development
  - A new multi-level hotel,
  - Conference centre
  - Residential development (partially over below grade parkade)
  - At-grade café, retail space, and meeting room
  - Over-water restaurant building and marina

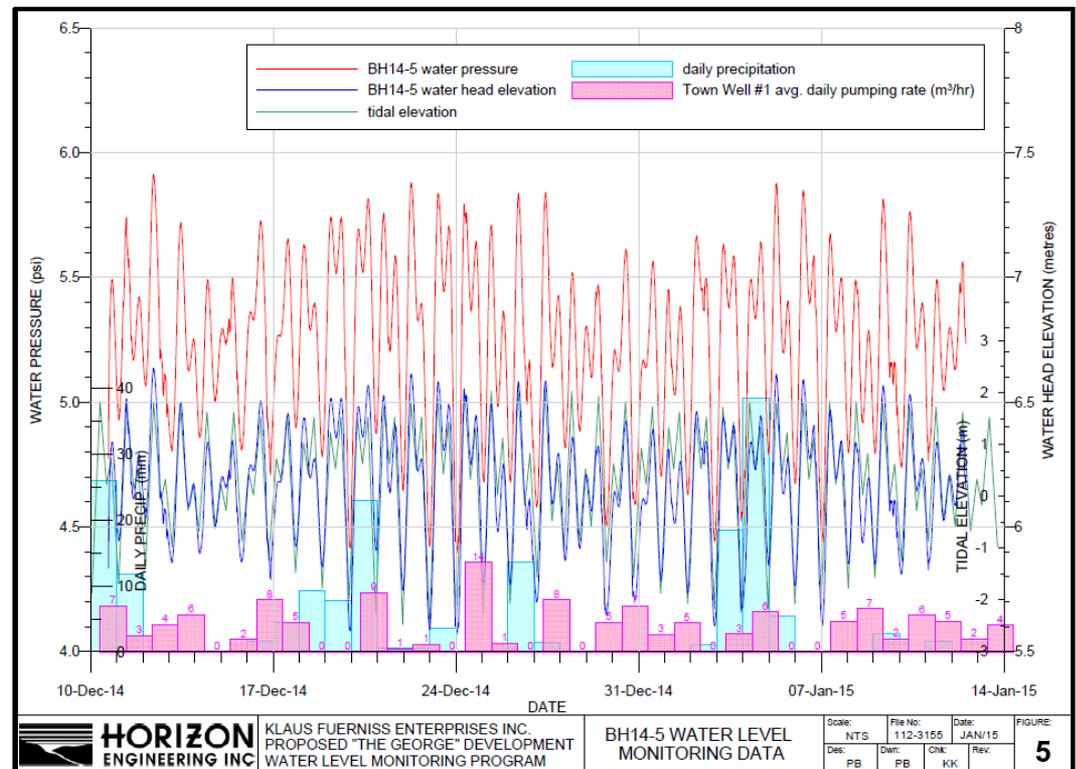
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- General site description
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- Proposed development
- Soil conditions
  - Surficial Soil (topsoil / fill)
  - Sand/Silty Sand/Peat/Till (Aquitard)
  - Sand/Gravelly Sand (Aquifer)
- Groundwater conditions
  - Non-artesian
  - Artesian
- Groundwater monitoring



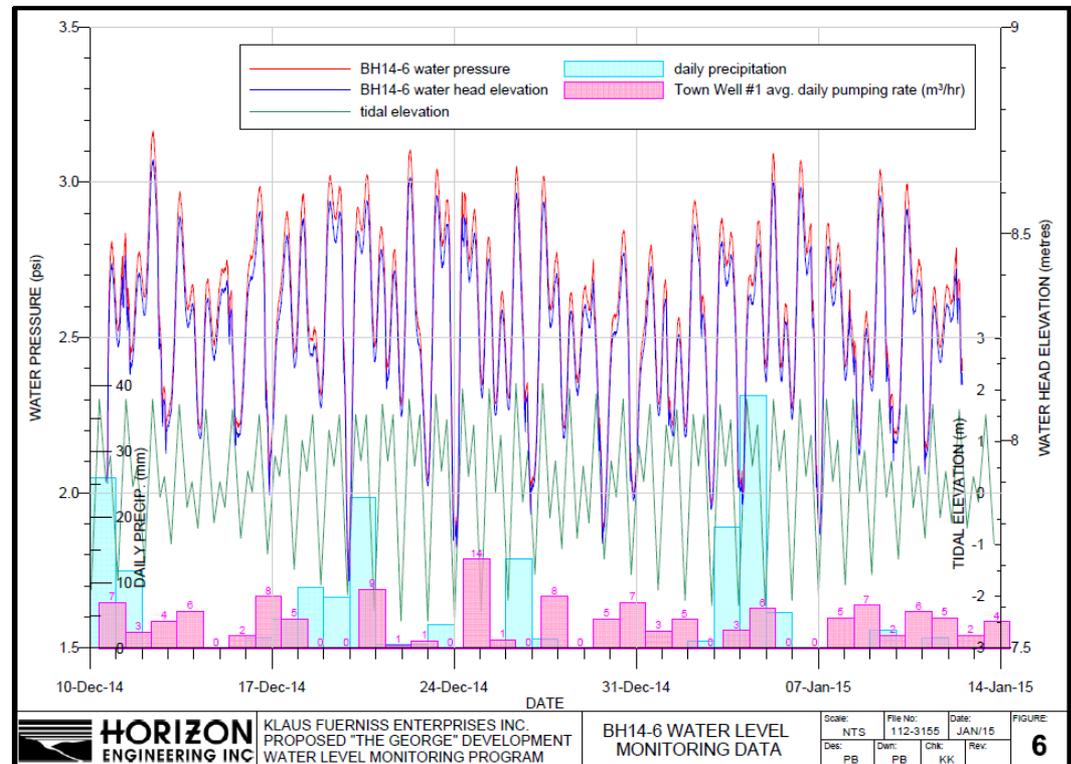
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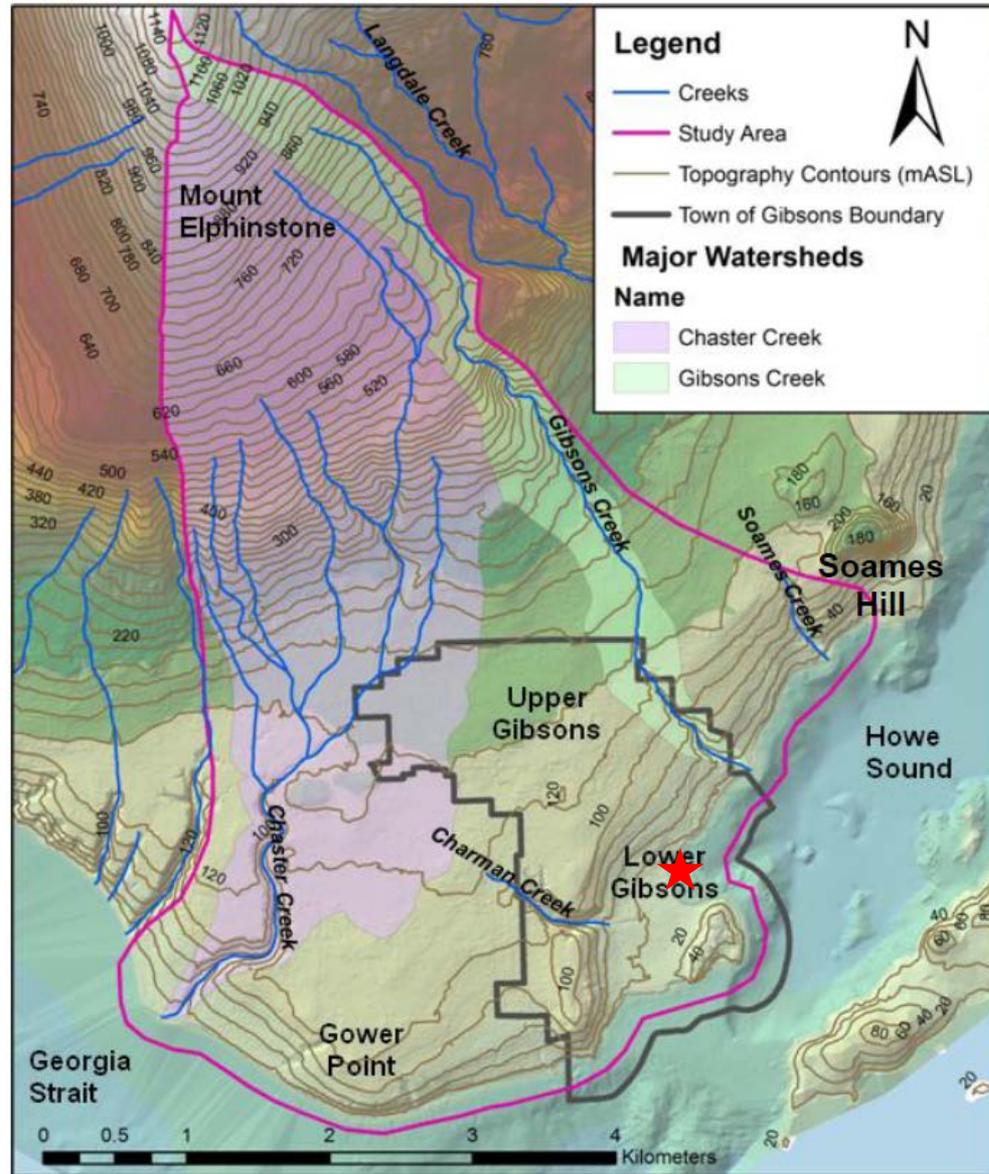
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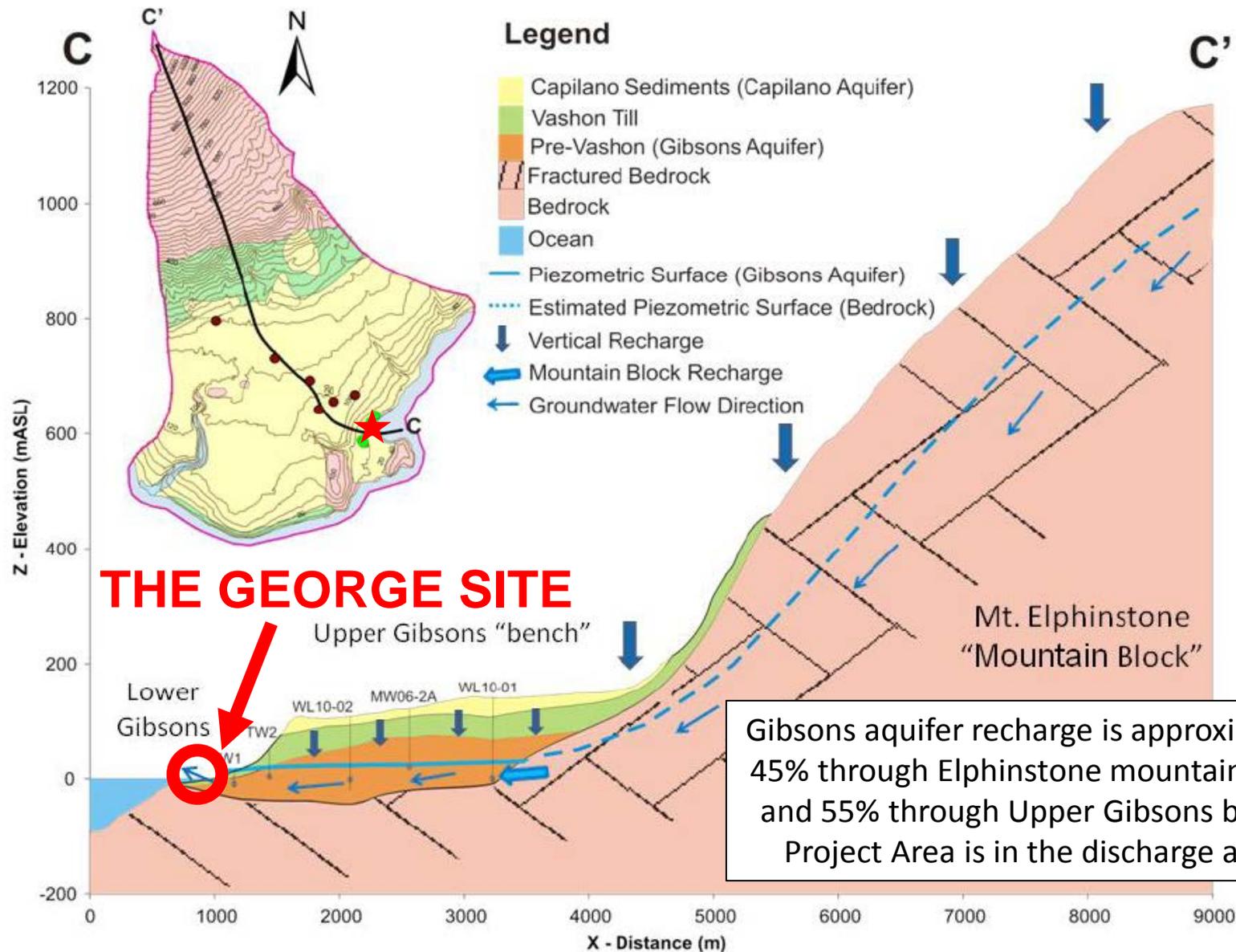


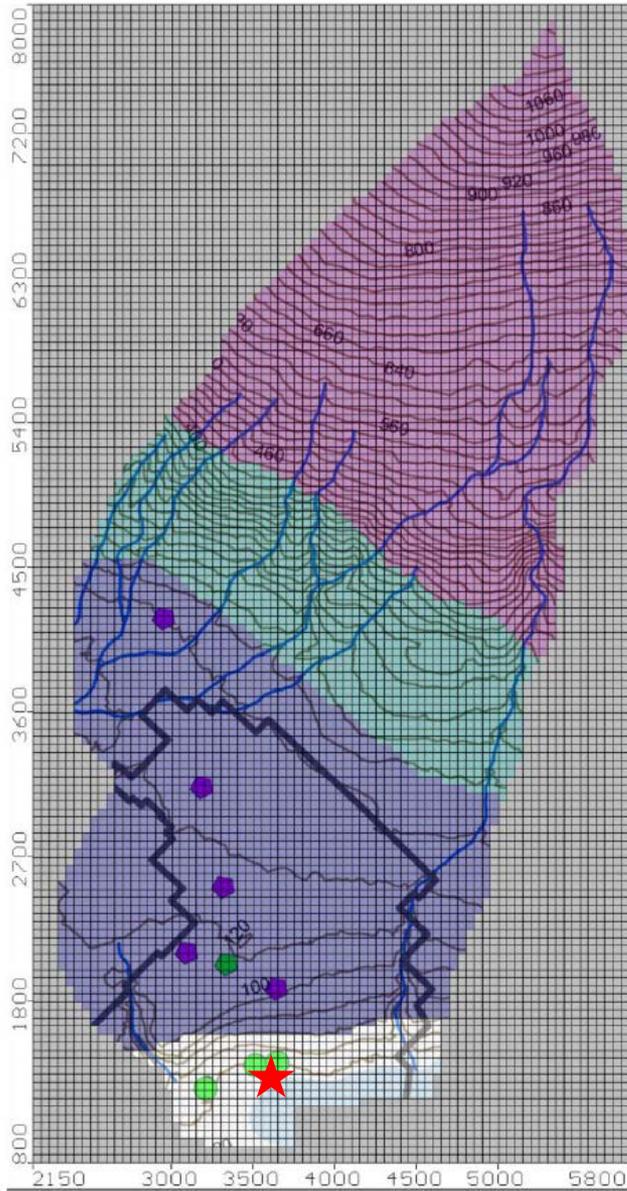
# HYDROGEOLOGY DISCUSSION

## Gibsons Groundwater Resource



Source: Doyle (2013) UBC Master's Thesis





**Legend**

**Recharge Zones**

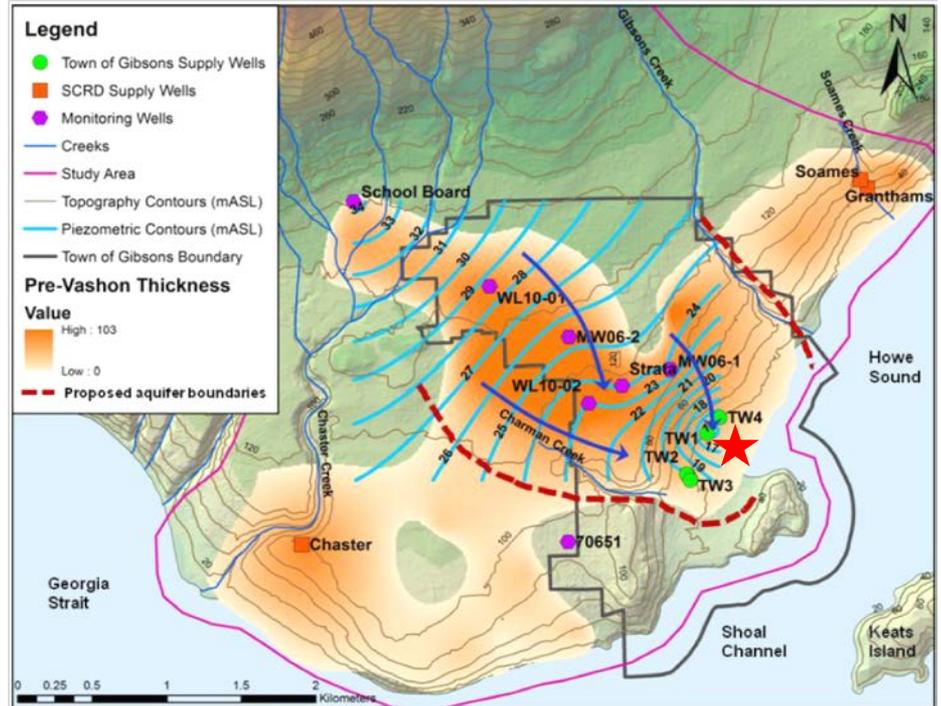
- 145 mm/year
- 130 mm/year
- 115 mm/year
- 0 mm/year

**Additional Map Elements**

- Monitoring (Observation) Wells
- Town of Gibsons Supply Wells
- Strata Condo Private Well
- Creeks
- Topography Countours
- Town of Gibsons Boundary
- Inactive Cells



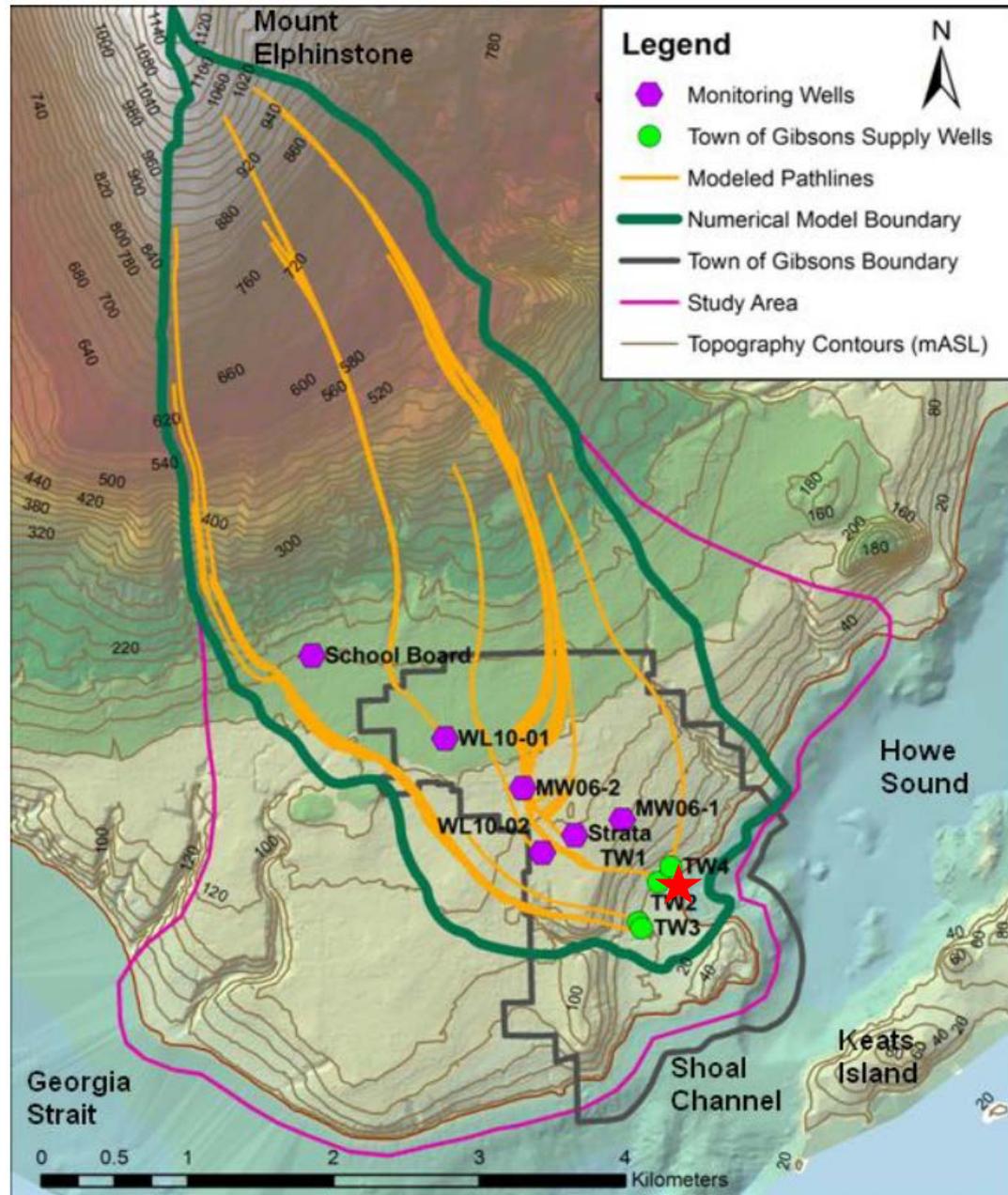
Numerical Model of Gibsons Groundwater Resource indicates that the project area is in a groundwater discharge zone (i.e., zero recharge).



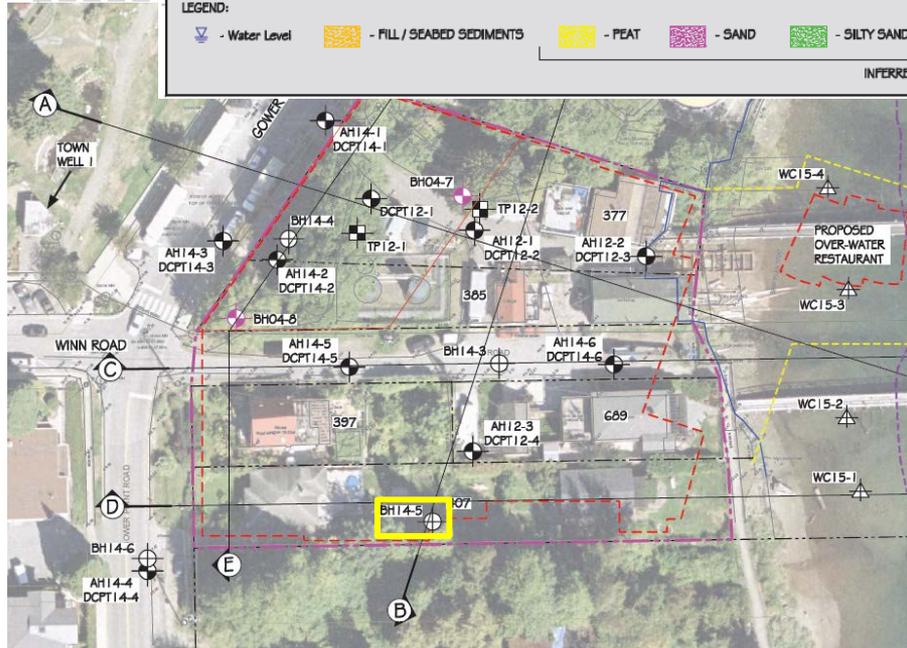
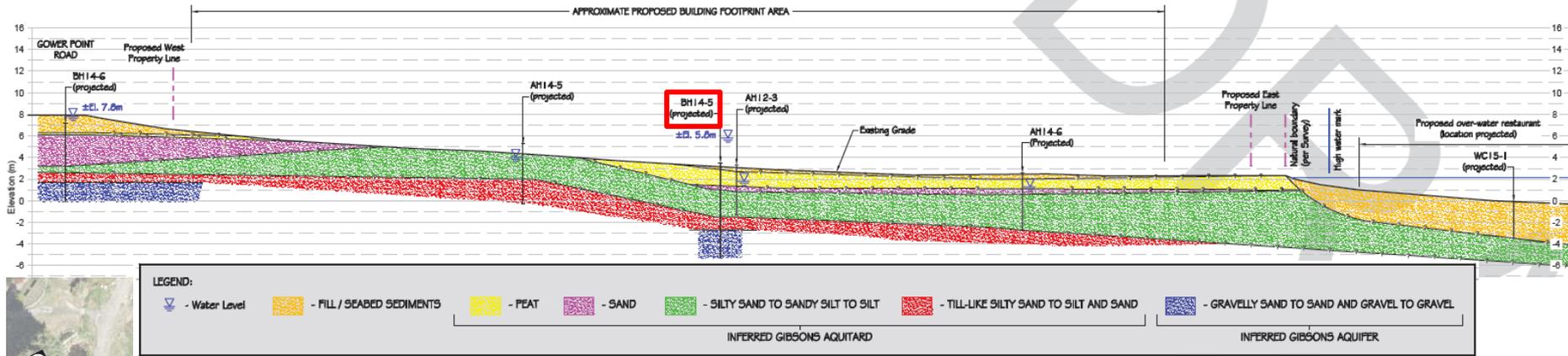
**Legend**

- Town of Gibsons Supply Wells
  - SCRD Supply Wells
  - Monitoring Wells
  - Creeks
  - Study Area
  - Topography Contours (mASL)
  - Piezometric Contours (mASL)
  - Town of Gibsons Boundary
- Pre-Vashon Thickness**
- Value**
- High : 103
  - Low : 0
- Proposed aquifer boundaries

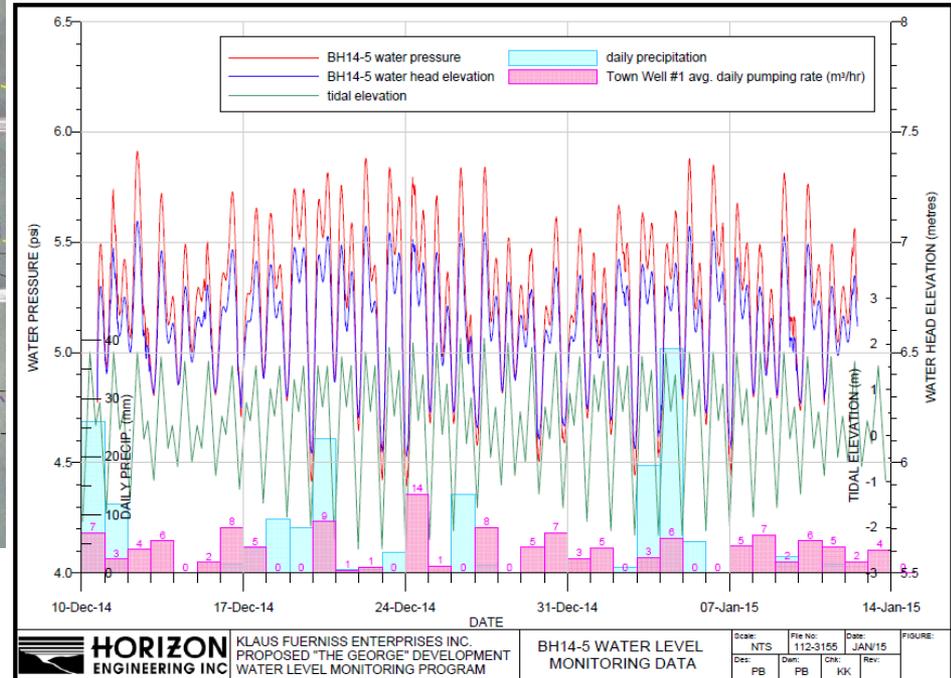
Numerical Model of Gibsons Groundwater Resource indicates that the *well-head protection zone* does not include the project area.

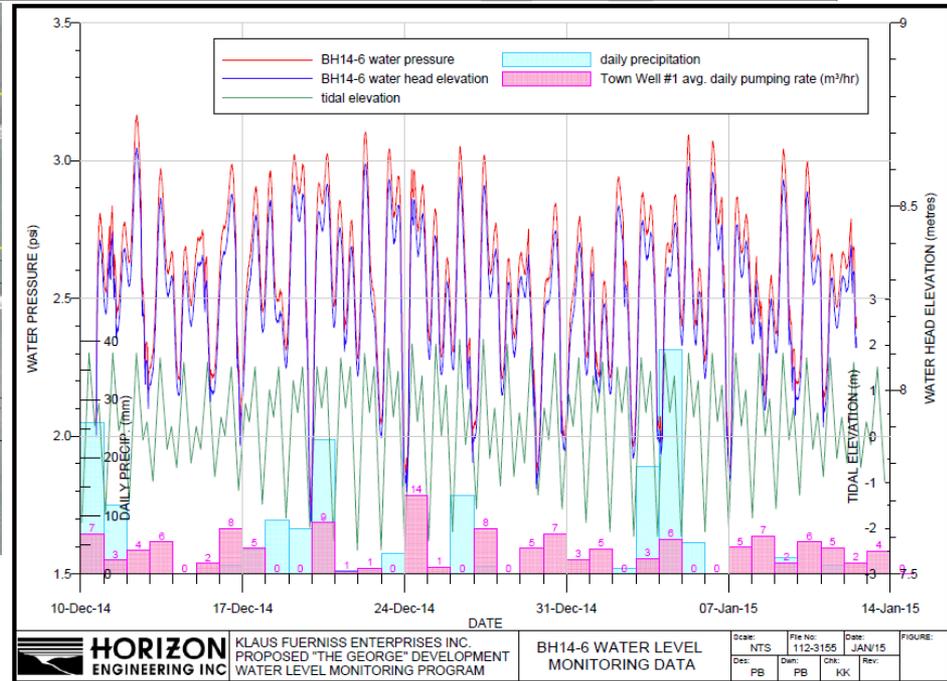
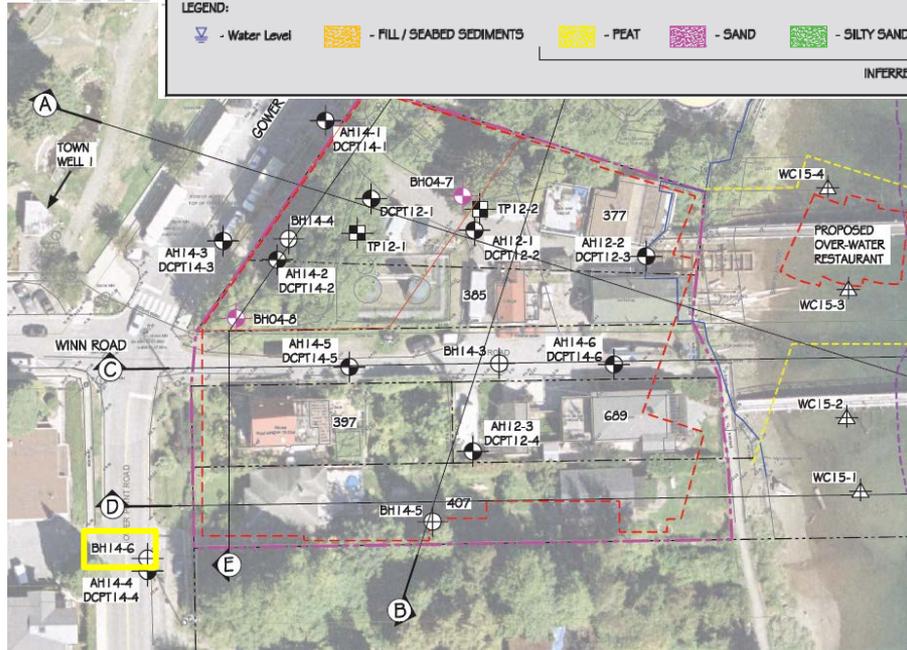
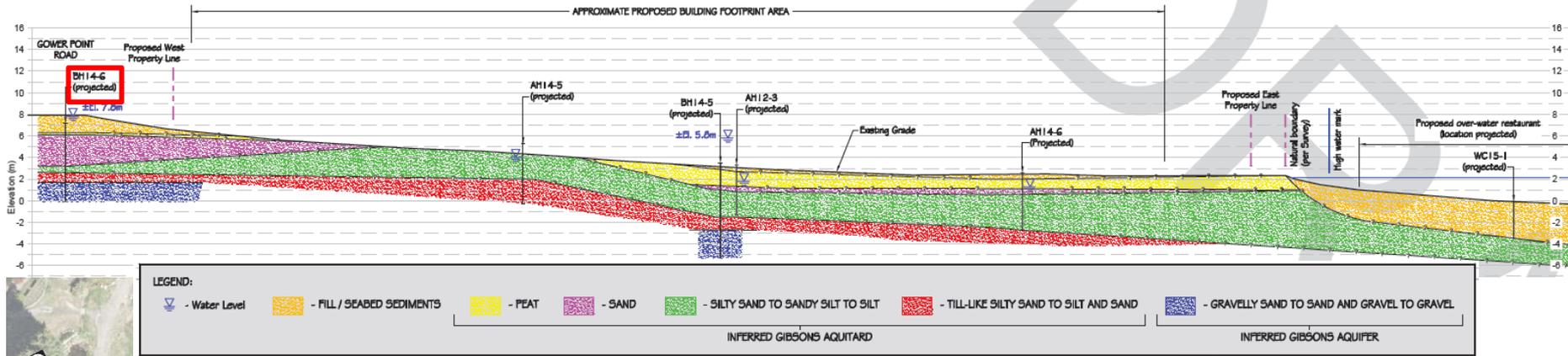


Source: Doyle (2013) UBC Master's Thesis

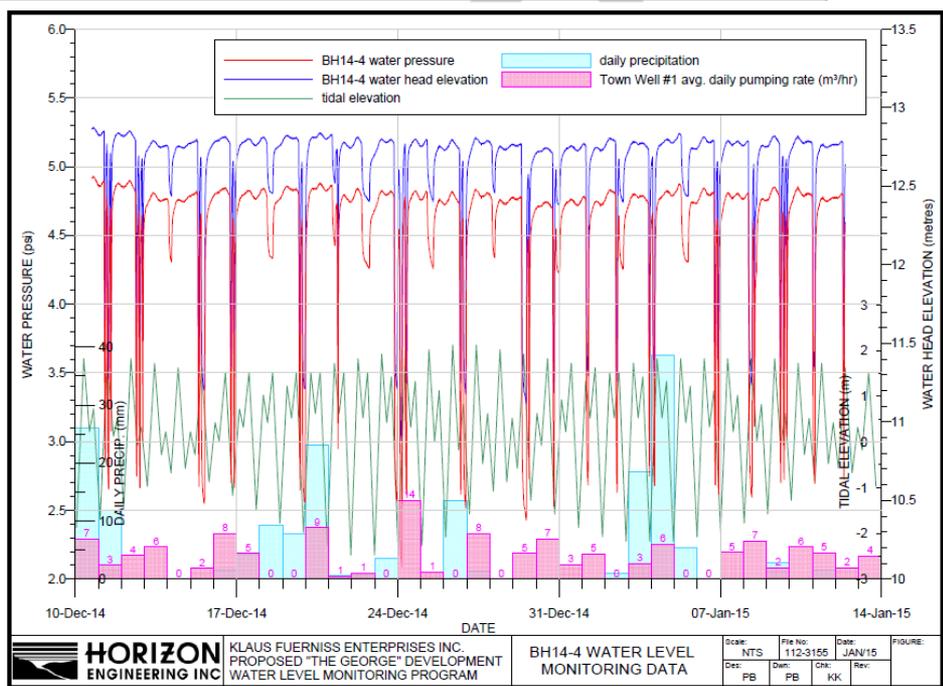
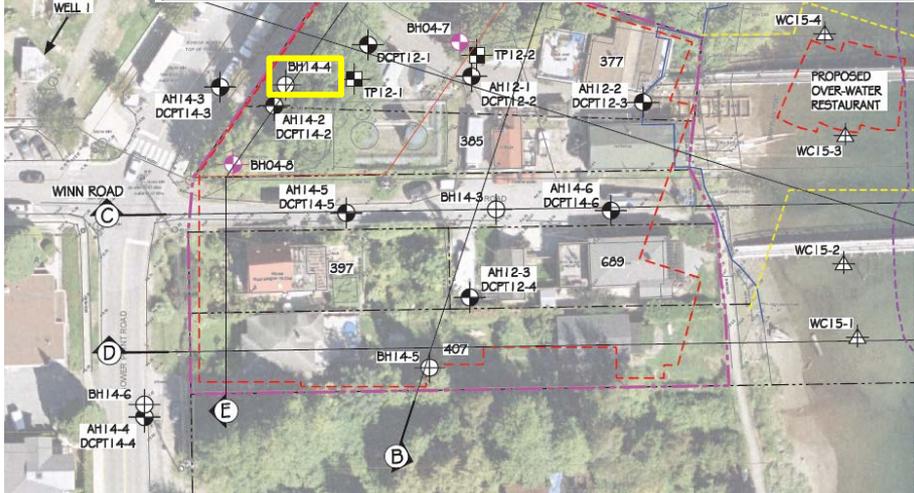
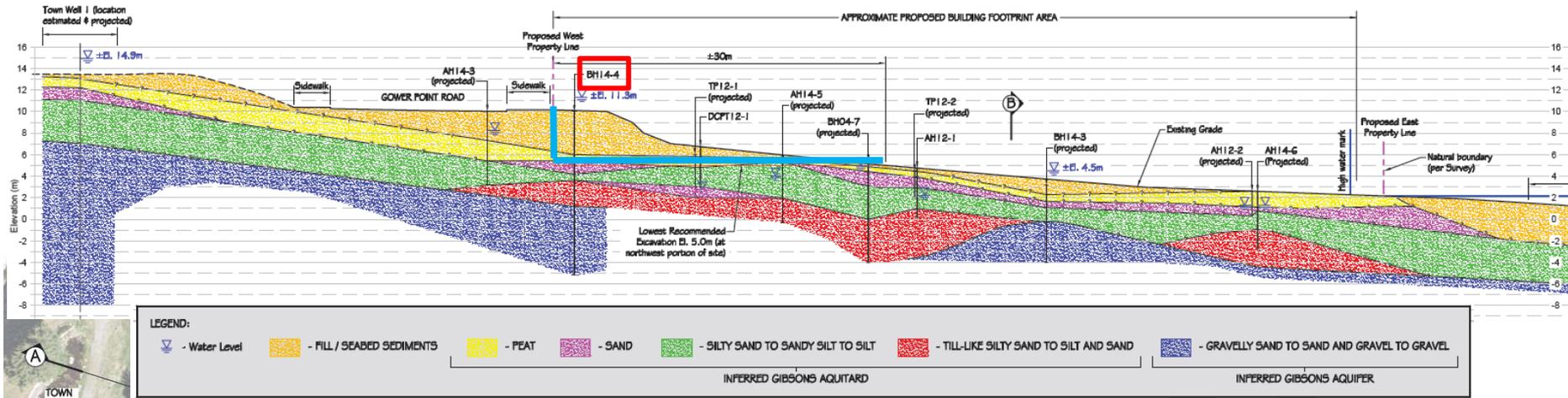


BH14-5, 90 m from the harbour, shows a direct connection with the tidal signature in Howe Sound.





BH14-6, 120 m from the harbour, shows a direct but more muted connection to the tidal signature in Howe Sound than BH14-5.



BH14-4 shows a muted tidal signature and strong apparent correlation with pumping at Town Well #1.

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# POTENTIAL GEOTECHNICAL CHALLENGES

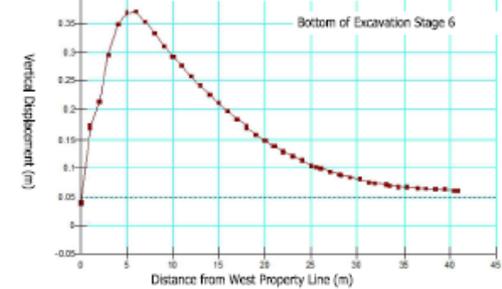
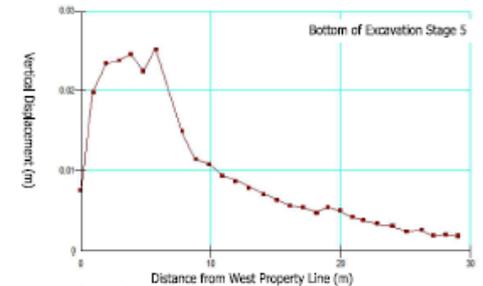
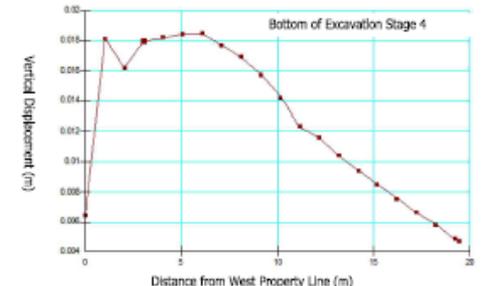
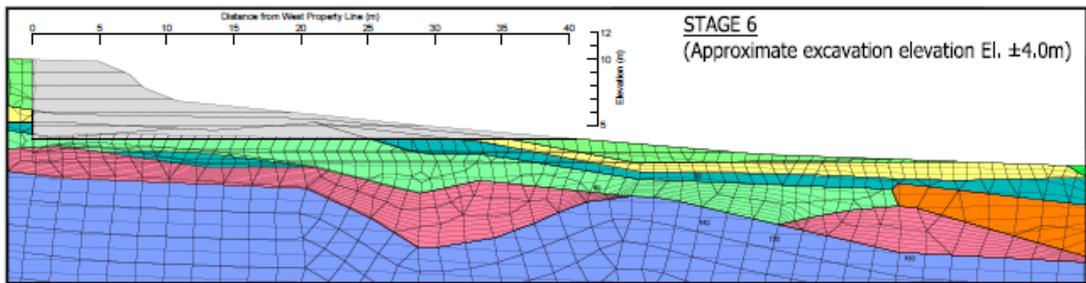
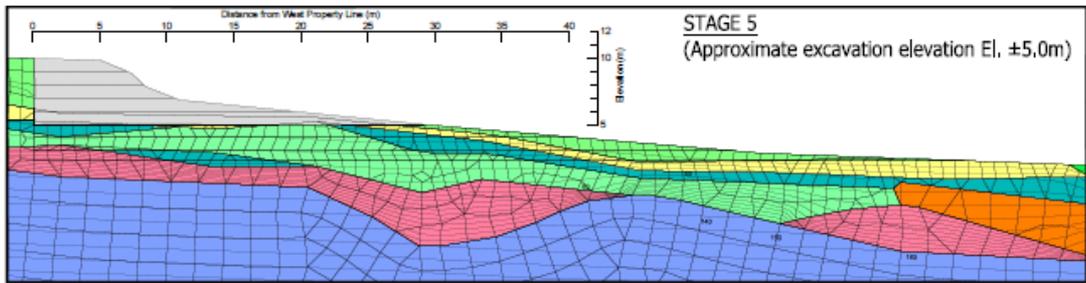
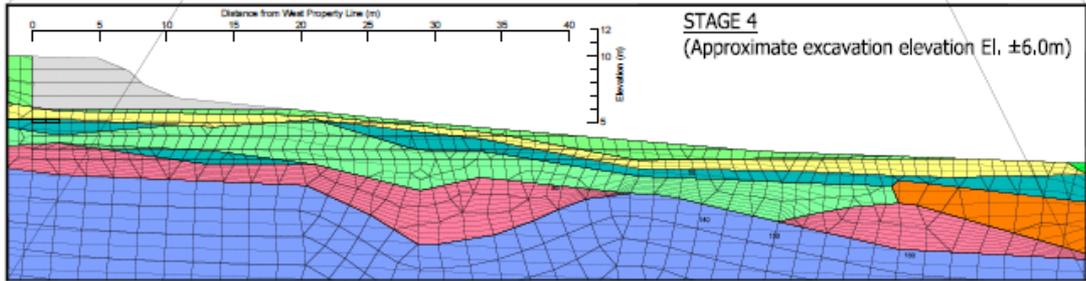
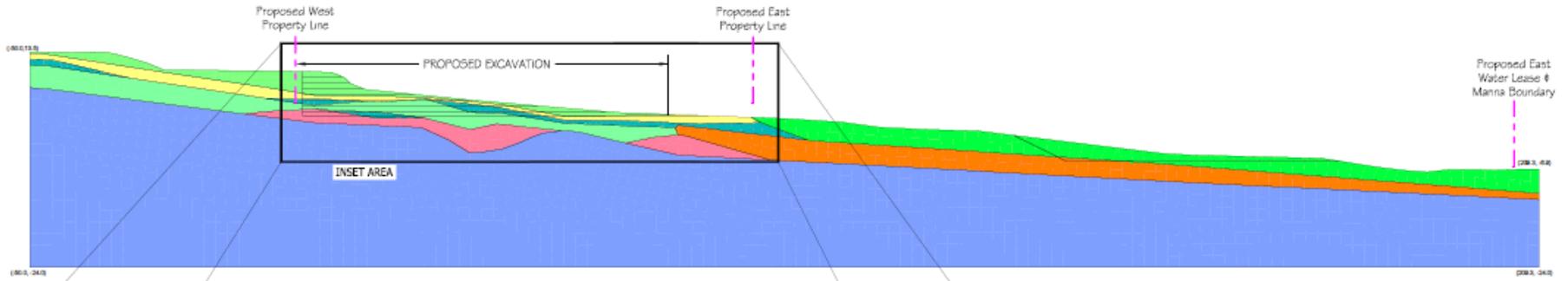
- Artesian groundwater pressures
- High non-artesian groundwater levels
- Sea level rise
- Tsunami hazard
- Loose and compressible soil
- Liquefaction
- Impact of dredging on foreshore area
- Methane buildup

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# ARTESIAN GROUNDWATER PRESSURES

- Artesian groundwater pressures have been observed within the Gibsons Aquifer.
- Hydraulic connections have been observed between the Gibsons Aquifer and the ocean at the central portion of the site and between the Gibsons Aquifer and Town Well #1 at the west portion of the site.
- A computer model was generated to analyse the site and subsurface conditions during and after construction of the proposed development based on existing information, published literature, and engineering judgement.
- The results of this modelling work indicate that the proposed excavation should not advance below a geodetic elevation of 5.0 metres (16 feet 5 inches) at the northwest portion of the site in order to ensure that the underlying Gibsons Aquifer is not compromised (even temporarily) due to excavation of the overlying materials.
- The results of these analyses are based on conservative soil strength properties. Therefore, there is an inherent Factor of Safety (which may be of the order of

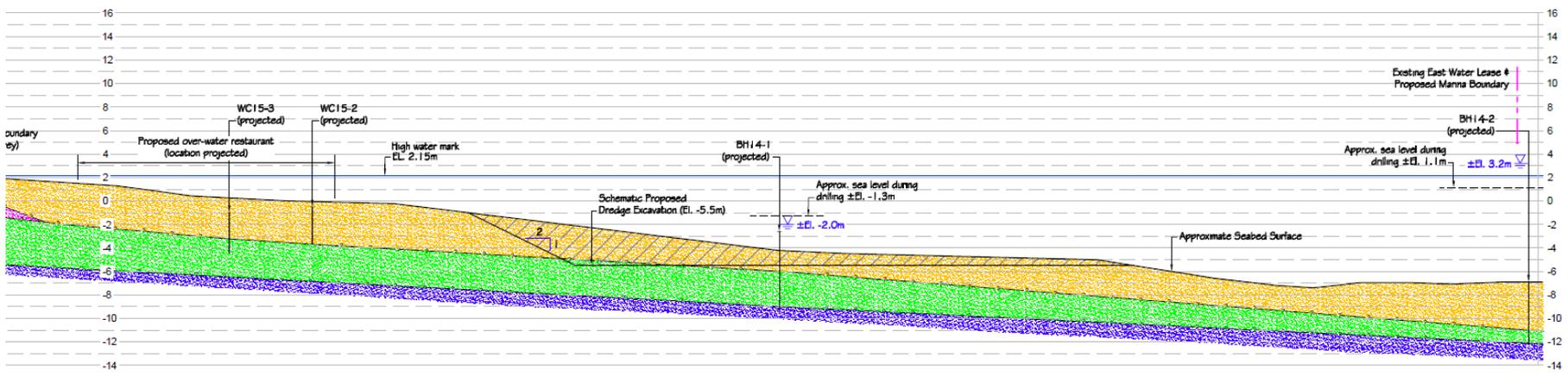
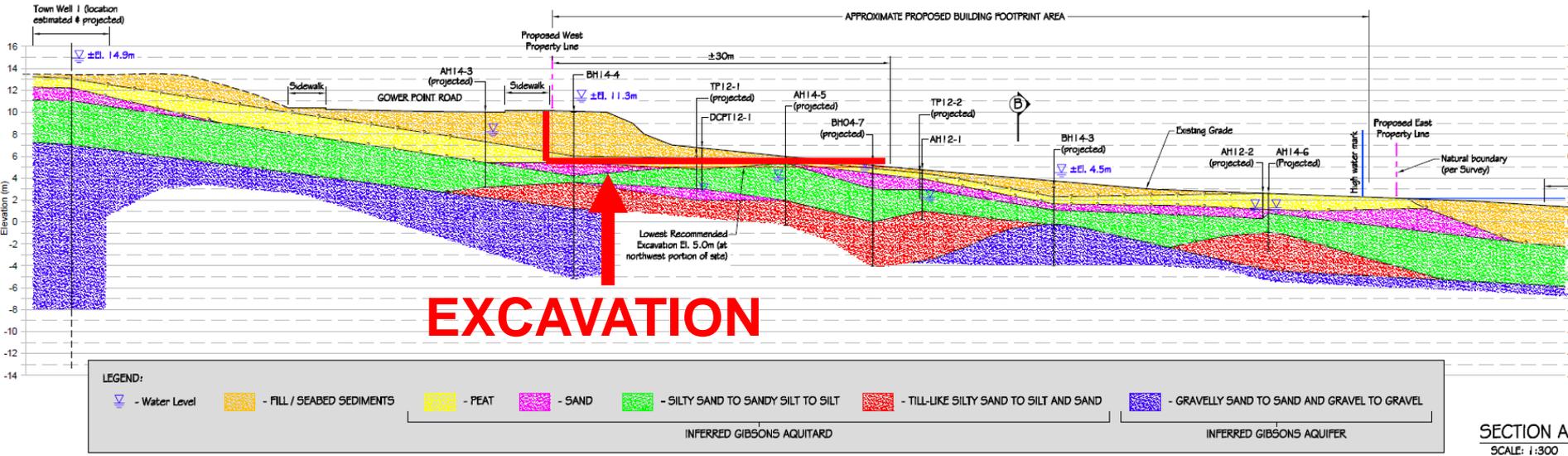




# ARTESIAN GROUNDWATER PRESSURES

- At the southwest, southeast, and northeast portions of the site, we recommend that the proposed excavation not advance below 0.5 metre (1 foot 8 inches) below existing grades in order to ensure that the Gibsons Aquifer is not compromised due to excavation of the overlying materials.
- Deeper excavation at the southwest portion of the site is not recommended due to the proximity of the Gibsons Aquifer to the existing site grades.





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## SEA LEVEL RISE AND TSUNAMI HAZARD

- All habitable spaces are recommended to be constructed at or above a Flood Construction Level (FCL) of approximately 5.33 metres (17 feet 6 inches), which takes into account potential effects of sea level rise and storm and tsunami waves during the design life of the proposed building.
- We envisage that habitable spaces could be constructed below the FCL if a sea dike is constructed around the building, which would be designed to protect the building from rising sea levels and future storm events. The proposed marina and over-water restaurant should be constructed at or above the FCL since they would otherwise be unprotected from the design flood conditions.

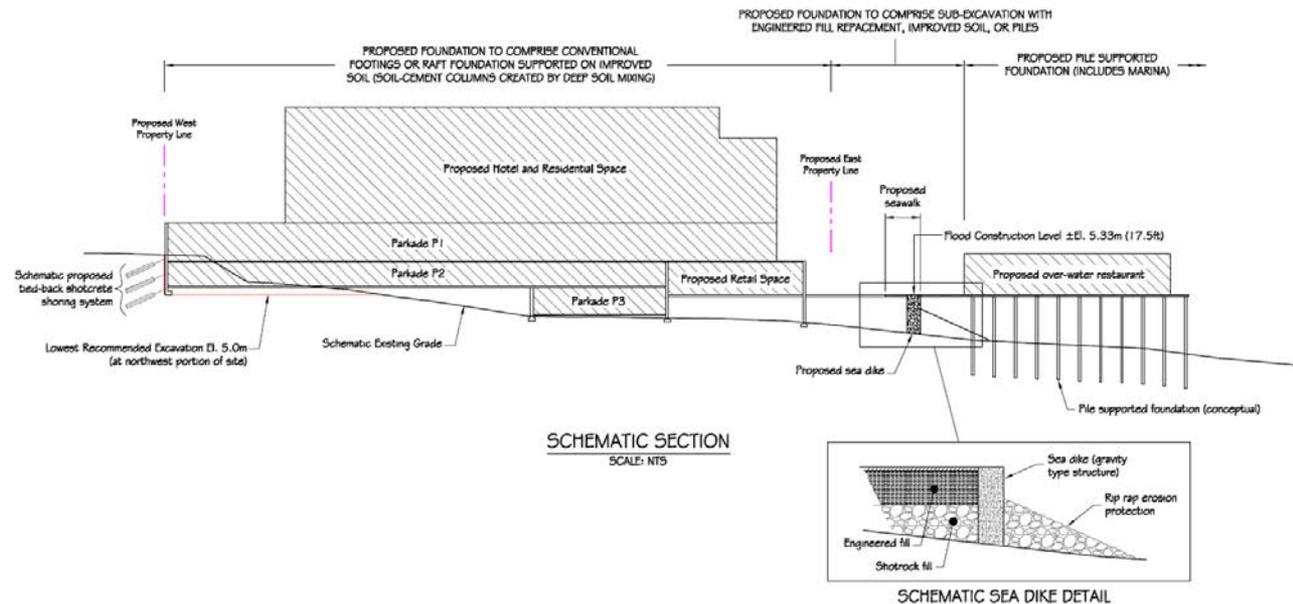
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## PROPOSED BUILDING ELEVATIONS

- We envisage that the lowest proposed top of slab elevations would be approximately 6.3 metres (20.5 feet) at the west portion of the site and 3.1 metres (10.2 feet) at the east portion of the site.
- Accordingly, we envisage that the proposed footing elevations would be approximately 5.4 metres (17.5 feet) at the west portion of the site and 2.2 metres (7.2 feet) at the east portion of the site.
- Therefore, we envisage that the proposed excavation would be approximately 5.1 to 5.8 metres (17 to 19 feet) deep below adjacent existing grades at the northwest portion of the site.
- Excavation at the southwest, northeast, and southeast portions of the site is envisaged to be less than approximately 0.5 metres (1.6 feet) deep below adjacent existing grades.

# PROPOSED BUILDING ELEVATIONS

- We envisage that the proposed finished floor elevation for the proposed café, retail space, meeting room, seawalk, and over-water restaurant at the east portion of the site would be approximately 5.3 metres (17.3 feet), which is consistent with the recommended FCL. The currently proposed lowest parkade floor elevation is below the FCL; therefore, a sea dike is envisaged to be required as part of the proposed development.



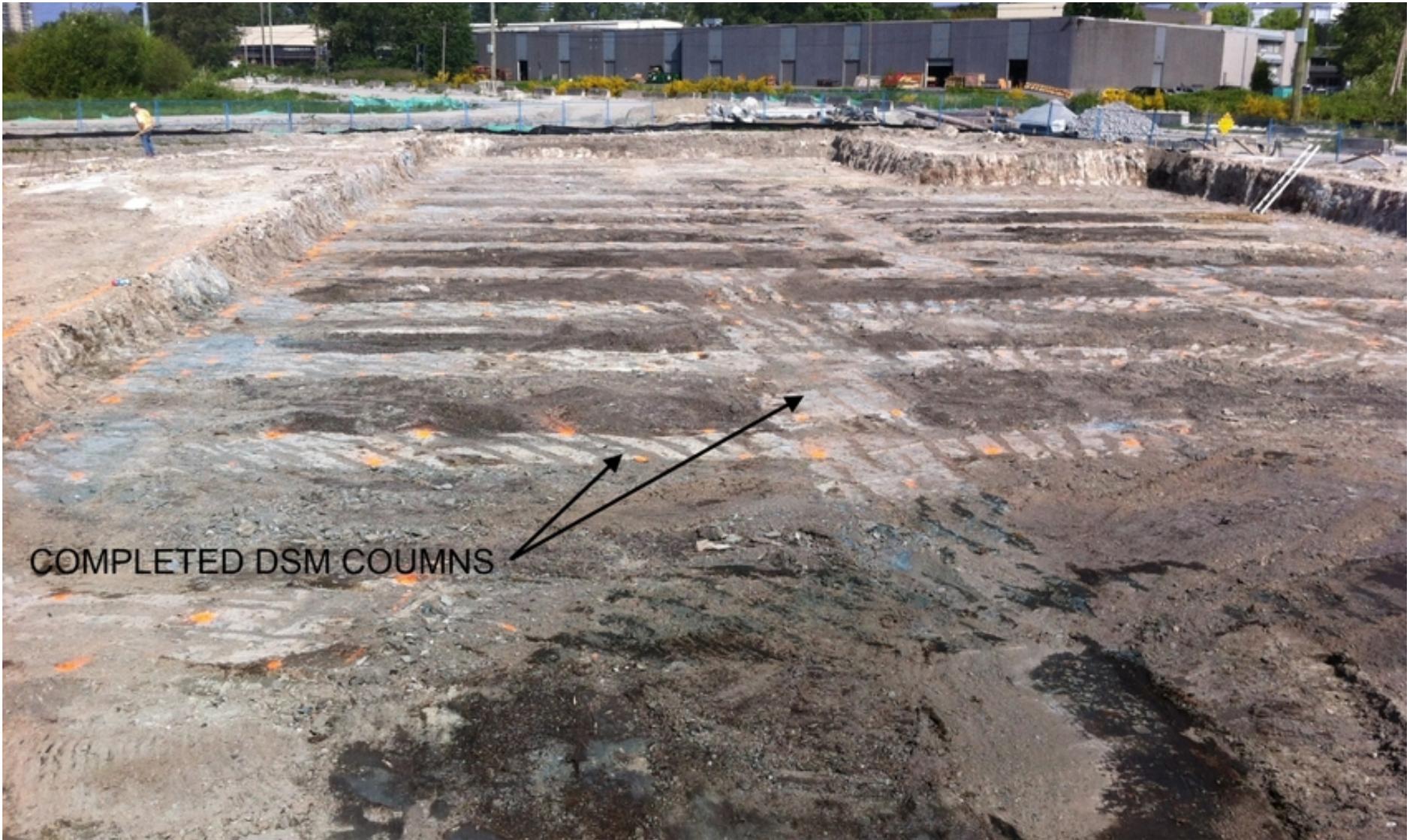
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## LOOSE AND COMPRESSIBLE SOILS

- We recommend that foundations for the entire building footprint are supported on conventional strip and pad foundations or on a raft foundation.
- Due to the presence of loose and compressible subgrade materials (which are judged to be unsuitable for supporting shallow foundations in their current state), ground improvement is recommended beneath proposed foundations such that suitable bearing is achieved.
- We envisage that deep soil mixing may be the preferred method of ground improvement at the subject site.



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- We envisage that deep soil mixing may be the preferred method of ground improvement at the subject site.
- We recommend that footings proposed at the east portion of the site, where excavation is not required, are lowered to the existing grades after the proposed ground improvement measures are complete. In these areas, floor slabs are recommended to be designed as suspended slabs.

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## LOOSE AND COMPRESSIBLE SOILS

- If subexcavation of settlement-susceptible materials in proximity to the shoreline is judged to be impractical for subgrade preparation at the proposed landscaping sidewalk and seawalk footprint areas, we recommend that these structures be supported by shallow foundations constructed on soil-cement columns following ground improvement or by piles. Alternatively, these structures could be designed as 'floating' sidewalks supported on a geogrid-reinforced earth slab.
- We recommend that all foreshore development structures be supported by drilled pipe pile foundations. We expect that insufficient resistance may be encountered above the Gibsons Aquifer to provide suitable pile capacity for the proposed structures; however, the materials that were inferred to comprise the aquifer are expected to provide suitable end bearing and/or frictional resistance for the proposed piles.

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## LOOSE AND COMPRESSIBLE SOILS

- We envisage that installing drilled pipe piles would not result in "leakage" of artesian groundwater from the aquifer around the piles; however, a detailed monitoring program should be implemented during pile installation to detect any breach of the aquifer, if it were to occur.
- If a passive approach to pile driving into the aquifer is found to be unacceptable, we envisage that piles could be fully sealed, as required, to prevent artesian groundwater from potentially leaking out around the proposed piles.

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# LIQUEFACTION

- The soil profile at the footprint area of the proposed building is considered to be locally potentially liquefiable; however, we envisage that after implementation of the proposed deep soil mixing ground improvement measures, the potential for liquefaction beneath the proposed building foundations would be eliminated.

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## NON-ARTESIAN GROUNDWATER

- Non-artesian groundwater is expected to be daylighted during excavation at the site, which we envisage would be managed with conventional drainage measures.
- Due to the naturally high non-artesian water levels expected at the site, we recommend that the below-grade portions of the building be designed as a waterproof structure. It is envisaged that an in-ground infiltration system would be installed at the eastern portion of the site to disperse intercepted groundwater into the existing, natural, subsurface peat and sand to silty sand materials.

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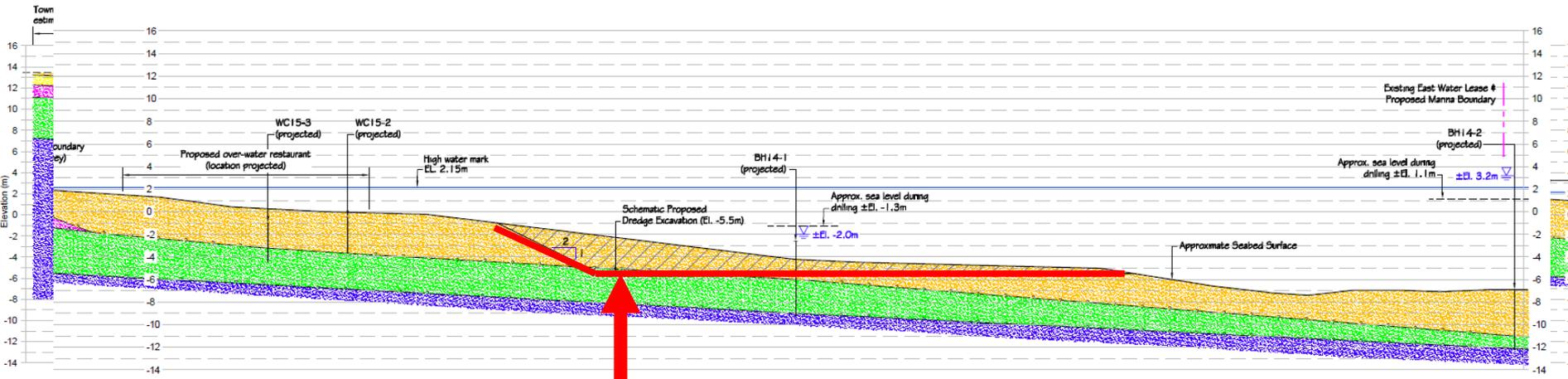
## DREDGING IN FORESHORE AREA

- We understand that dredging is proposed to be carried out near the shoreline within the west and north portions of the existing water lease area in the harbour.
- The soils that are proposed to be removed during dredging are inferred to generally comprise seabed sediments (and fill materials at the north foreshore area), though we envisage that the proposed dredging excavation may locally intercept the underlying Gibsons Aquitard materials.
- The seabed sediments were observed to comprise materials that are inferred to be not be significantly more dense than water; therefore, we envisage that "blowout" of the underlying aquitard materials following removal of overlying seabed sediments during dredging would not be expected to occur.
- Although a hydraulic connection between the ocean and the underlying aquifer is envisaged to exist in the subject area, we recommend that dredging be limited to the seabed sediments to reduce the risk of impacting the aquifer.

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## DREDGING IN FORESHORE AREA

- We recommend that dredging of seabed sediments be carried out by means of hydraulic dredging; where denser / harder seabed and/or fill sediments are encountered near the surface, we envisage that mechanical dredging may be required.



SECTION A  
SCALE: 1:300

**Dredging area**



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## METHANE BUILD-UP

- A methane venting system is recommended to be constructed beneath any portion of the building that is being constructed at or above existing grades where unsaturated organic materials, such as peat, remain below.

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# CONSTRUCTION CONSIDERATIONS

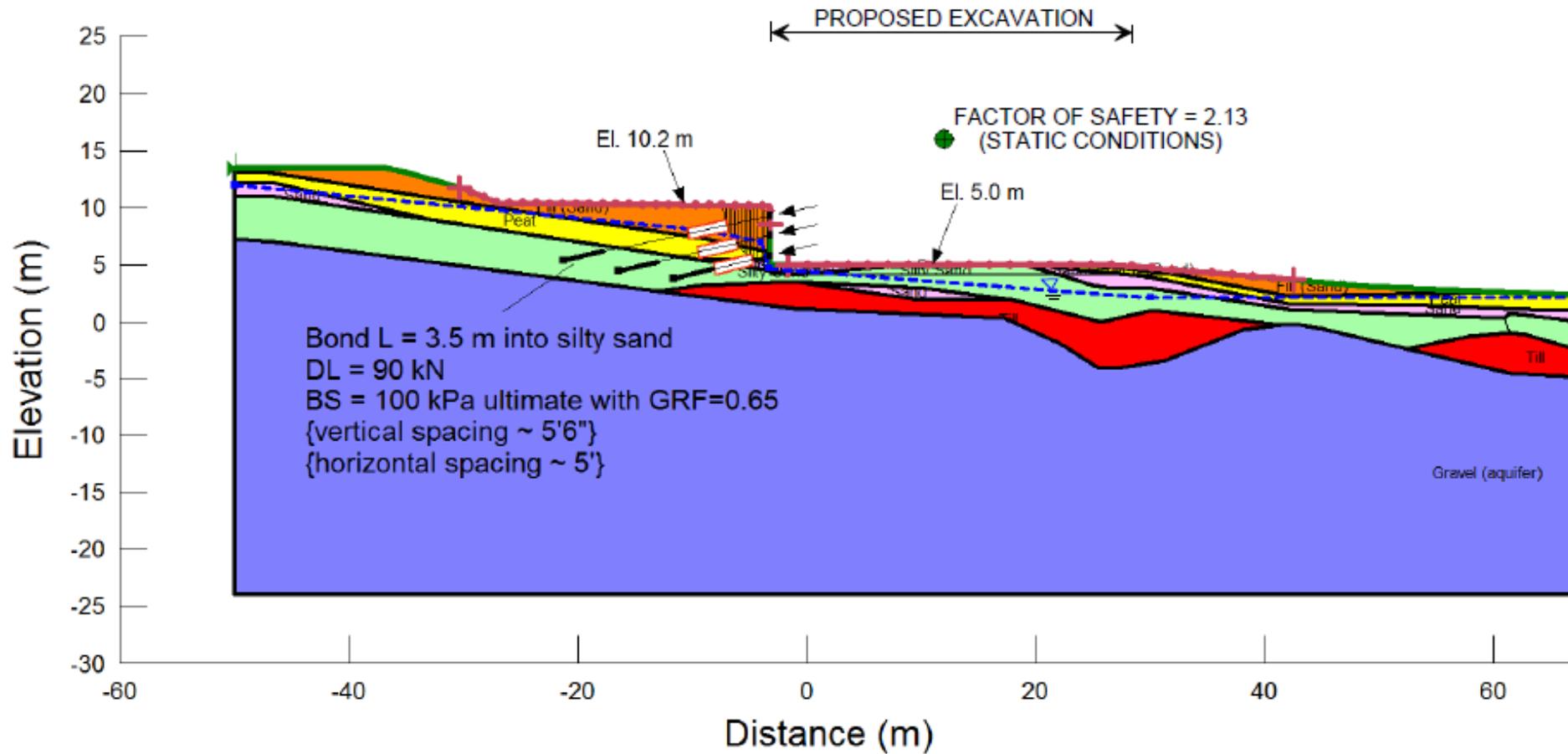
- As bulk excavation approaches the final excavation elevations, we recommend that regular surveying by a British Columbia Land Surveyor be carried out within the excavation to confirm that the lowest recommended excavation elevations are not exceeded.
- We recommend that the excavation be carried out in stages (in plan view). At each stage, the ground surface should be surveyed and monitored such that any potential signs of heaving and upward groundwater seepage are detected, respectively.
- Based on the available information and the computer modelling described in this report, we envisage there to be no risk of ground heaving or upward groundwater seepage into the excavation if our recommendations in this report are implemented.
- It should be noted that after completion of excavation to the design elevations and confirming that there is no impact on the aquifer, subsequent construction activities can proceed; specifically, ground improvement and construction of the foundation.



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# CONSTRUCTION CONSIDERATIONS

- We envisage that there will be insufficient room for sloping on the northwest, north, and south sides of the proposed excavation at the northwest portion of the site.
- It is envisaged that temporary excavation support using tied-back shotcrete shoring will be suitable.
- A preliminary slope stability analysis was carried out on the temporary shoring system proposed at the west property line in this area, which indicated that this system would be suitably stable under static conditions.



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Questions?

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**Karim Karimzadegan, M.A.Sc., P.Eng.**

**Horizon Engineering Inc.**

**114 – 2433 Dollarton Highway, North Vancouver**

**Tel. 604-990-0546 Fax 604-990-0583**

**[www.horizoneng.ca](http://www.horizoneng.ca)**

**[karim@horizoneng.ca](mailto:karim@horizoneng.ca)**