# Cowichan Valley Regional District Coastal Slope Stability Assessment

# Stantec and Palmer

**Dr. Richard Guthrie, P.Geo.**
**Stantec, Vice President**
**Director Geohazards**

- 27 Years experience (including 15 on Vancouver Island as the regional and provincial geomorphologist)
- MSc and PhD on landslides
- Global landslide, hazard, and risk expert (over 90 publications)

**Robin McKillop, M.Sc., P.Geo.**
**Palmer, Vice President**
**Geomorphologist**

- 18 Years experience including landslide mapping in CVRD and shoreline erosion across Canada
- Terrain stability and hazard mapping expert

**Hawley Beaugrand, M.Sc., P.Geo. Stantec, Associate Geomorphologist**

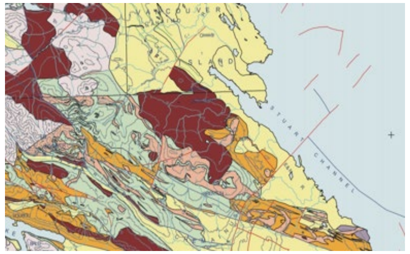
- 14 Years experience specializing in terrain, fluvial, and coastal geomorphology
- Geohazards technical lead
- Master's degree from UVic in coastal geomorphology

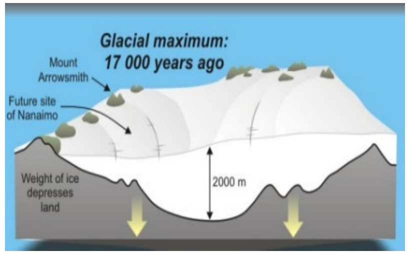
**Cory McGregor, P.Geo.**
**Palmer, Geomorphologist**

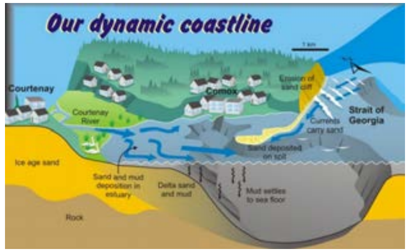
- 8 Years experience in mountain, fluvial, and glacial environments and the geohazards of these regions
- Extensive mapping across BC, AB, SK, YT, NT

Photo from https://saltairnews.ca/

# Geology → Geomorphology → Settlement






Images from Geoscape Nanaimo (McColl et al. 2005) and Geomorphology of Vancouver Island (Guthrie, 2005)

## Scope of Work

Conduct a coastal slope stability assessment along the Saltair coastline (including Stocking and Porter Creeks) to identify and characterize changes in slope stability considering a future sea level rise of 1 m

Based on observations of increased incidence of slope failure along the coastal zone.

# Background

- Flat-over-steep terrain, relief sea level to 50 m, steep (>35°) to moderately steep (27-35°)
- Complicated surficial geology related to glacial advance/retreat, change in sea levels, glacial outwash
- Surficial geology mapped as:
  1. Predominantly thick & continuous till
  2. Predominantly marine deposits
- Geotechnical reports generally describing relatively shallow failures excepting one report that identified a “backscarp passing through a house”

# 1 m Sea Level Rise


# Field Observations

- Relatively shallow failures common
- Failures related to uncontrolled discharge of stormwater
- High clay content & clay seams observed along portions of the bluff with the greatest relief
- Majority of shoreline hardened
- Natural shoreline segments remaining undercut

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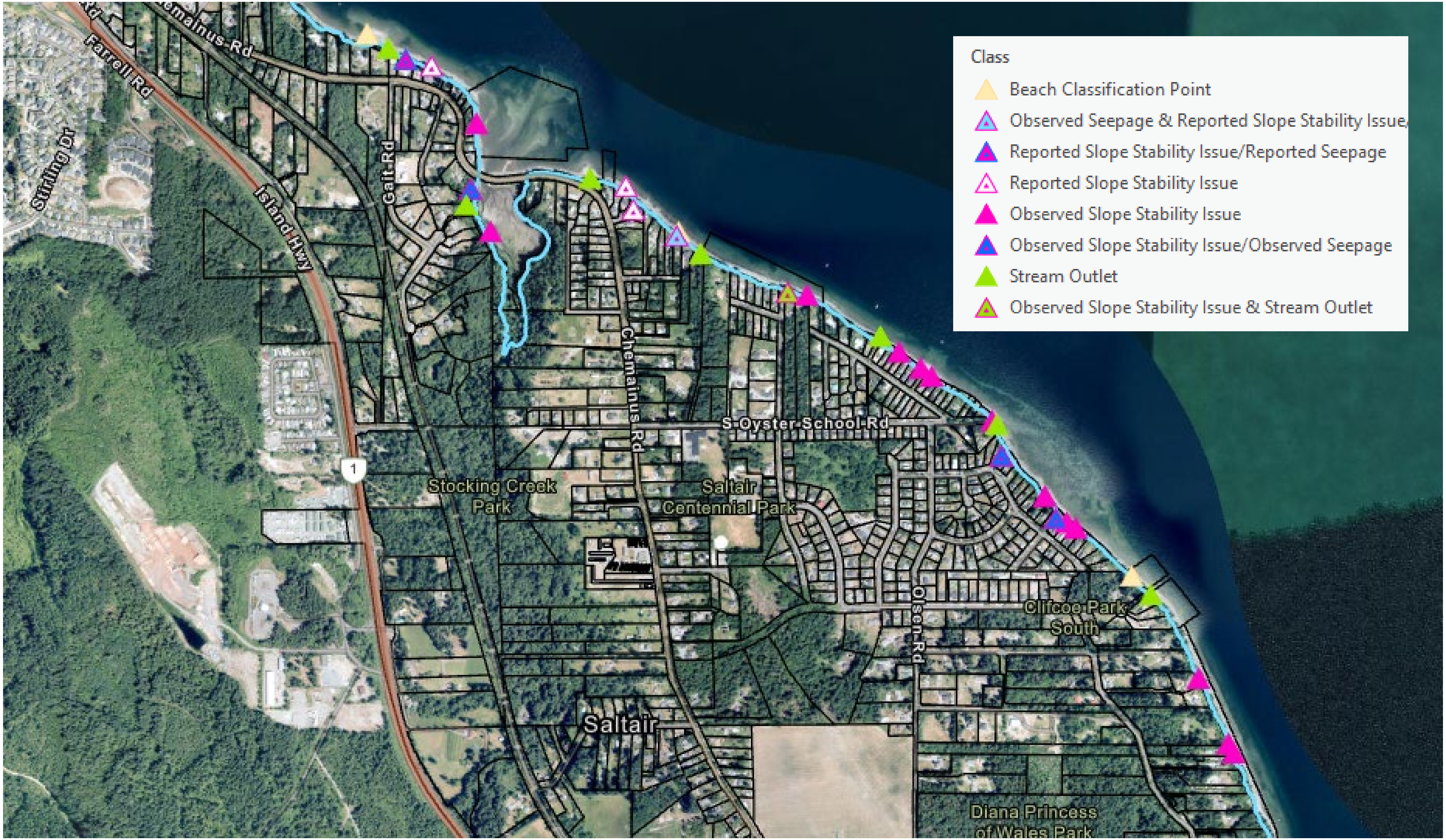
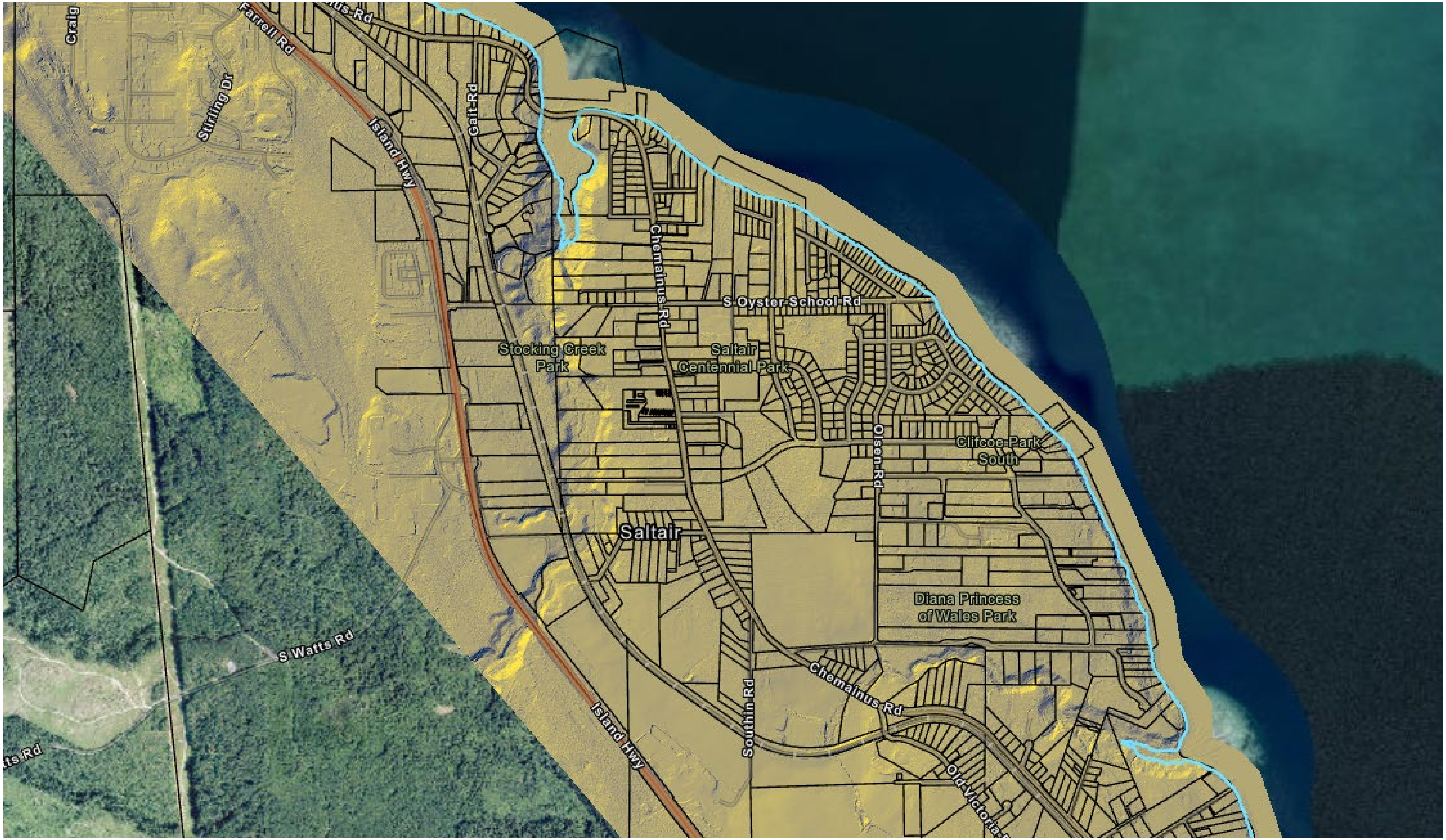
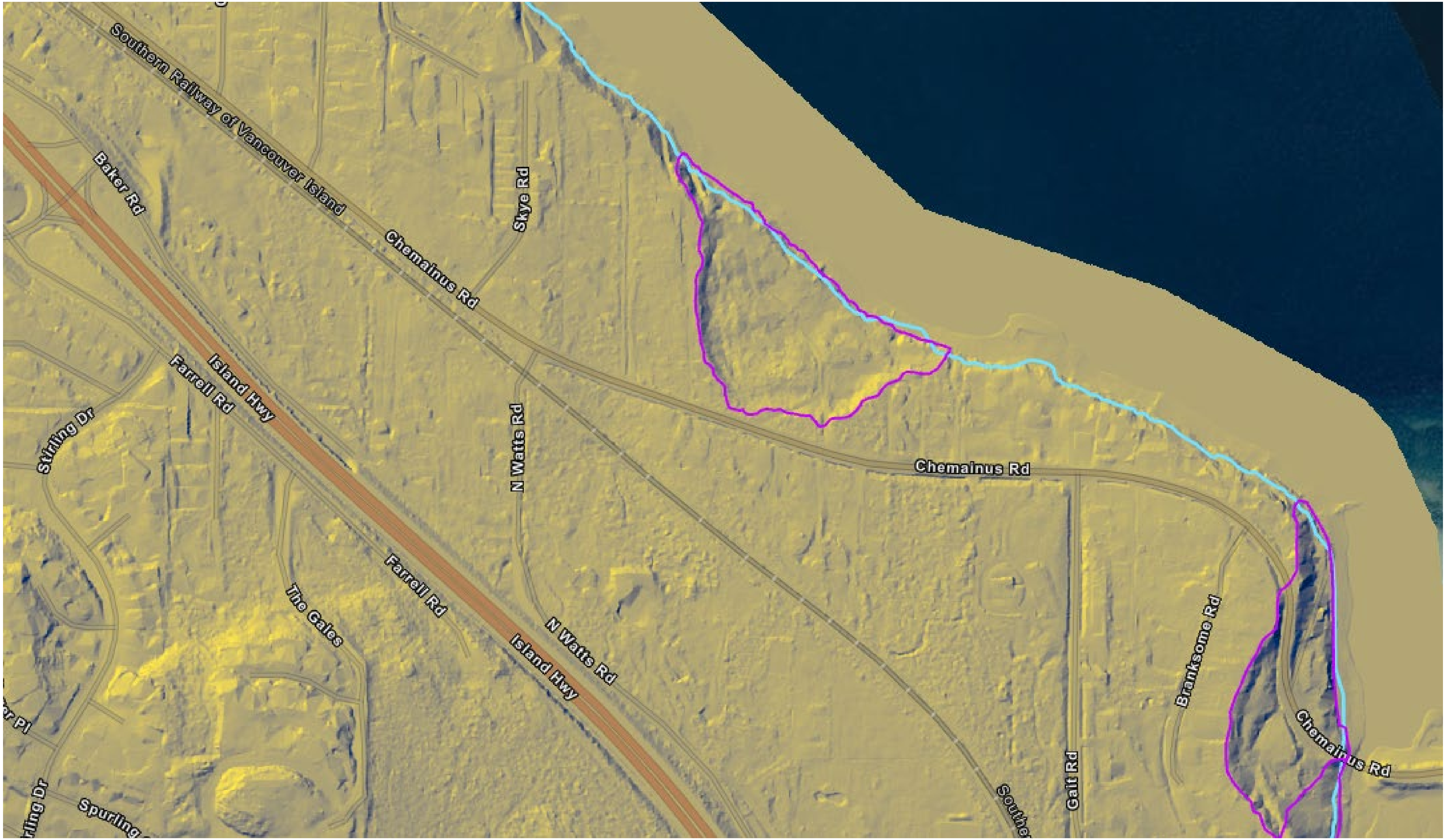
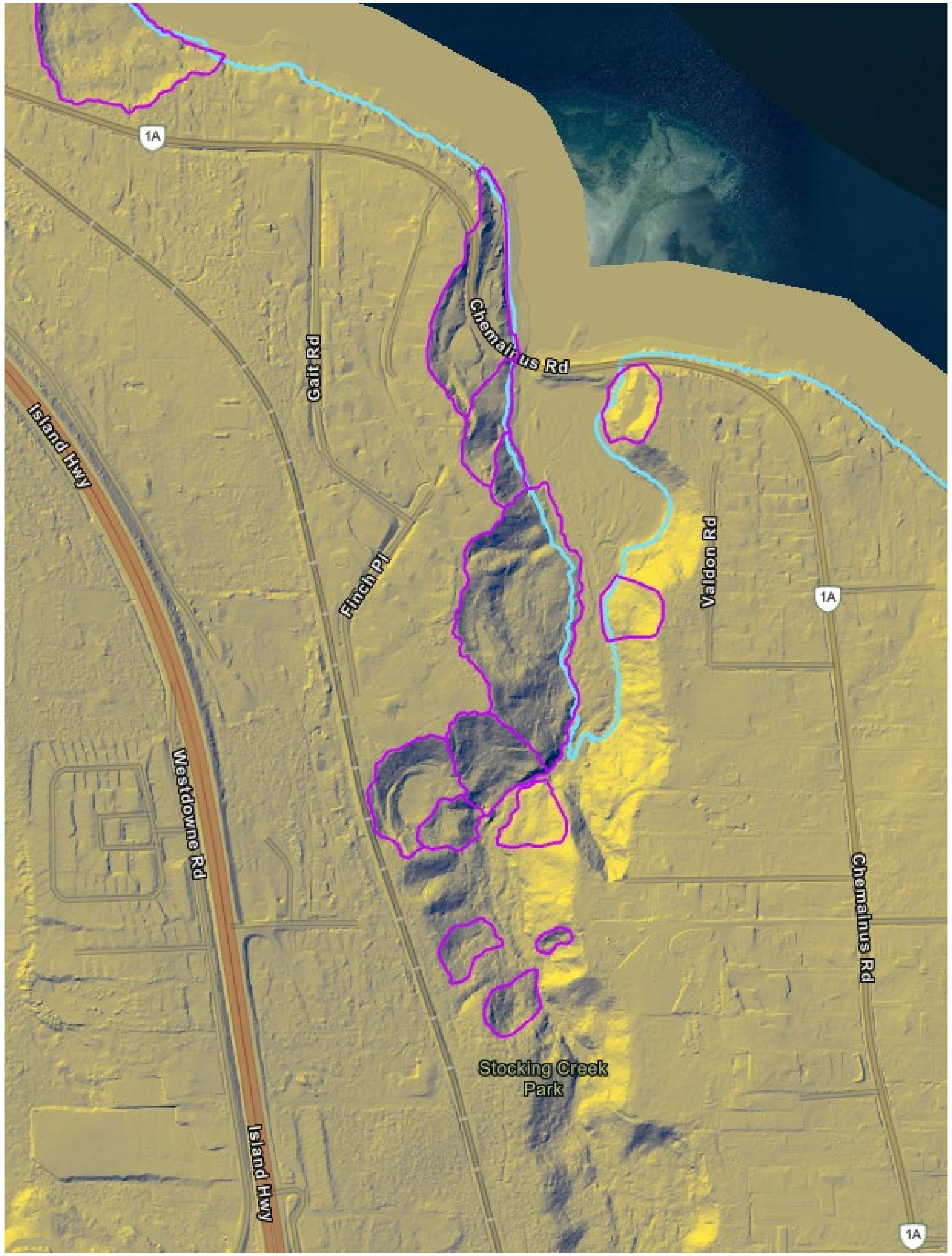
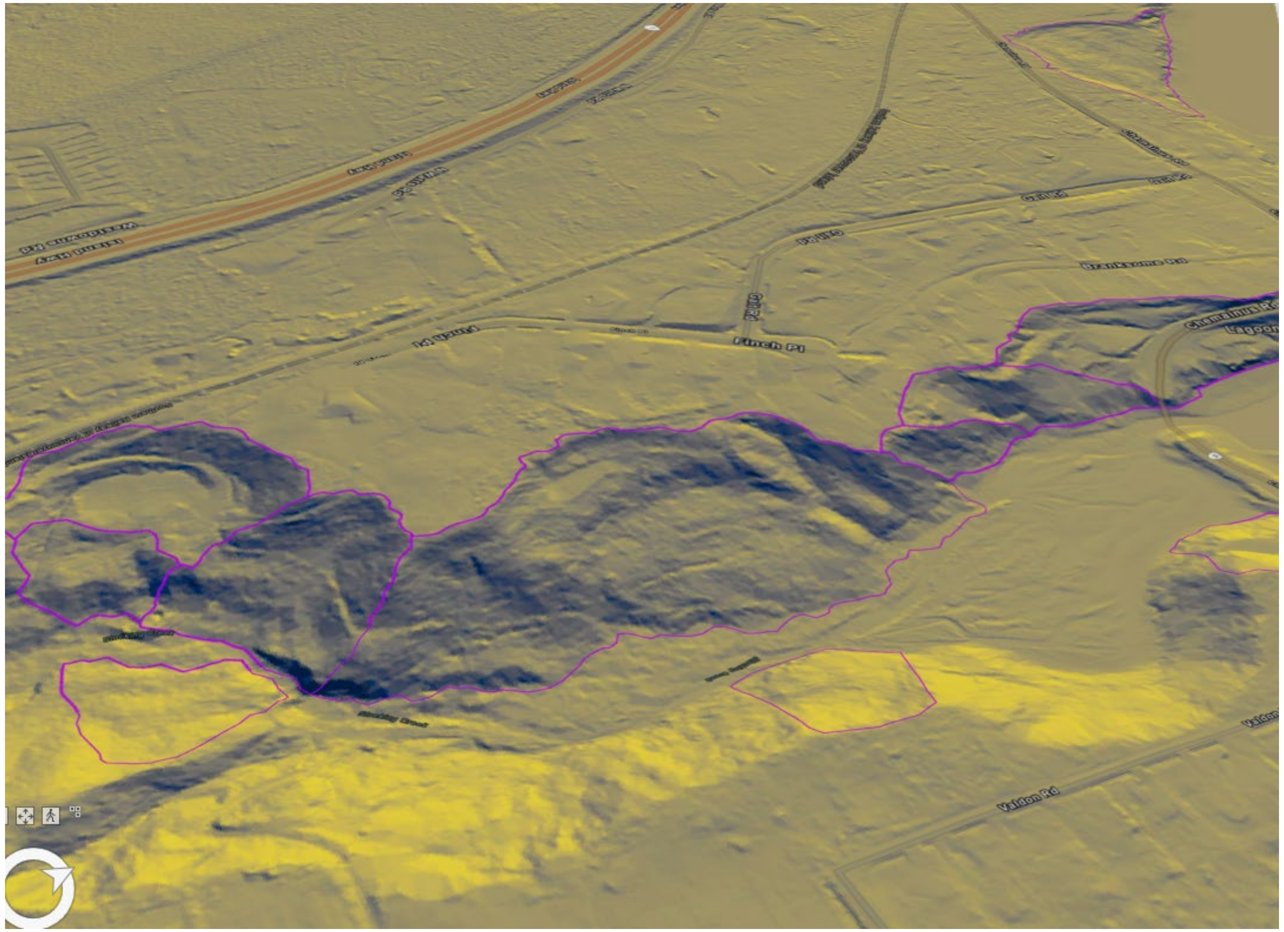

Class
Beach Classification Point
Observed Seepage & Reported Slope Stability Issue/
Reported Slope Stability Issue/Reported Seepage
Reported Slope Stability Issue
Observed Slope Stability Issue
Observed Slope Stability Issue/Observed Seepage
Stream Outlet
Observed Slope Stability Issue & Stream Outlet
Chemainus Rd
Farrell Rd
Stirling Dr
Galt Rd
Island Hwy
1
S Oyster School Rd
Stocking Creek Park
Saltair Centennial Park
Olsen Rd
Clifcoe Park South
Saltair
Diana Princess of Wales Park

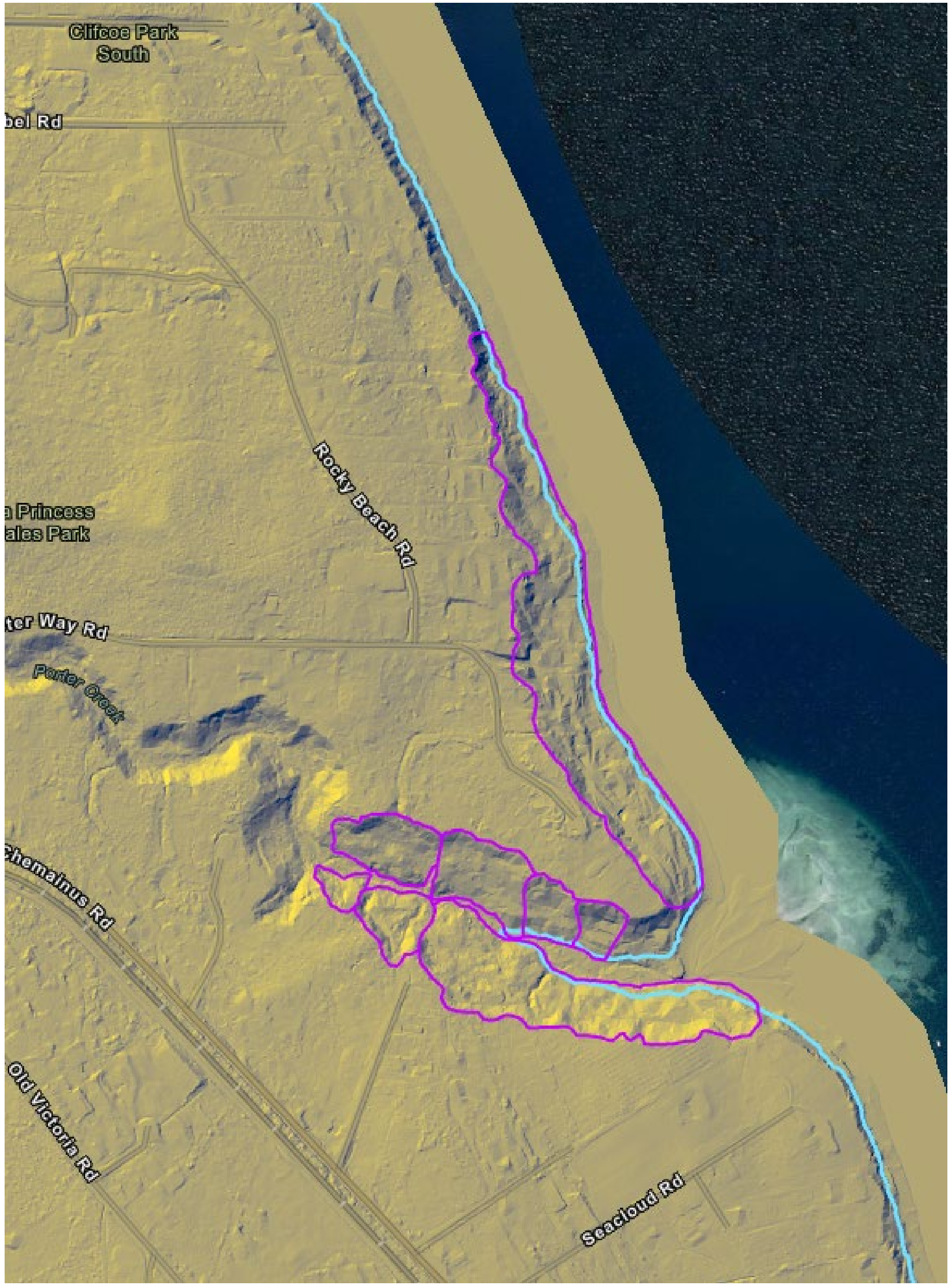

Craig
Farrell Rd
Stirling Dr
Galt Rd
Island Hwy
Chemainus Rd
S Oyster School Rd
Stocking Creek Park
Saltair Centennial Park
Olsen Rd
Clifcoe Park South
Saltair
Diana Princess of Wales Park
S Watts Rd
Southin Rd
Old Victoria

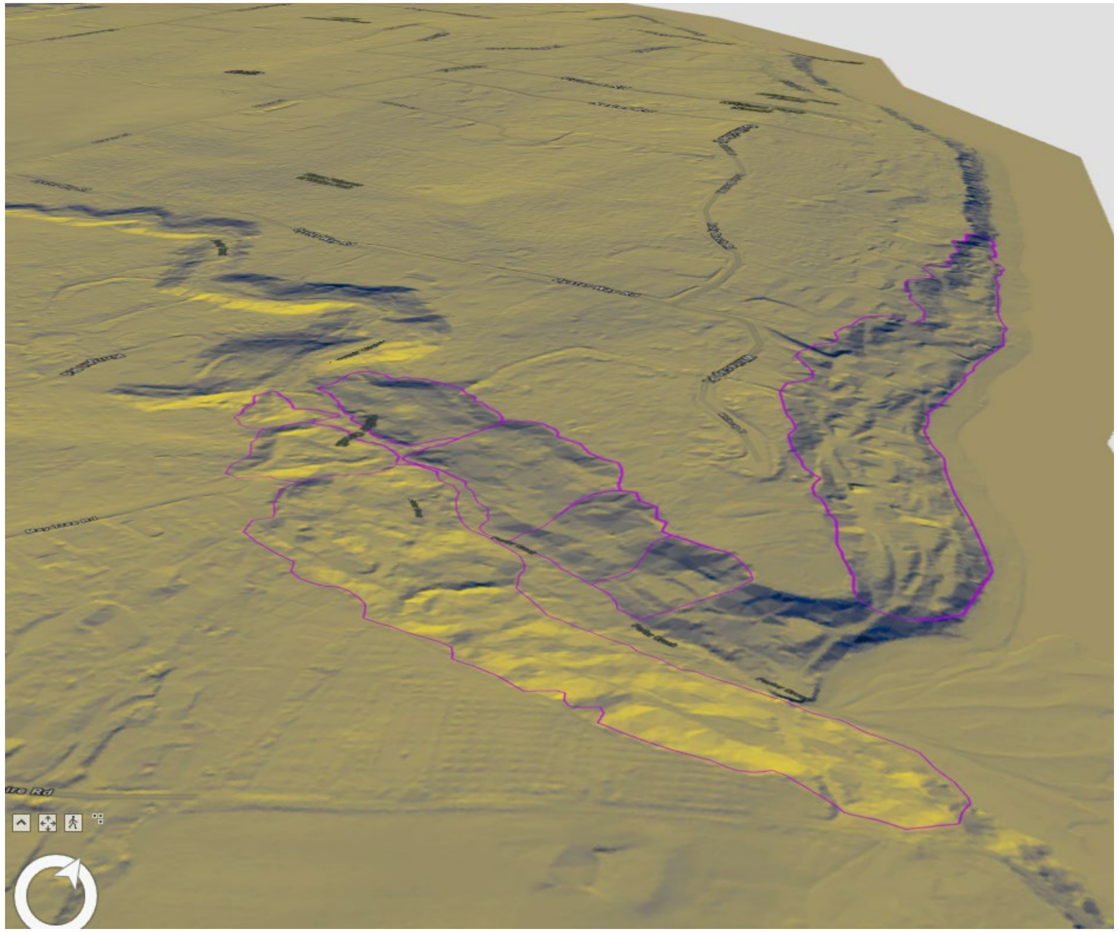

Southern Railway of Vancouver Island
Baker Rd
Skye Rd
Chemainus Rd
Island Hwy
Farrell Rd
Stirling Dr
N Watts Rd
Chemainus Rd
The Gales
Farrell Rd
N Watts Rd
Island Hwy
Branksome Rd
Chemainus Rd
Gait Rd
Spurling Cres
Stirling Dr

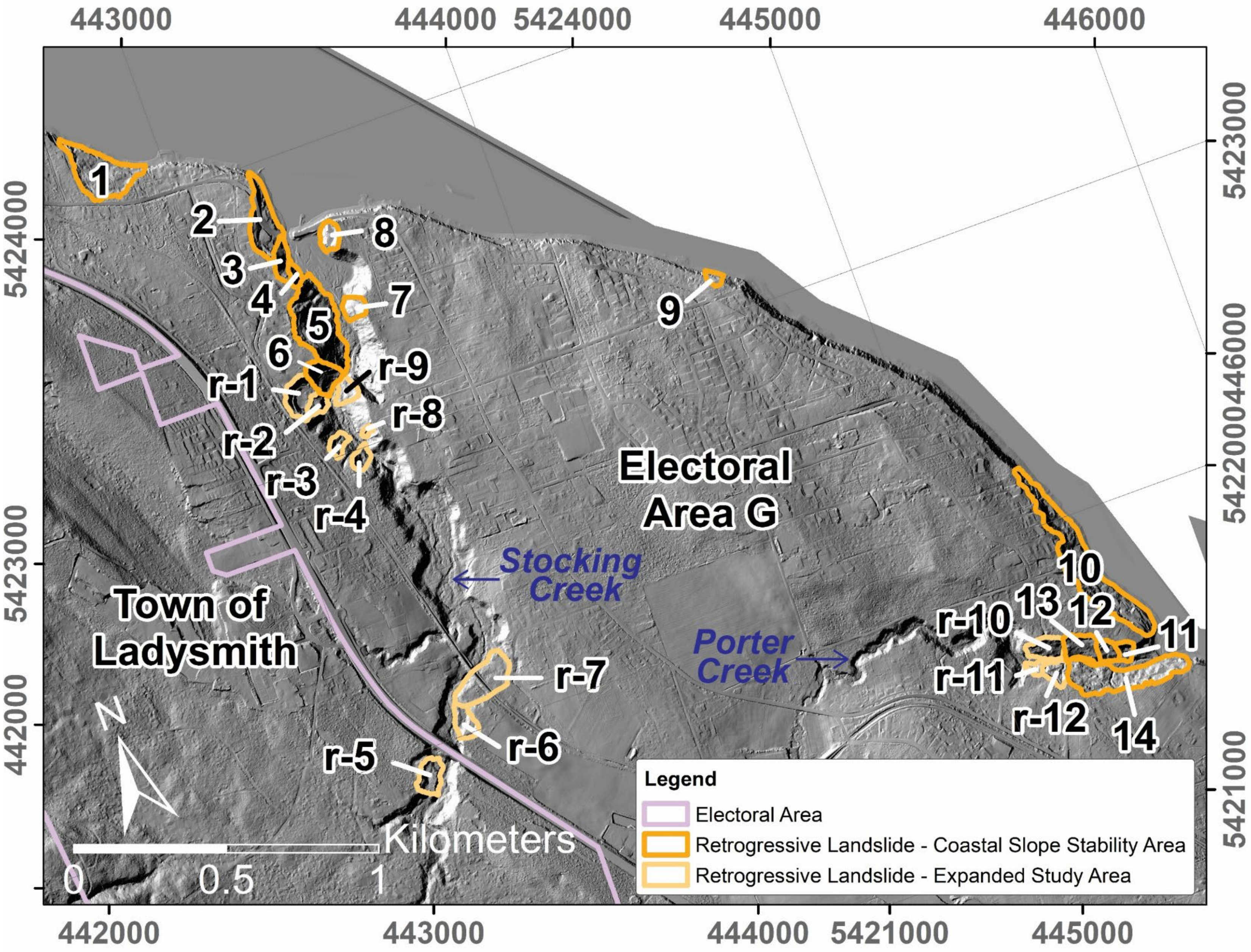

Southern Railway of Vancouver Island
Baker Rd
Chemainus Rd
Skye Rd
Island Hwy
Farrell Rd
Stirling Dr
N Watts Rd
Chemainus Rd
The Gales
Farrell Rd
N Watts Rd
Island Hwy
Branksome Rd
Chemainus Rd
Galt Rd
Spurling


1A
Chemainus Rd
Gait Rd
Island Hwy
Finch Pl
Valdon Rd
1A
Westdowne Rd
Chemainus Rd
Stocking Creek
Park
Island Hwy
1A


Finch Pl


Clifcoe Park
South
Rocky Beach Rd
Porter Creek
Chemainus Rd
Old Victoria Rd
Seacloud Rd





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r-6
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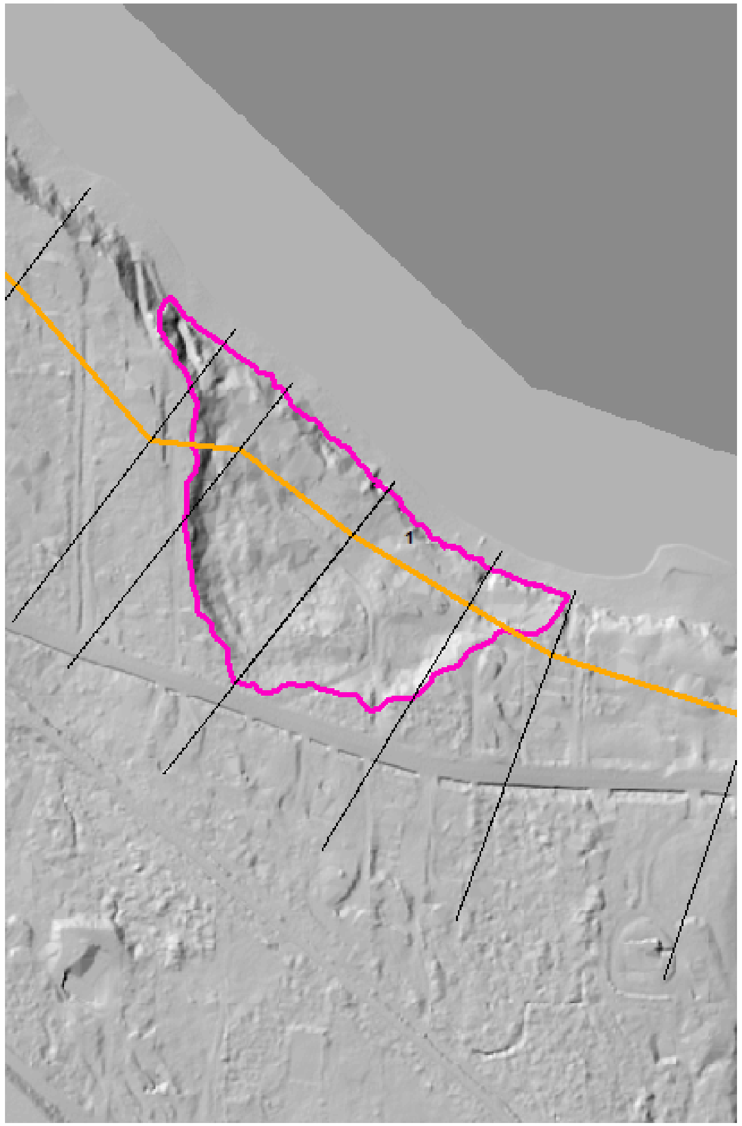
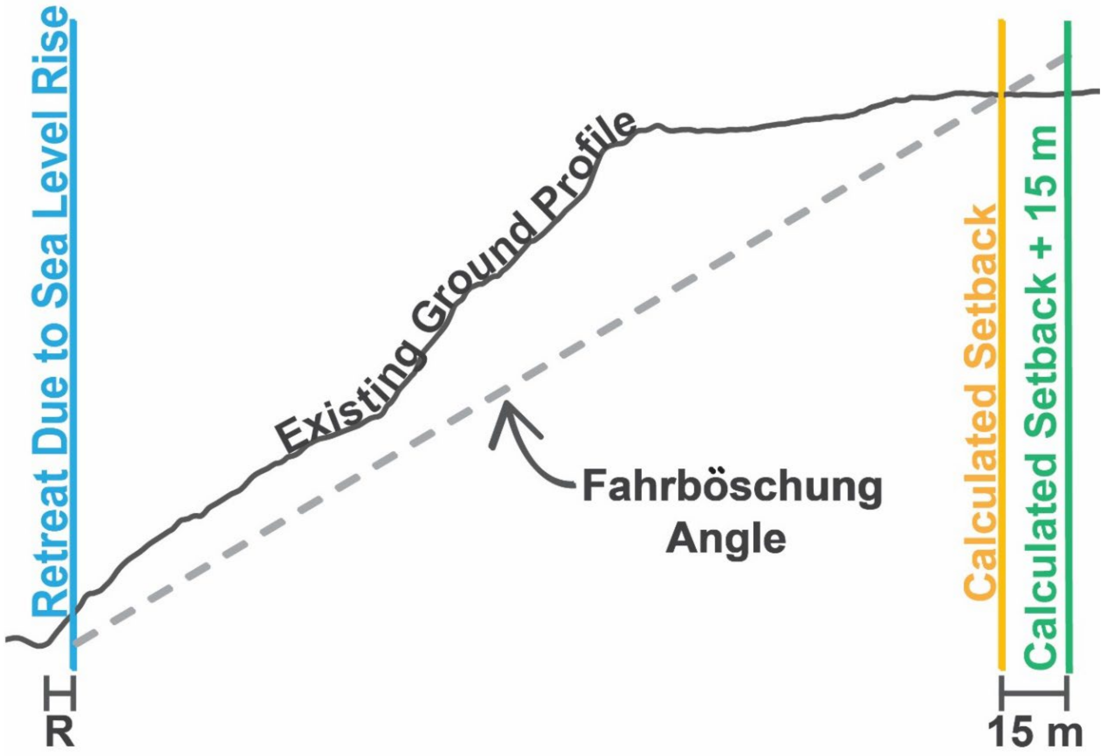
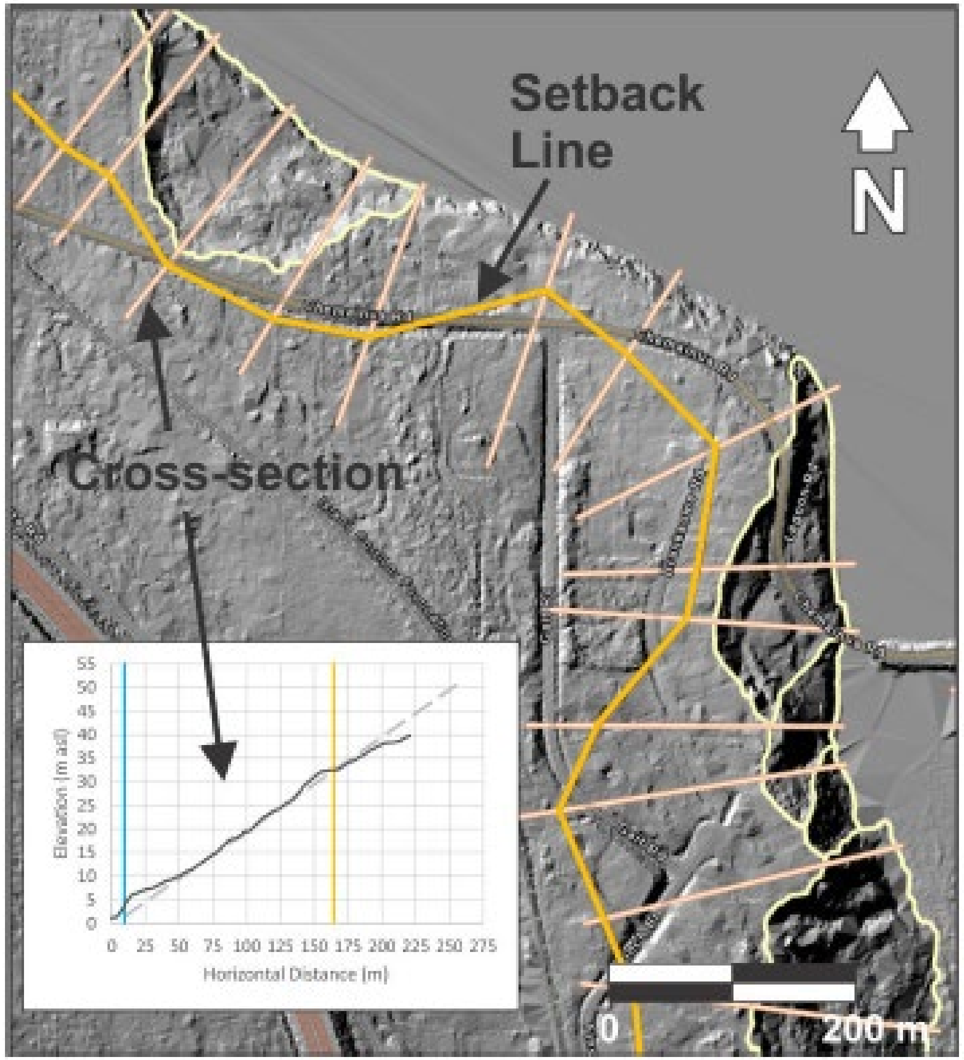
r-8
r-9
r-10
r-11
r-12
Electoral Area G
Town of Ladysmith
Stocking Creek
Porter Creek
N
0
0.5
1
Kilometers
Legend
Electoral Area
Retrogressive Landslide - Coastal Slope Stability Area
Retrogressive Landslide - Expanded Study Area

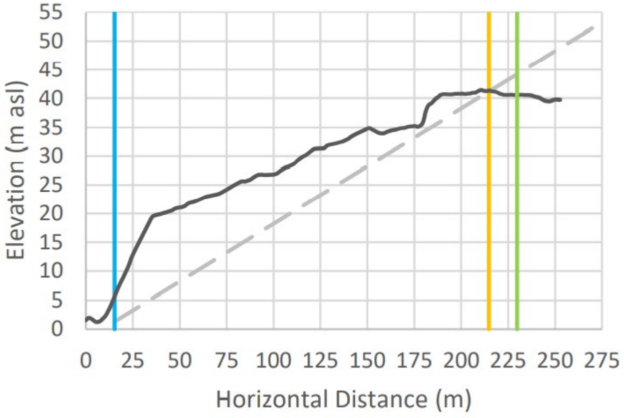
# Coastal Setback Distances

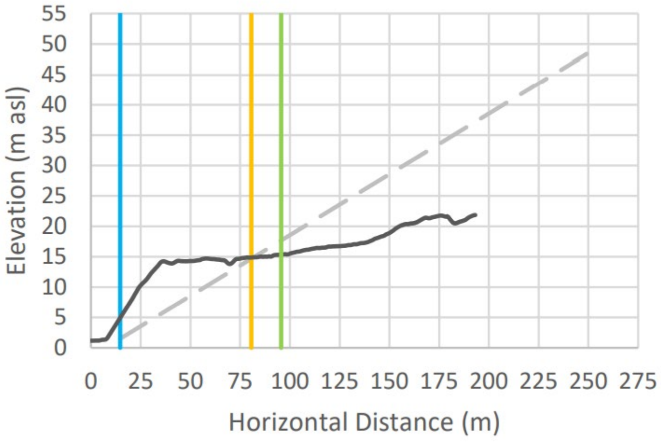
- Fahrböschung angle method
- Cruden, Tedder, and Thomson (1989)
- Lowest measured Fahrböschung angle of mapped retrogressive landslides inferred limit of retrogression

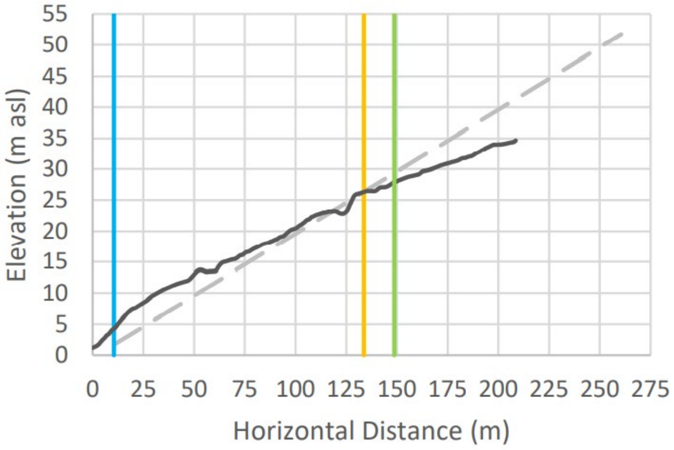


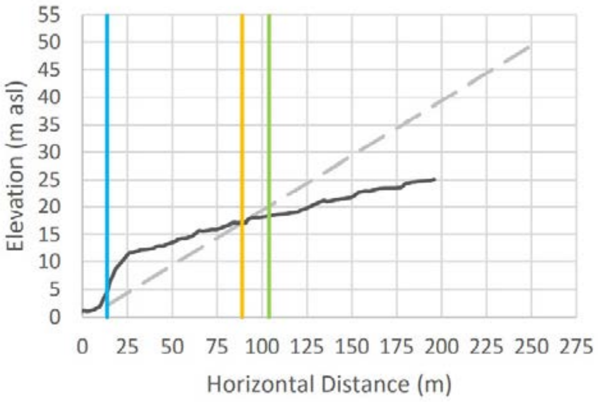



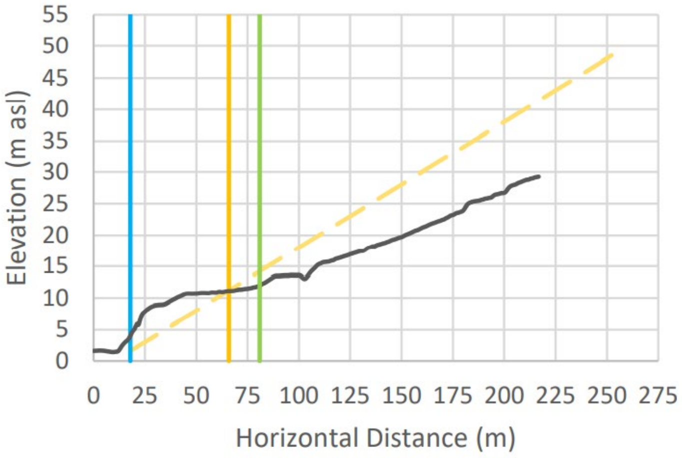
# Coastal Setback Distances

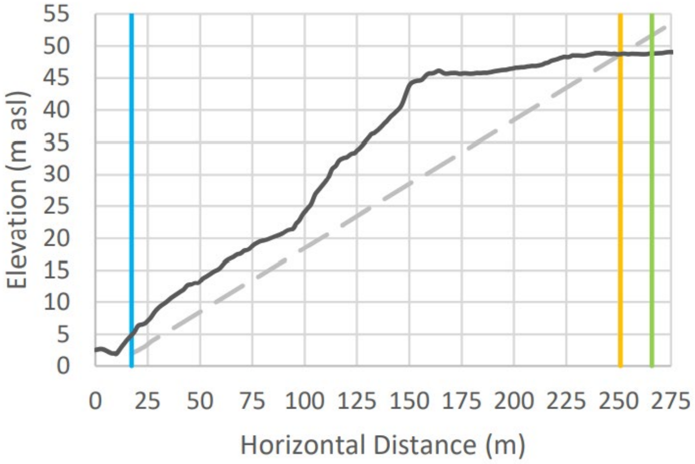


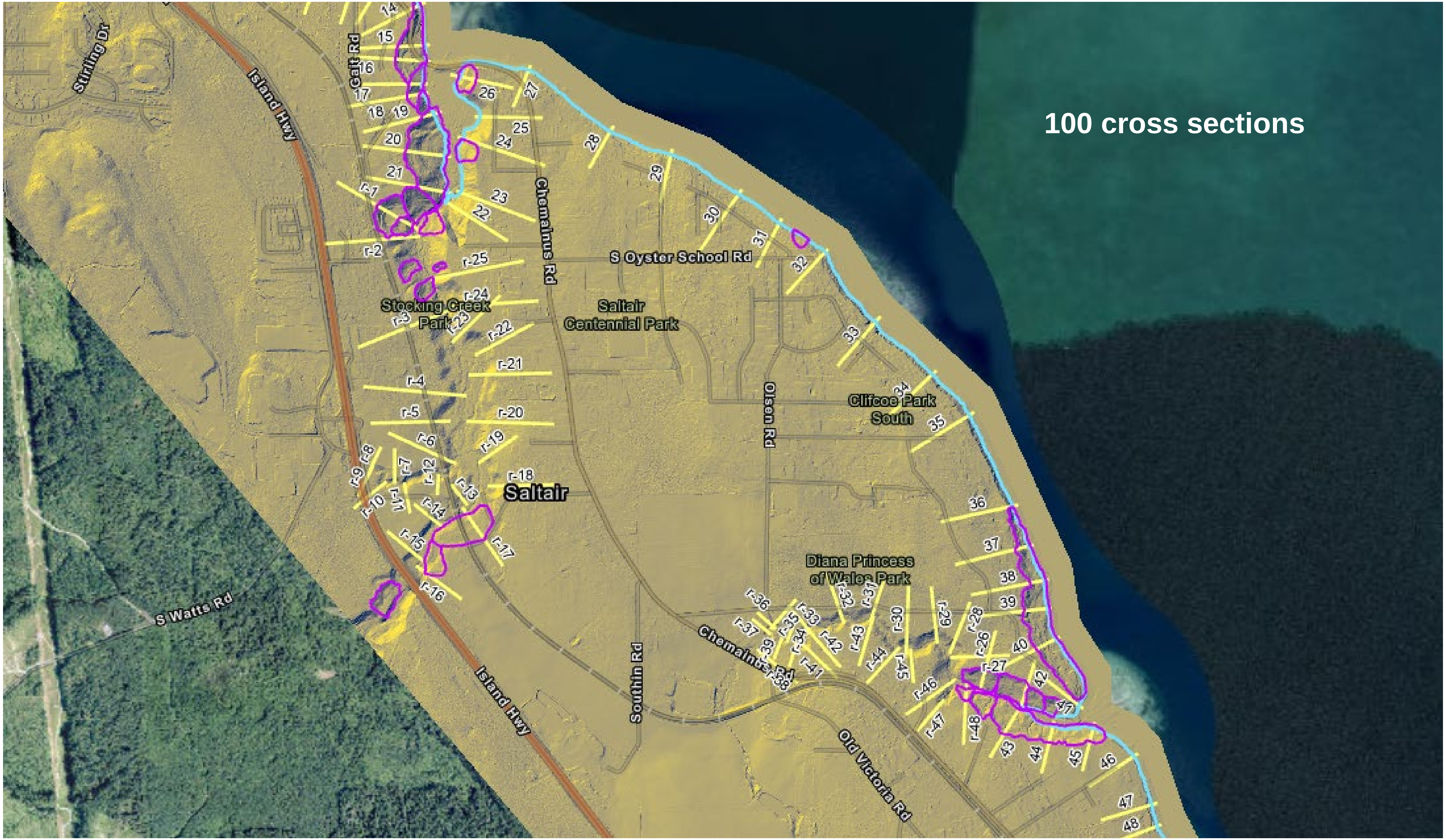



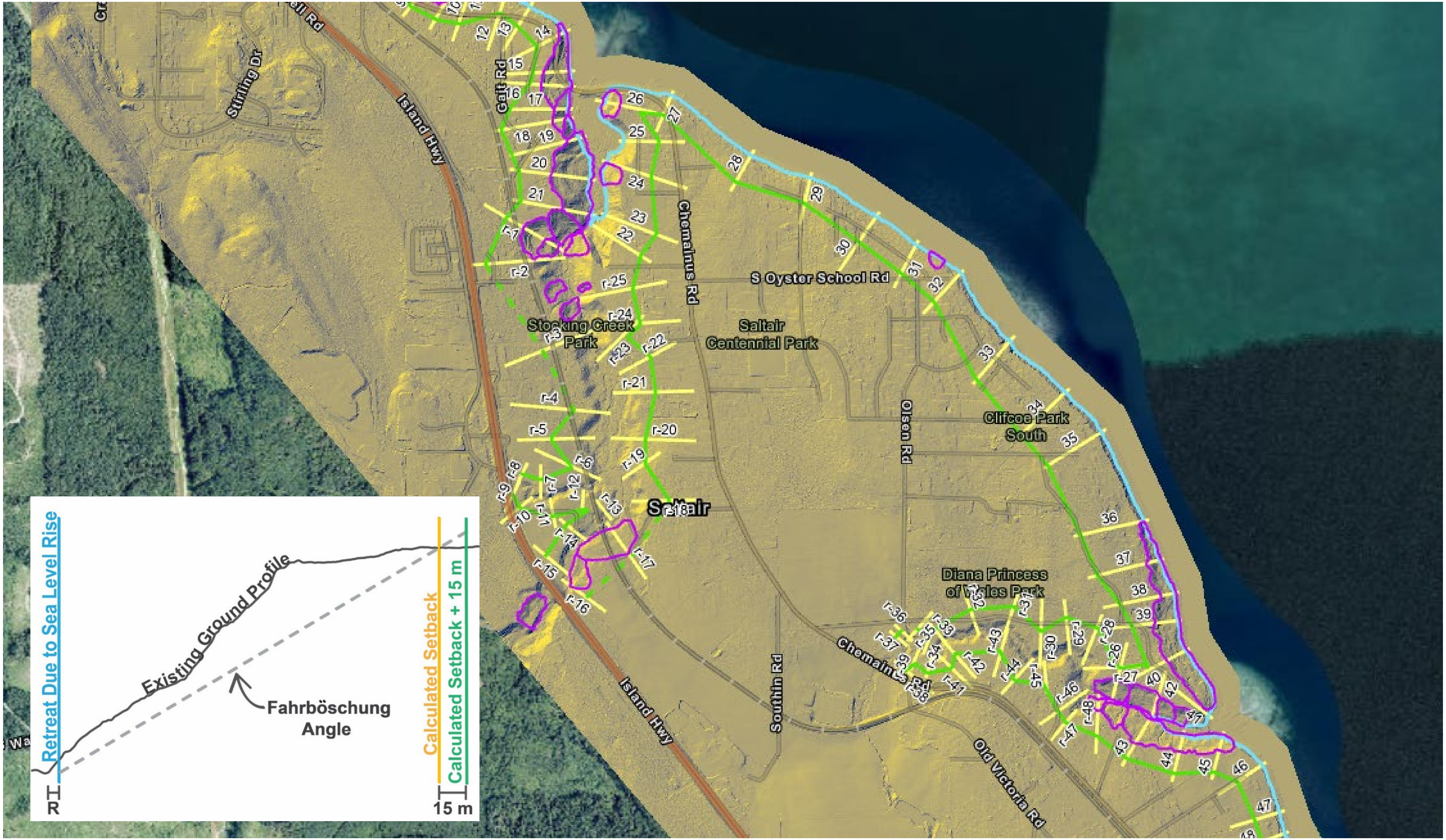



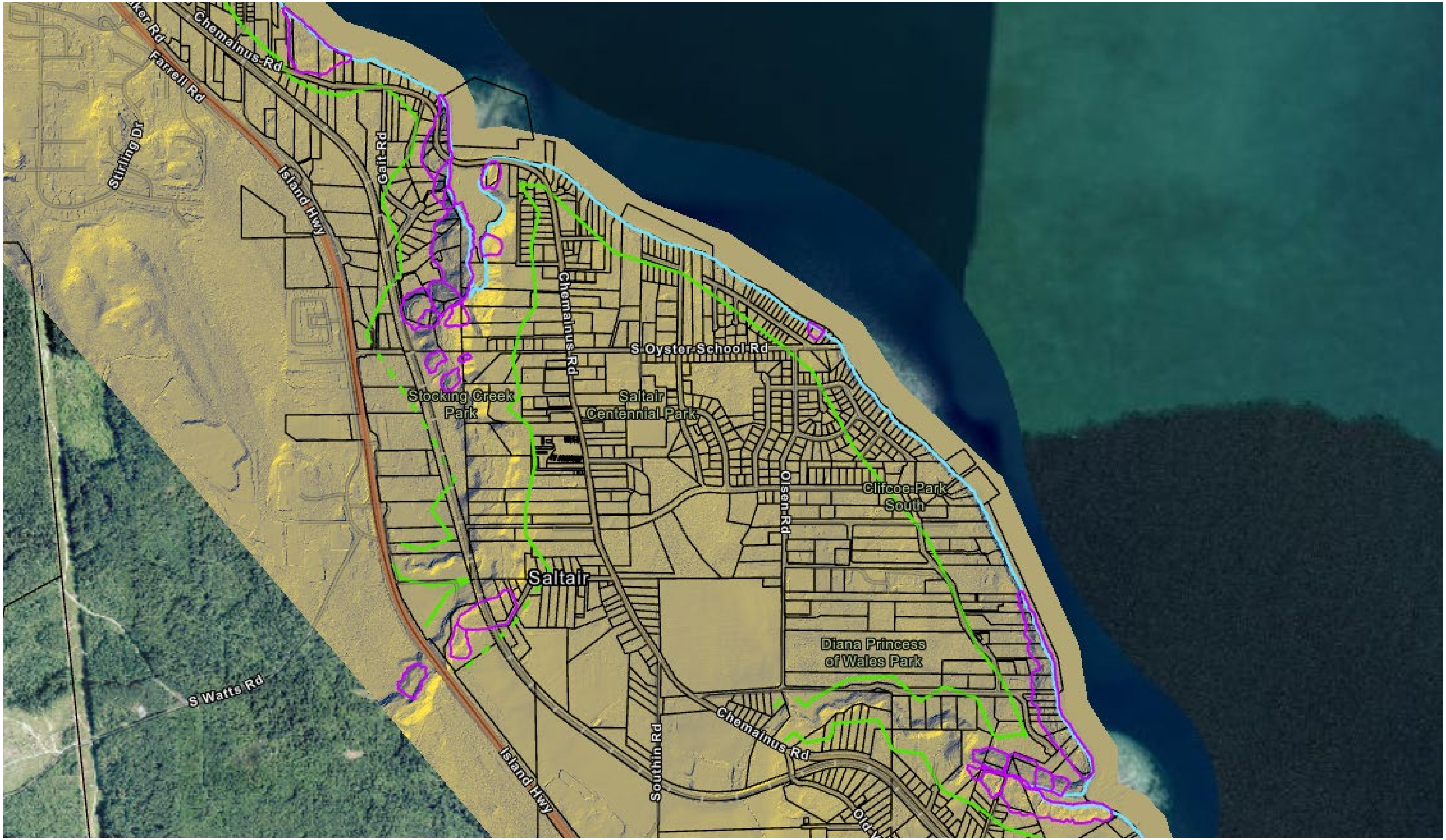




100 cross sections
Stirling Dr
Island Hwy
Galt Rd
Chemainus Rd
S Oyster School Rd
Stocking Creek Park
Saltair Centennial Park
Olsen Rd
Clifcoe Park South
Saltair
Diana Princess of Wales Park
S Watts Rd
Southin Rd
Chemainus Rd
Old Victoria Rd


Island Hwy
Stirling Dr
Galt Rd
Chemainus Rd
S Oyster School Rd
Stocking Creek Park
Saltair Centennial Park
Olsen Rd
Clifcoe Park South
Saltair
Diana Princess of Wales Park
Southin Rd
Old Victoria Rd
Retreat Due to Sea Level Rise
Existing Ground Profile
Fahrböschung Angle
Calculated Setback
Calculated Setback + 15 m
R
15 m


Chemainus Rd
Farrell Rd
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Park
Saltair
Centennial Park
Olsen Rd
Cliffcoe Park
South
Saltair
Diana Princess
of Wales Park
S Watts Rd
Southin Rd
Chemainus Rd
Island Hwy

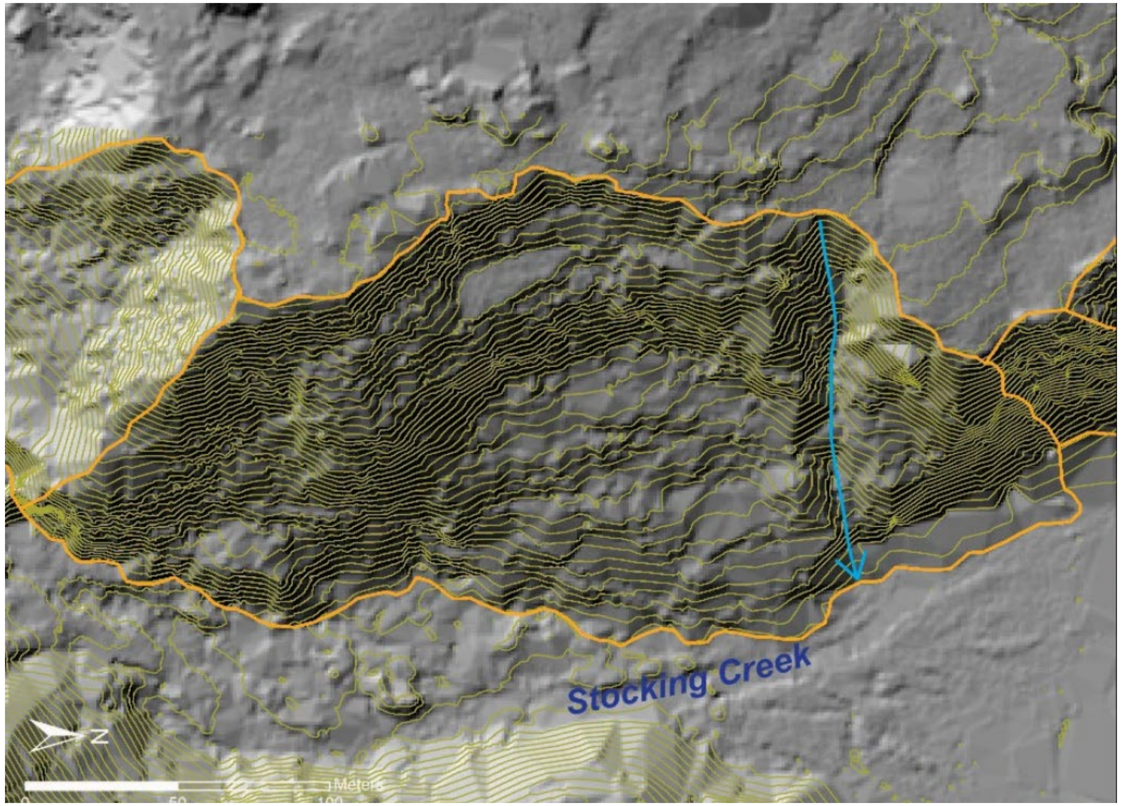
# Annual Probability of Occurrence

$$H_{T,S} = H_T \times H_s$$

$H_S$ = area of landslide/area of setback zone
$H_T$ = random age assigned within reasonable age range (5-500) across 10 iterations

$$PO = 1 - \left(\left(1 - H_{T,S1}\right) \times \left(1 - H_{T,S2}\right) \times \ldots \left(1 - H_{T,Sn}\right)\right)$$

Calculated PO for each iteration
Final PO = average of all PO’s


Stocking Creek
N
Meters


Davis Lagoon
Google Earth
N

| LS | Area (ha) | $H_S$ | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $H_T$ | $H_T$ | $H_T$ | $H_T$ | $H_T$ | $H_T$ | $H_T$ | $H_T$ | $H_T$ | $H_T$ |
| 1 | 2.59 | 0.028455 | 0.005682 | 0.002915 | 0.002326 | 0.004274 | 0.062500 | 0.045455 | 0.002695 | 0.002591 | 0.012346 | 0.004098 |
| 2 | 1.72 | 0.018966 | 0.003040 | 0.002525 | 0.002262 | 0.003003 | 0.002179 | 0.002695 | 0.004587 | 0.003663 | 0.003413 | 0.002976 |
| 3 | 0.57 | 0.006246 | 0.002941 | 0.002985 | 0.002217 | 0.005319 | 0.002387 | 0.008065 | 0.002242 | 0.003236 | 0.002075 | 0.005814 |
| 4 | 0.25 | 0.002729 | 0.083333 | 0.041667 | 0.003049 | 0.005435 | 0.002755 | 0.003448 | 0.055556 | 0.002096 | 0.062500 | 0.015873 |
| 5 | 3.44 | 0.037835 | 0.003155 | 0.002088 | 0.018519 | 0.003356 | 0.002976 | 0.002882 | 0.004149 | 0.003195 | 0.007692 | 0.007194 |
| 6 | 0.89 | 0.009776 | 0.003067 | 0.002053 | 0.002000 | 0.004149 | 0.004132 | 0.003717 | 0.002833 | 0.002985 | 0.003413 | 0.142857 |
| 7 | 0.46 | 0.005044 | 0.003367 | 0.009709 | 0.004484 | 0.016949 | 0.014085 | 0.050000 | 0.013889 | 0.007692 | 0.002551 | 0.005882 |
| 8 | 0.50 | 0.005471 | 0.005236 | 0.040000 | 0.027027 | 0.007937 | 0.002326 | 0.002604 | 0.033333 | 0.008130 | 0.007519 | 0.003236 |
| 9 | 0.20 | 0.002208 | 0.003086 | 0.003268 | 0.007519 | 0.002273 | 0.002183 | 0.013699 | 0.002950 | 0.020408 | 0.003012 | 0.003077 |
| 10 | 4.61 | 0.050644 | 0.006289 | 0.028571 | 0.002217 | 0.002907 | 0.025641 | 0.002740 | 0.017857 | 0.010000 | 0.002439 | 0.002825 |
| 11 | 0.30 | 0.003247 | 0.016667 | 0.007246 | 0.003922 | 0.066667 | 0.004149 | 0.007299 | 0.007692 | 0.003861 | 0.002203 | 0.007576 |
| 12 | 0.41 | 0.004545 | 0.015873 | 0.006667 | 0.004717 | 0.002000 | 0.003367 | 0.002137 | 0.002208 | 0.003984 | 0.009009 | 0.027027 |
| 13 | 0.85 | 0.009375 | 0.002132 | 0.008333 | 0.010101 | 0.007576 | 0.002545 | 0.004587 | 0.002375 | 0.002137 | 0.013158 | 0.003497 |
| 14 | 2.93 | 0.032199 | 0.002604 | 0.005882 | 0.002558 | 0.007874 | 0.007246 | 0.002146 | 0.004292 | 0.002141 | 0.010870 | 0.002924 |
| | | **PO** | **0.001215** | **0.002404** | **0.001361** | **0.001225** | **0.003664** | **0.002129** | **0.001871** | **0.001073** | **0.001628** | **0.002391** |
| | | | | | | | | | | | **Average PO** | **0.001896** |
| | | | | | | | | | | | **Standard Deviation** | **0.000791** |

| | | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LS** | **Area (ha)** | **$H_S$** | **$H_T$** | **$H_T$** | **$H_T$** | **$H_T$** | **$H_T$** | **$H_T$** | **$H_T$** | **$H_T$** | **$H_T$** | **$H_T$** |
| 1 | 2.59 | 0.028455 | 0.005682 | 0.002915 | 0.002326 | 0.004274 | 0.062500 | 0.045455 | 0.002695 | 0.002591 | 0.012346 | 0.004098 |
| 2 | 1.72 | 0.018966 | 0.003040 | 0.002525 | 0.002262 | 0.003003 | 0.002179 | 0.002695 | 0.004587 | 0.003663 | 0.003413 | 0.002976 |
| 3 | 0.57 | 0.006246 | 0.002941 | 0.002985 | 0.002217 | 0.005319 | 0.002387 | 0.008065 | 0.002242 | 0.003236 | 0.002075 | 0.005814 |
| 4 | 0.25 | 0.002729 | 0.083333 | 0.041667 | 0.003049 | 0.005435 | 0.002755 | 0.003448 | 0.055556 | 0.002096 | 0.062500 | 0.015873 |
| 5 | 3.44 | 0.037835 | 0.003155 | 0.002088 | 0.018519 | 0.003356 | 0.002976 | 0.002882 | 0.004149 | 0.003195 | 0.007692 | 0.007194 |
| 6 | 0.89 | 0.009776 | 0.003067 | 0.002053 | 0.002000 | 0.004149 | 0.004132 | 0.003717 | 0.002833 | 0.002985 | 0.003413 | 0.142857 |
| 7 | 0.46 | 0.005044 | 0.003367 | 0.009709 | 0.004484 | 0.016949 | 0.014085 | 0.050000 | 0.013889 | 0.007692 | 0.002551 | 0.005882 |
| 8 | 0.50 | 0.005471 | 0.005236 | 0.040000 | 0.027027 | 0.007937 | 0.002326 | 0.002604 | 0.033333 | 0.008130 | 0.007519 | 0.003236 |
| 9 | 0.20 | 0.002208 | 0.003086 | 0.003268 | 0.007519 | 0.002273 | 0.002183 | 0.013699 | 0.002950 | 0.020408 | 0.003012 | 0.003077 |
| 10 | 4.61 | 0.050644 | 0.006289 | 0.028571 | 0.002217 | 0.002907 | 0.025641 | 0.002740 | 0.017857 | 0.010000 | 0.002439 | 0.002825 |
| 11 | 0.30 | 0.003247 | 0.016667 | 0.007246 | 0.003922 | 0.066667 | 0.004149 | 0.007299 | 0.007692 | 0.003861 | 0.002203 | 0.007576 |
| 12 | 0.41 | 0.004545 | 0.015873 | 0.006667 | 0.004717 | 0.002000 | 0.003367 | 0.002137 | 0.002208 | 0.003984 | 0.009009 | 0.027027 |
| 13 | 0.85 | 0.009375 | 0.002132 | 0.008333 | 0.010101 | 0.007576 | 0.002545 | 0.004587 | 0.002375 | 0.002137 | 0.013158 | 0.003497 |
| 14 | 2.93 | 0.032199 | 0.002604 | 0.005882 | 0.002558 | 0.007874 | 0.007246 | 0.002146 | 0.004292 | 0.002141 | 0.010870 | 0.002924 |
| | | **PO** | **0.001215** | **0.002404** | **0.001361** | **0.001225** | **0.003664** | **0.002129** | **0.001871** | **0.001073** | **0.001628** | **0.002391** |
| | | | | | | | | | | | **Average PO** | **0.001896** |
| | | | | | | | | | | | **Standard Deviation** | **0.000791** |

# Probability of Occurrence

- Annualized PO 0.0019
- Occurring with a return period of 1:530

| | Number of Years | | | | |
|---|---|---|---|---|---|
| | **1** | **10** | **50** | **100** | **500** |
| **Exceedance Probability** | 0.001896 | 0.018802 | 0.090538 | 0.172880 | 0.612882 |
| **Exceedance Probability (%)** | 0.19 | 1.88 | 9.05 | 17.29 | 61.29 |

# Recommendations

**PUBLIC**

- **Geotechnical report** - Development or redevelopment within the setback require detailed geotechnical assessment by a QP
- **Development Permit Area** – Additional Guidelines (next slide) – note these are in addition to some of the recommendation in the Stantec report already included in the DPA.  Remember this proposed DPA is an amended DPA. The current DPA for Saltair – requires a geotechnical report and the guidelines exist but not as detailed.

**CVRD**

- More detailed investigation to:
  - Differentiate terrain within the study area
  - Better constrain age of mapped landslides
- Develop Guidance document to practitioners to ensure assessments sufficiently address hazards
- Stormwater management plan for key locations

# Bylaw 4427 DPA 7 Amendment

**Additional Guidelines for Parts of Area G (UDPA7.2)**

**LH16** Driveway and surface runoff or other concentrated surface runoff should not be directed towards the crest of the bluff. Reduce potential slope instability by directing water through drains or pipes to the bottom of the bluff or a professionally-identified destination such as a stormwater storage area.

**LH17** Avoid installation of ponds, swimming pools and lawn irrigation systems in the area.

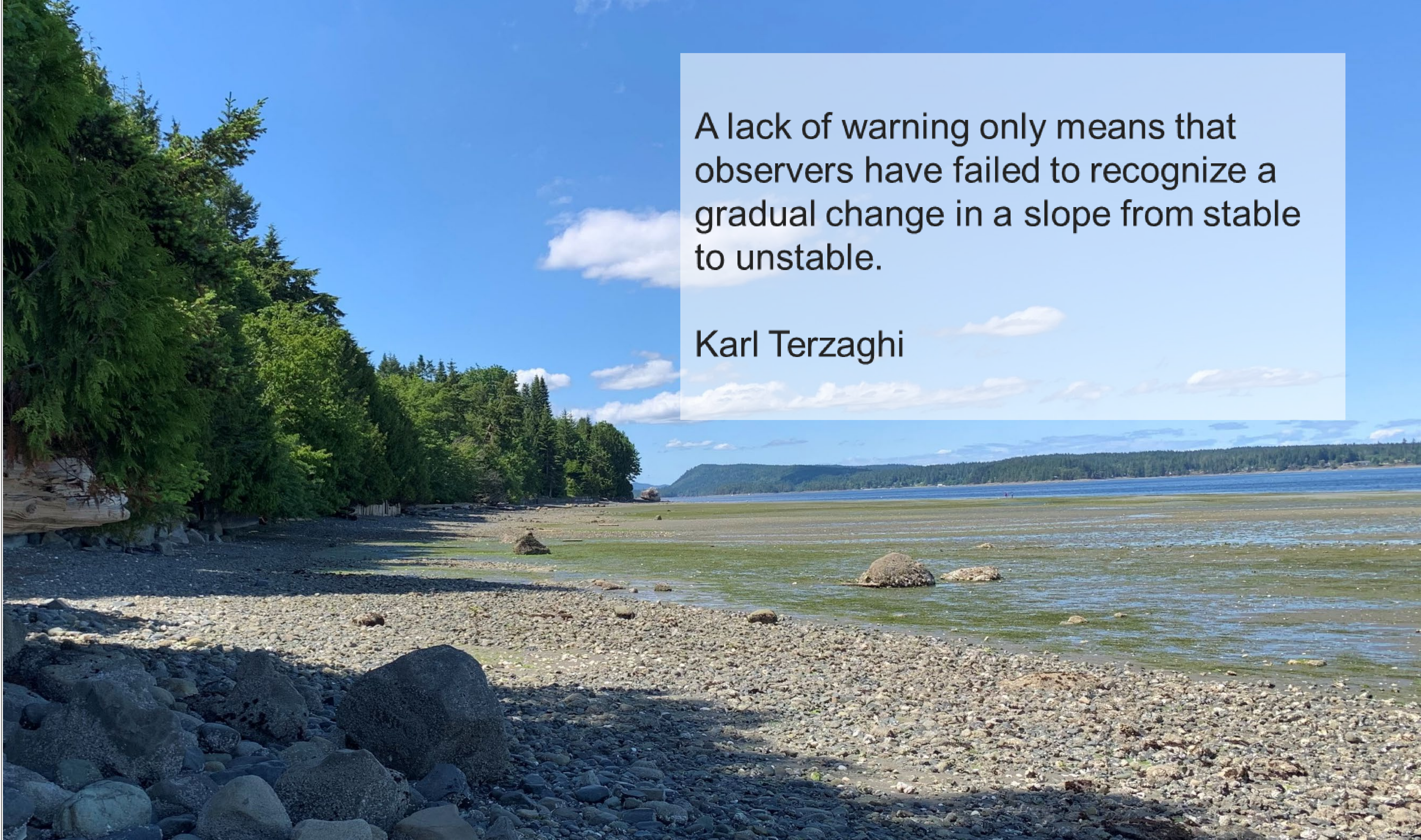
**LH18** Development should not involve dumping of soil or other material over the bluff edge

**LH19** Consideration should be given prior to the removal of any vegetation, of interdependency effects where a group of plants living together protect each other from disturbance by wind, erosion and other natural processes.

**LH20** Revegetation undertaken to promote slope stability should be designed and supervised by a landscape architect or other qualified person.

**LH21** Native species identified for the coast by the Stewardship Centre for British Columbia Stewardship Centre for British Columbia (2016). Your marine waterfront – Canadian edition should be used for revegetation.

DRAFT Bylaw located here: https://www.cvrd.ca/DocumentCenter/View/103845/2022-04-20-Bylaw-4427



A lack of warning only means that observers have failed to recognize a gradual change in a slope from stable to unstable.

Karl Terzaghi