Lower Mainland Surficial Geology

From Wisconsin Ice Age to Protocol 21

BCEIA BEST Conference 2018

Whistler, BC

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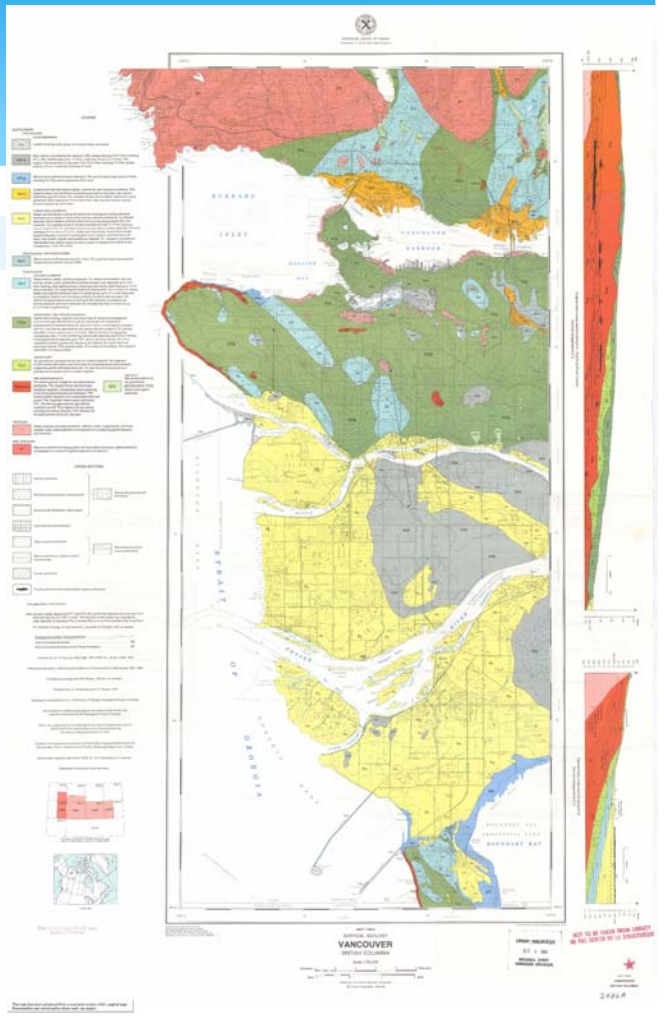
Presentation Outline

1. Surficial Geology - it's more than just a map!
2. Wisconsin Glaciation – Present : A brief synopsis of sediments in the Lower Mainland
3. Distribution of Sediments and determining the Stratigraphy
4. Why consider the detailed geology of your site and P21 applicability?
5. Key Conclusions

Introduction

Surficial Geology – It's more than what you see at the surface!

- ✓ Complex surficial geology in the Lower Mainland
- ✓ Thick sedimentary package overlying bedrock
- ✓ Glacial, fluvial and bog deposits; varying porosity, organic content and mineralogy.



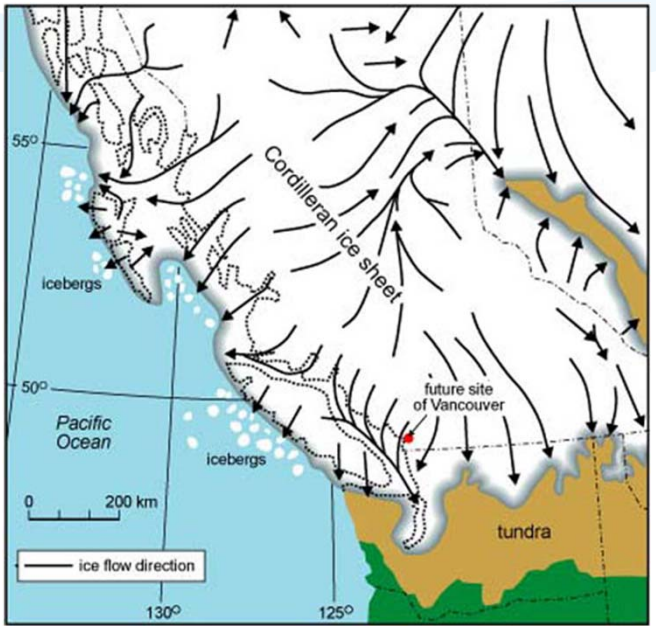
GSC Map 1486A, Surficial Geology Vancouver, 1980

Wisconsin Glaciation

75,000 to 11,000 BP

Cordilleran ice sheet

- ✓ Covered all of BC
- ✓ Ice more than 2km thick
- ✓ Ice sheet repeatedly advancing and receding
- ✓ Tide-water glaciers/ice sheets in the Straight of Georgia
- ✓ Sea level is low due to water locked on land in ice sheet
- ✓ Glacial maximum approximately 25,000 years ago



Cordilleran ice sheet 25,000 years ago
(Clague, J., & Turner, B., 2003)

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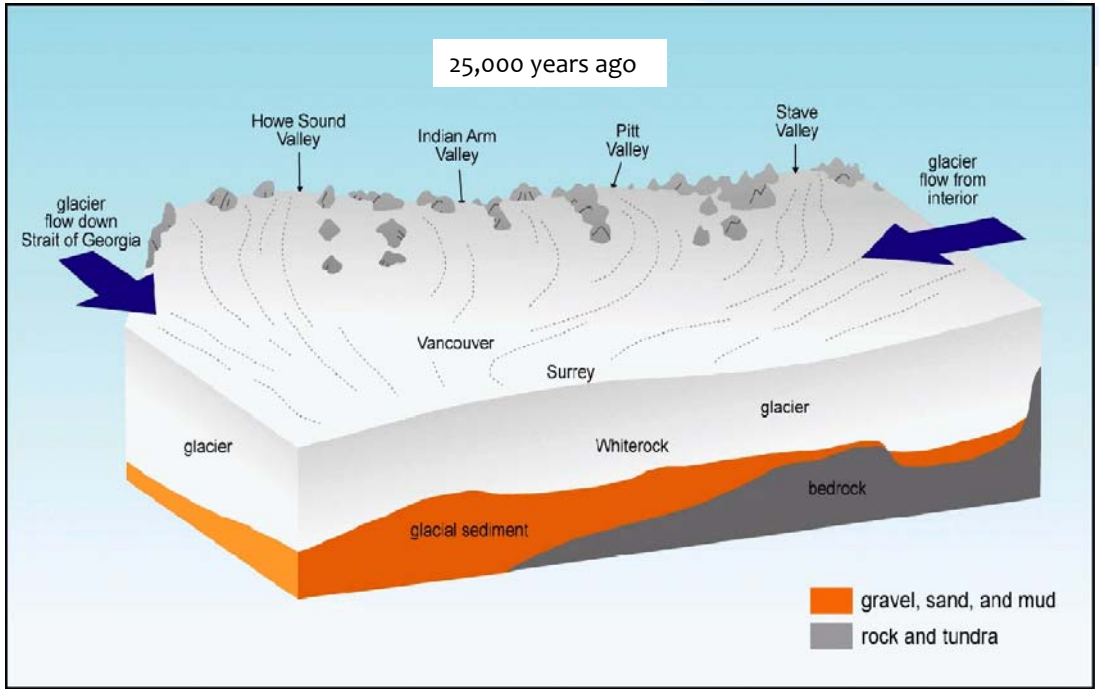
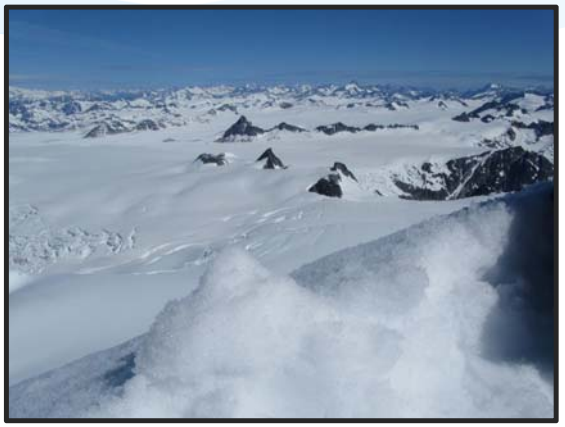
Glacial Maximum Advance



Ice Cover in Lower Mainland, at its maximum extent
(Clague, J., & Turner, B., 2003)



Homathko Icefield, BC

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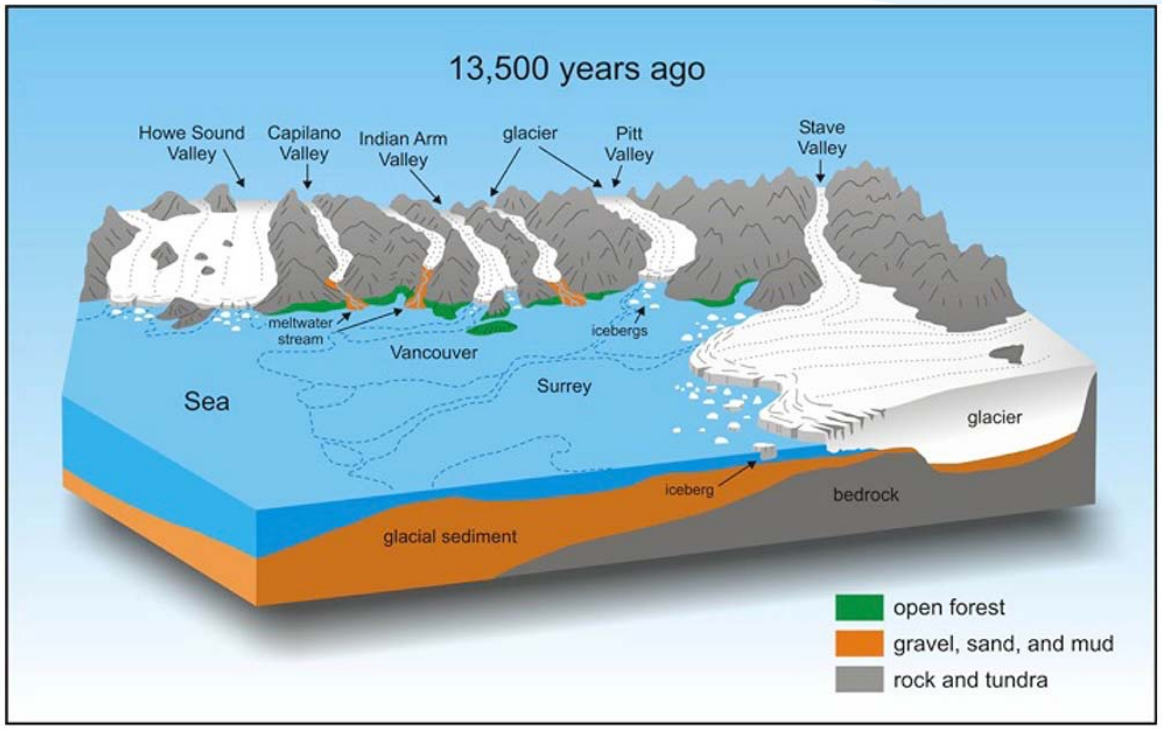
Cordilleran Ice Sheet Retreat

Rapid glacial melting to deglaciation between 18,000 and 11,000 years ago



Lower Mainland during retreat of Cordilleran Ice Sheet
(Clague, J., & Turner, B., 2003)

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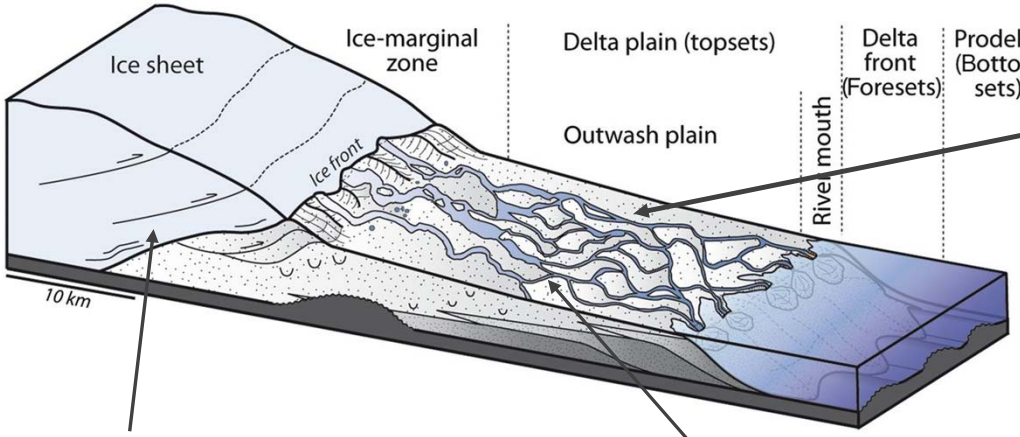
Meltwaters and Glacial Outwash

Receding Glacier



Bridge Glacier Outwash Plain, BC

Till – Unsorted materials (silt, sand, gravel and boulders) produced by glacial erosion, entrained by glacial drift and dumped as glacier melts

Outwash – Sands and gravel transported by rivers (melted ice) and deposited ahead of glacier

(Diagram from Girard, F., Ghienne, J.-F., and Rubino, J.-L. , 2012)

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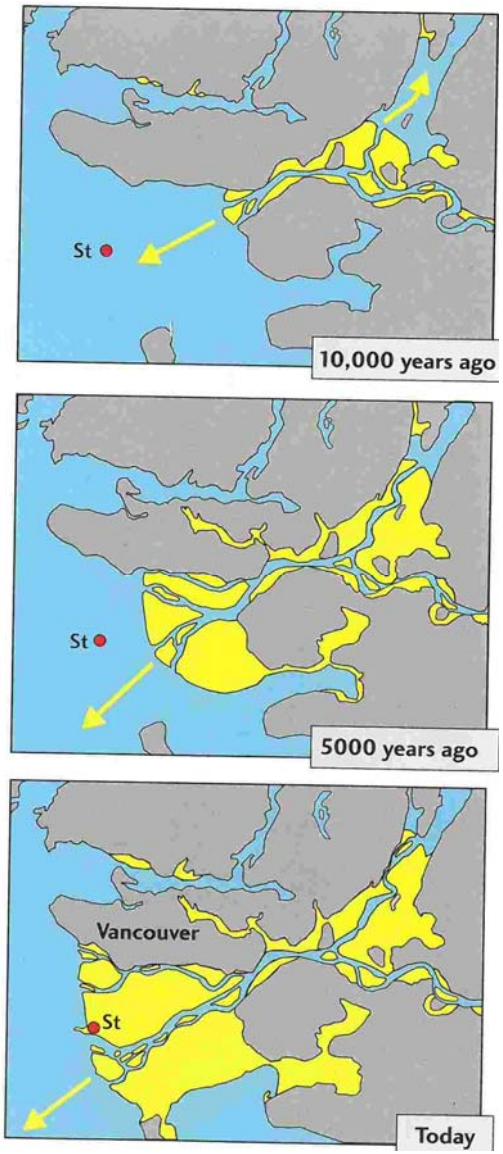
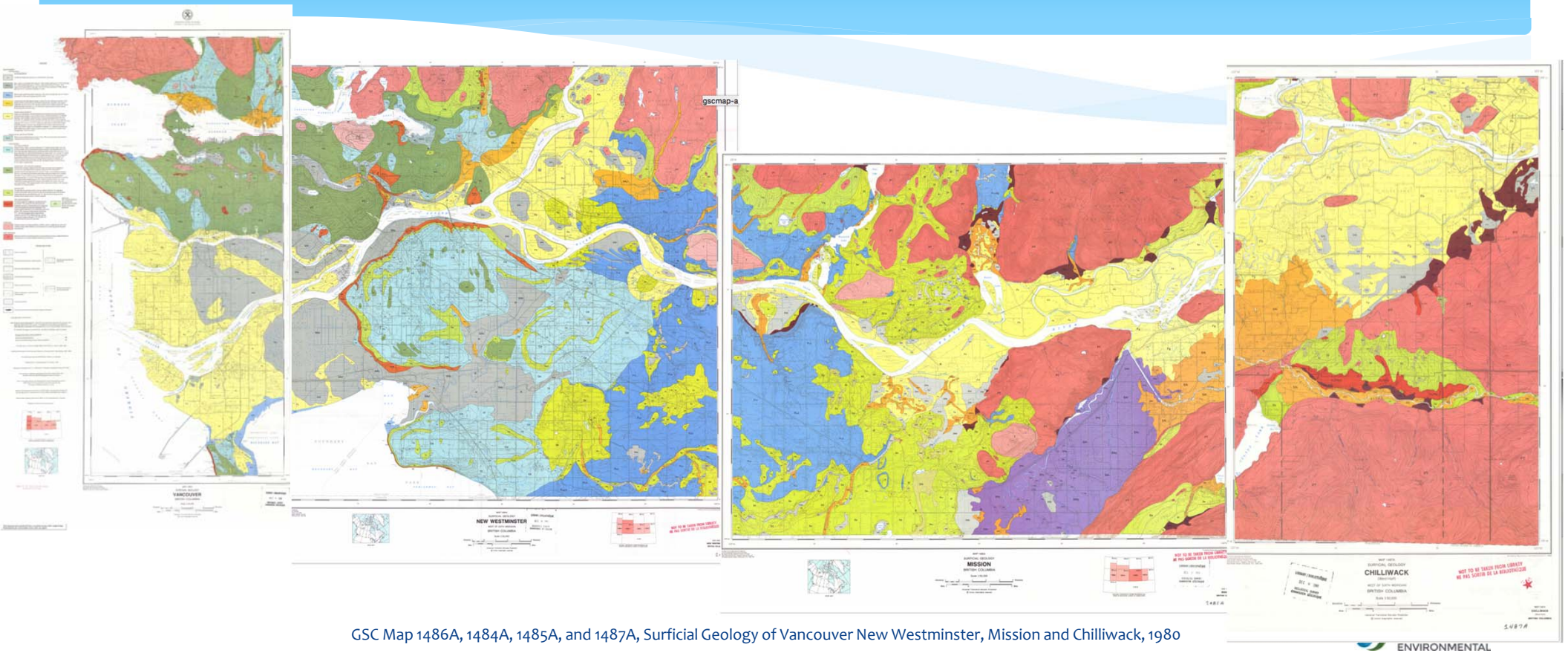
After the Ice Age

- ✓ Most glaciers retreated into mountains.
- ✓ Sea level was 200 m higher than present, at end of Ice Age.
- ✓ Sea retreat caused by rebound of land.
- ✓ After ice disappeared, the Fraser River extended its floodplain and delta as sea retreated.

Pitt Meadows towards Pitt Lake. Fraser River floodplain advanced and filled Pitt Valley, isolating Pitt Lake from the Straight of Georgia.

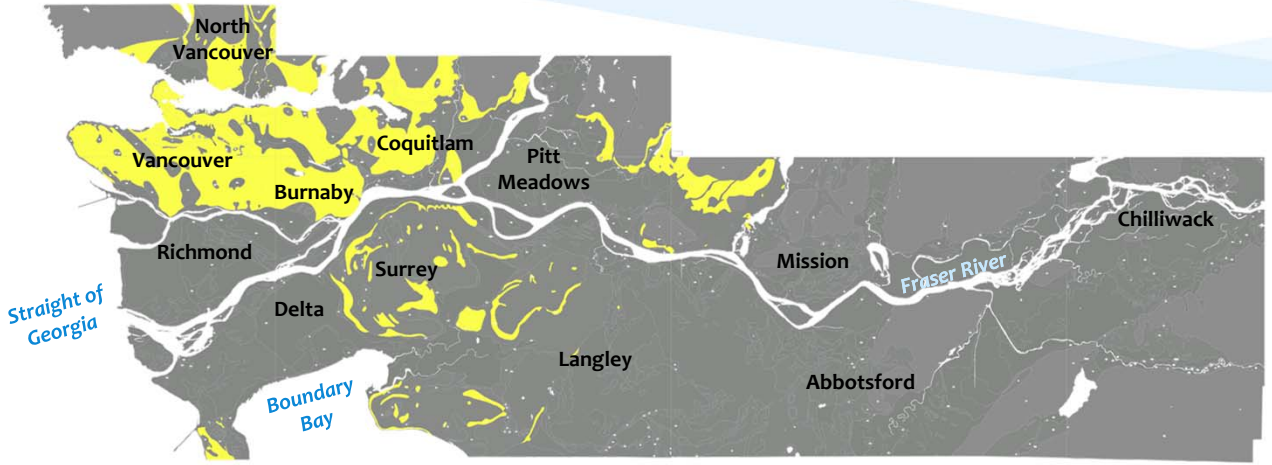


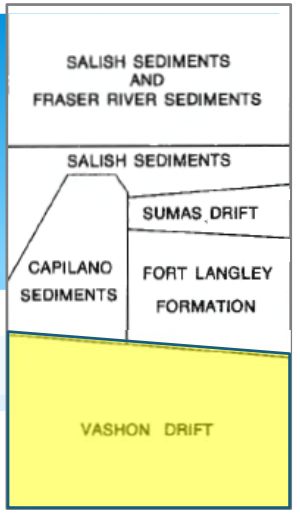
Sediments in the Lower Mainland



GSC Map 1486A, 1484A, 1485A, and 1487A, Surficial Geology of Vancouver New Westminster, Mission and Chilliwack, 1980

Lower Mainland Surficial Geology





Lithostratigraphic Units
(Armstrong, 1984)

Vashon Drift

Glacial till, glaciofluvial and glaciolacustrine (lake) deposits. Till is grey hardpan/dense silt with sand lenses. Glaciofluvial sandy gravel outwash. 30 to 60 m thick.

Vashon Drift till – Stanley Park

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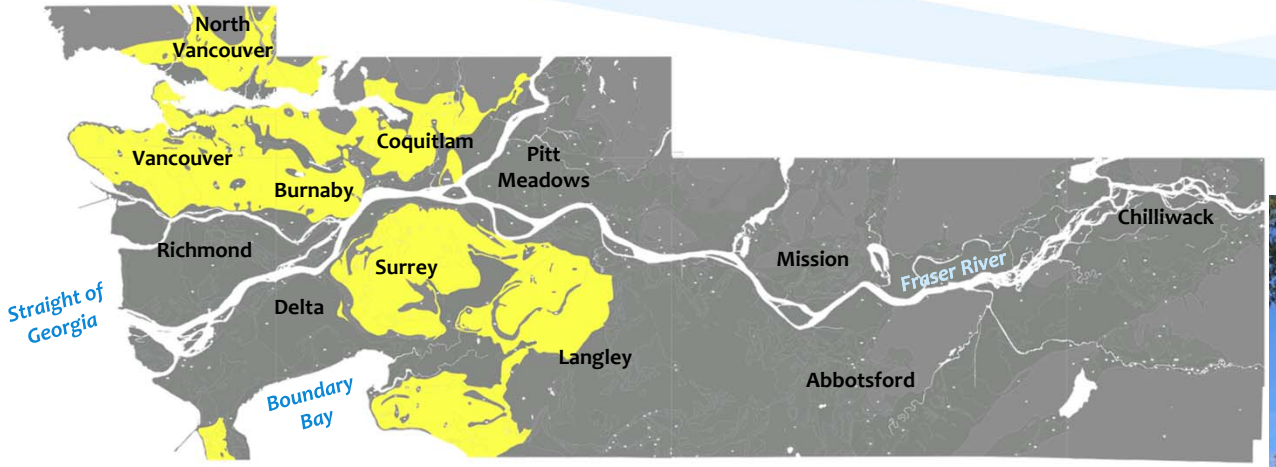
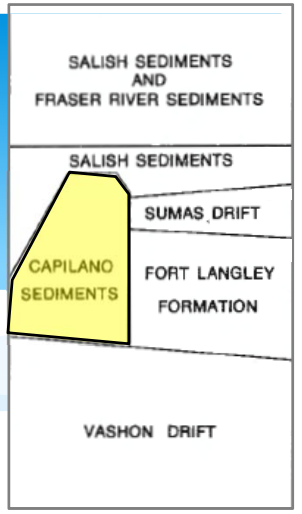
Lower Mainland Surficial Geology





Capilano Sediments

Raised marine, deltaic and fluvial deposits; beach sands, marine and non-marine silts, and river sands, with gravel; typically 3 to 30 m thick but can be as thick as 60 m.

Outcrop – Stanley Park

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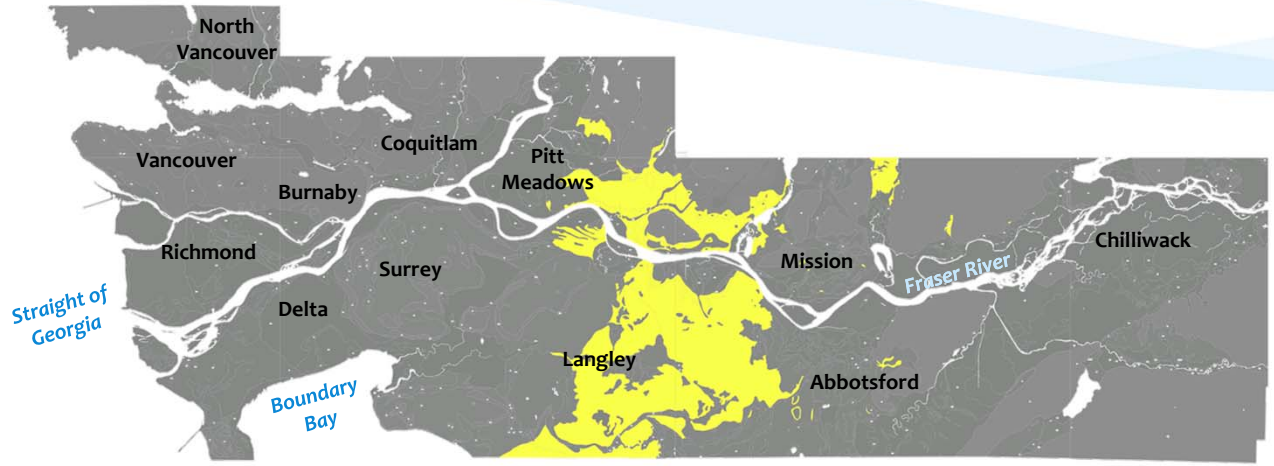
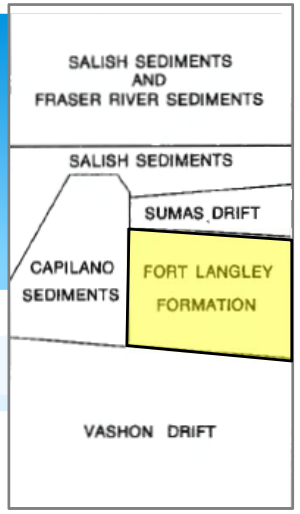
Lower Mainland Surficial Geology





Lithostratigraphic Units
(Armstrong, 1984)

Fort Langley Formation

Ice-contact, outwash, glacial and marine sediments; composing sandy loam, silty sand, sandy gravel and marine shales; similar to the Capilano deposits; typically found in the east of Langley and is 8 to 90 m thick.

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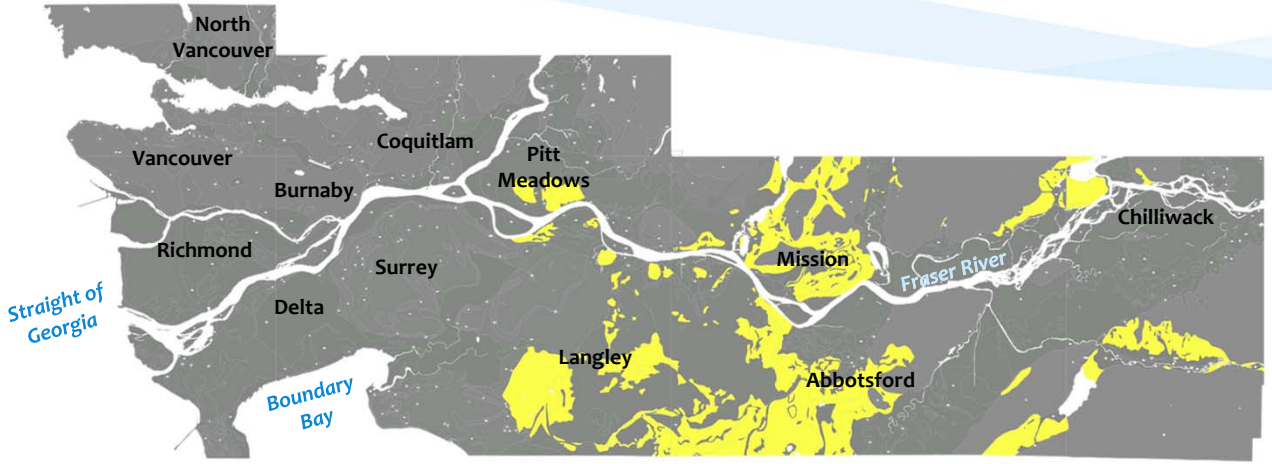
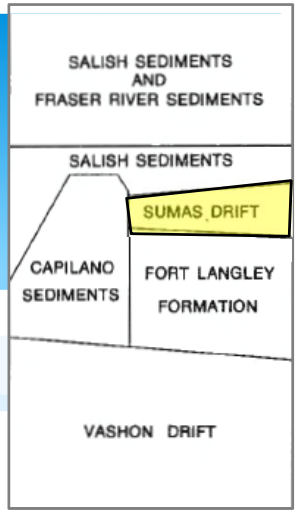
Lower Mainland Surficial Geology





Lithostratigraphic Units
(Armstrong, 1984)

Sumas Drift

Glacial outwash deposits containing sands and gravels with lenses of silt; typically 5 to 40 m thick.

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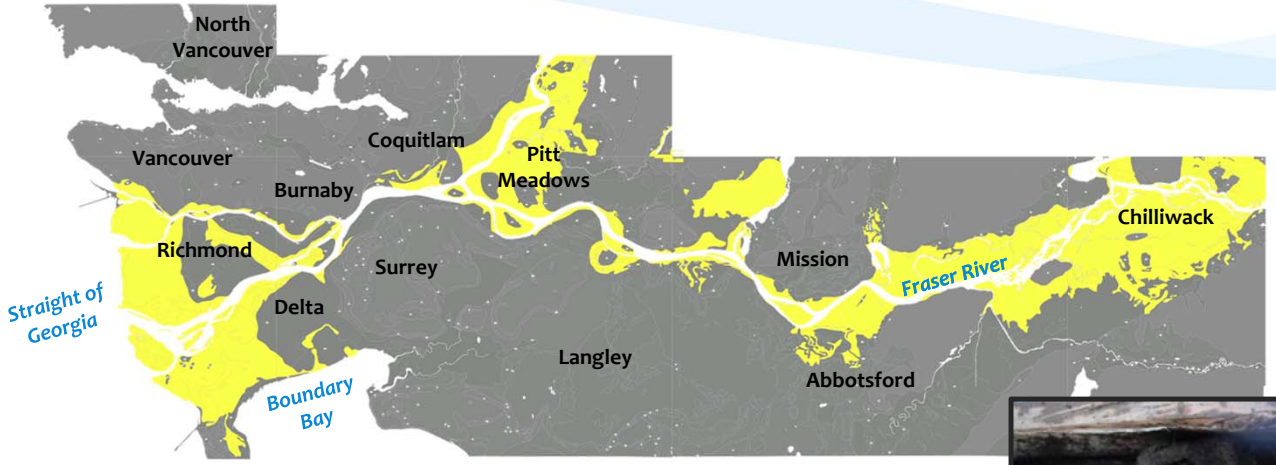
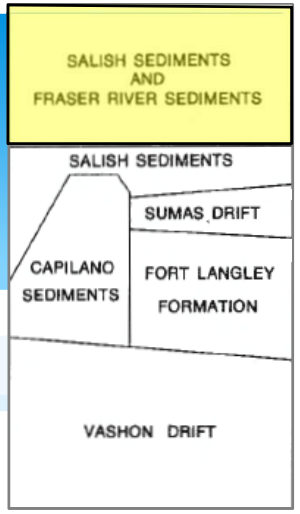
Lower Mainland Surficial Geology





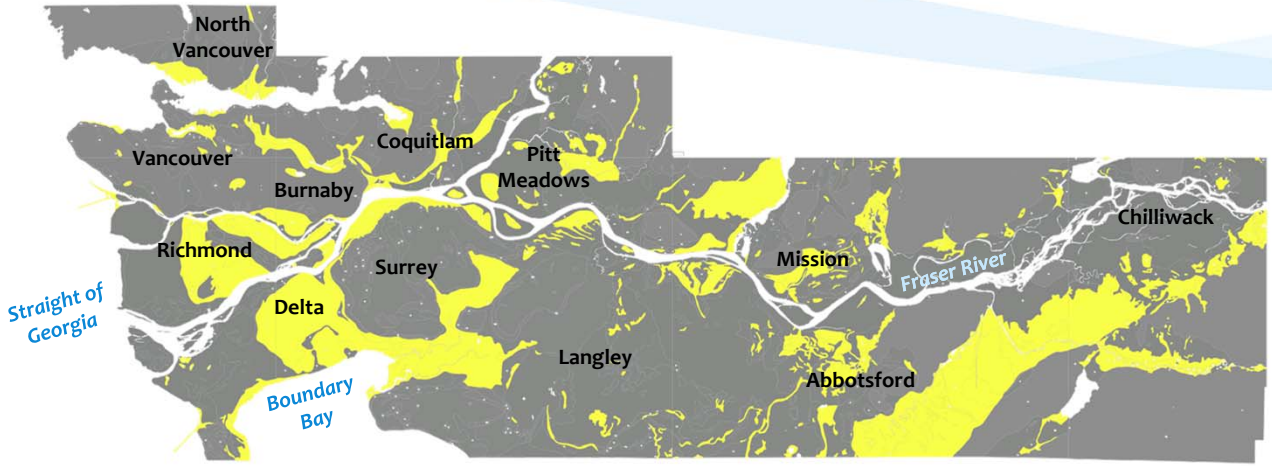
Lithostratigraphic Units
(Armstrong, 1984)

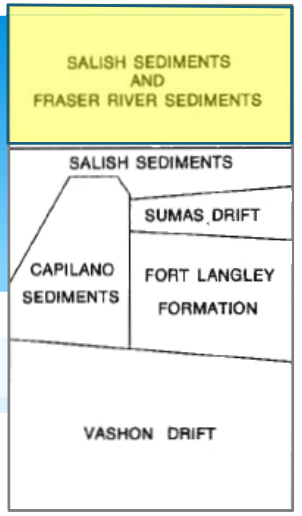
Fraser River Sediments

Deposits from the Fraser River, including: sand channels, organic silt and sand over bank deposits; up to 40 m thick.

Fraser River organic silt (top) and sand channel deposit (bottom), Coquitlam

Lower Mainland Surficial Geology





Lithostratigraphic Units
(Armstrong, 1984)

Salish Sediments

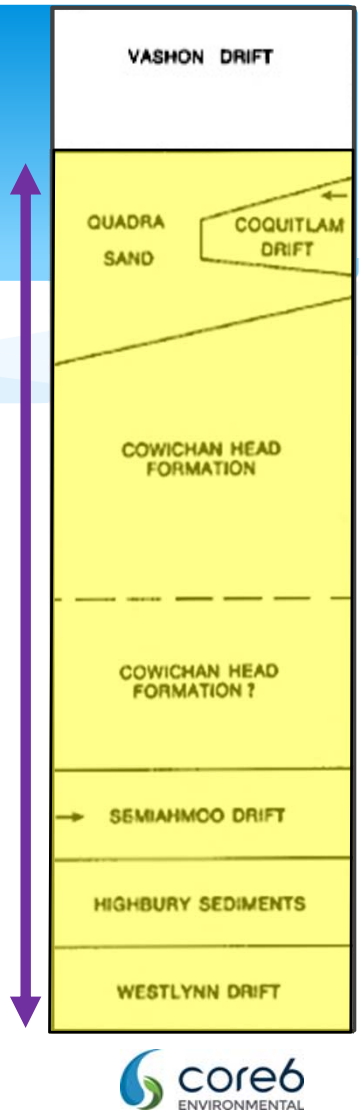
Bog and Lake deposits; silty loam and peat; typically 2- 14 m thick.

Salish peat, Coquitlam

Lower Mainland Surficial Geology

Pre-Vashon Deposits - Glacial, non-glacial and glaciomarine sediments:

- ✓ Quadra glaciofluvial and fluvial channel sand and gravel;
- ✓ Coquitlam till, glaciomarine and glaciolacustrine deposits;
- ✓ Cowichan Head fluvial, organic colluvial and swamp sediments;
- ✓ Semiahmoo till, glaciofluvial, glaciomarine and glaciolacustrine deposits;
- ✓ Highbury fluvial and swamp deposits;
- ✓ Westlyn glaciofluvial sandy gravel.



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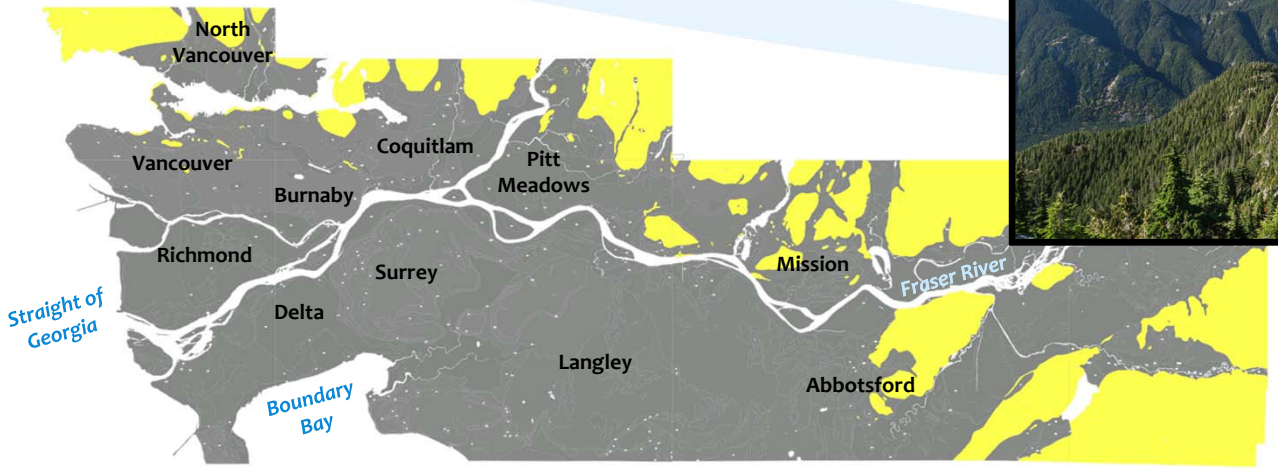
Lower Mainland Surficial Geology

Mount Seymour, BC



Bedrock

Sandstone, siltstone and shale at low elevations (near sea level); granites and other volcanic rocks form the uplands and the North Shore Mountains.

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Why Is It Important?

- ✓Planning for field investigation
- ✓CSR Protocol 21 – Drinking Water Applicability
- ✓In the field
- ✓Report writing
- ✓Other considerations

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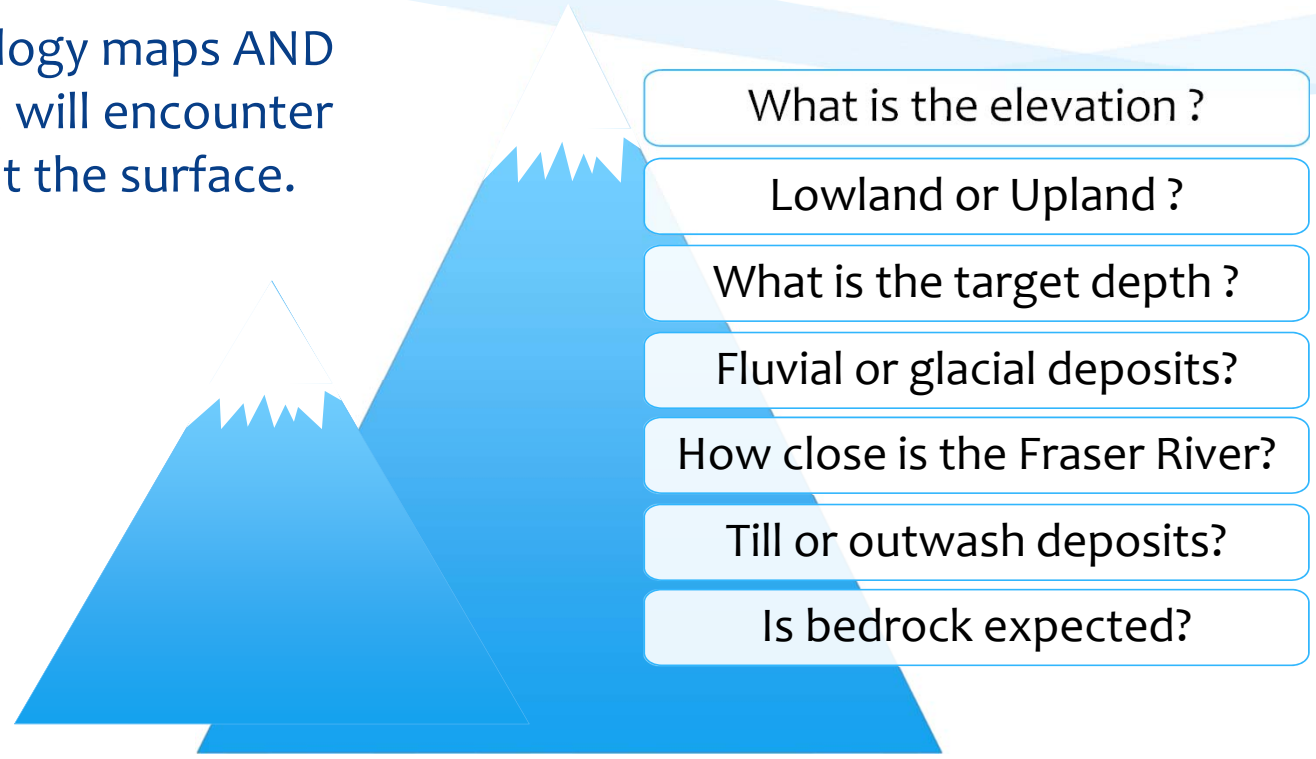
Know What to Expect Before You Go

Check surficial geology maps AND cross-sections. You will encounter units that are not at the surface.



- What is the elevation ?
- Lowland or Upland ?
- What is the target depth ?
- Fluvial or glacial deposits?
- How close is the Fraser River?
- Till or outwash deposits?
- Is bedrock expected?

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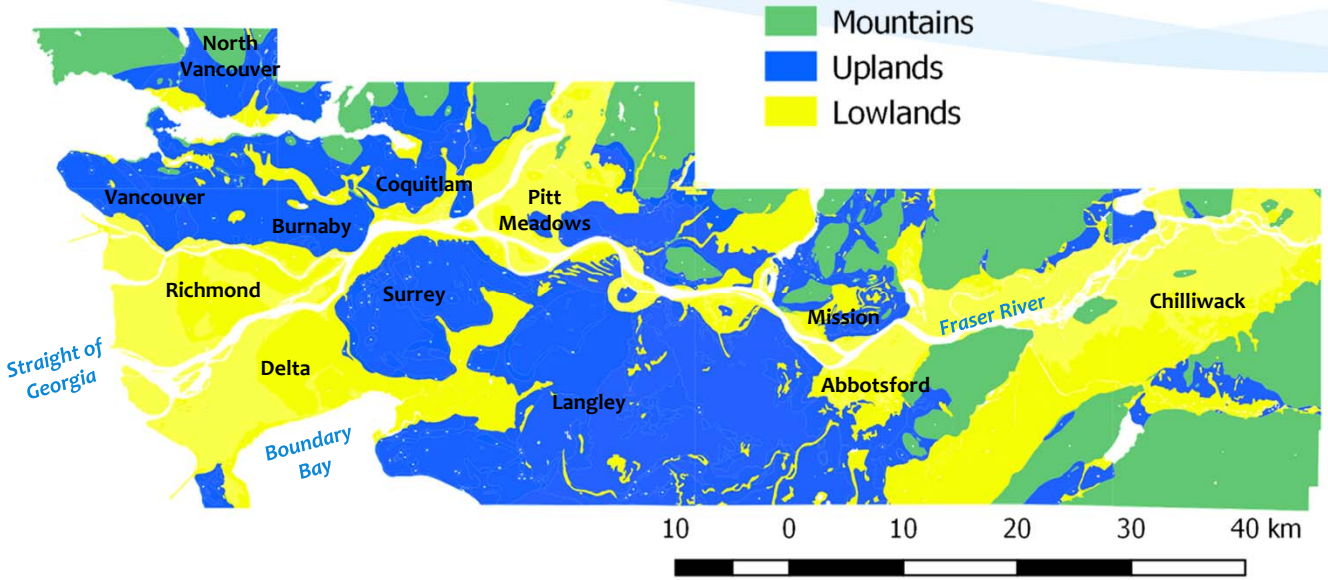
Lowlands or Uplands ?



Distribution of the three majors landscapes in the Lower Mainland

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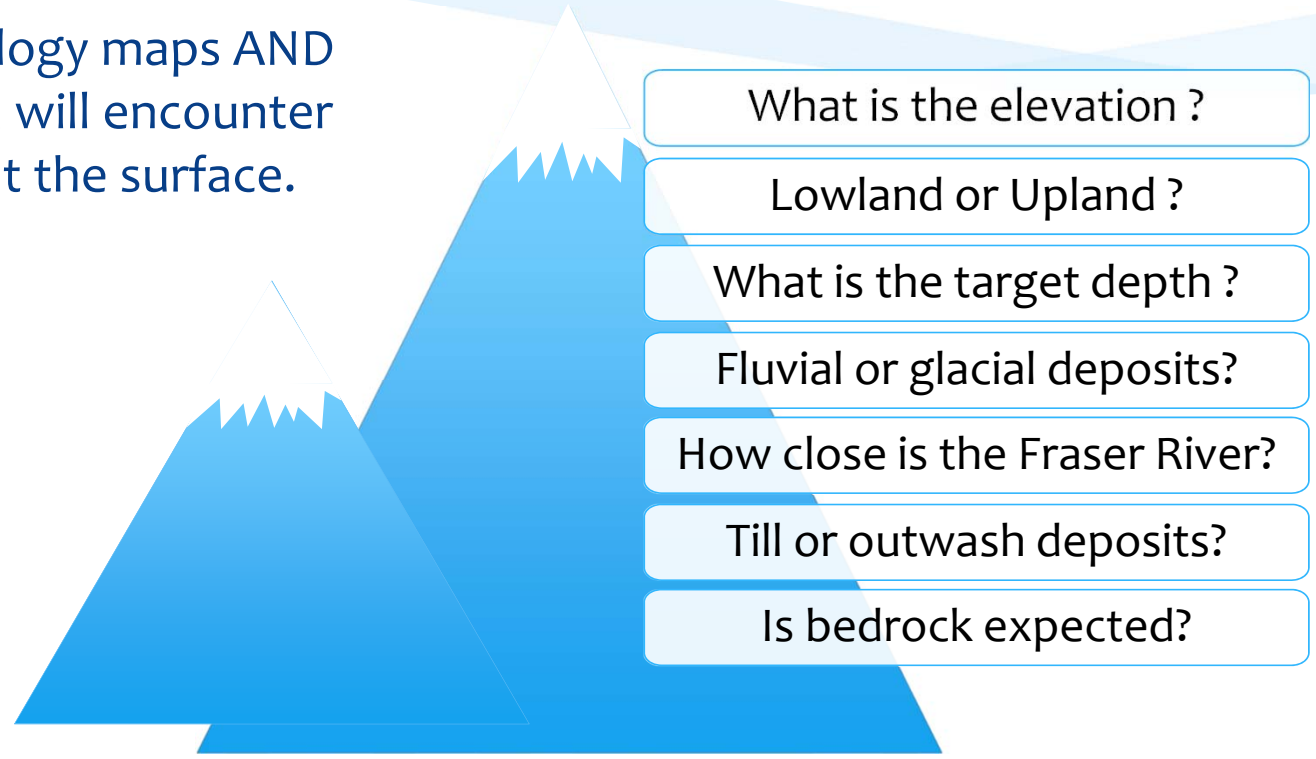

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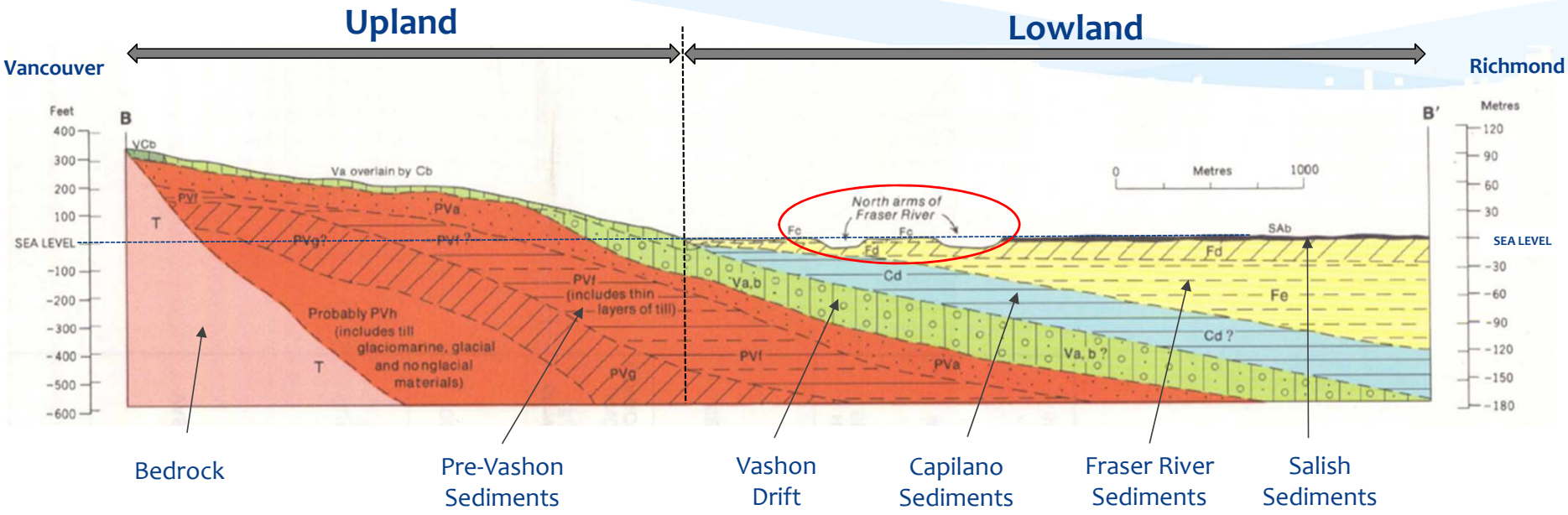
Lowlands Stratigraphy



Diagrammatic North-South Cross-Section of the Fraser River Delta at Mitchell Island

(GSC Map 1486A, Surficial Geology Vancouver, 1980)

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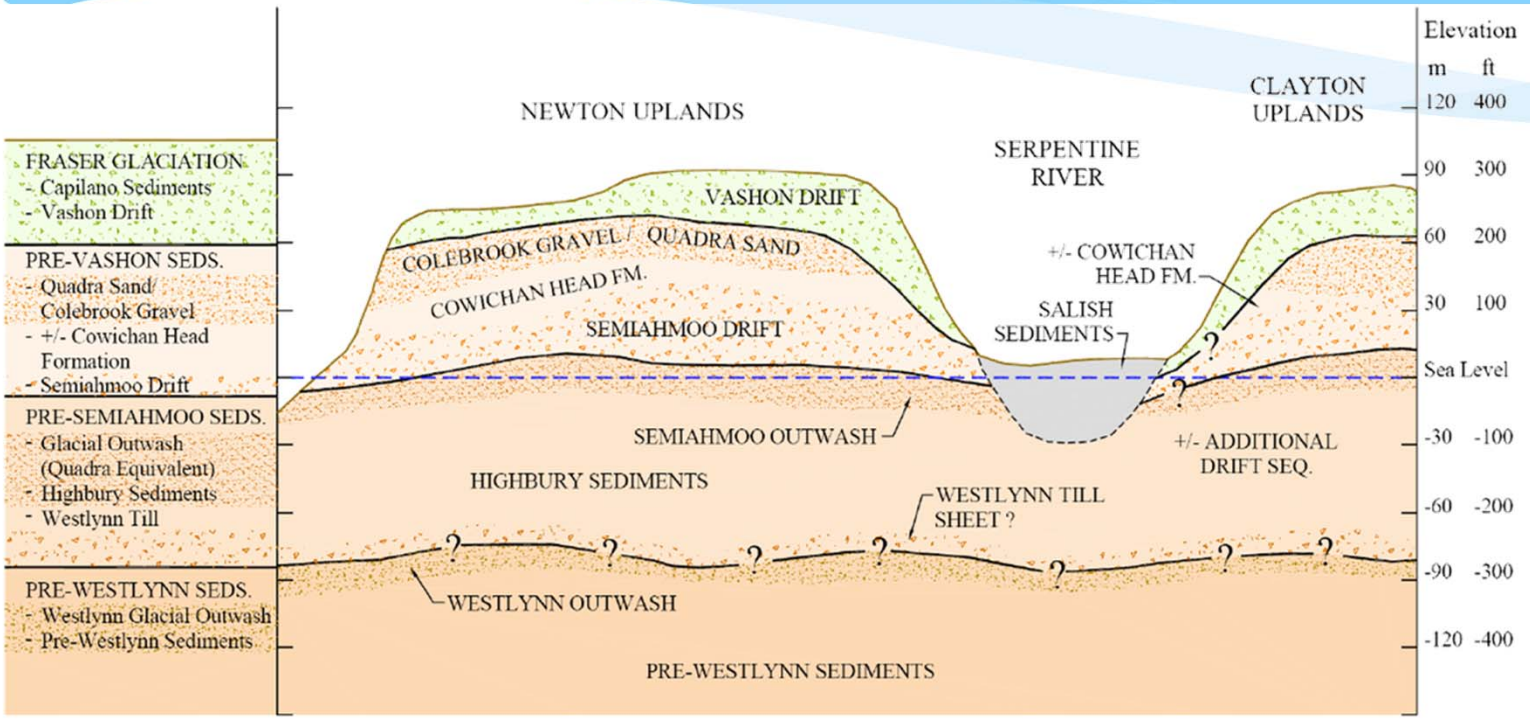
Uplands Stratigraphy



Quadra Sands Outcrop - UBC

Schematic East-West Stratigraphic Cross-Section through Surrey

(Gartner Lee Limited, 2004)

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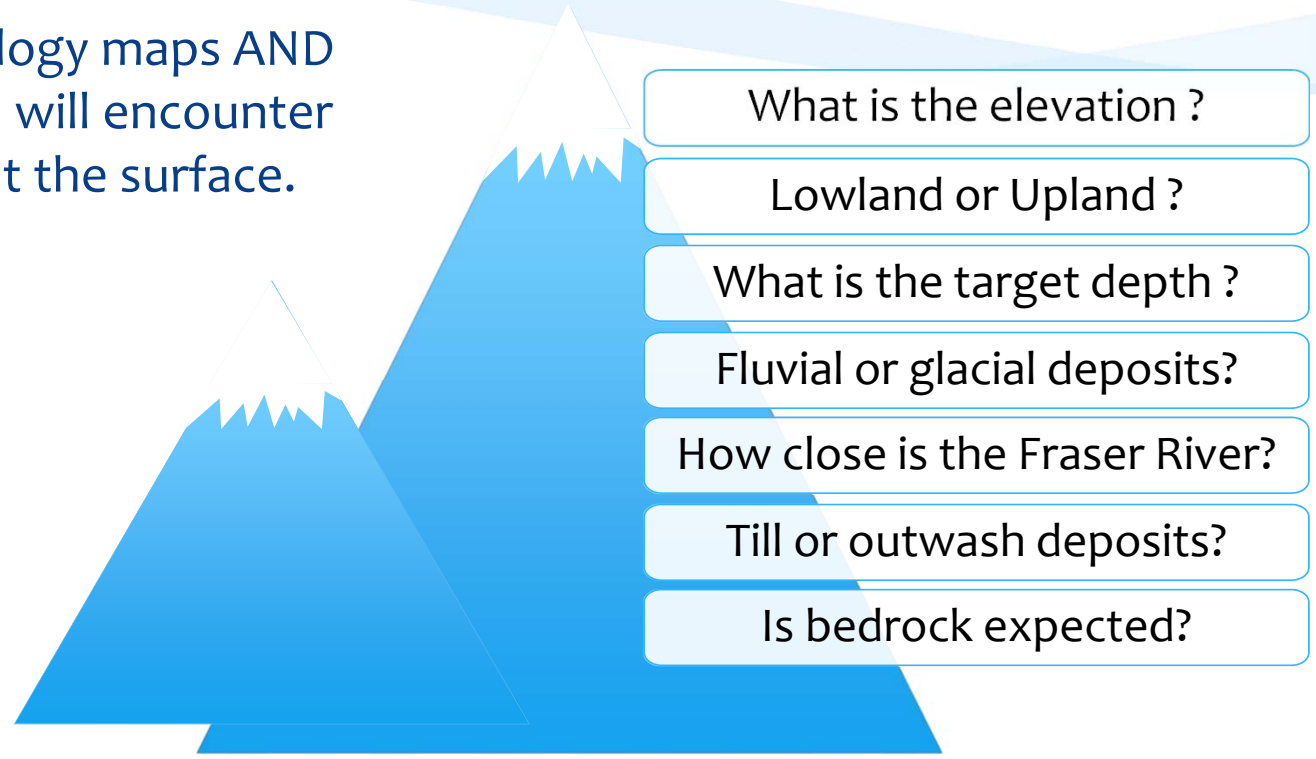

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CSR Protocol 21 – Drinking Water Applicability

✓Is there an aquifer present?

Drinking Water Aquifer: Saturated unconsolidated geological units with yields greater or equal to 1.3L/min or hydraulic conductivity greater or equal to 1×10^{-6} m/s.

✓Is the aquifer protected?

Natural confining barrier:

Type A: Geological unit with hydraulic conductivity less than 1×10^{-7} m/s and minimum thickness of 5 m.

Type B: Geological unit with hydraulic conductivity between 1×10^{-7} m/s and 1×10^{-6} m/s and ratio thickness/hydraulic conductivity greater than 5×10^{7} s.

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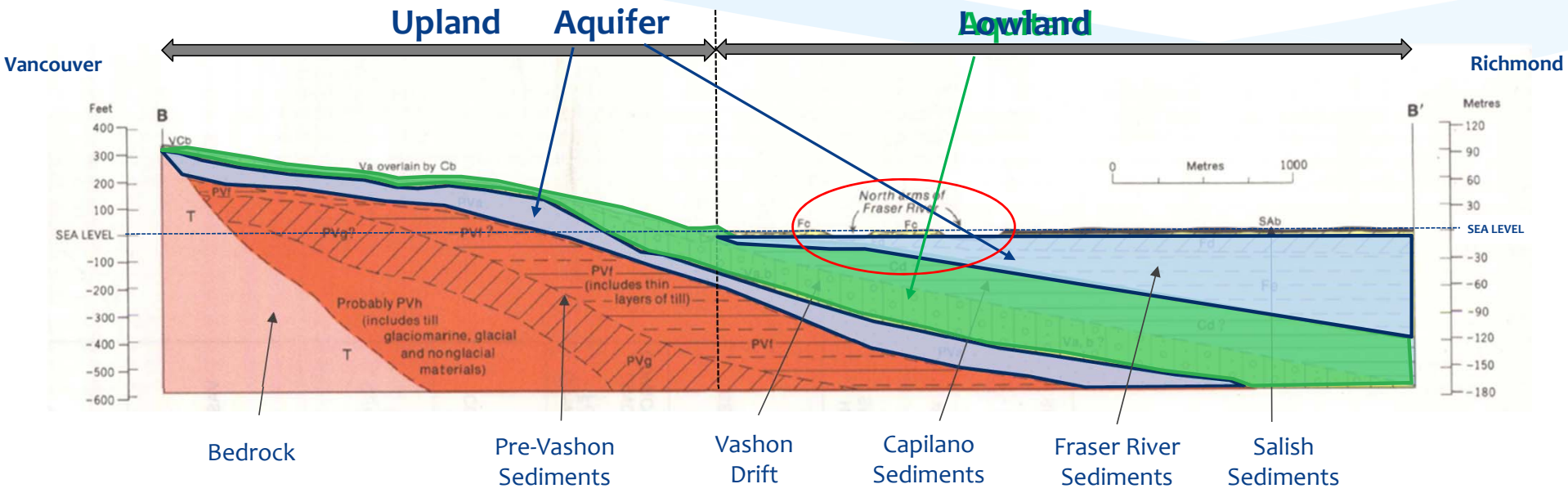
Lowlands – Aquifers and Aquitards



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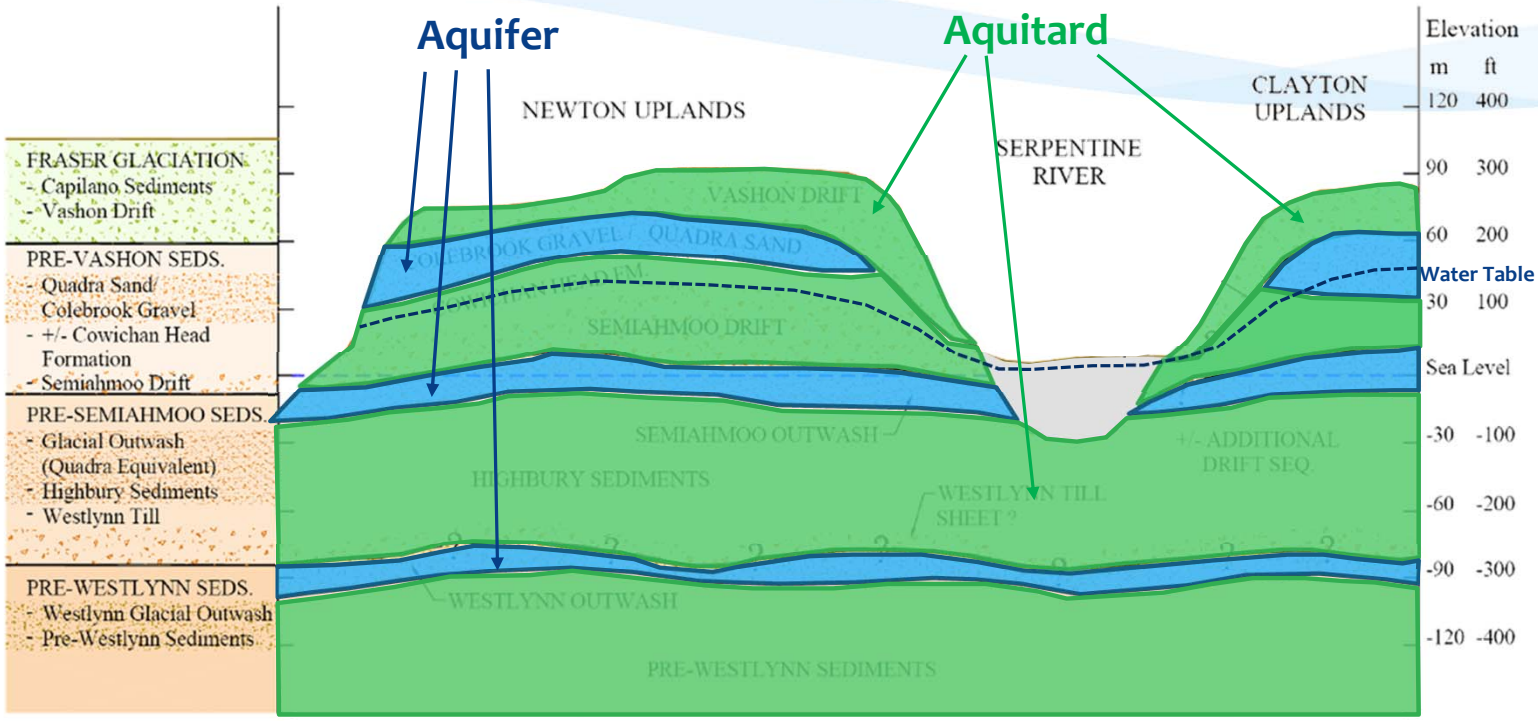
Uplands – Aquifers and Aquitards



Schematic east-west stratigraphic cross-section through Surrey

(Gartner Lee Limited, 2004)

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In the Field

- ✓ Is what you see what you expected? Is it consistent with regional surficial geology?
- ✓ Does what you see make sense?
- ✓ There is very little clay in till; if you think it's clay, it's probably silt!
- ✓ Capilano Sediments or Vashon Drift?
- ✓ Capilano Sediments and Fort Langley Formation were former marine deposits; look for gypsum and shells!

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Report Writing

- ✓ Link field observation with regionally mapped stratigraphic units.
- ✓ Is site geology consistent with regionally mapped aquifers? Check on iMAP BC or Water Resources Atlas.

Unit	Core Sample	Field Description	Logged Geologic Unit	Regional Geological Interpretation	Hydrostratigraphic Unit
1		Dark grey silt, minor sand and gravel, trace roots	FILL	Fill	Fill Aquitard
2		Organic peat, reddish brown, fibrous, stiff, wet	PEAT	Salish bog sediments	Peat Aquitard
3		Organic silt, dark brown, trace wood debris, stiff, wet	SILT	Fraser River overbank sediments	Silt Aquitard
4		Fine to medium grained sand grey, well sorted, loose, wet	SAND	Fraser River channel sediments	Sand Aquifer
5		Grey fine sand, some silt, minor gravel, very dense, wet	TILL	Vashon Drift	Till Aquitard

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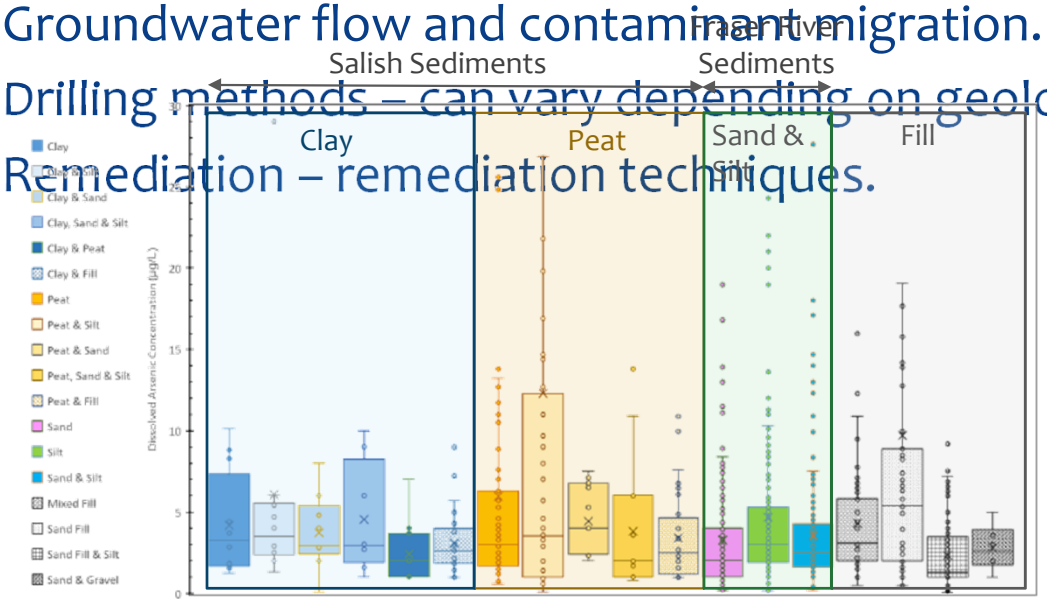
Other Considerations

- ✓ Natural background concentrations: Geological units can provide some information on groundwater geochemistry.
- ✓ Groundwater flow and contaminant migration.
- ✓ Drilling methods – can vary depending on geological units.
- ✓ Remediation – remediation techniques.



Dissolved Arsenic Concentrations (µg/L) in Groundwater by Screened Soil Type
(Goddard, 2017)

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Key Conclusions

- ✓ Complex depositional processes.
- ✓ Lower Mainland surficial geology comprised of glacial, fluvial and marine deposits.
- ✓ Check surficial geology maps AND cross-sections. You will encounter units that are not at the surface.
- ✓ Saturated outwash deposits represent good aquifers.
- ✓ Link field observations with regional geology.

Fraser River Delta

References

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- Goddard, M.L., 2017. *The baseline arsenic concentration in the groundwater of the Fraser River Delta, British Columbia, Canada*. Master thesis.

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Thank You!
Questions?

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