# Disaster at the Mouth of the River

## Contaminant Risks Facing BC's Towns Built on Alluvial Fans and Deltas

Presented by Collen Middleton, RP.Bio., P.Biol.

Sept. 21, 2022

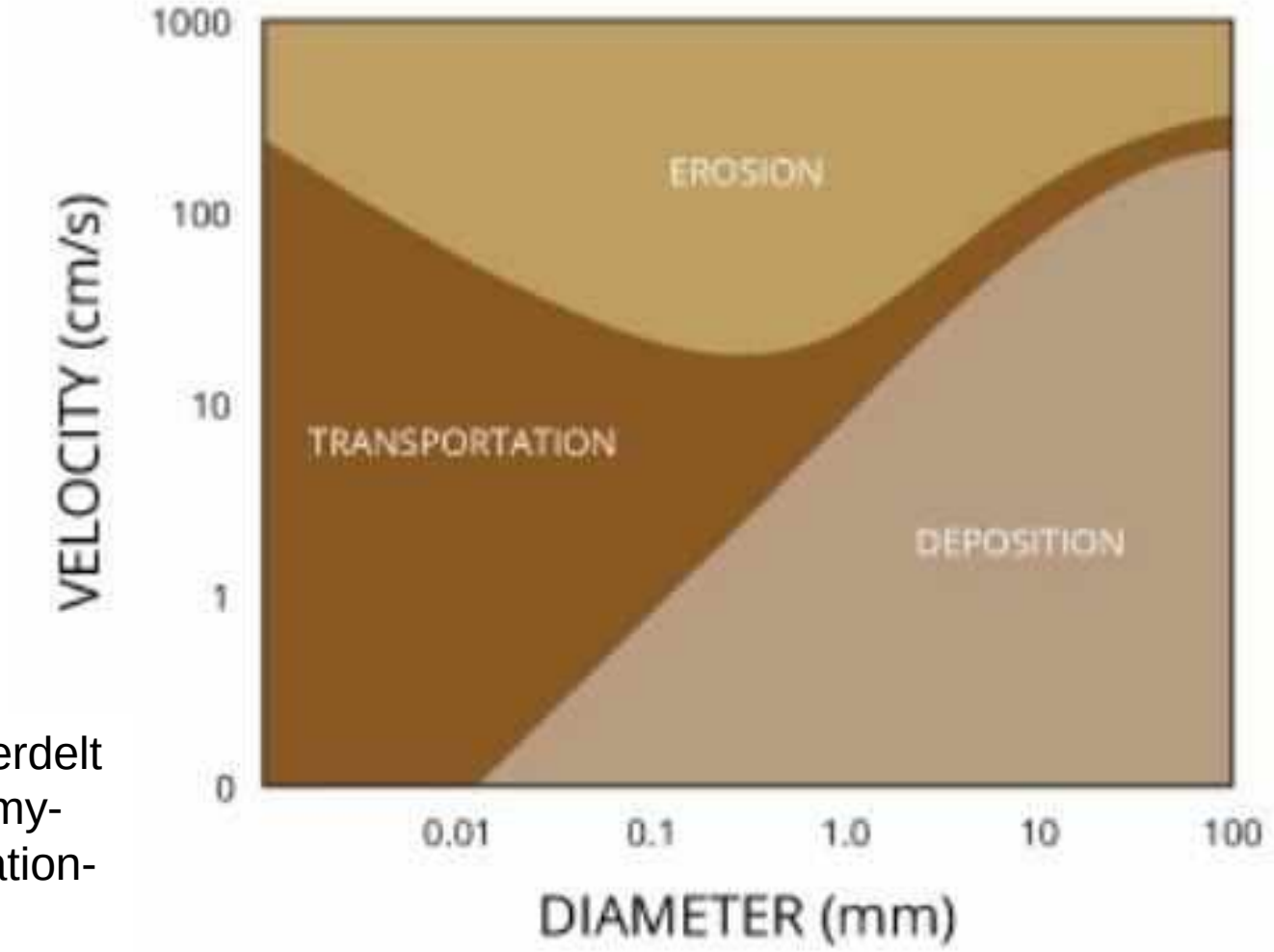
Waterline

# Outline

- Depositional structure
- Pros of building on alluvial deposits?
- Cautionary tales
- Natural vulnerability
- Settlements in BC on alluvial deposits
- Man-made induced hazards and flood conditions
- Contaminant risks and pathway-receptor models
- How can risks be better assessed/forecasted?
- Tools and mitigations

Waterline

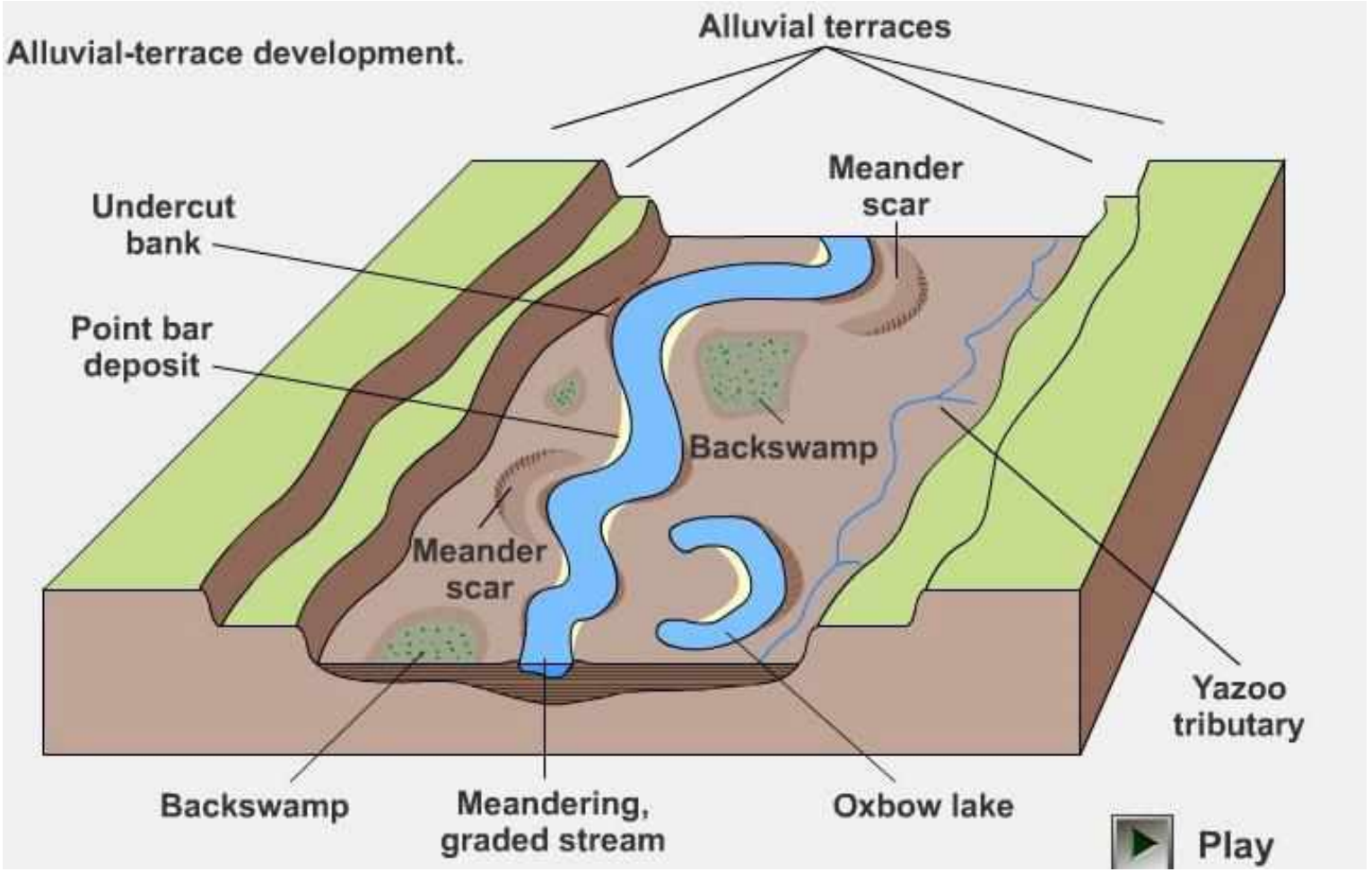
# Sediment Transport




https://mississippiriverdelta.org/learning/anatomy-of-a-delta-the-foundation-of-new-land/

Waterline

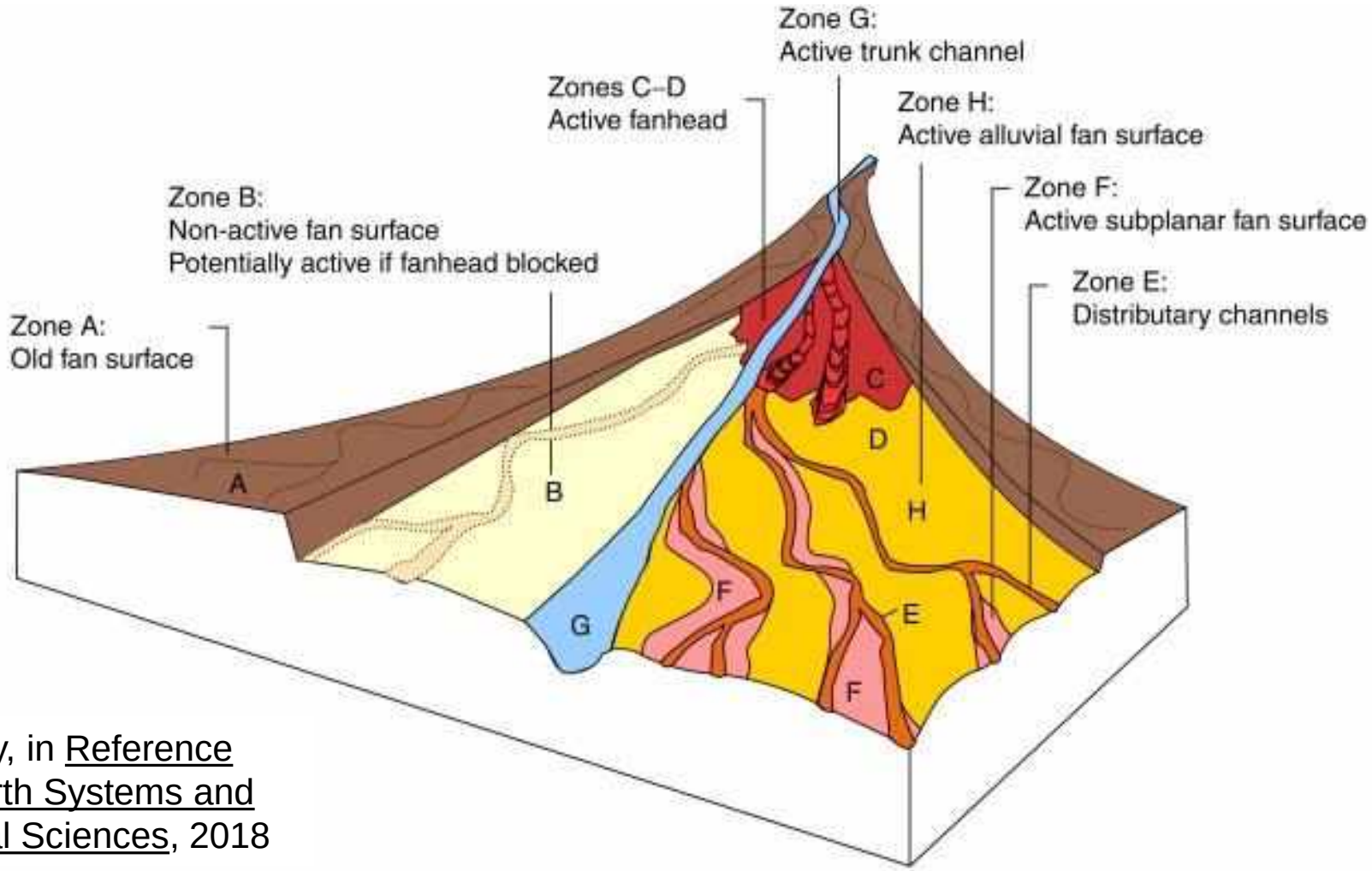
# Depositional Structure - Floodplain




2022. The British Geographer

Waterline

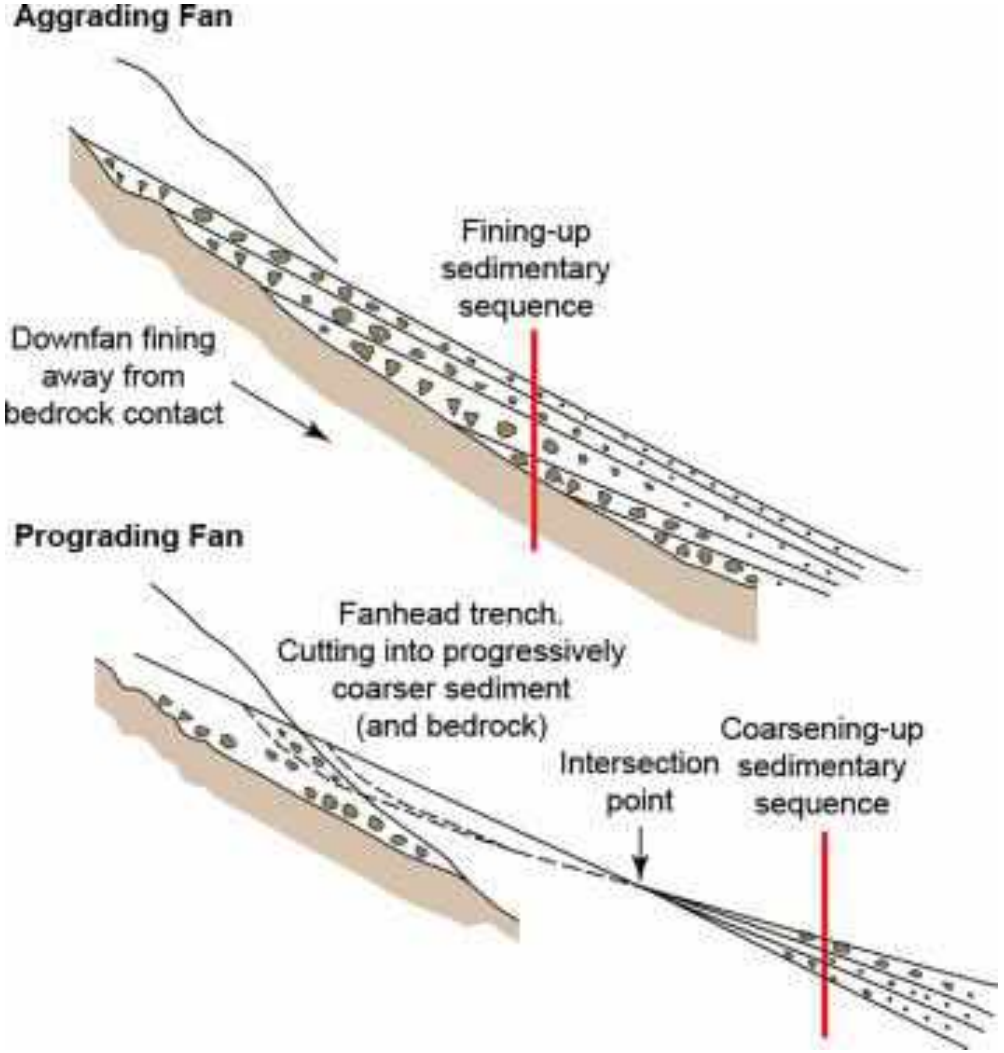
# Depositional Structure - Alluvial Fan




Adrian Harvey, in Reference Module in Earth Systems and Environmental Sciences, 2018

Waterline

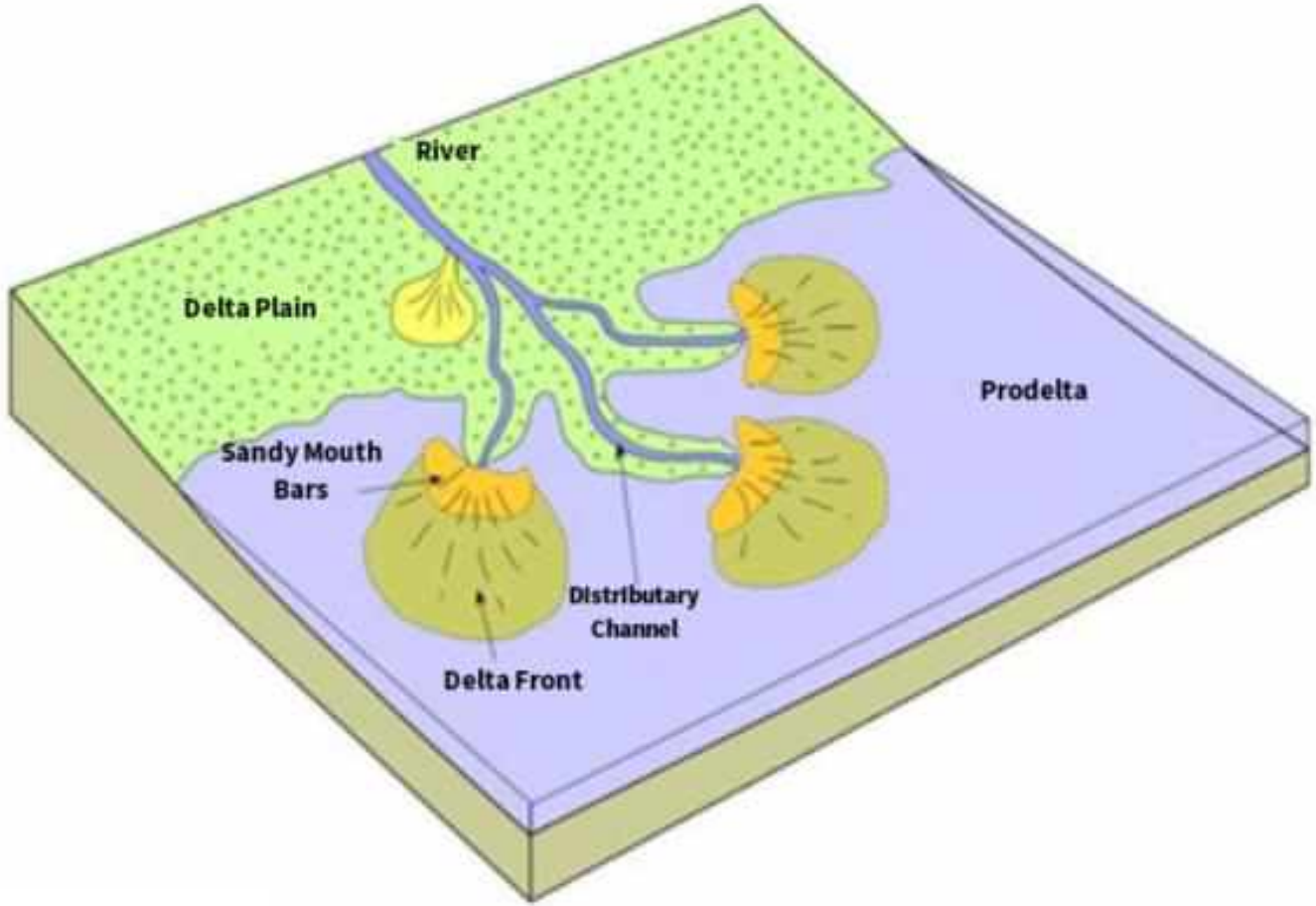
# Depositional Structure - Alluvial Fan




Adrian Harvey, in Reference Module in Earth Systems and Environmental Sciences, 2018

Waterline

# Depositional Structure - Delta




https://mississippiriverdelta.org/learning/anatomy-of-a-delta-the-foundation-of-new-land/

Waterline

# Pros of Building on Alluvial Deposits

- Relatively flat, lack of geographical barriers (straightforward planning)
- Relatively easy earthworks (simple excavation no blasting, limited drilling)
- Ample sand and gravel for concrete/road base manufacture
- Rapidly draining soils
- Access to drinking water
- Groundwater supply
- Transportation/Trade (historical and present-day)
- Fish spawning grounds
- Waterfowl habitat

Waterline

# Natural Hazards of Alluvial Deposits

- Highly erodible sediments (silts, sands, gravels lack cohesion)
- High permeability soils (fast contaminant travel time)
- Avulsion events and dynamic surface flow during peak flood
- Shallow unconfined aquifers (short contaminant travel distance)
- Flood events (floodplains!)
- Liquefaction in seismic events
- Salt water intrusion

Waterline

# Cautionary Tales

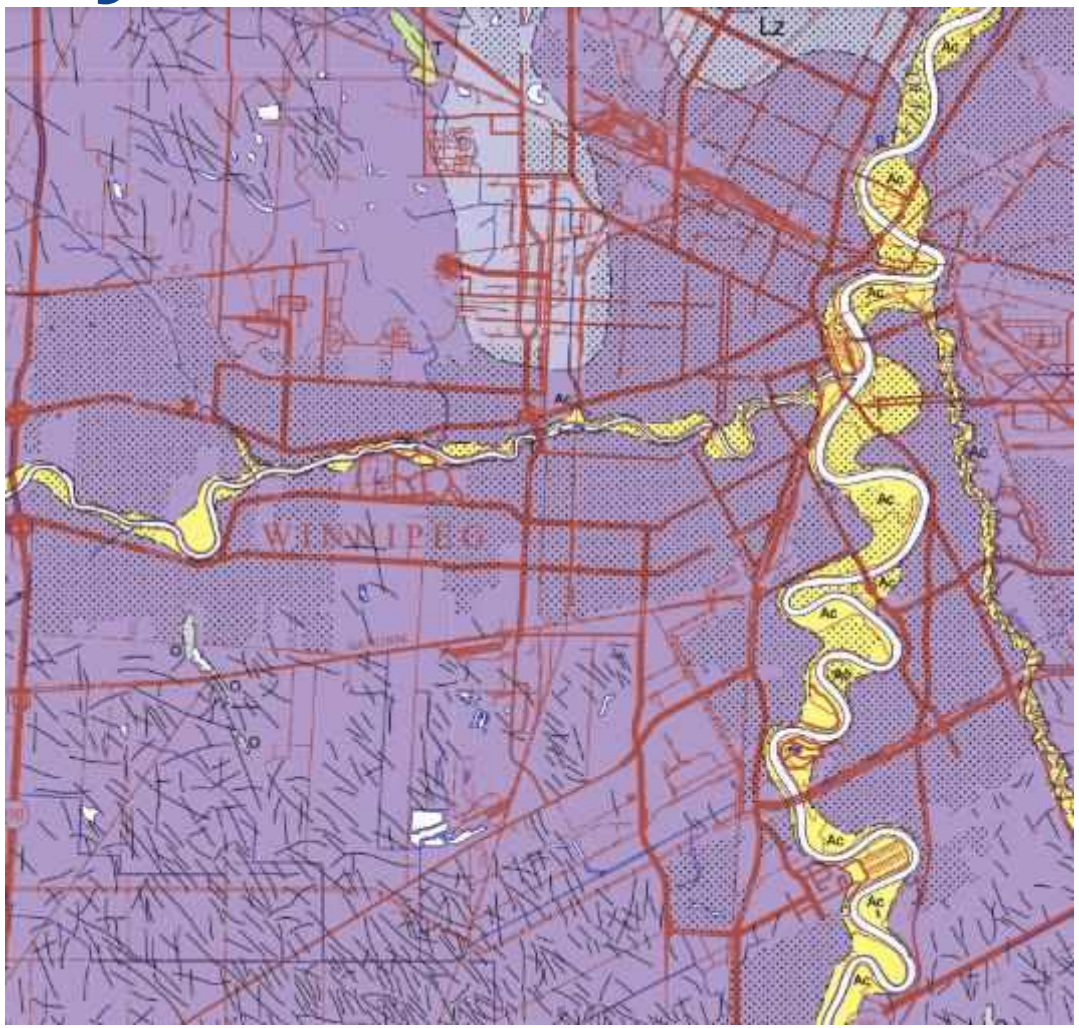

1950

2022

**Downtown Winnipeg, Manitoba**

Waterline

# Cautionary Tales




**Downtown Winnipeg, Manitoba**

Waterline

# Cautionary Tales

## Red River, Winnipeg

*“Few places on Earth are better prepared for floods than flat and often soggy Manitoba, where water from an area the size of Egypt winds up as it makes its way to Lake Winnipeg.*

*This province has entire towns surrounded by ring dikes, cities protected by flood channels and municipalities in possession of an arsenal of earth-moving, water-pumping and sandbag-filling machines.*

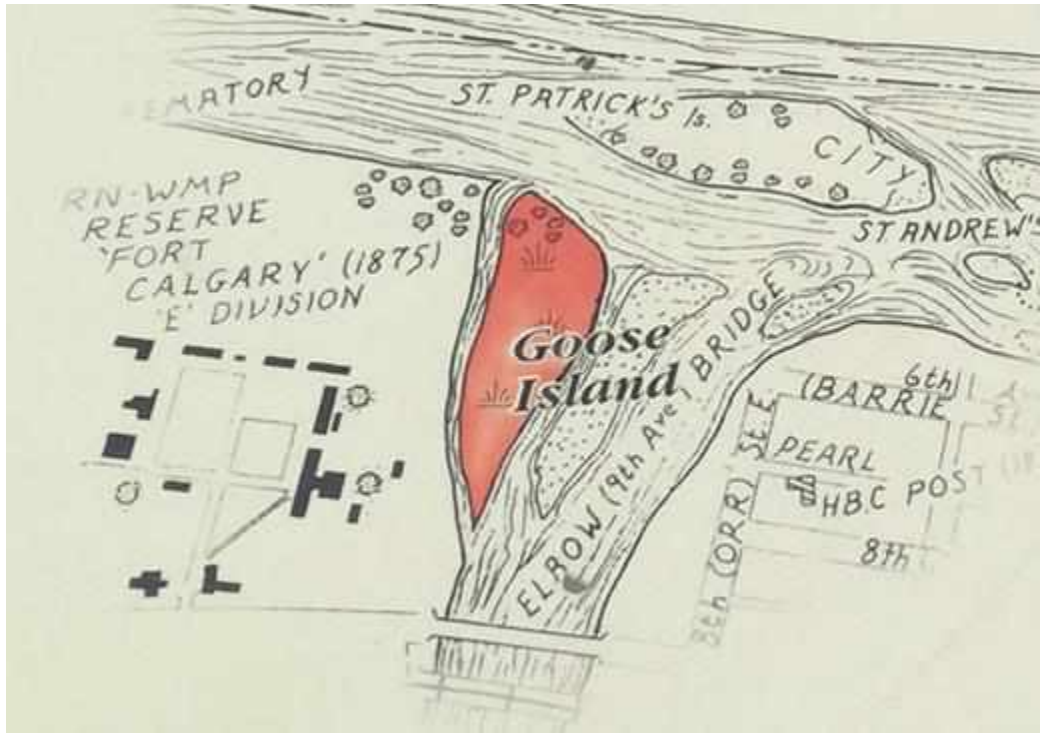
*Yet nothing prepared Manitoba for a flood season where multiple corners of the province took turns fighting and cleaning up after floods of a significant, if not historic, size.”*

*May 26, 2022 – CBC News*

*https://www.cbc.ca/news/canada/manitoba/flood-2022-manitoba-analysis-1.6465372*

Waterline

# Calgary




c. 1905

2021

Waterline

# Cautionary Tales

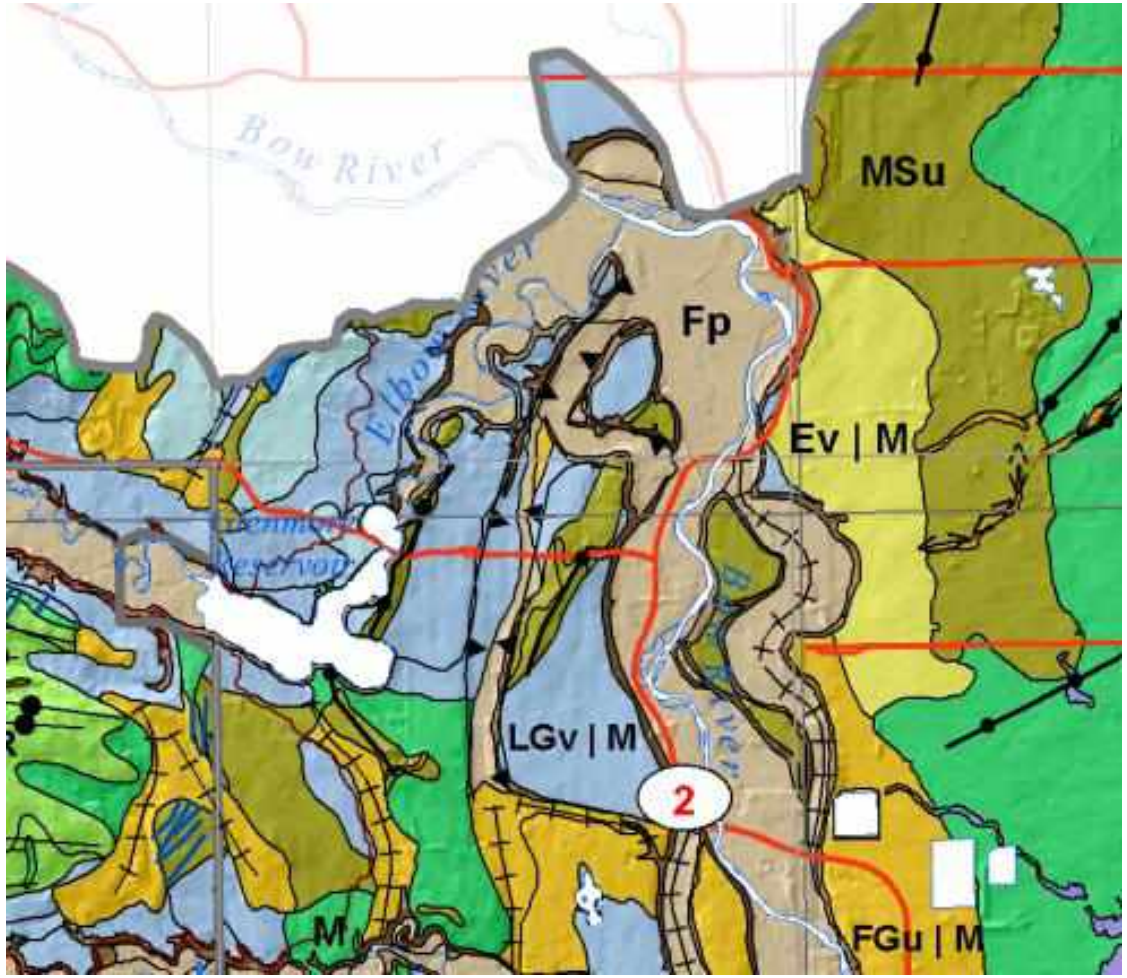
1929

2013

**Calgary, Alberta**

Waterline

# Calgary – Surficial Geology



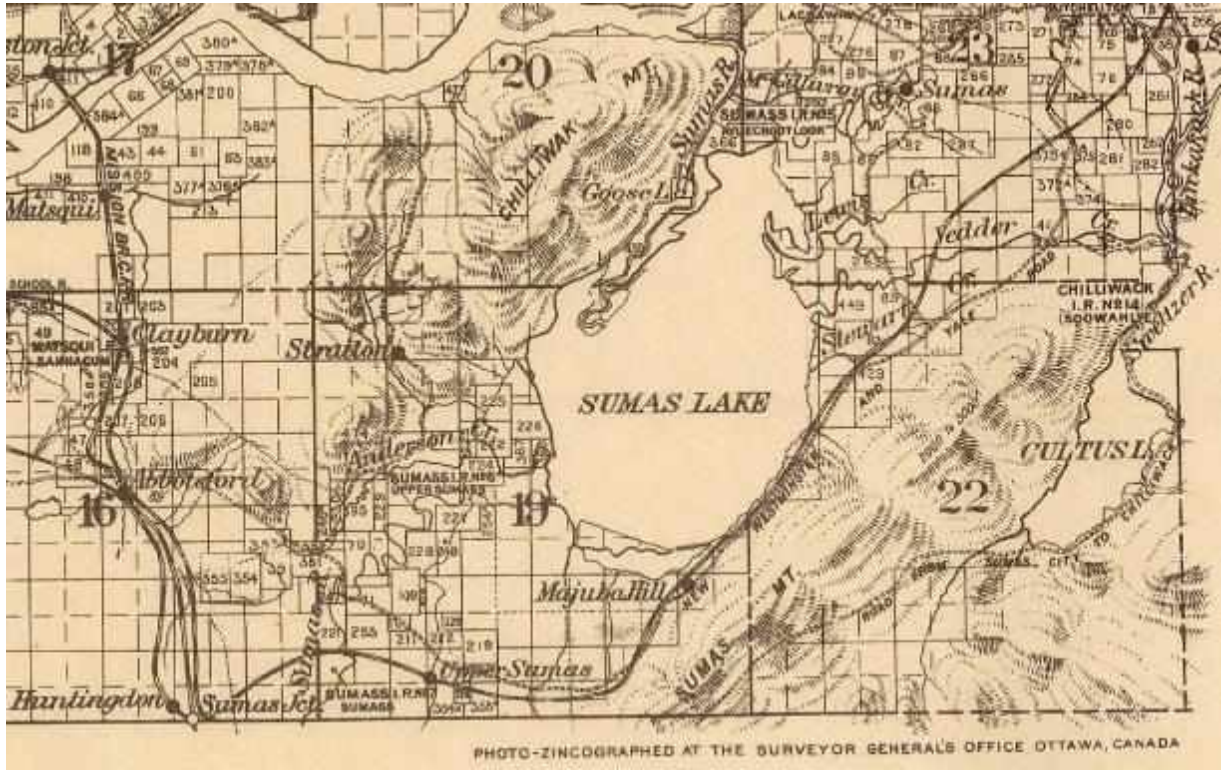

Waterline

# Cautionary Tales


**Attiwapiskat, Ontario**

Waterline

# Disaster in our homeland




1913

c. 1920s

**Sumas Prairie, Abbotsford, BC**

Waterline

# Disaster in our homeland

Satellite image ©2021 Maxar Technologies

Satellite image ©2021 Maxar Technologies

2021

**Sumas Prairie, Abbotsford, BC**

Waterline

# Disaster in our homeland


Satellite image ©2021 Maxar Technologies

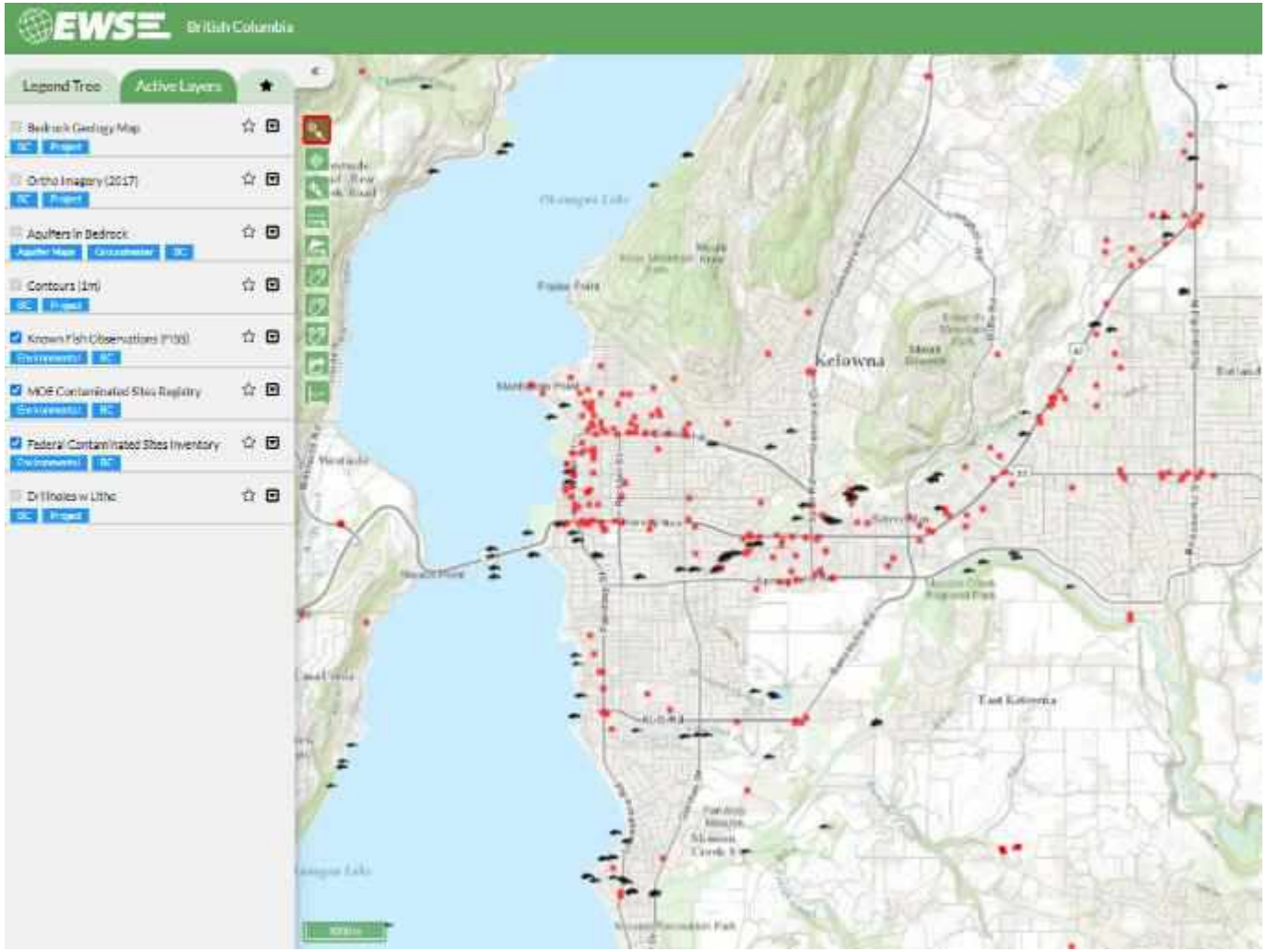
Satellite image ©2021 Maxar Technologies

**2021**

**Sumas Prairie, Abbotsford, BC**

Waterline

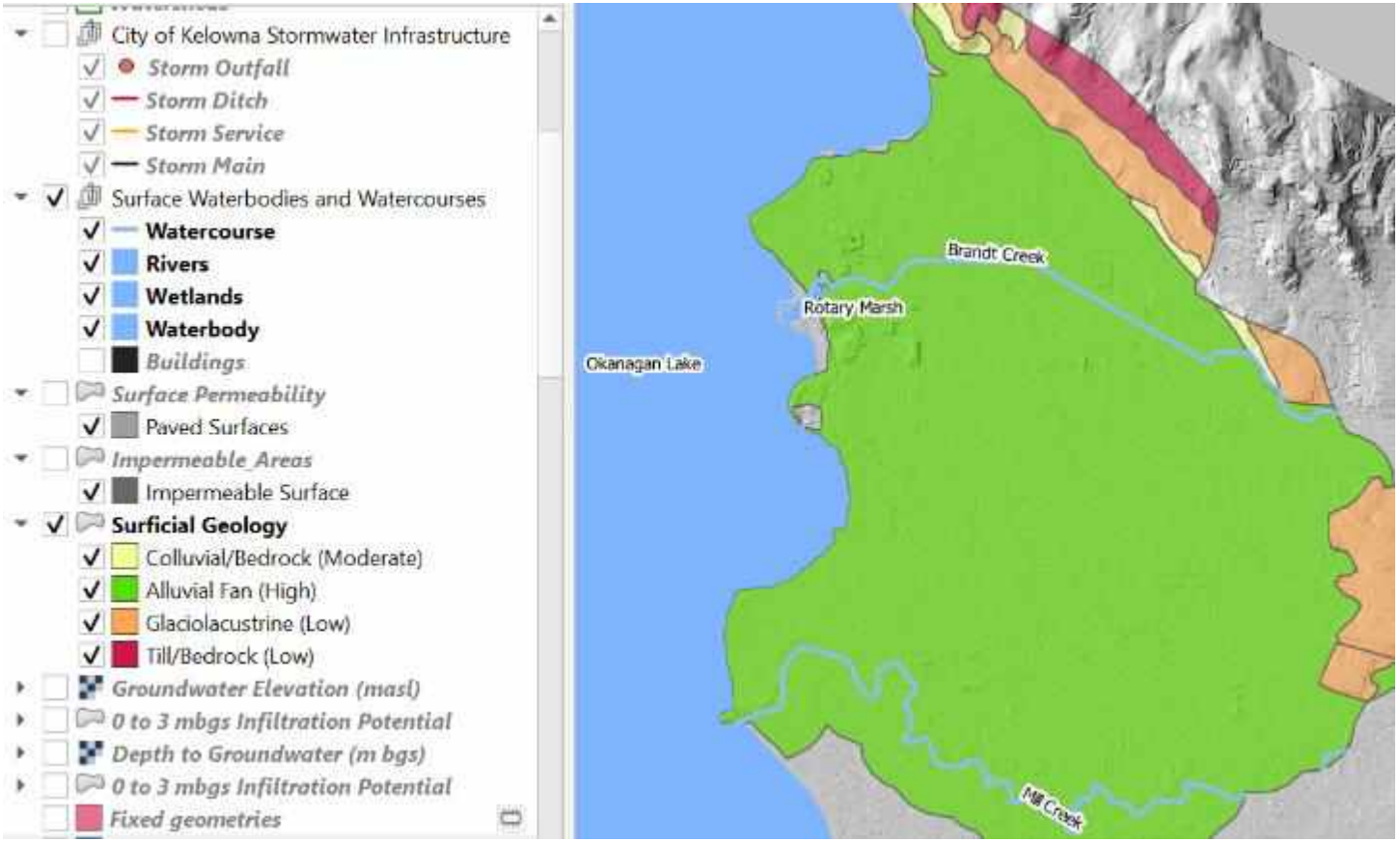
# Kelowna, BC




**Alluvial Fan throughout Downtown**

Waterline

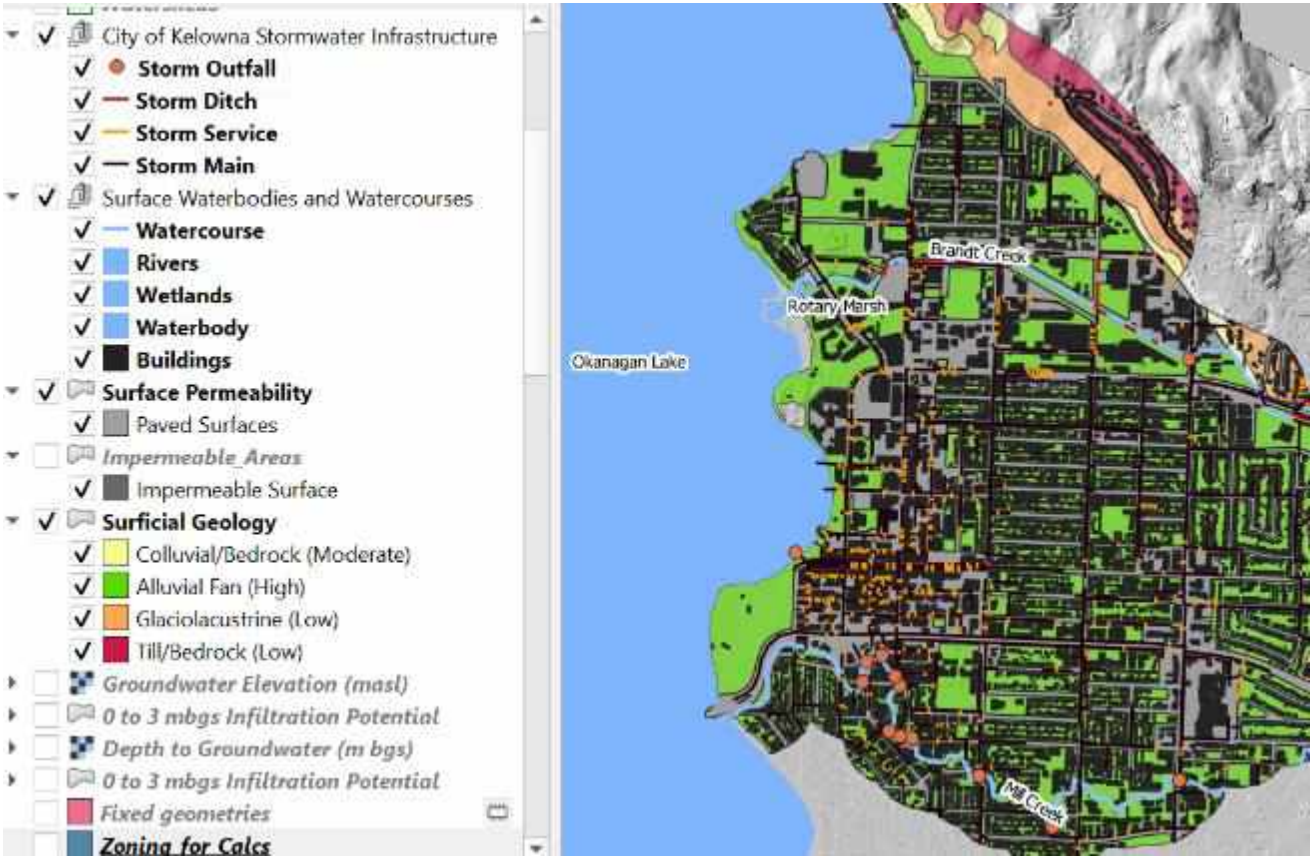
# A Downtown on an Alluvial Fan




**Downtown Kelowna, BC**

Waterline

# A Century of Urban Development




**Downtown Kelowna, BC**

Waterline

# Disaster in our homeland

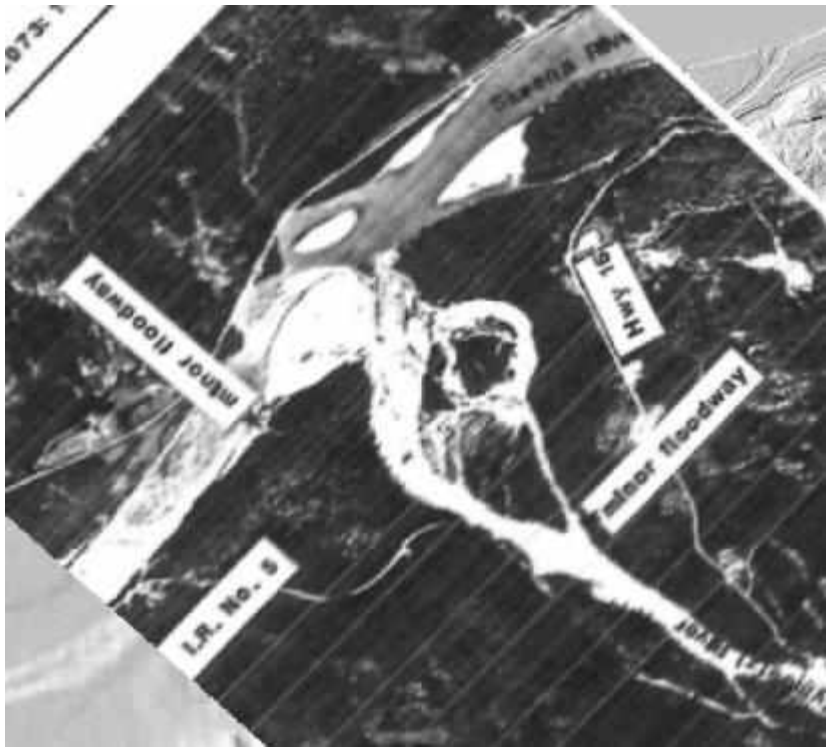

c. 1903

2017

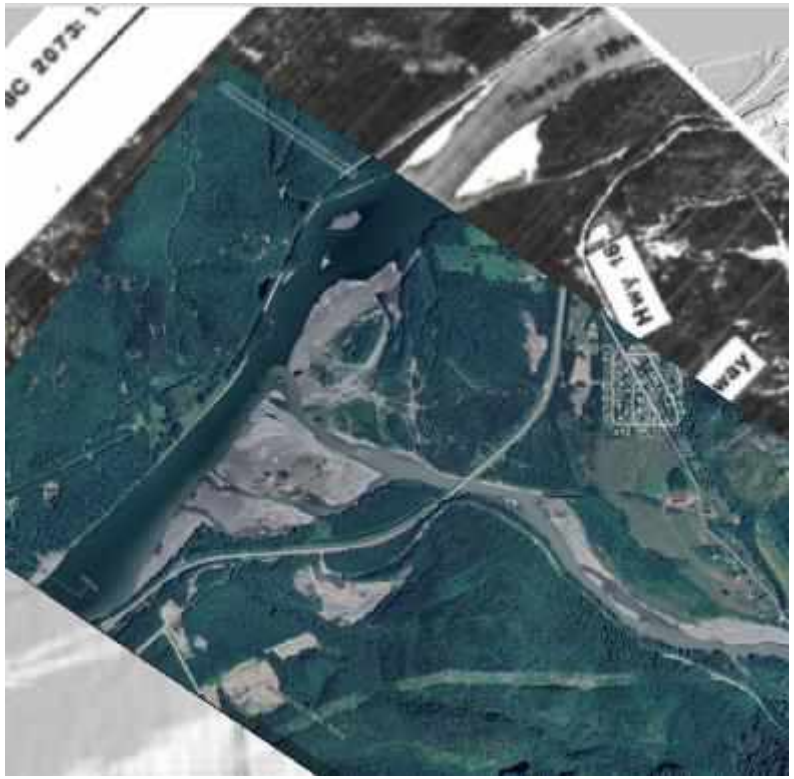
**Downtown Kelowna, BC**

Waterline

# Disaster in our homeland




1956




2021

**Copper River (near Terrace)**

Waterline

# BC's Settlements on Alluvial Deposits

**bc_aquifers**

- Unconfined sand and gravel - alluvial or colluvial fan
- Unconfined sand and gravel - deltaic
- Unconfined sand and gravel - late glacial outwash

**surficial_geology_canada**

- Alluvial deposits

**surficial_geology**

- Af: Alluvial sediments - Fan sediments
- Ap: Alluvial sediments - Floodplain sediments
- At: Alluvial sediments - Terraced sediments

**soil_parent_material**

- Fluvial

Waterline

# BC's Settlements on Alluvial Deposits

**bc_aquifers**

- Unconfined sand and gravel - alluvial or colluvial fan
- Unconfined sand and gravel - deltaic
- Unconfined sand and gravel - late glacial outwash

**surficial_geology_canada**

- Alluvial deposits

**surficial_geology**

- Af: Alluvial sediments - Fan sediments
- Ap: Alluvial sediments - Floodplain sediments
- At: Alluvial sediments - Terraced sediments

**soil_parent_material**

- Fluvial

Waterline

# Man-Made Induced Hazards

- Armouring, berms/dams, river/creek diversions/restrictions
- Road base construction and surface/subsurface flow restrictions (culverts)
- Water main/storm drain leaks (sink holes)
- Undercutting of foundations and underground storage infrastructure
- Constructed foundations changing groundwater hydrodynamics
- Paved surfaces, stormwater management infrastructure

Waterline

# Flood Conditions

- **High lake/sea levels**
- High precipitation events
- High snow melt conditions
- Shallow groundwater
- Restricted surface water flow
- Loss of evapotranspiration

**Antarctica's "Doomsday Glacier" On Edge Of Disaster, Says Study. Here's What Will Happen If It Disintegrates**

The scary new study has alerted us about the rapid disintegration of one of the biggest glaciers in the world.

World | Edited by Amit Chaturvedi | Updated: September 12, 2022 7:24 pm IST

TRENDING

"Yes, We Encroached On Storm Water Drain": Bengaluru's Tech Park Giant

The Many Quirks Of King Charles: Ironed Shoelaces, Breakfast Box

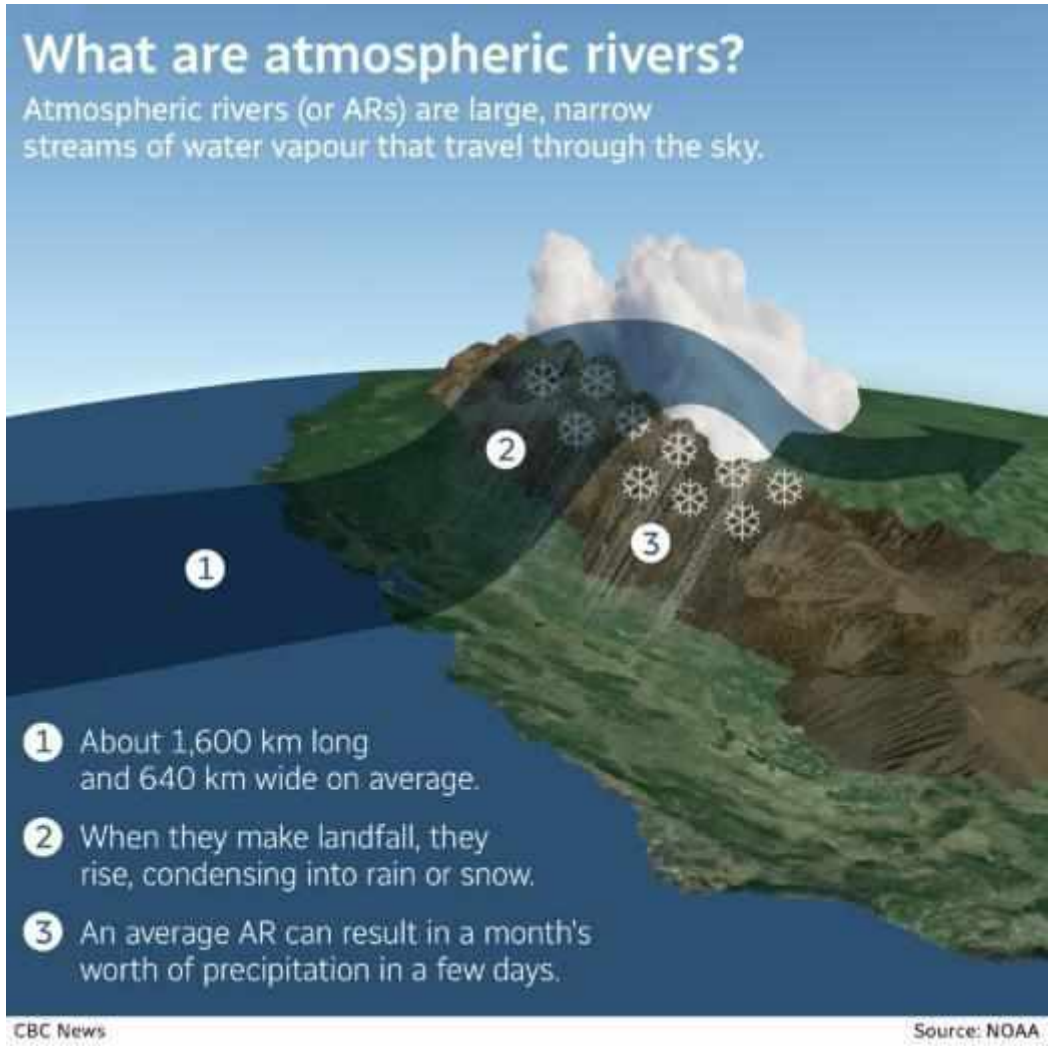
"Want To Make One Thing Very Clear...": Amit Shah On Hindi Language Stand

The Thwaites glacier in Antarctica is among the biggest glaciers in the world.

Waterline

# Flood Conditions

- High lake/sea levels
- **High precipitation events**
- High snow melt conditions
- Shallow groundwater
- Restricted surface water flow
- Loss of evapotranspiration




Waterline

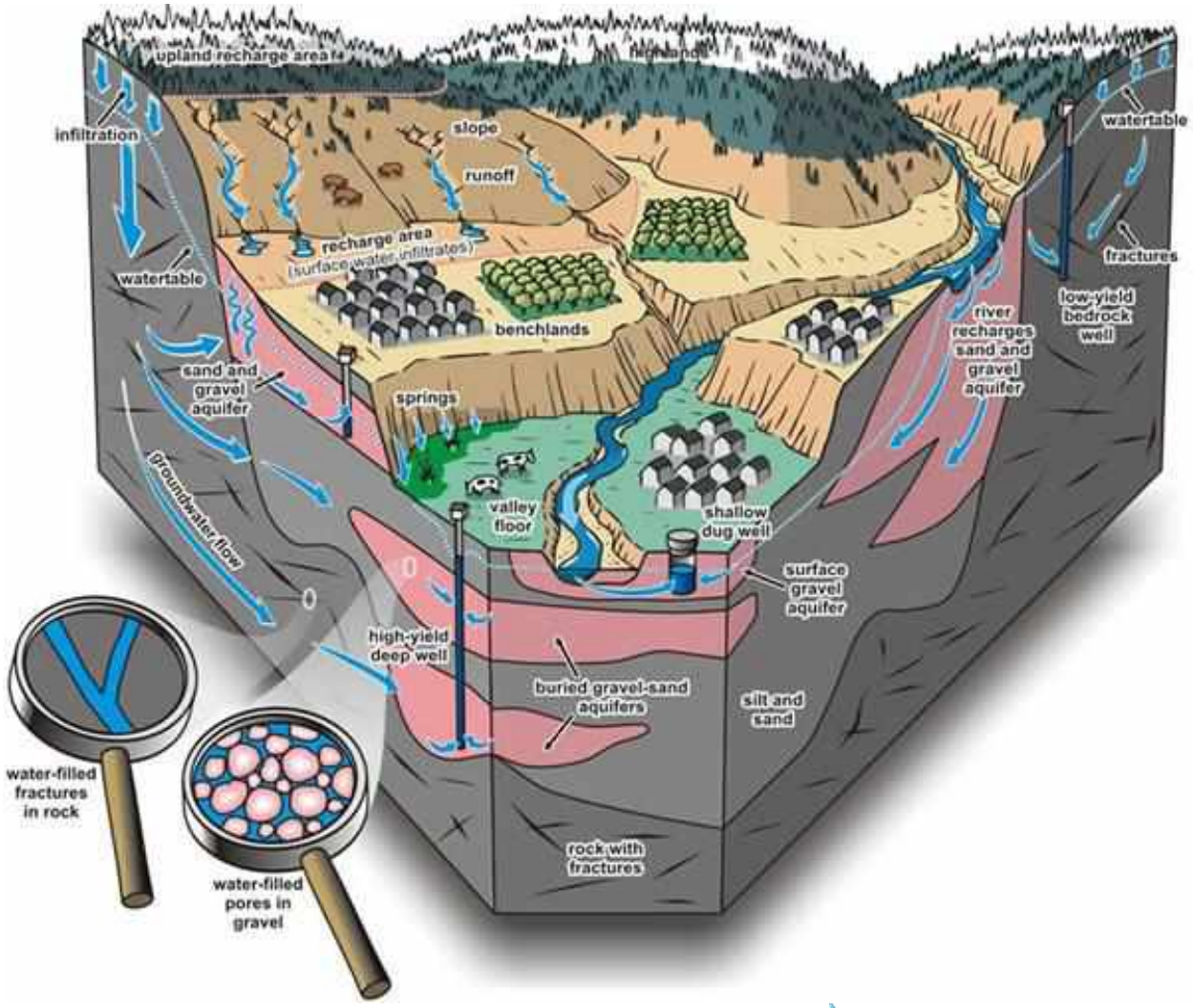
# Flood Conditions

- High lake/sea levels
- High precipitation events
- **High snow melt conditions**
- Shallow groundwater
- Restricted surface water flow
- Loss of evapotranspiration

Waterline

# Flood Conditions

- High lake/sea levels
- High precipitation events
- High snow melt conditions
- **Shallow groundwater**
- Restricted surface water flow
- Loss of evapotranspiration




Waterline

# Flood Conditions

- High lake/sea levels
- High precipitation events
- High snow melt conditions
- Shallow groundwater
- **Restricted surface water flow**
- Loss of evapotranspiration

Waterline

# Flood Conditions

- High lake/sea levels
- High precipitation events
- High snow melt conditions
- Shallow groundwater
- Restricted surface water flow
- **Loss of evapotranspiration**

# Game Changing Climate

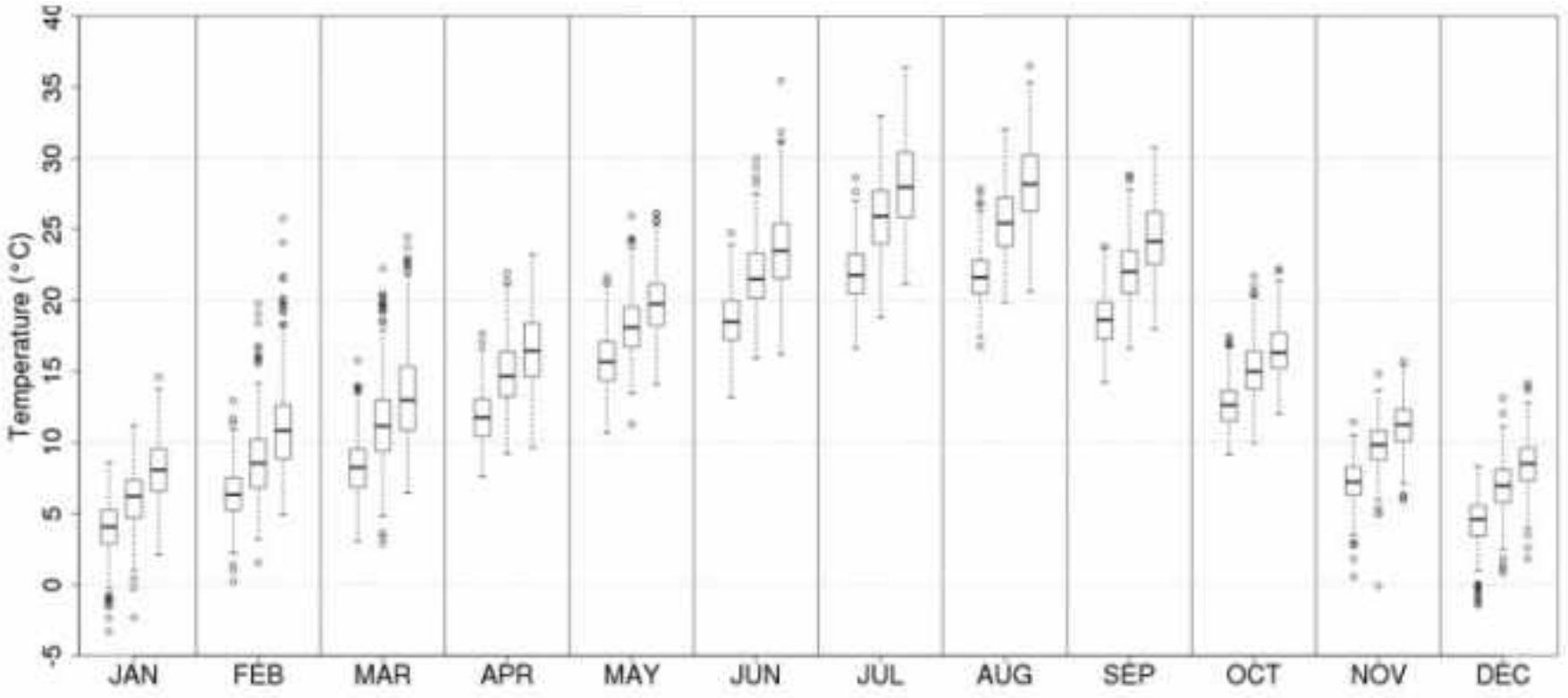
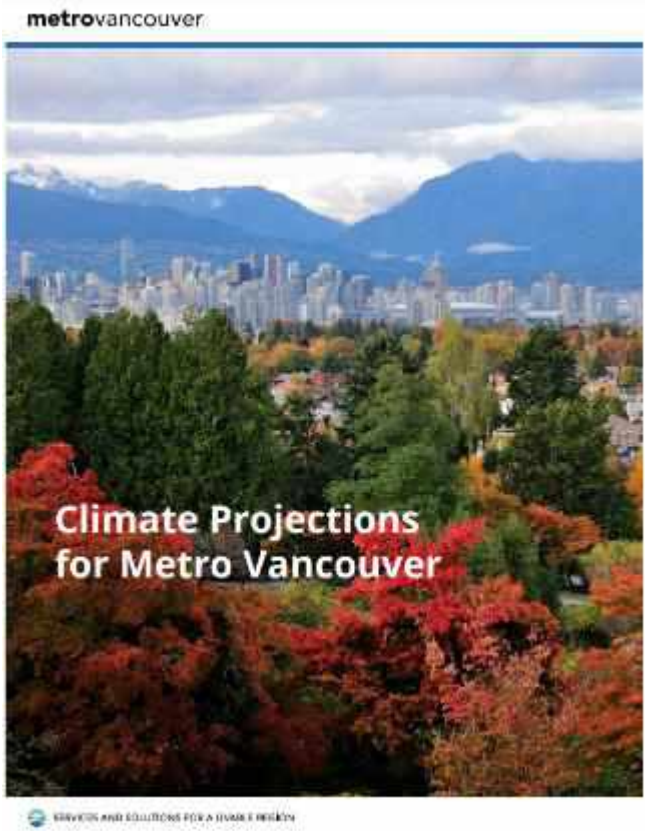



FIGURE 3: MONTHLY DAYTIME HIGH TEMPERATURE – PAST, 2050s, AND 2080s

*Boxes from left to right in each month indicate past, 2050s, 2080s. Further explanation of how to read the box-and-whisker plots is provided above in the Methodology section.*




Waterline

# Game Changing Climate

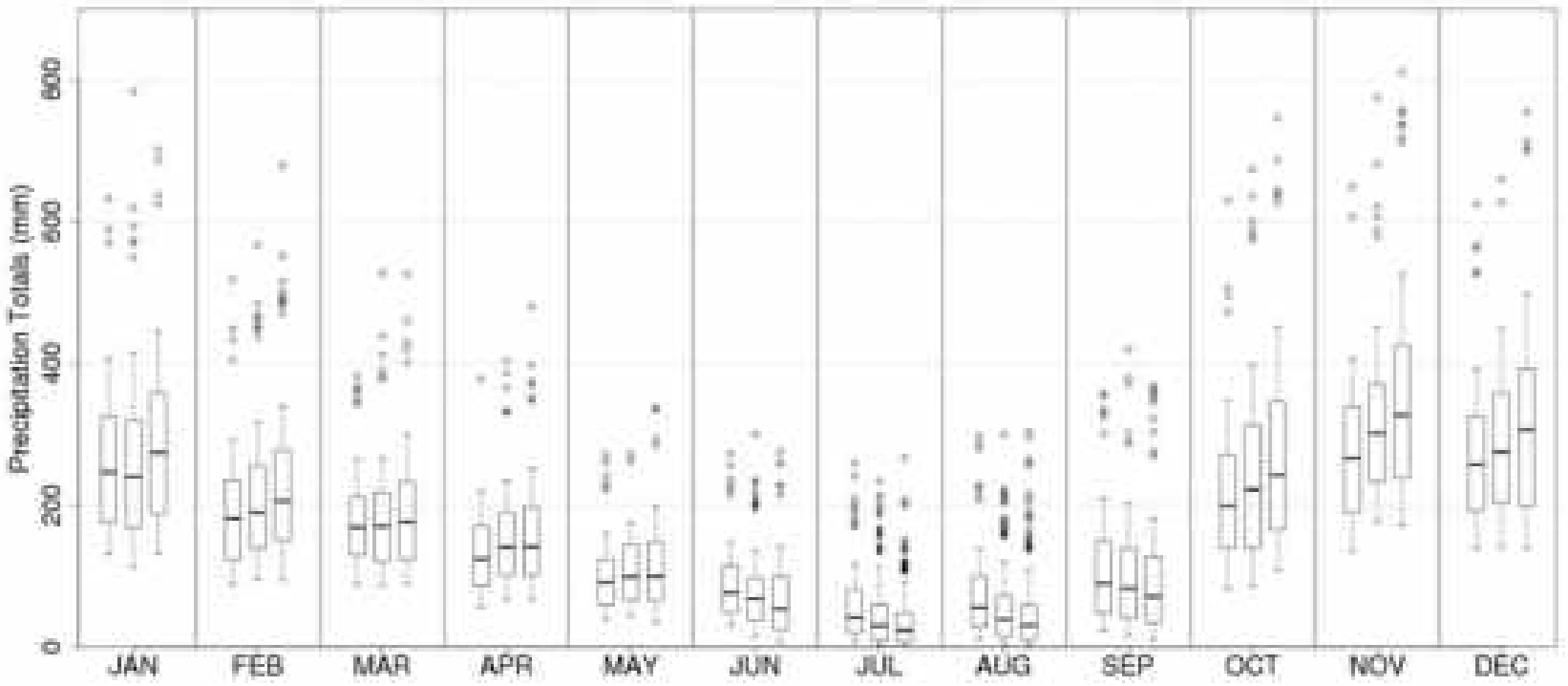
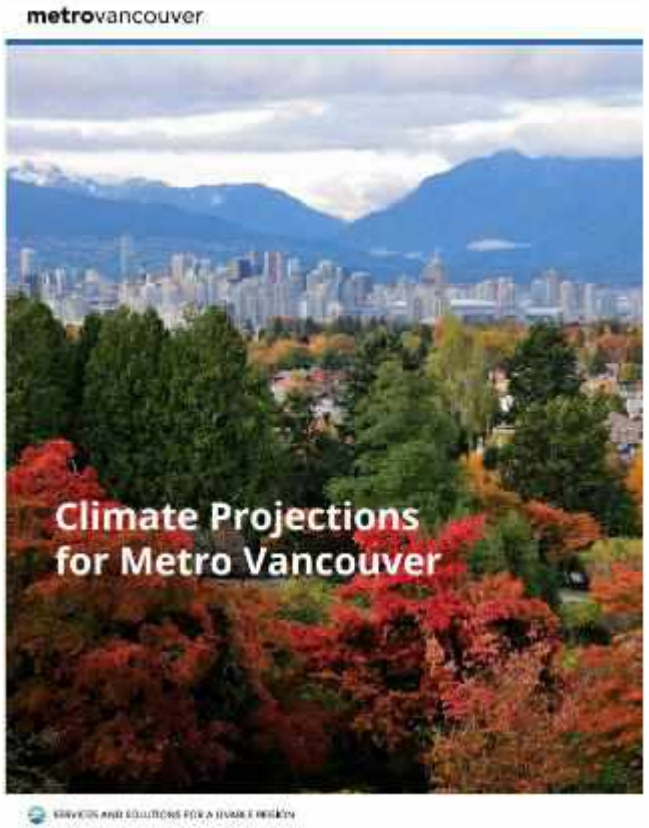



FIGURE 7: MONTHLY TOTAL PRECIPITATION – PAST, 2050s, AND 2080s

*Boxes from left to right in each month indicate past, 2050s, 2080s. Further explanation of how to read the box-and-whisker plots is provided above in the Methodology section.*




Waterline

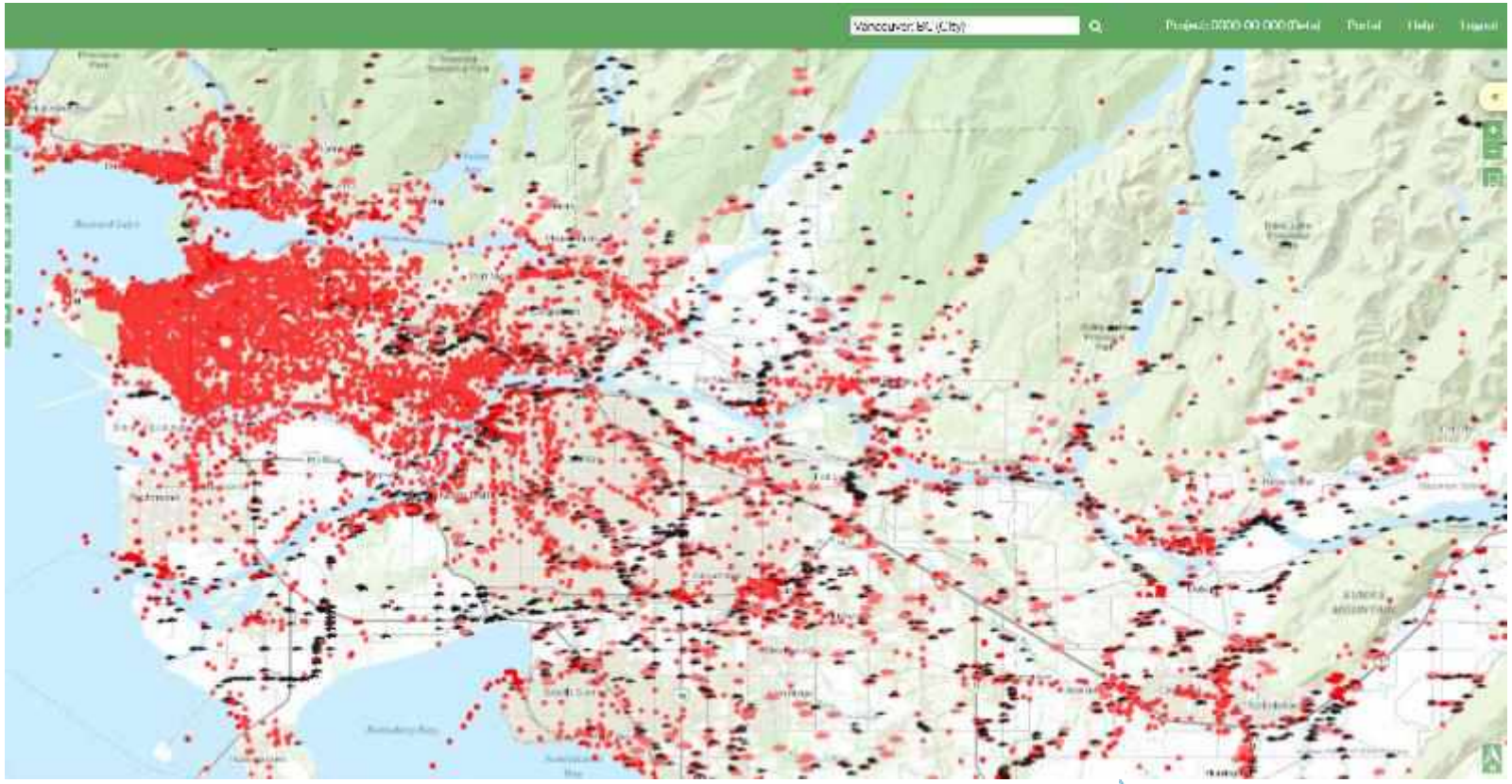
# Game Changing Climate

- **WE KEEP BEING SURPRISED…WHY?**
- Where the water used to go does not mean the water will continue to go (avulsion, overland flooding, urban development, sedimentation)
- ‘New normal’ peak flood and drought
- Forest fires exposing land to erosion + flood events more severe
- Change in aquifer recharge/discharge patterns.
- Sedimentation is complex – redistribution of fine and coarse
- Rising sea level, lake levels, changing hydrodynamics of fans and deltas.

Waterline

# Contaminant Risks

- Well integrity
- Cracked/ corroded/ leaking hydrocarbon pipes
- migration of manure (e.coli), pesticides, herbicides, fertilizers.
- Compromised hydrocarbon storage tanks
- Inundated/damaged septic tanks



Waterline

# Improving Risk Assessment

- Numerical Modelling – PCSWMS, Modflow, USGS, MoundSolv, etc.
- Bench scale experiments – alluvial morphology/avulsion studies – UBC (Booker, W. 2018 depicted)

Waterline

# Improving Risk Assessment

- Surficial Geology (BioTerrain, TEM projects), PEM, Regional Soil Mapping (1970s to 1990s)
- Published Public Data
  - Stormwater management infrastructure
  - Water utilities
  - LiDAR
  - Climate Data, Hydrometric Station Data
  - Percolation Testing, Geotechnical Borehole Logging

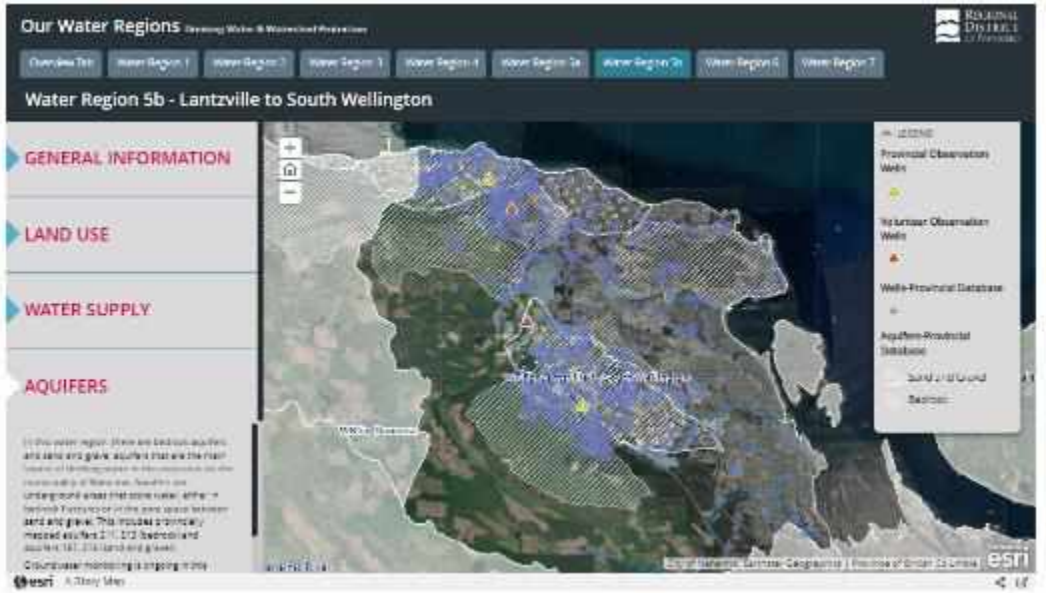

Waterline

# Municipality-led Planning

- Vancouver's Citywide Integrated Rainwater Management Plan
- Town of Gibsons
- City of Victoria
- Squamish
- Regional District of Nanaimo
- City of Kelowna
- Etc. etc.!

# Tools and Mitigations

- **Groundwater / Surface Water constraints mapping (updated floodplain mapping)**
- Infiltration Potential Mapping
- Green Infrastructure/Infiltration Projects
- Wetland Conservation
- Identify High Risk Infrastructure
- Urban Forestry
- Well Integrity
- Housekeeping / Storage / Containment

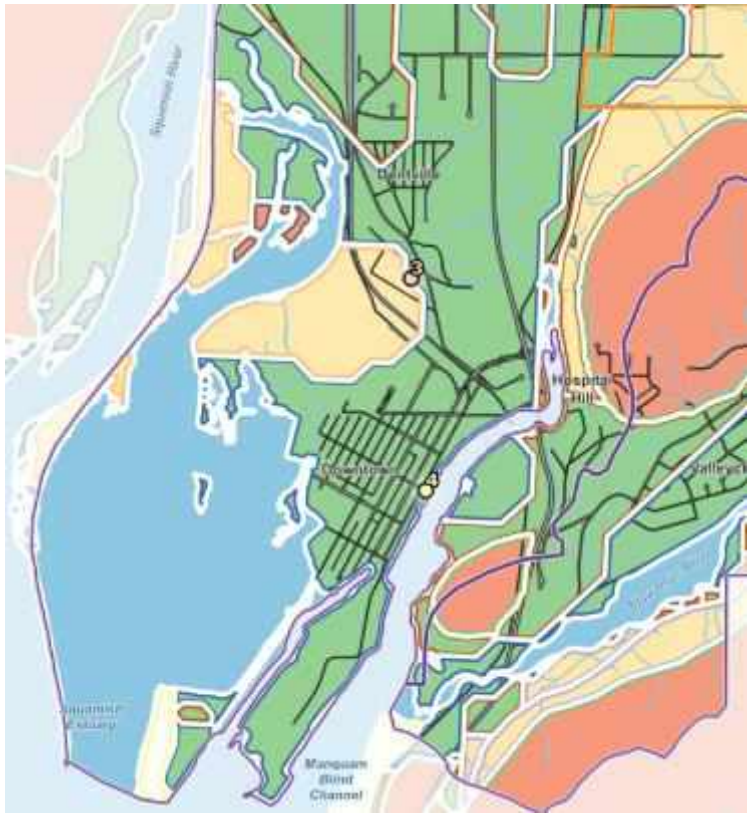



Regional District of Nanaimo

Waterline

# Tools and Mitigations

- Groundwater / Surface Water constraints mapping
- **Infiltration Potential Mapping**
- Green Infrastructure/Infiltration Projects
- Wetland Conservation
- Identify High Risk Infrastructure
- Urban Forestry
- Well Integrity
- Housekeeping / Storage / Containment



Waterline

# Tools and Mitigations

- Groundwater / Surface Water constraints mapping
- Infiltration Potential Mapping
- **Green Infrastructure/Infiltration Projects**
- Wetland Conservation
- Identify High Risk Infrastructure
- Urban Forestry
- Well Integrity
- Housekeeping / Storage / Containment

2019 – BC Institute of Technology

Waterline

# Tools and Mitigations

- Groundwater / Surface Water constraints mapping
- Infiltration Potential Mapping
- Green Infrastructure/Infiltration Projects
- **Wetland Conservation**
- Identify High Risk Infrastructure
- Urban Forestry
- Well Integrity
- Housekeeping / Storage / Containment

Waterline

# Tools and Mitigations

- Groundwater / Surface Water constraints mapping
- Infiltration Potential Mapping
- Green Infrastructure/Infiltration Projects
- Wetland Conservation
- **Identify High Risk Infrastructure**
- Urban Forestry
- Well Integrity
- Housekeeping / Storage / Containment

2021 – Globe and Mail

Waterline

# Tools and Mitigations

- Groundwater / Surface Water constraints mapping
- Infiltration Potential Mapping
- Green Infrastructure/Infiltration Projects
- Wetland Conservation
- Identify High Risk Infrastructure
- **Urban forestry**
- Well Integrity
- Housekeeping / Storage / Containment

2022 – Vancouver Citywide Rainwater Management Plan

Waterline

# Tools and Mitigations

- Groundwater / Surface Water constraints mapping
- Infiltration Potential Mapping
- Green Infrastructure/Infiltration Projects
- Wetland Conservation
- Identify High Risk Infrastructure
- Urban Forestry
- **Well Integrity**
- Housekeeping / Storage / Containment

Waterline

# Tools and Mitigations

- Groundwater / Surface Water constraints mapping
- Infiltration Potential Mapping
- Green Infrastructure/Infiltration Projects
- Wetland Conservation
- Identify High Risk Infrastructure
- Urban Forestry
- Well Integrity
- **Housekeeping / Storage / Containment**

Waterline

# “One and Done” is not a Solution!

- Need to develop AND implement a multitude of tools and mitigations.







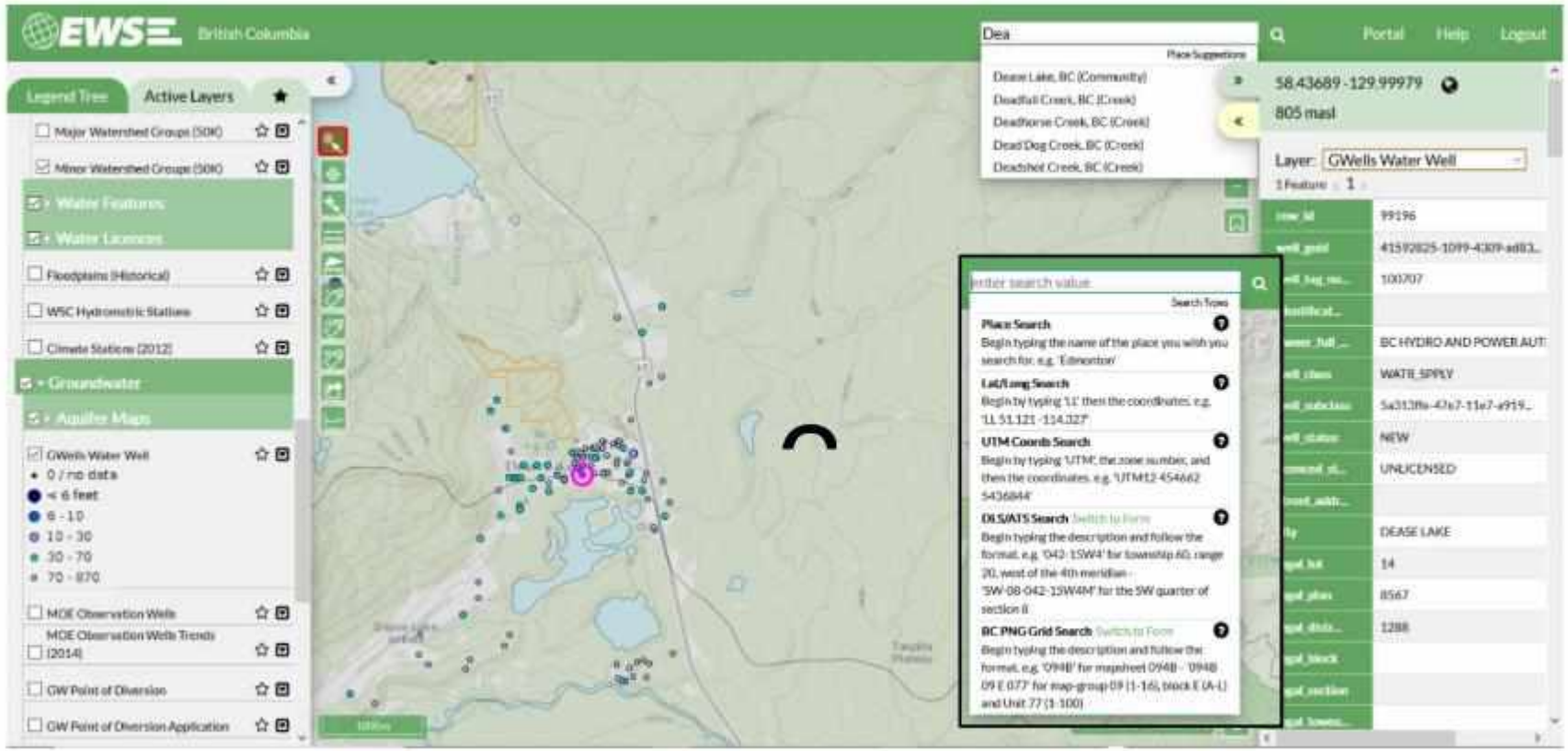

Waterline

# Waterline Resources Inc.

- Enviroweb Services (EWS)
  - Specialized web-based platform for managing and interpreting groundwater, surface-groundwater interactions, wetlands and contaminant risk data
- Highest concentration of hydrogeology specialists in Western Canada
- Wetlands, Soil Science, Surface Water-Groundwater Interactions, Contaminated Site Assessment and Remediation

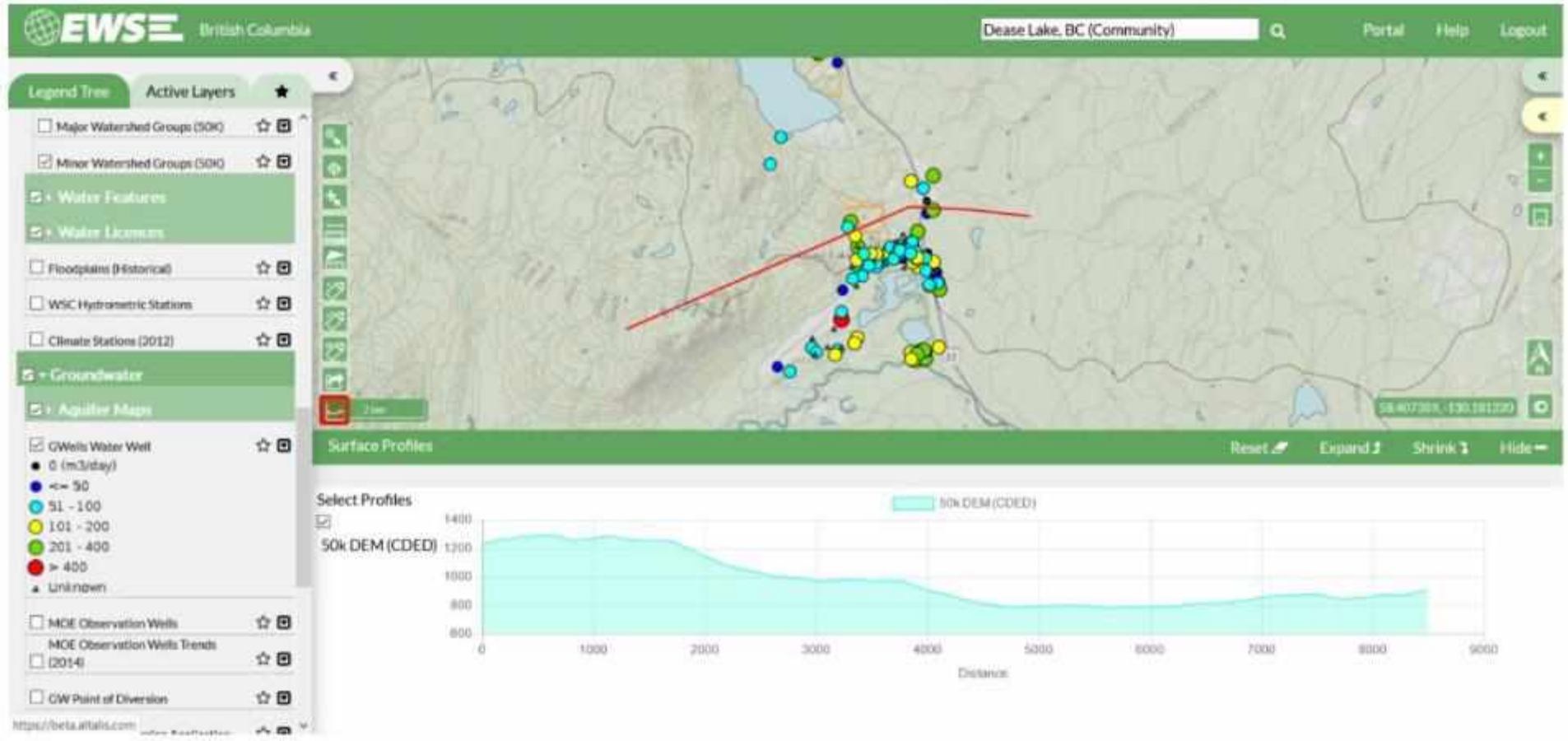
Waterline

# Waterline Resources Inc.




Waterline

# Waterline Resources Inc.



# A Final Thought


https://thetyee.ca/News/2022/06/20/Fighting-Floods-Living-With-Water/

Waterline


Water Well
Flood/Landslide Alert/Order Zones
Thanks
Hope
Coquitlam
Port Coquitlam
Pitt Meadows
Maple Ridge
Agassiz
Mission
Chilliwack
Langley
Abbotsford
White Rock
Waterline