



KERR WOOD LEIDAL
consulting engineers

Flood Protection Challenges and Innovative Solutions in Urban Areas:

Sea Island Dike Design Case Study

Dave Murray, P.Eng. & Amir Taleghani, EIT
CWRA National Conference 2015 – Winnipeg, Manitoba
June 4 2015

1. Urban Flood Challenges – Infrastructure and Development
2. Urban Flood Challenges – Sea Level Rise
3. Flood Management at Vancouver Airport
4. Dike Design Case Study
5. Conclusions and Q&A

Urban Water Challenges

“Urban areas are particularly vulnerable to the expected increase in extreme weather conditions due to their high population densities and concentration of industry and infrastructure”

- CWRA 2015 Theme



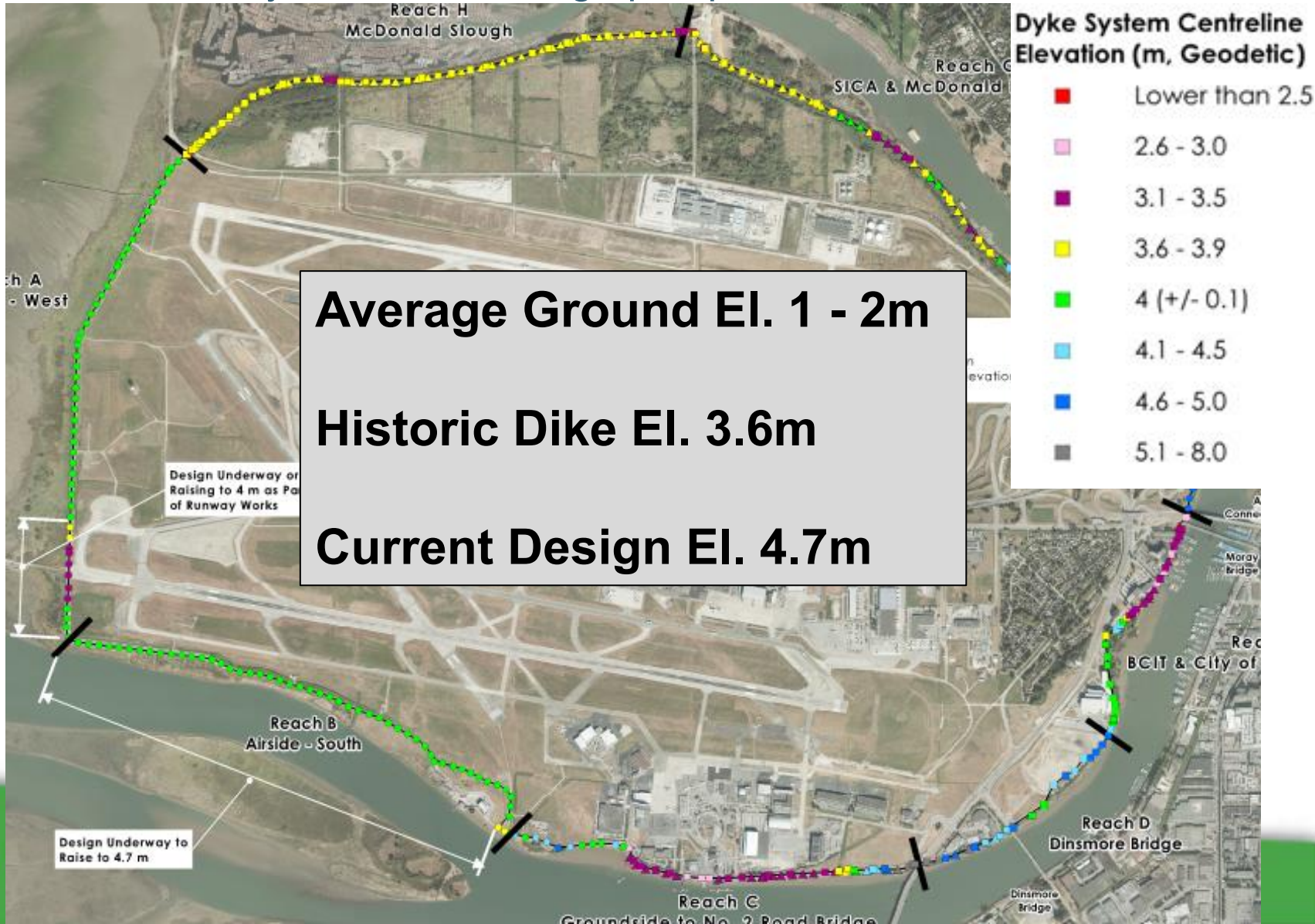


Vancouver International Airport (YVR)

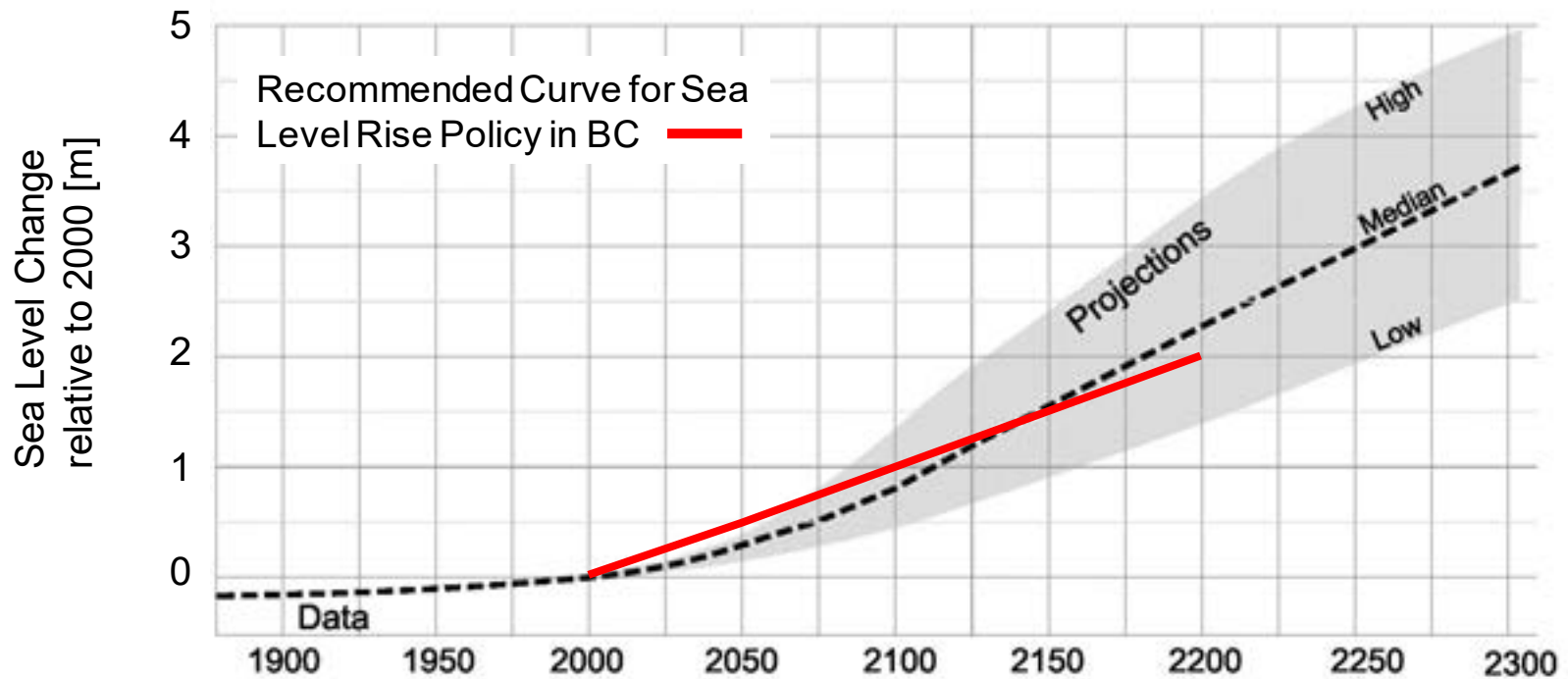
- Regional & National transportation hub
- Concentration of infrastructure
- Commercial development interests

Flood Management and Sea Level Rise Adaptation - "Protect" Strategy

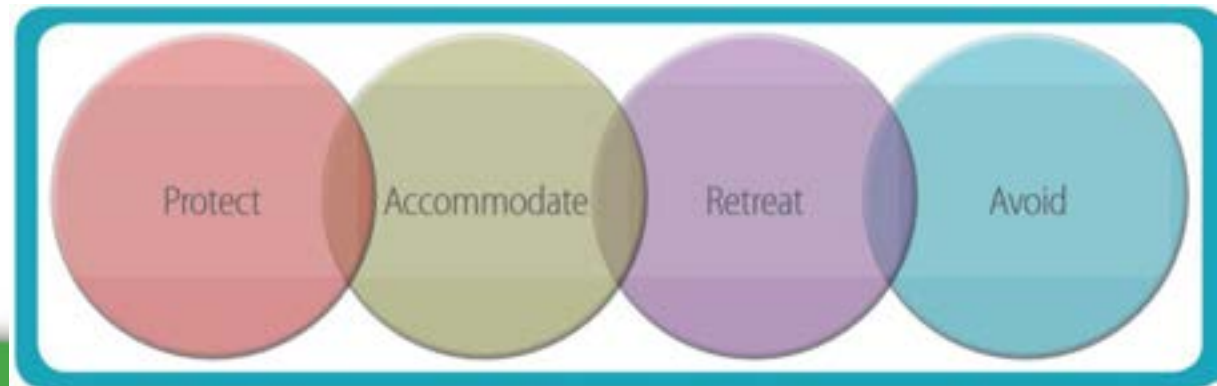
15 km perimeter dike system + 6 drainage pump and flood boxes



Urban Challenges - Sea Level Rise Adaptation 6



BC MoE 2011



Case Study: Grauer Road Dike Replacement

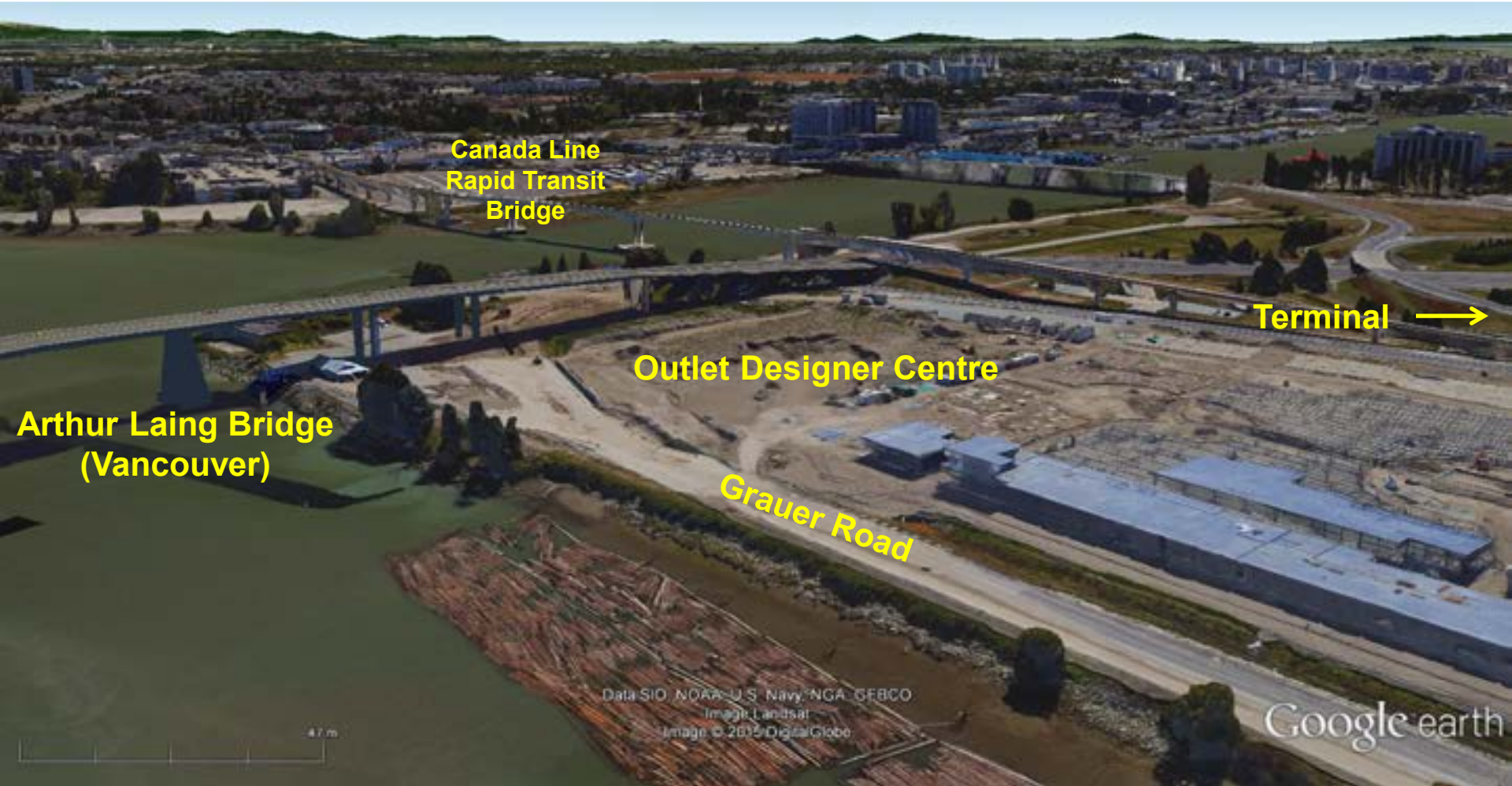
Location and History



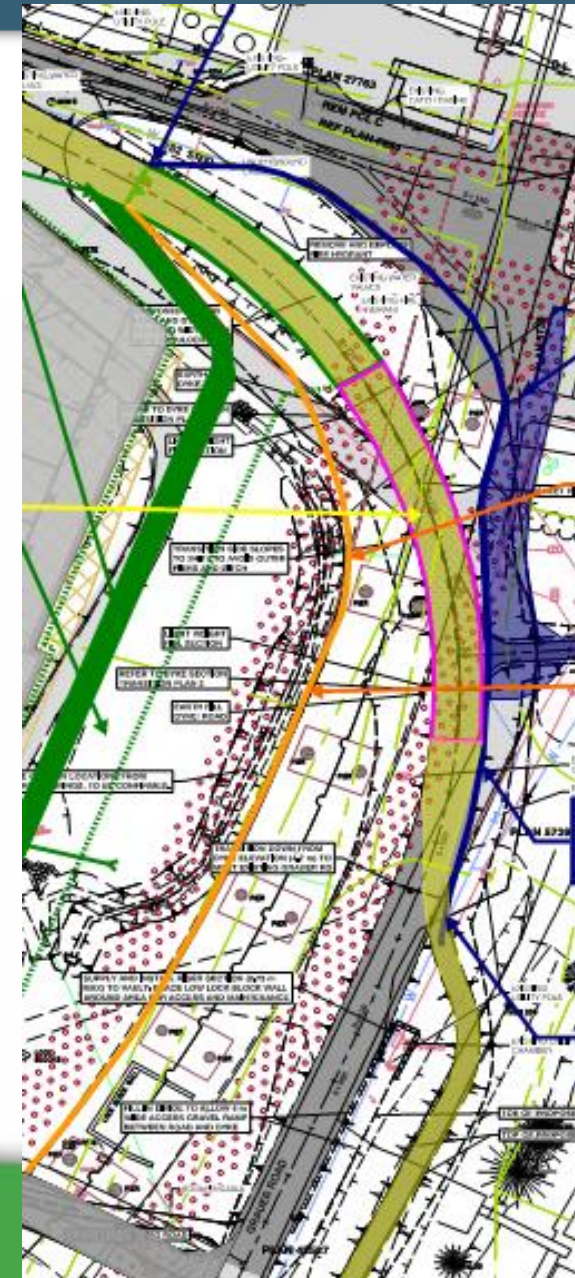
Dike Design Crest Elevation: 4.7 m Geodetic

- Incorporates 1 m of Sea Level Rise
- Approx. 500-year return period Fraser River flood level in year 2100
- Existing setback dike alignment (red) no longer viable due to development

Development and Infrastructure



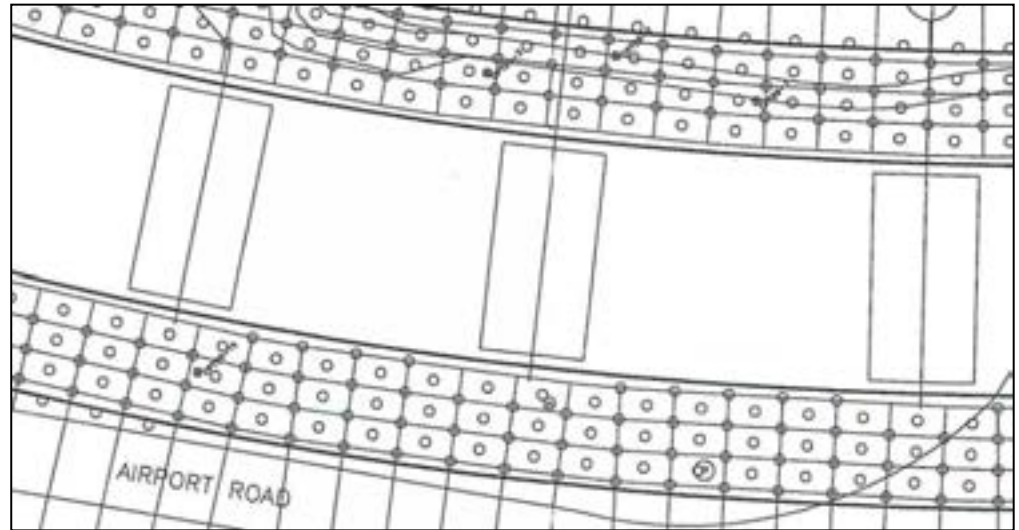
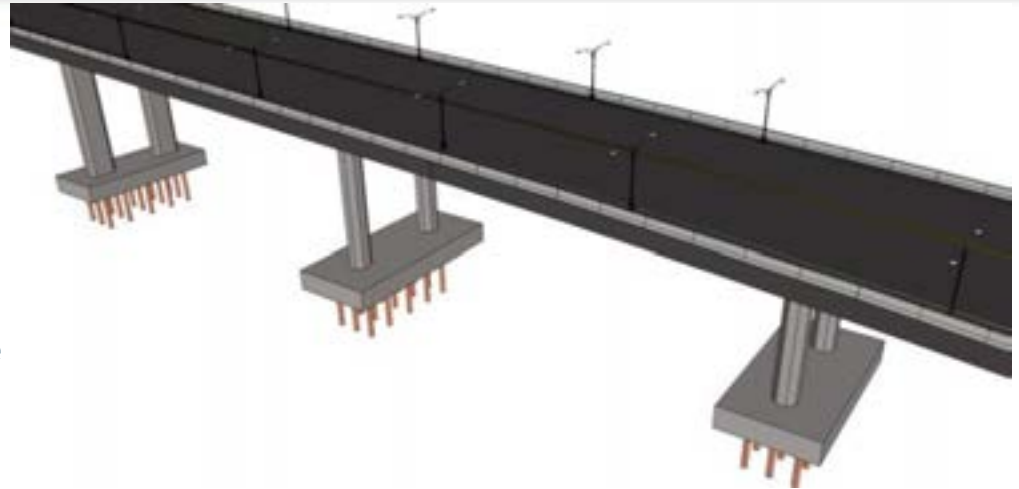
Balancing Space Between Development and Flood Protection



Arthur Laing Bridge Foundation Design Challenges

10

- Bridge foundation bearing capacity and settlement under typical dike fill load
- Bridge structural response during earthquake – “flexibility of piers”
- 800 Stone Columns installed along either side of bridge in 1990’s for ground improvement = ideal seepage path!



Design Your Way Out of the Problem



KERR WOOD LEIDAL
consulting engineers

Dike Fill Considerations: Lightweight vs. Buoyancy vs. Seepage



Expanded Polystyrene (EPS)
Unit Weight = 0.1 – 0.4 kN/m³

Would float away without anchor!



Pumice
Unit Weight = ~7 kN/m³

***Won't float away, but porous!
Stability and seepage concerns***

Steel Sheetpile Design

- Thick & deep steel sheet pile down the middle
- Weld sheet pile joints to reduce seepage



Bringing the concept together... The “Lightweight Dike” Solution

13



KERR WOOD LEIDAL
consulting engineers

From Concept to Detailed Design to Construction 14

Road gravel base layers above

EPS layer to mitigate road cracking due to differential settlement

Bridge Foundation

11 m Buried Steel Sheet Pile

Pumice Fill Around Sheetpile

Building the wall to be buried



Ready for road base layers





**Sub-excavate for pumice and
Trench for installing sheetpile**



Drive piles in sections



Then pull up whole wall to final elevation





**Burying the sheet pile and transition to standard dike
away from bridge loading zone**



Retaining walls maintain original “flexible” response of piers under seismic event



Survey Target for
Settlement Monitoring

Tilt Meter



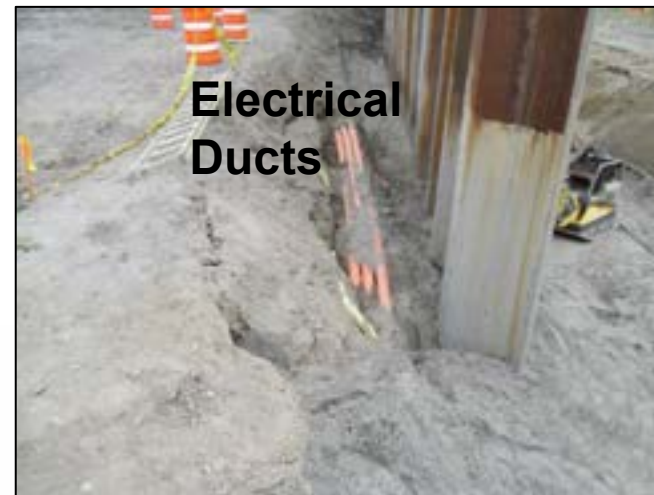
15 m bridge clearance

11 m tall sheetpile

- Sheetpiles installed in one piece sections with special smaller driving head
- Twice daily monitoring/survey for settlement and movement during driving

Construction Challenges – Archaeology, Utilities 21

- Musqueam First Nation Marpole Midden Material
- Keeping utilities out of dike





Completed in 2014 on schedule for opening of Outlet Designer Centre.

- **Owner:** Vancouver Airport Authority
- **Lead Consultant:** Kerr Wood Leidal
- **Geotechnical Sub-consultant:** Golder Associates
- **Bridge Structural Sub-consultant:** Ausenco
- **General Contractor:** Jacob Bros. Construction

First lightweight flood dike application we are aware of in Canada.

1. Assess & Communicate **Flood Risk** to all stakeholders.
2. Adapt through integrated flood **land use planning** – consider future development
3. Some development & infrastructure will *always* need to be protected – incorporate **resilience and innovation into design!**

Thank you! Questions?

24



Dave Murray, P.Eng., AscT, CPESC
Senior Water Resources Engineer
President, Canadian Water Resources Association
dmurray@kwl.ca
250-595-4223

Amir Taleghani, EIT
Junior Water Resources Engineer
ataleghani@kwl.ca
604-294-2088



KERR WOOD LEIDAL
consulting engineers