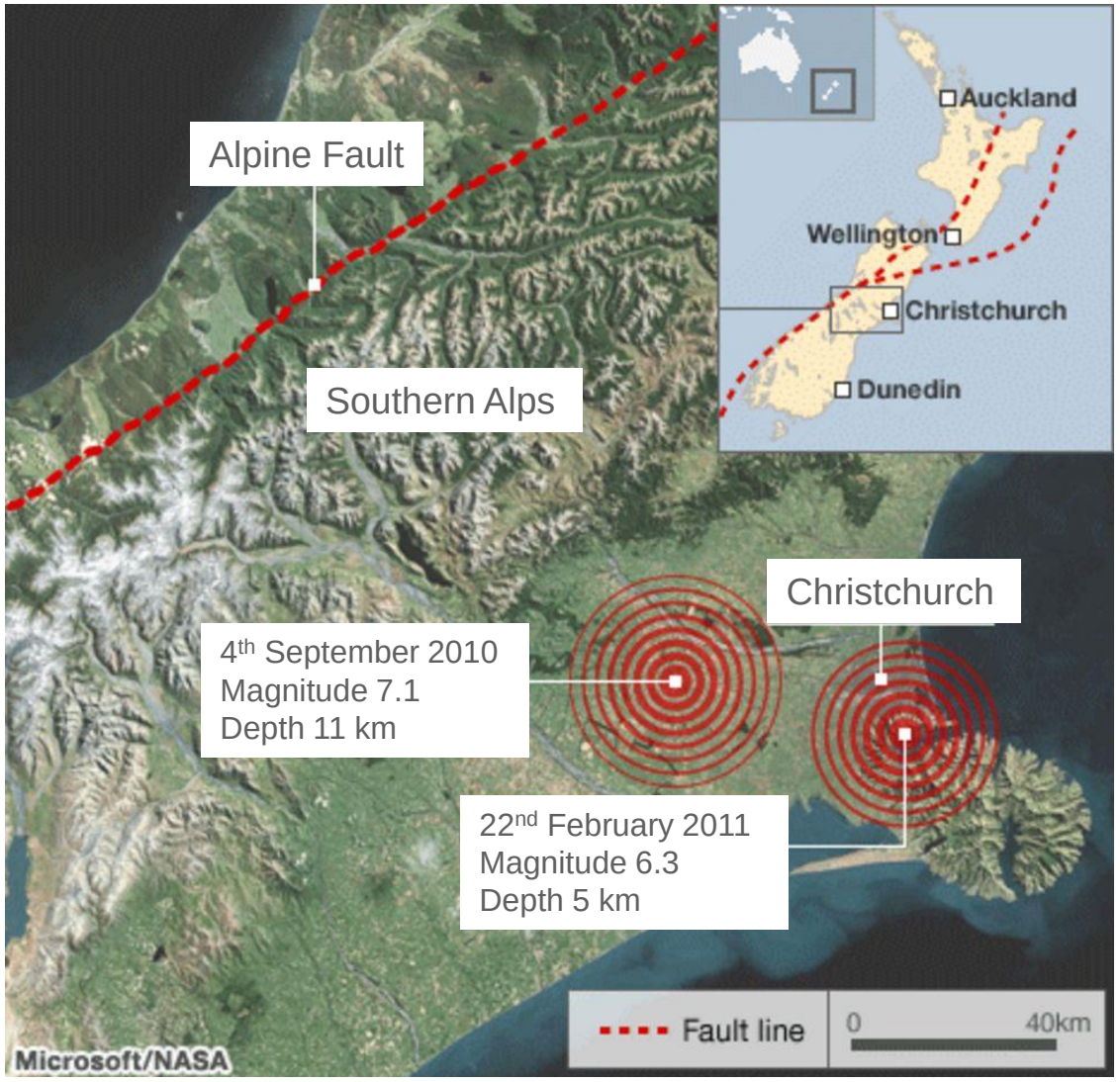
Turning The Red Zone Green – Regenerative Stormwater Design In The Ōtākaro Avon River Corridor

Hamish Cotter and Vicki Clarke, May 2023

Background – Canterbury Earthquakes

- 4th September 2010:
  - 7.1 magnitude earthquake
  - 45 km west of Christchurch, 11 km deep
  - Widespread damage to land, buildings and infrastructure

- 22nd February 2011:
  - 6.3 magnitude earthquake
  - 10 km southeast of Christchurch, 5 km deep
  - 185 deaths
  - Further significant damage to land, buildings and infrastructure



Background – Canterbury Earthquakes

- Land damage due to:
  - Liquefaction
  - Lateral spread
  - Ground cracking
  - Settlement


Aranui


New Brighton

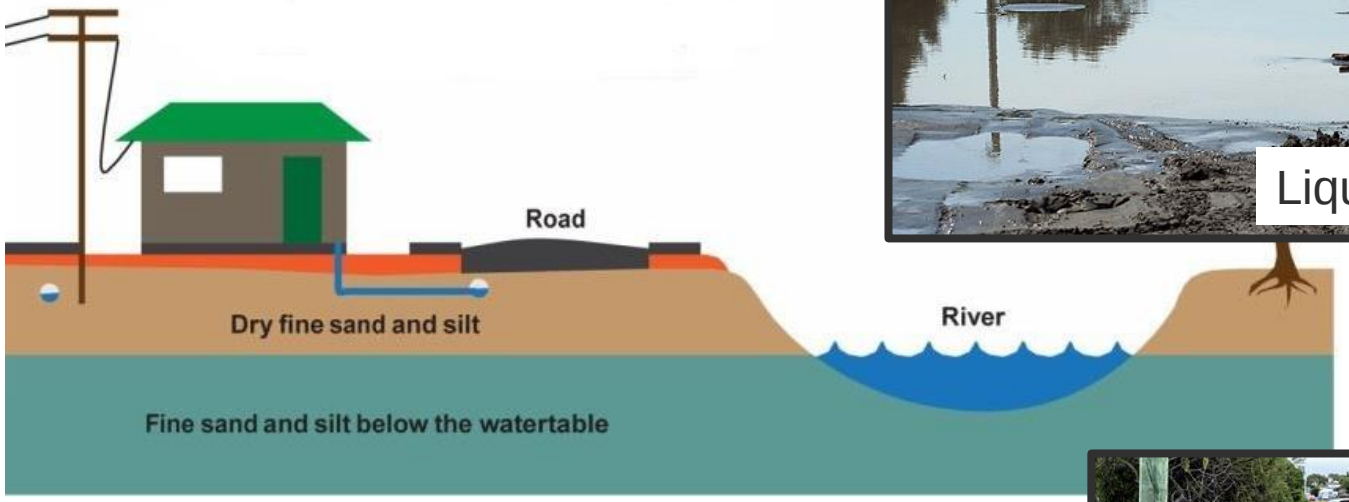

New Brighton

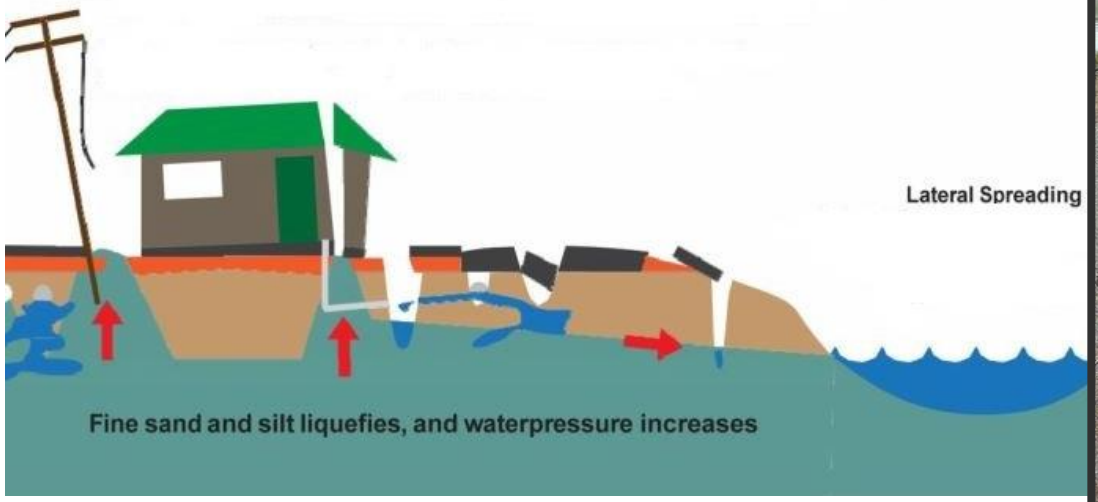

Avonside Drive

Background – Canterbury Earthquake

- **Liquefaction:**
  - Area with loose sands or silts
  - High ground water table
  - Earthquake

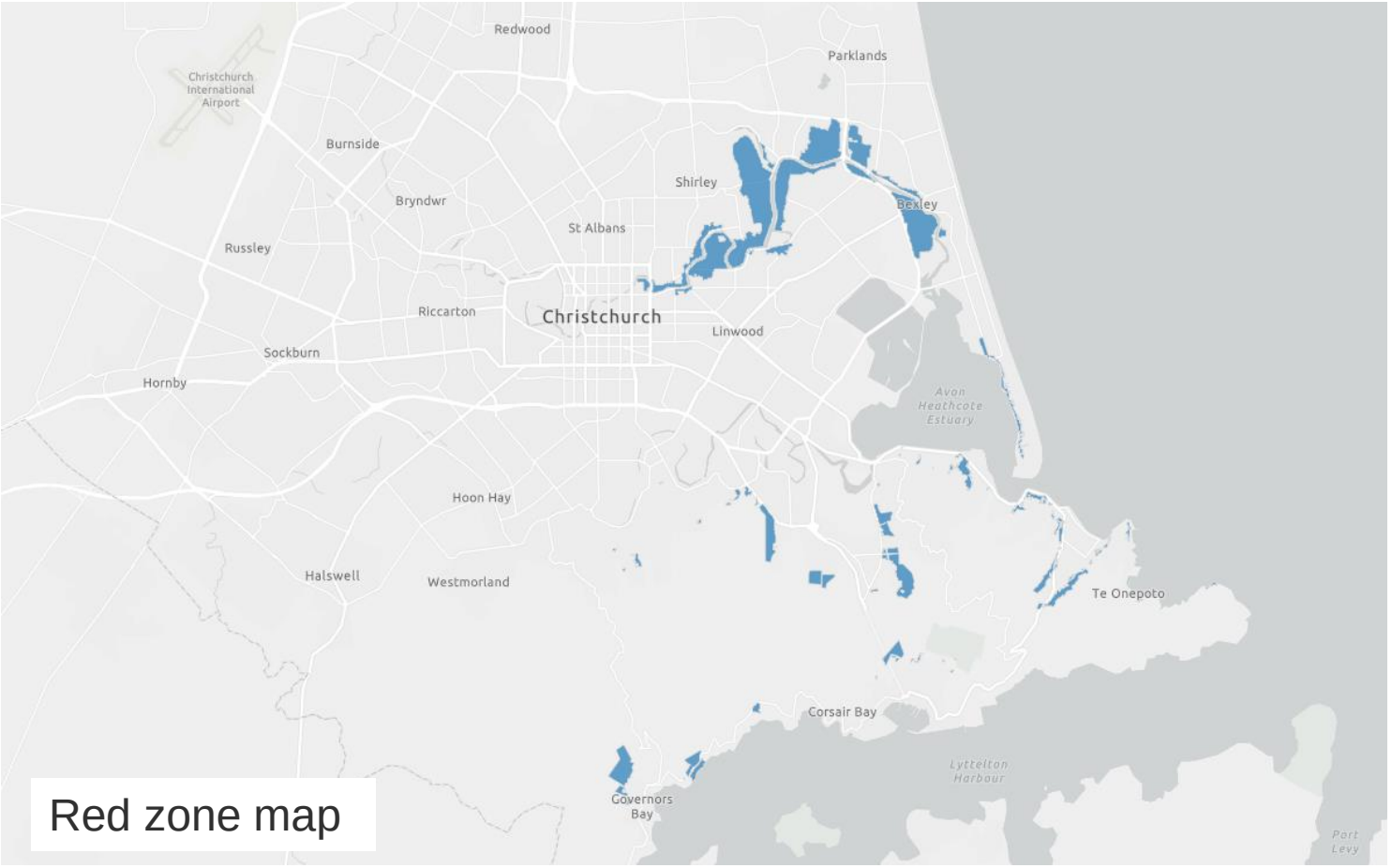
- **Lateral spreading:**
  - Can occur following liquefaction
  - Near sloping ground or
  - Near rivers and streams
  - Movement towards the free face





Background – Red Zone

- **Red zone:** Residential areas where the damage was so significant that it was considered unsuitable for rebuilding / reinhabiting (~600 hectares in total)



Red zone map

Background – Red Zone

Red zone = 2 x

Central Park, New York

Background – Red Zone

Red zone = 4 x

Hagley Park, Christchurch

Background – Red Zone

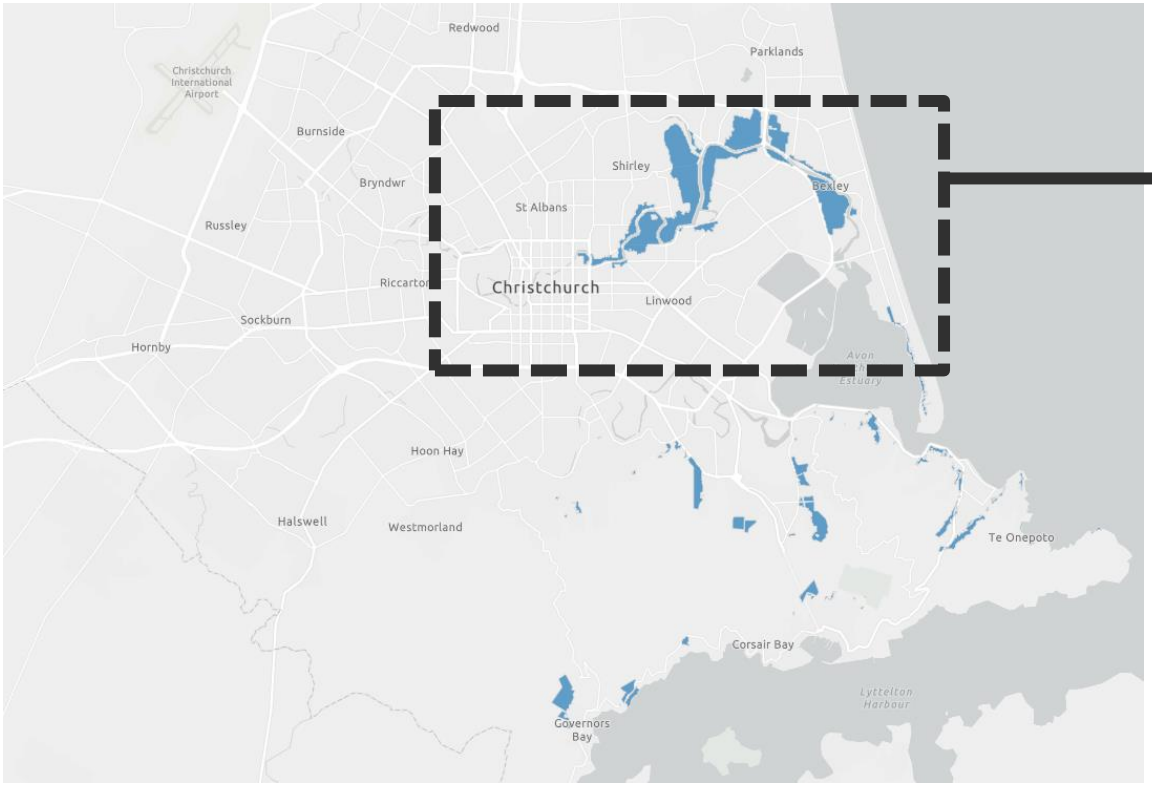
- From August 2011, the Crown made voluntary offers to purchase red zone properties
- By December 2015, over 7,000 property owners in the red zone had accepted the Crown's offer and their properties were subsequently demolished

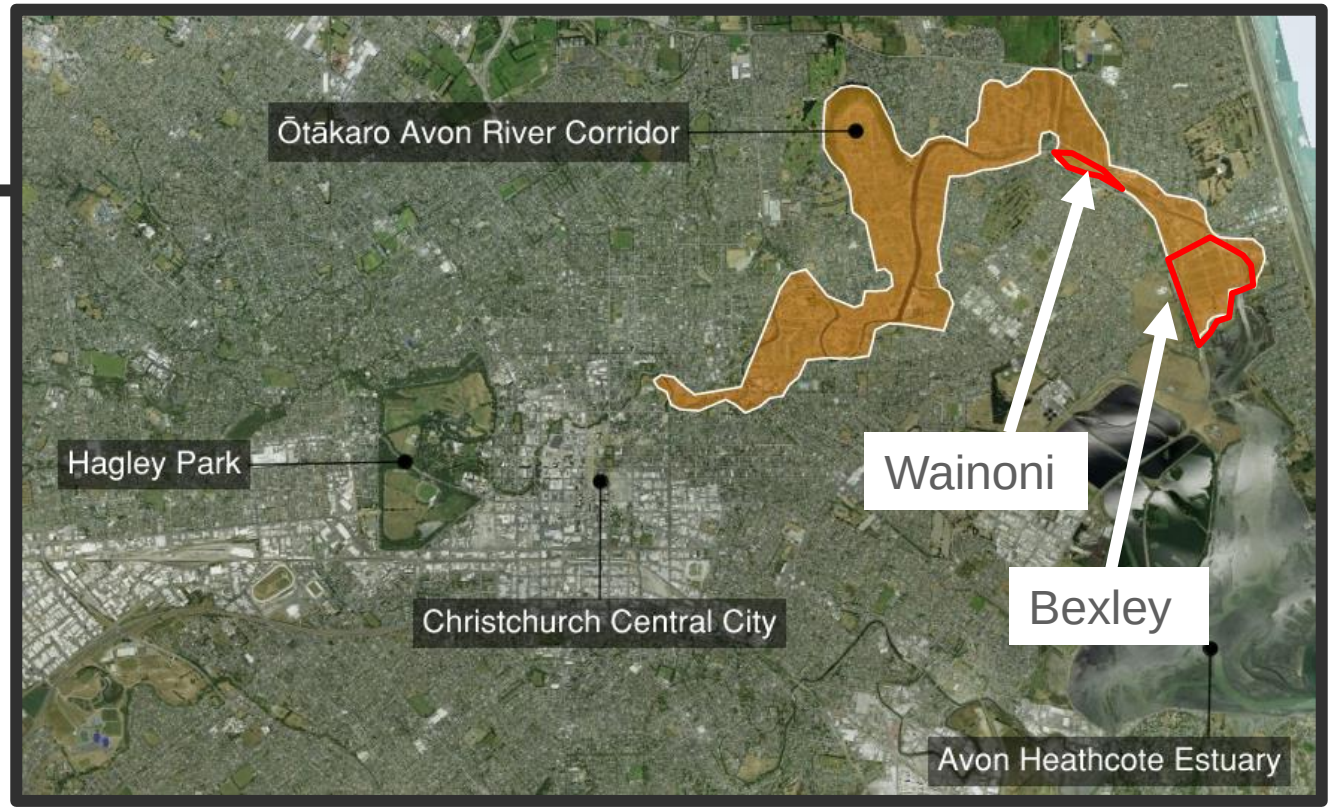
Bexley, Christchurch, 2010

Bexley, Christchurch, 2022

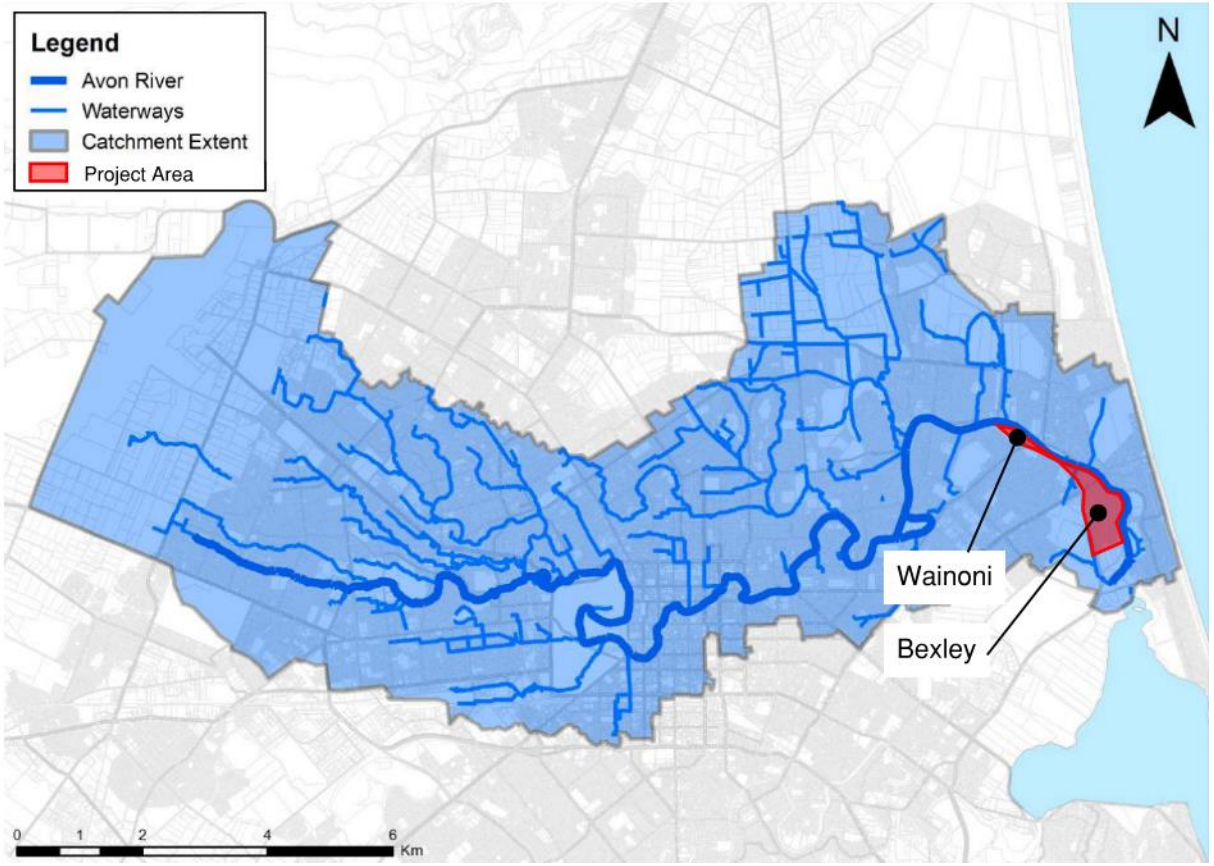
Background - Project Area

- Of the red zone, one area that sustained quite severe damage is a continuous tract of land that lies adjacent to the Ōtākaro / Avon River on the eastern side of Christchurch (orange)
- This area is now known as the **Ōtākaro Avon River Corridor (ŌARC)**
- Focal point of this project is **Wainoni** and **Bexley**





Background - Project



Historically an area of high ecological / cultural value

Reduction in the overall value, due to:

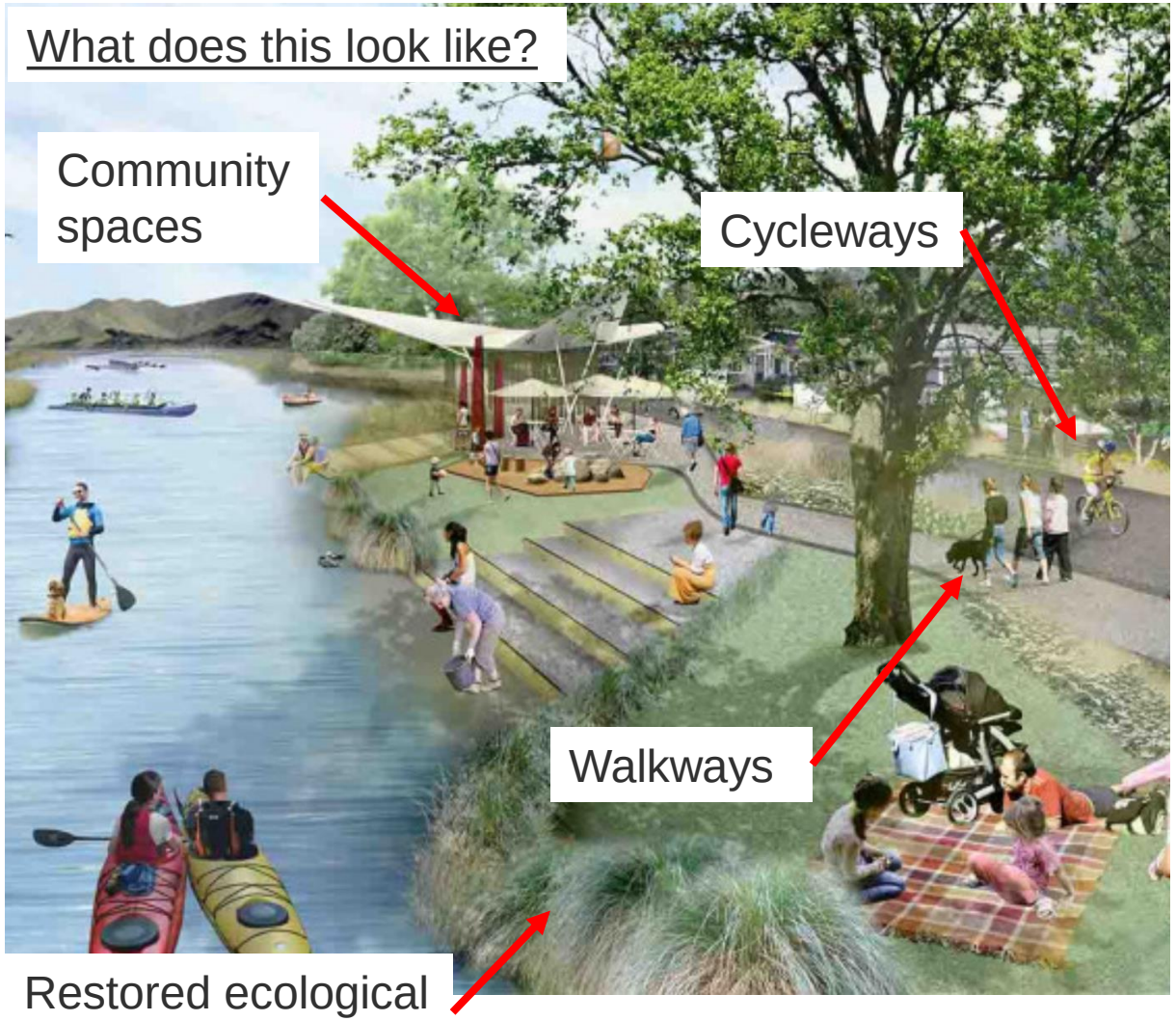
- Residential development
- Damage from earthquakes
- Vulnerability to flooding

In 2022, Council engaged Beca to undertake investigations / design work on the Wainoni and Bexley areas

Project's primary aim is to provide flood resilience and stormwater management in these areas

Background – Regeneration Plan

- ŌARC Regeneration Plan (Regenerate Christchurch)
- It provides a vision and objectives for future land use and opportunities in the area
- **Aims:**
  - Restored native habitat with good water quality
  - Safe, strong and healthy communities
  - Opportunities for enhanced community participation, recreation and leisure



Project Challenges

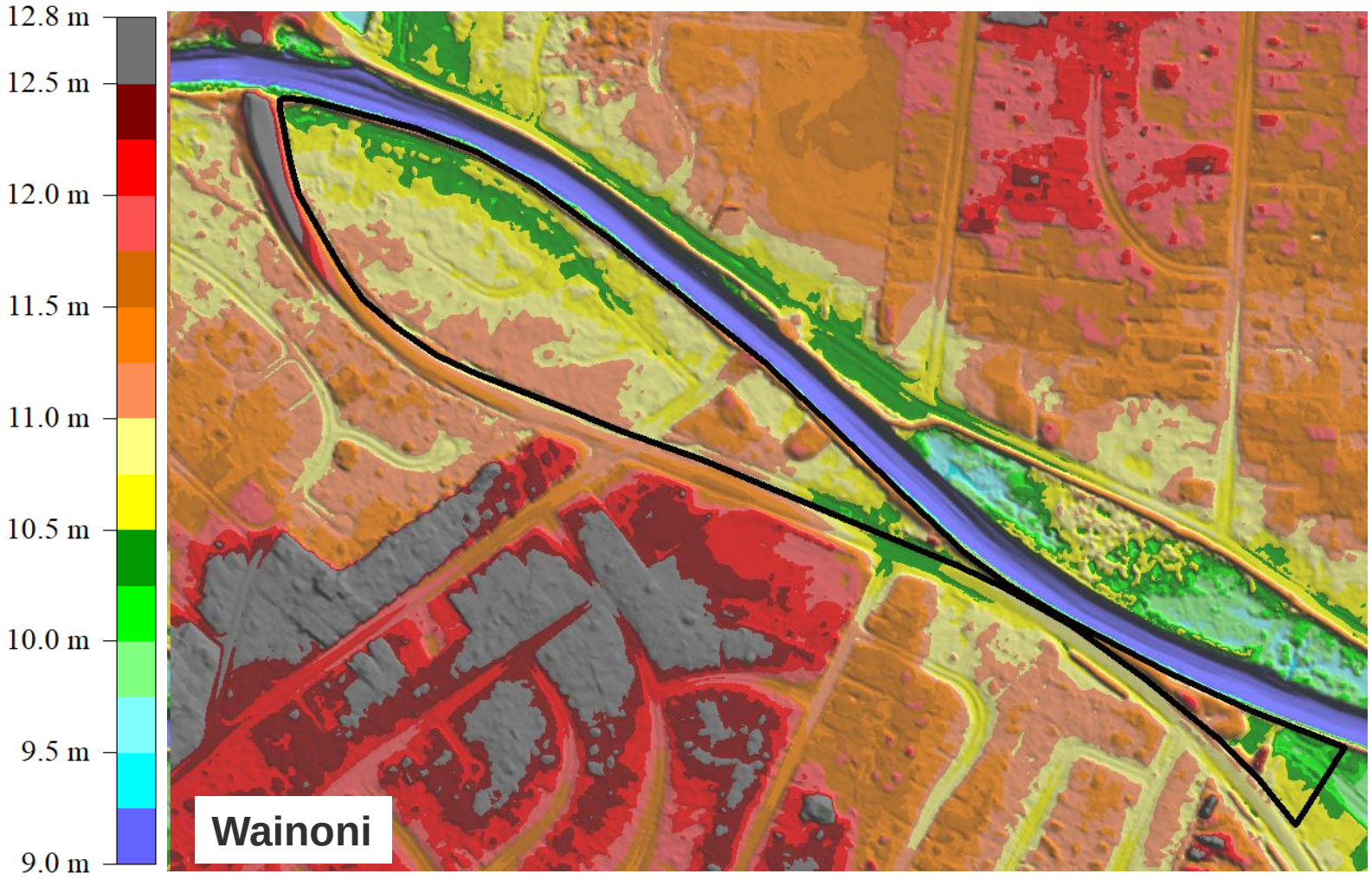
- Space constraints
- Site levels
- Ground conditions
- Contaminated land
- Integration with other projects

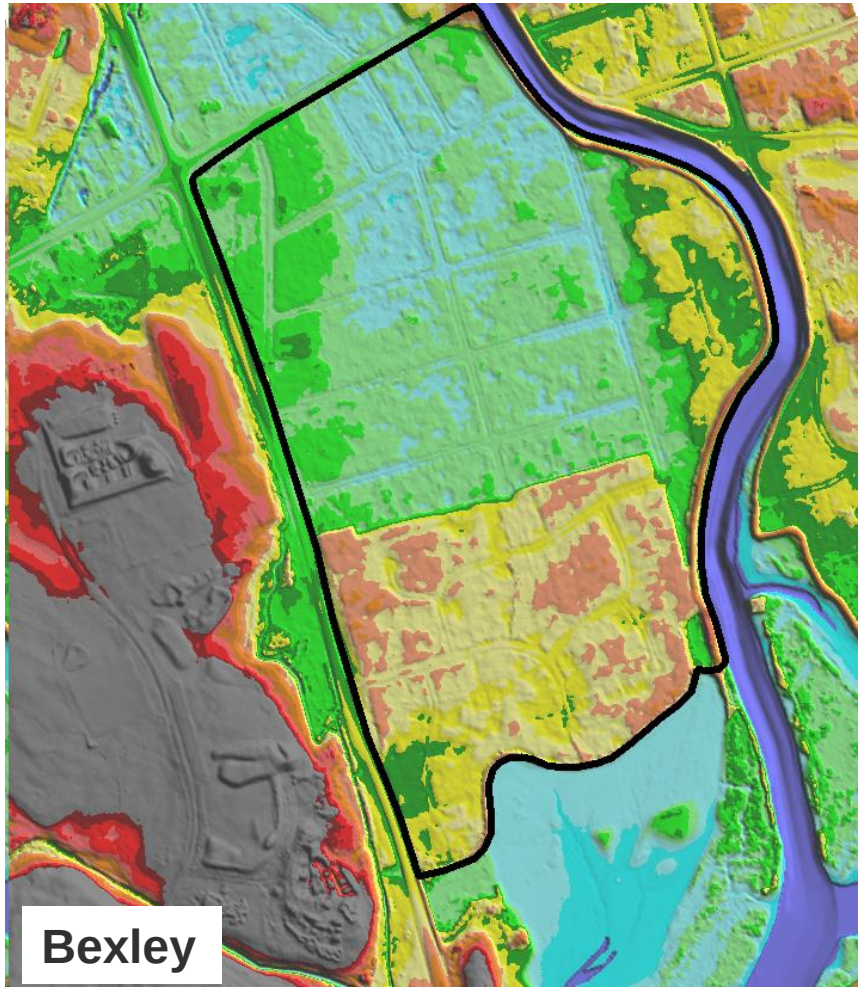
Project Challenges – Space Constraints

Wainoni

Bexley

Project Challenges – Site Levels

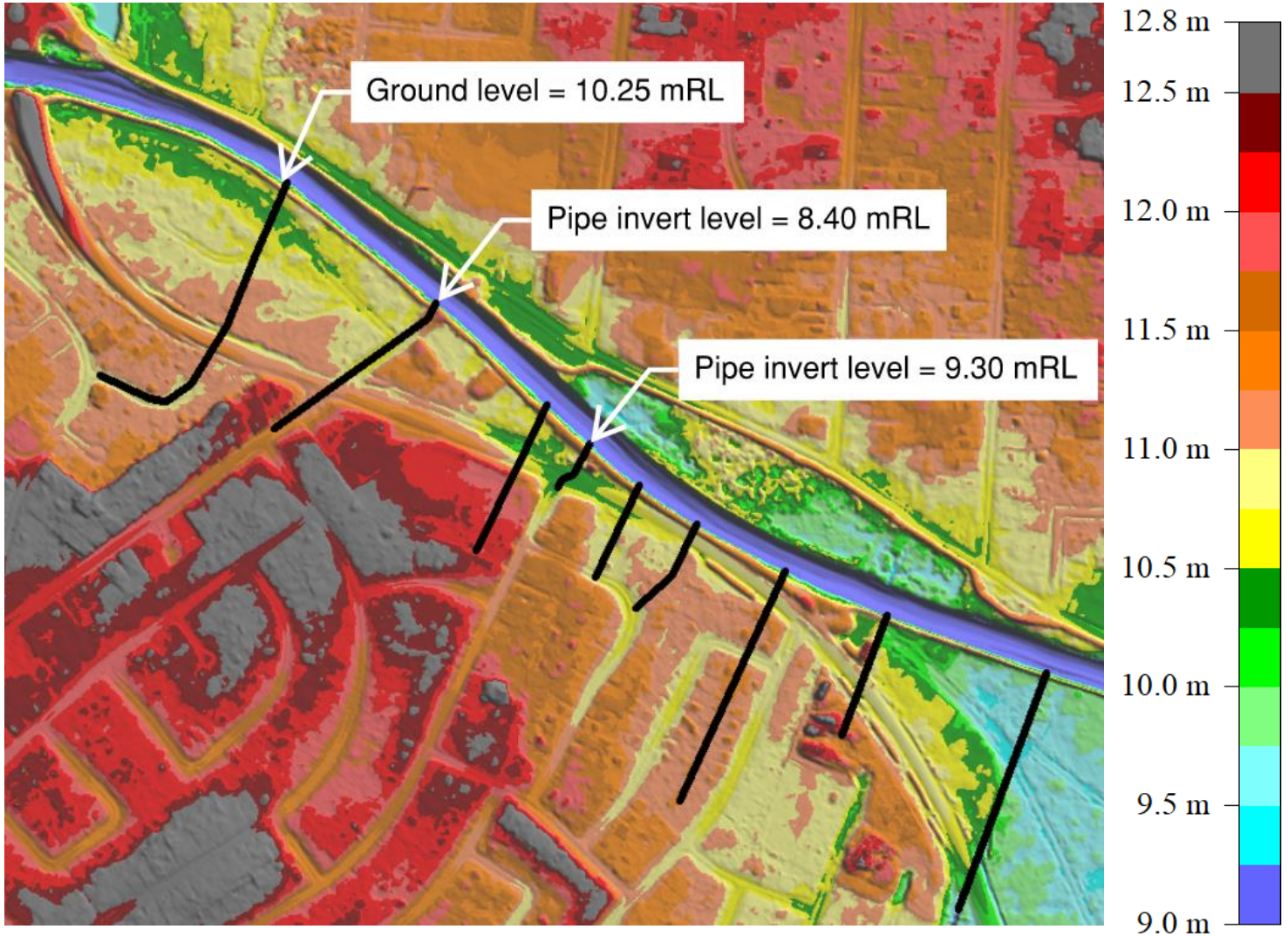




Units are in mRL and are relative to Christchurch Drainage Datum

Project Challenges – Site Levels

- Tidally influenced river levels
  - Mean level of sea = 9.46 mRL
  - Mean high water springs = 10.50 mRL
- High, saline groundwater
- Relatively low-lying gravity stormwater network
- Rising sea levels



Elevations are relative to Christchurch Drainage Datum

Project Challenges – Contaminated Land

- Both sites contain areas of contaminated land
- Sources of contamination are likely from:
  - Demolition of residential housing (from the red zone)
  - Coal tar used in residential roads
- Huge number of investigations
  - 93 machine test pits
  - 395 hand test pits
  - 12 groundwater monitoring bores
  - Still ongoing

Project Challenges – Ground Conditions

Wainoni and Bexley sites

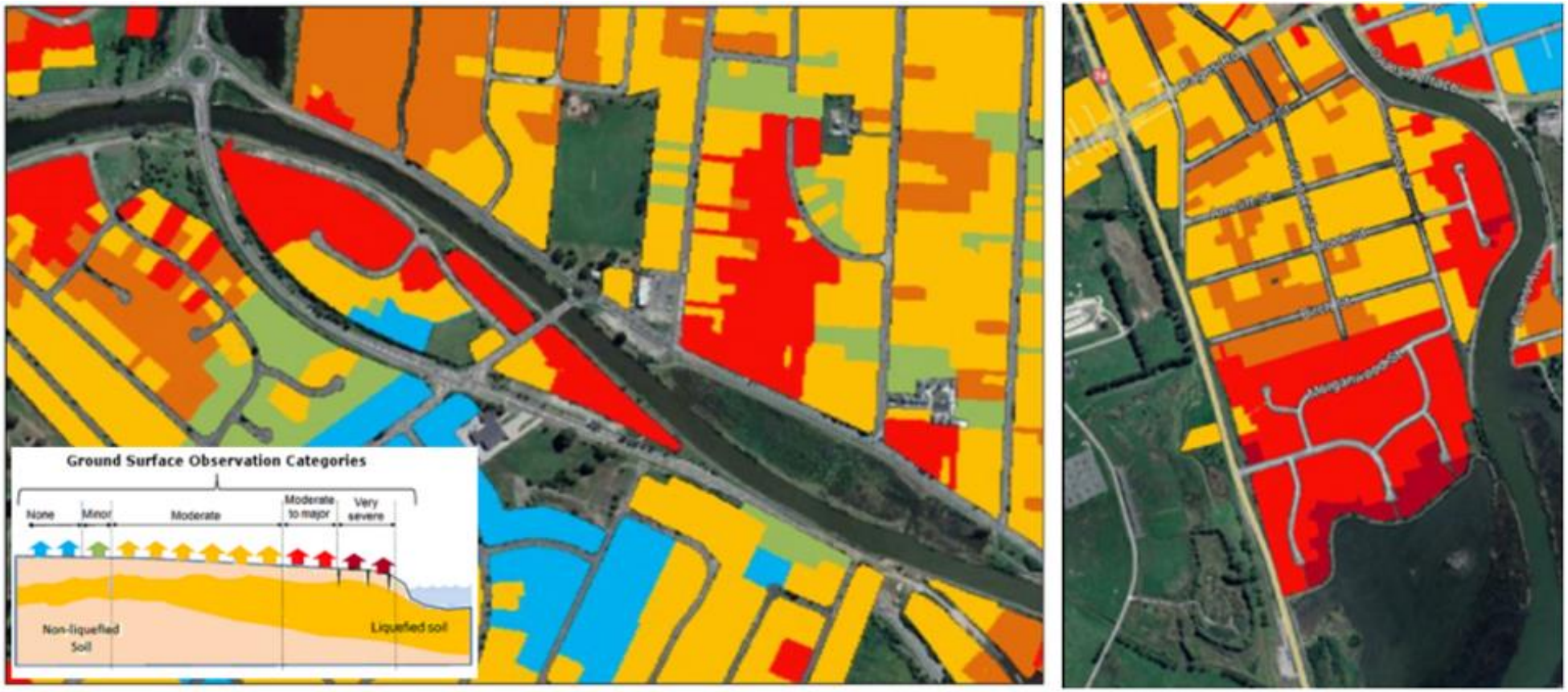
- Loose sandy and silty soils
- High groundwater levels
- Free face of riverbank


Liquefaction


Lateral spread

… **Highly susceptible to liquefaction and lateral spreading**

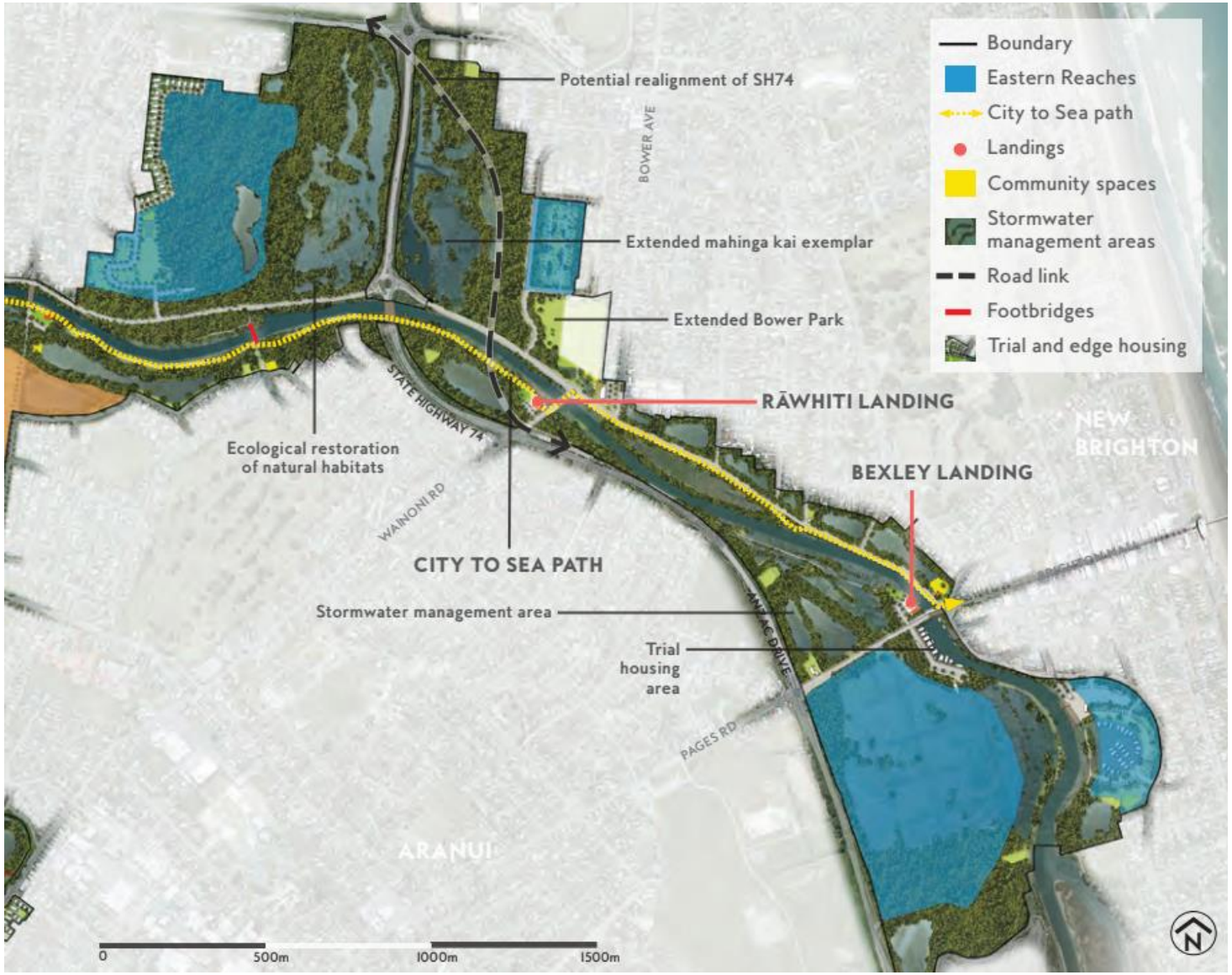
Project Challenges – Ground Conditions



Source: New Zealand Geotechnical Database

Project Challenges – Integration with other Projects

- City to Sea pathway
- Waitaki project design
- Bexley tidal wetland
- Pages Road bridge renewal



Design - Wainoni

Design - Wainoni

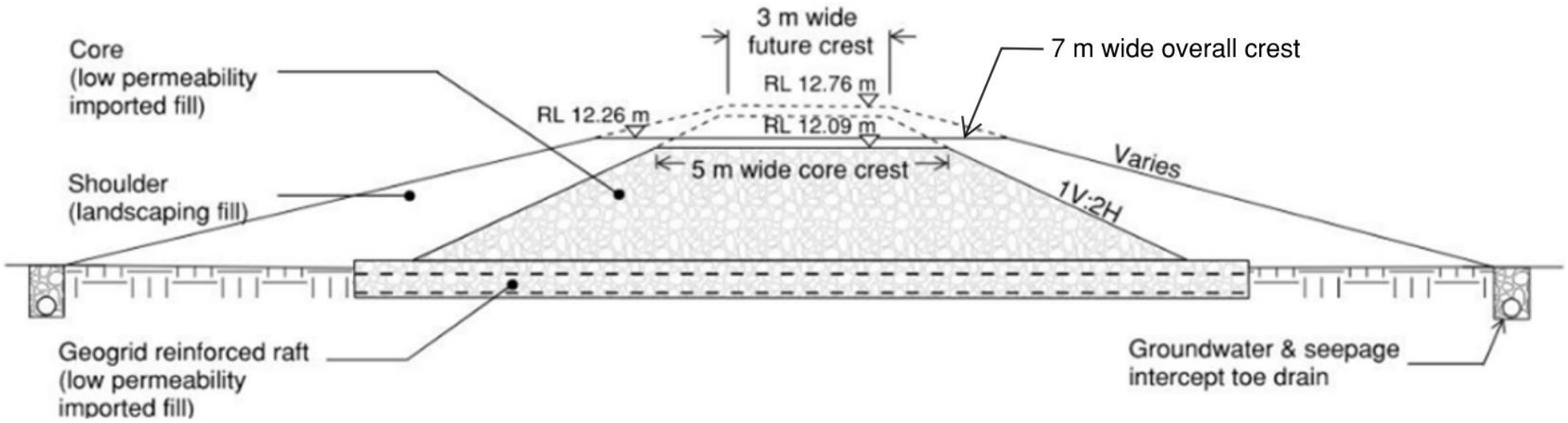
Stopbank:

- Located as far from river as possible to mitigate risk of lateral spread

Design - Wainoni

Stopbank:

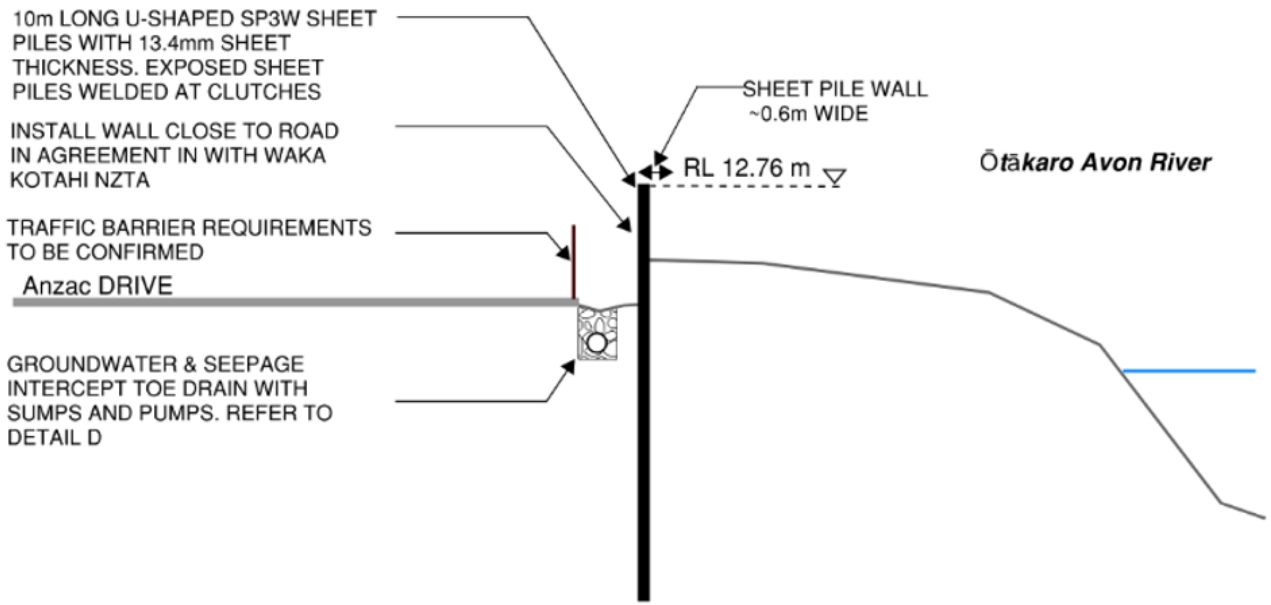
- Earth embankment with a core of low permeability engineered fill
- Flood protection up to 100-year ARI event with allowances for sea level rise, freeboard and tolerances
- Crest to allow for possible future upgrade
- Sheet pile reinforcement to mitigate risk of transverse cracking



Design - Wainoni

Flood Wall:

- Pinch point between Anzac Drive / SH74 and river
- Insufficient space for earth embankment stopbank
- Single row of cantilevered sheet piles



Design - Wainoni

Stormwater Treatment Facility:

- Preference for land based systems
- On river side of stopbank
  - Bund to provide flood protection
- Creates new free face
  - Pumped inflow to keep depth as shallow as possible
  - Offsets required from surrounding infrastructure to mitigate lateral spread risk
- Total area available is 27,000 m^2

Design - Wainoni

Stormwater Treatment Facility:

Catchments

- Large part of catchment included in another project
- Total catchment area to be treated = 114 ha
- First flush volume = 11,500 m^3

Design - Wainoni

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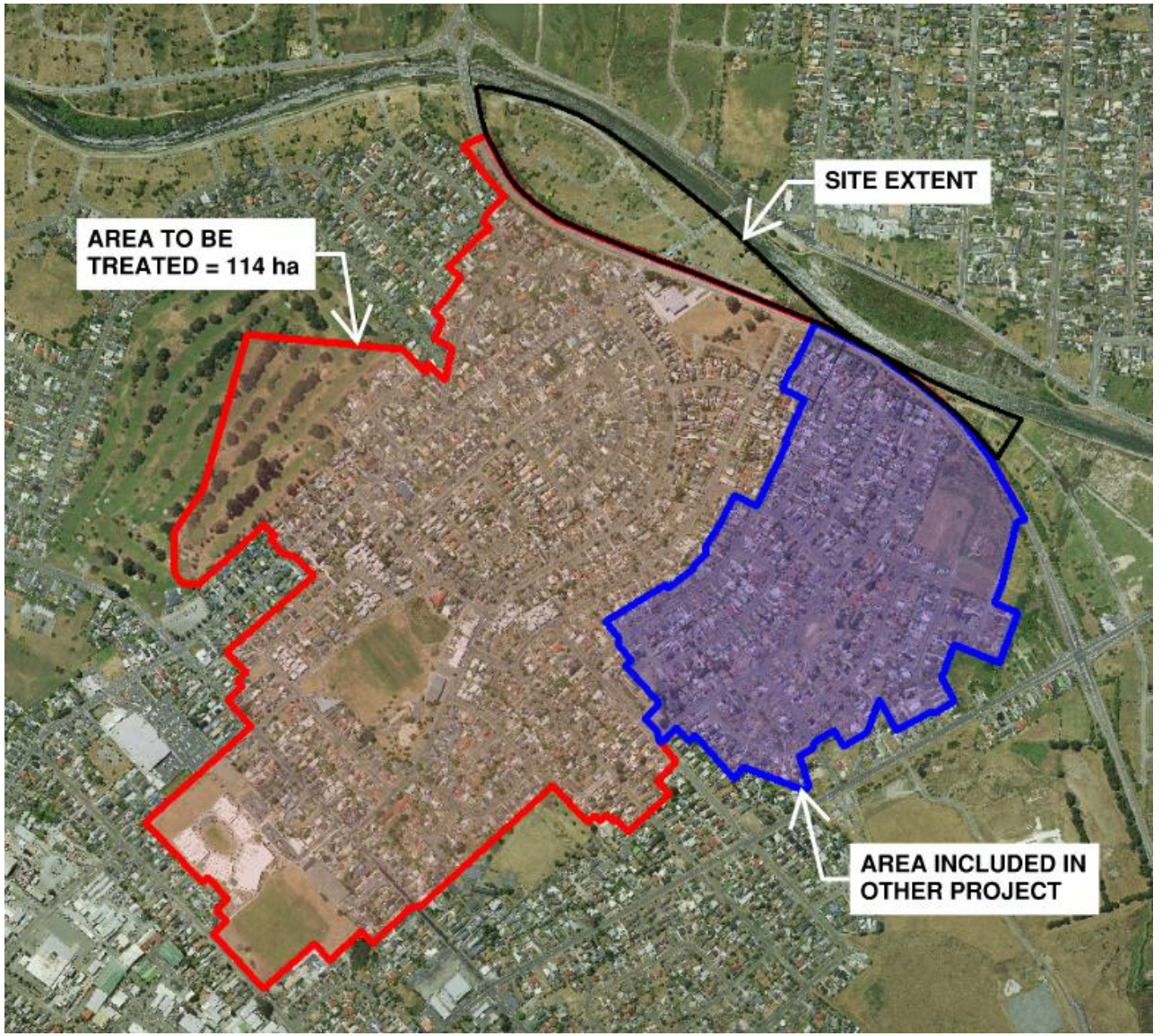
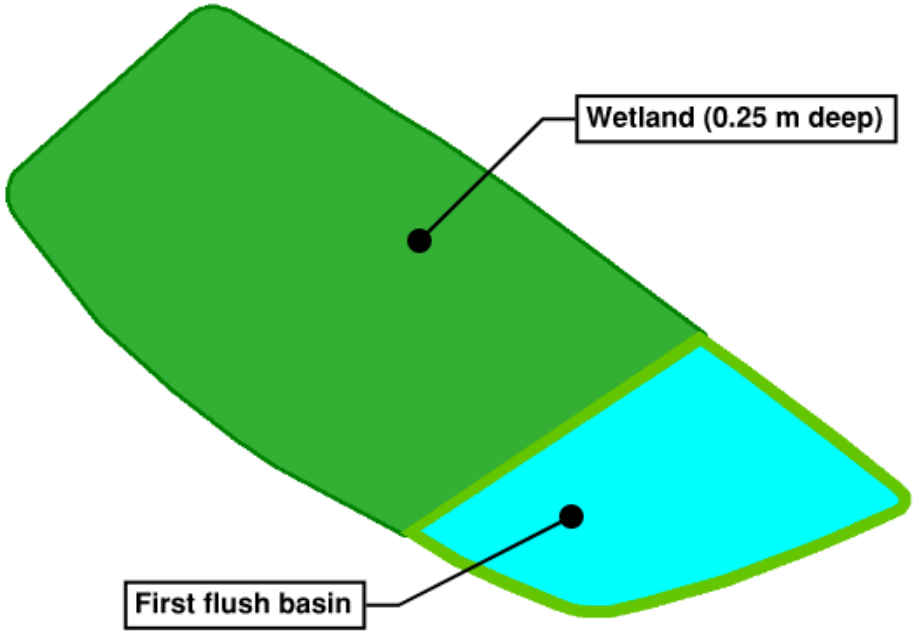


Design - Wainoni

Stormwater Treatment Facility:

- Christchurch City Council wetland sizing method

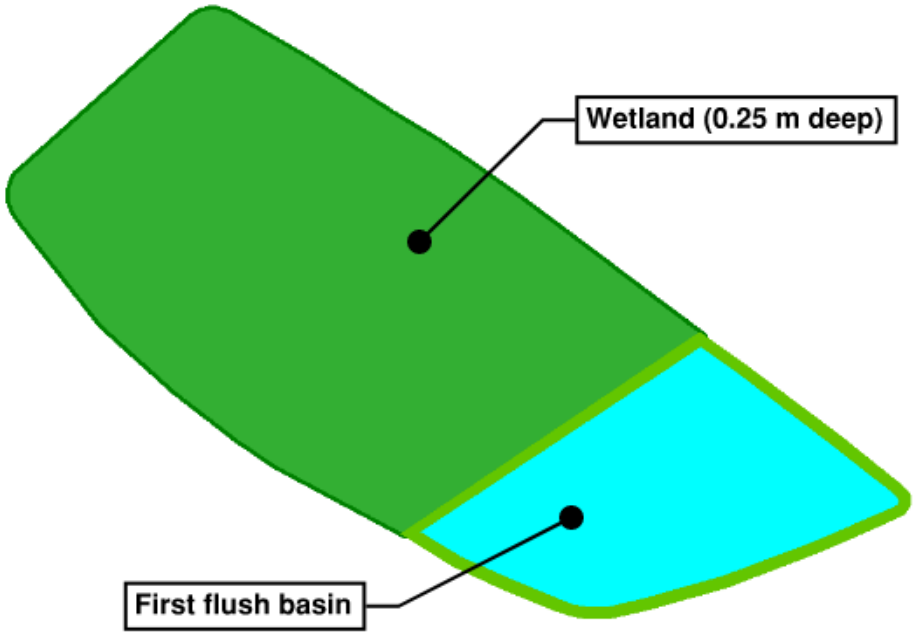


  - Results in a wetland footprint of **42,000 m^2**
  - Total area available = 27,000 m^2

Design - Wainoni

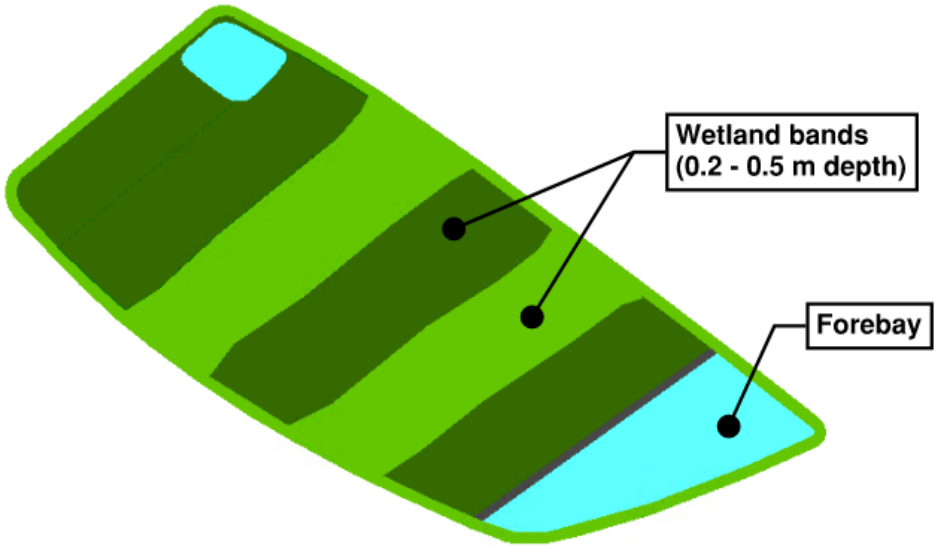
Stormwater Treatment Facility:

- Christchurch City Council wetland sizing method



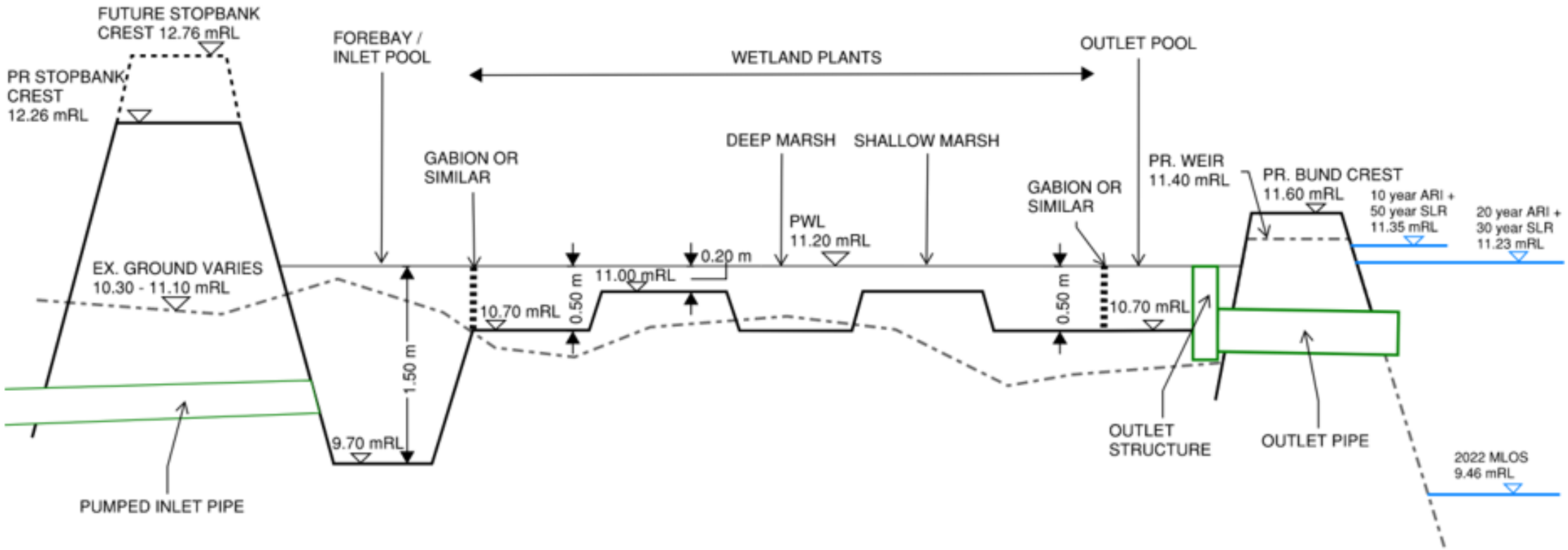
  - Results in a wetland footprint of **42,000 m²**
  - Total area available = 27,000 m²

- Auckland Council wetland sizing method



  - Results in a wetland footprint of **29,000 m²**

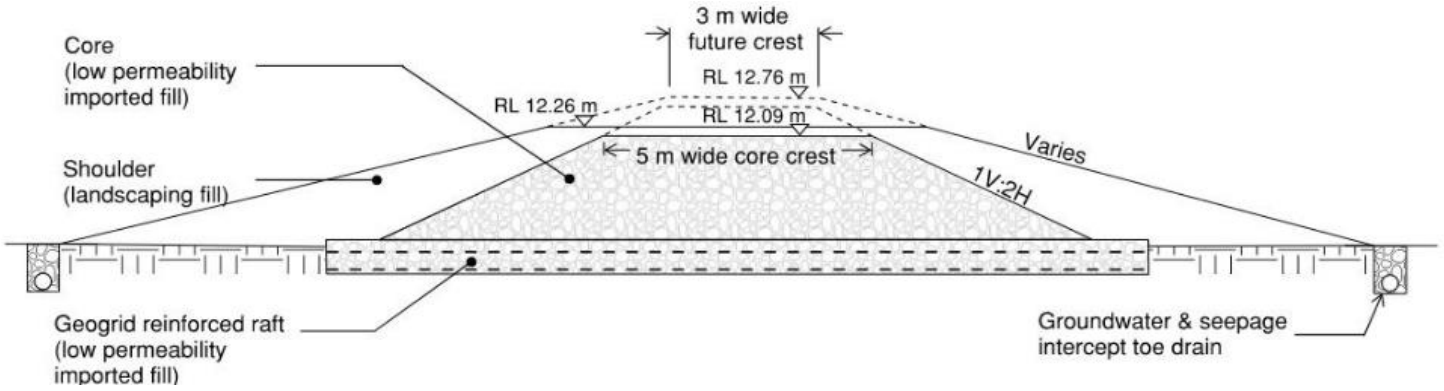
Design - Wainoni



Design - Bexley

Stopbank:

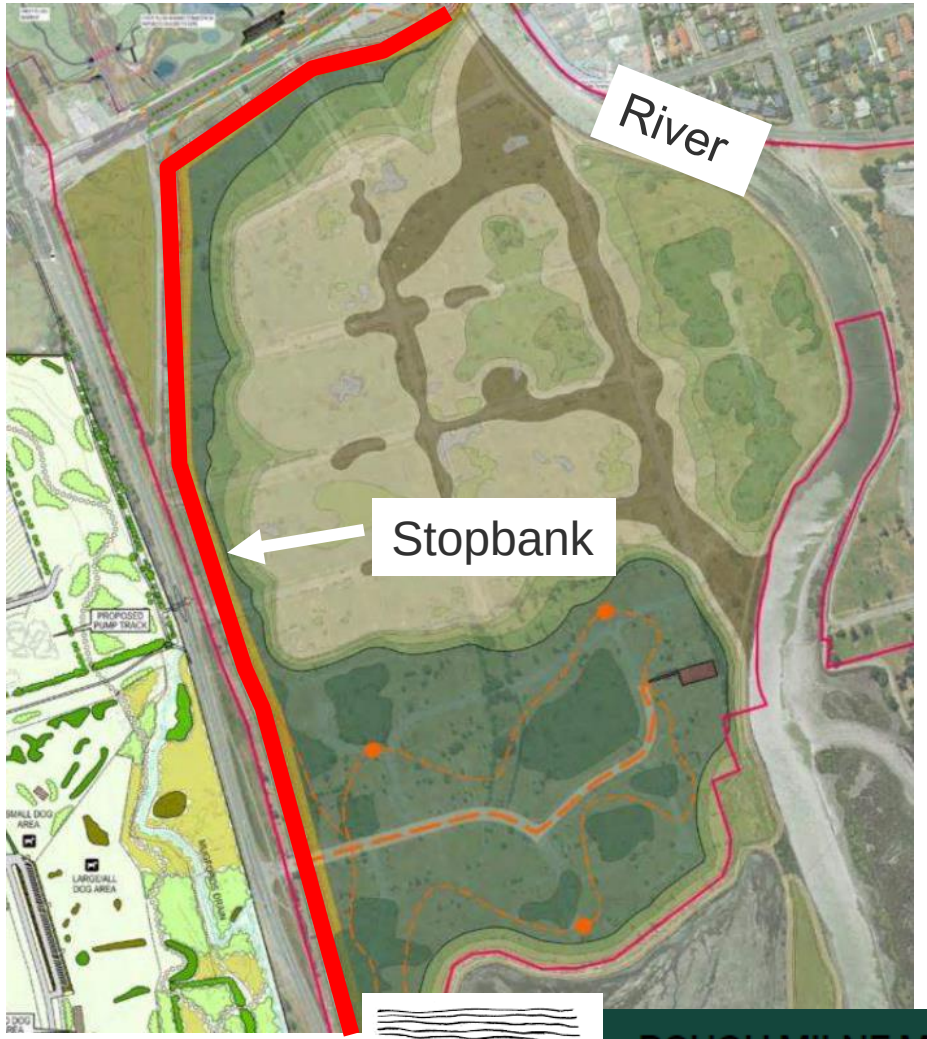
- Positioned as far from the river as possible to:
  - Reduce the risk of lateral spread
  - Maximise space for the Bexley tidal wetland
- Same cross section as Wainoni



Design - Bexley

Tidal wetland:

- Tidal wetland between the stopbank and the river (designed by Rough Milne Mitchell)
- Provides salt marsh and wetland ecological habitat
- Recreation paths and natural landscaping
- Education of the public
- Essentially, the river will ‘reclaim this land’
- Want to **maximise the area** as much as possible, as it is considered area with highest ecological potential in entire OARC area



Design - Bexley

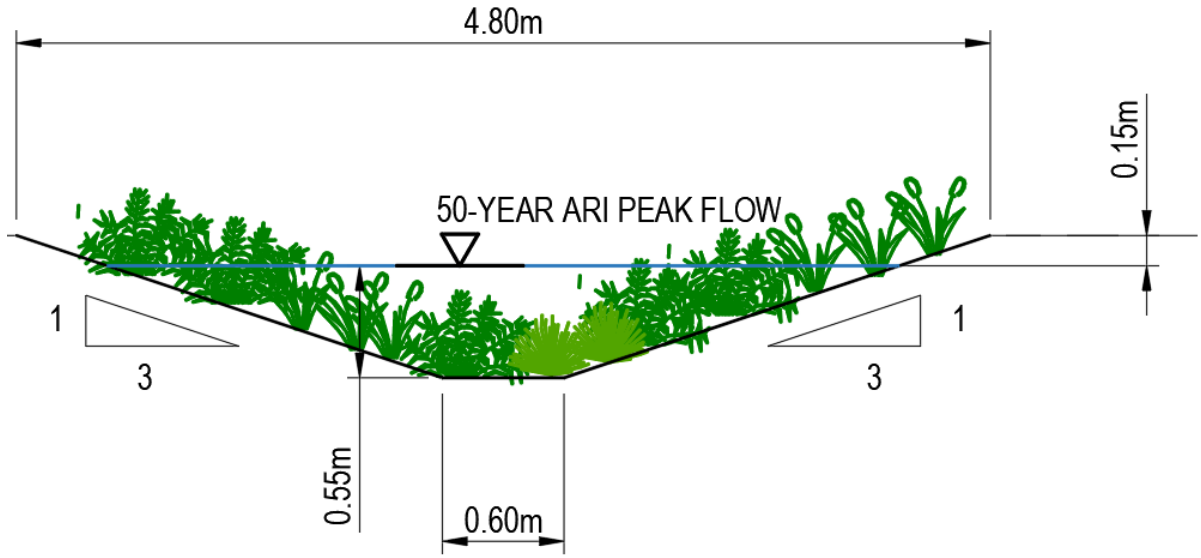
Stormwater management and treatment:

- Three upstream catchments
- Capped former landfill located in the eastern section of the Estuary Drain catchment (green)
- Introducing leachate contaminants to the typical stormwater runoff
- A large area would be required to treat Estuary Drain catchment runoff, reducing space available for the tidal wetland (if on-site)

Design - Bexley

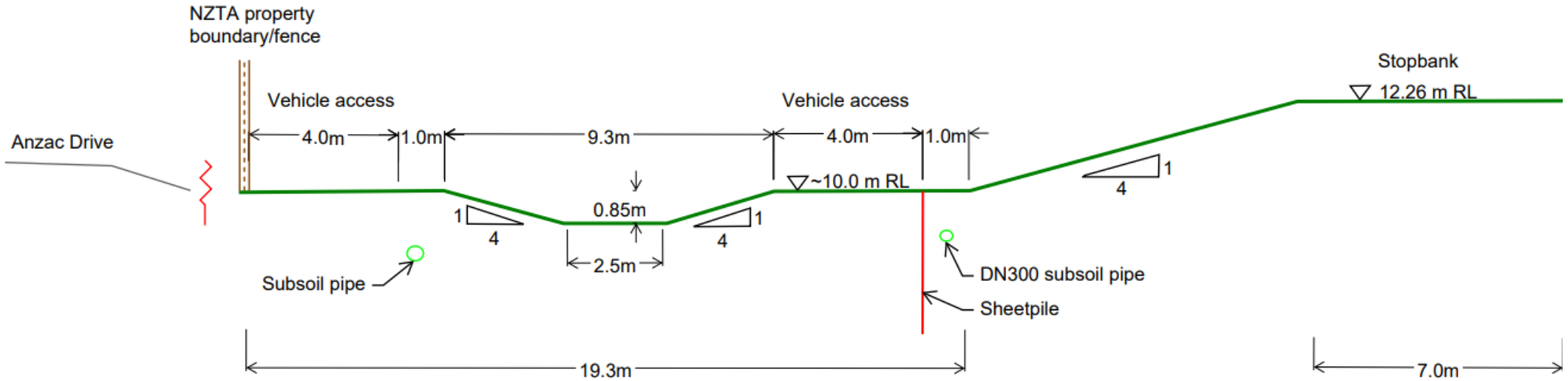
Anzac Drive / Pages Road Catchments:

- Relatively small and linear, hard to justify the use of a large wetland for treatment
- Swales identified as a suitable starting point
- Vegetated swales were preferred over grass swales due to:
  - More effective treatment
  - High groundwater in the area (hard to mow)
- Preference to keep swales as shallow as possible due to:
  - Prevent intrusion of saline groundwater from the adjacent river
  - Reduce the risk of lateral spread



Design - Bexley

- To prevent the intrusion of saline groundwater:
  - Sheet pile on river side of swale to stop groundwater flow into the base of the swale
  - Subsoil pipe prior to sheet pile to collect groundwater and drainage from stopbank
- To prevent the intrusion of landfill contaminated groundwater (from under adjacent road):
  - Subsoil pipe on landfill side of the swale to collect contaminated groundwater flows



Next Steps

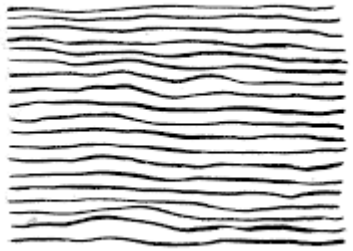
- Investigation into alternative treatment methods for the Wainoni site
- Options investigation for location and type of stormwater treatment facility for the Estuary Drain catchment
- Preliminary design for both sites

Conclusions

- Two sites that present several design challenges:
  - Spatial constraints
  - Low-lying ground that is susceptible to liquefaction and lateral spreading
  - High, saline groundwater
  - Tidally influenced river and groundwater levels
  - Contaminated land
- These challenges have required cooperation between Council and various disciplines to arrive at design solutions
- Investigations and design are ongoing

Acknowledgements

Christchurch City Council



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